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URBAN WATER CENTRE: *educate and celebrate!*

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Summary

This thesis explores the role of water in urban landscape architectural design and identifies strategies that will conserve and optimise the use of water in the built environment.

This is done through selecting a site in Pretoria at the intersection of the Apies River channel and Nelson Mandela drive and designing an Urban Water Centre that explores; exposes and celebrates water in the urban context. The design creates opportunities for kids from nearby schools, students from TUT, residents from the area, pedestrians and tourists to interact on a physical and emotional level with water. Educating people about water conservation is an important aspect of the project and raising awareness is the first step.

The design addresses the city-wide need for green public open space and provides opportunities for urbanites to connect with water and the Apies River.

This connection is established through the facilitation of significant encounters with water. These include physical contact play with water, creating interest and anticipation around rain events and through translating some of the associated attributes of water into a solid surface.

The design approach is influnced by studying the Sustainable Sites Initiative's ecosystem service approach. Green Star SA is investigated for a possible application to landscape architecture. The findings from the Sustainable Sites Initiative are enhanced by General Systems Theory and then used to generate systems that supports the the desired experiences.

The first and largest system lifts some of the base flow from the Apies River channel with a waterwheel, where after it is purified in a constructed wetland and a chlorine-free disinfecting process. The clean water is then displayed in a play pond that partially drains through a gravity driven vortex generator. The vortex generator aerates and cools down the water while adding movement; sound and a sense of the passage of time to the human experience. From the vortex, water flows into a constructed pebble lined stream that children can play in and experience stream ecology. The pebbles and vegetation refers back to the Apies River before it was lined with concrete. From the stream the water rejoins the channel.

The second on site water system addresses rainwater. The design creates anticipation and curiosity associated with rain events. Rainwater from one of the on site buildings are harvested and displayed in a rain-meter garden. A first-flush system intercepts the first dirty water where after it drizzles down a rain-curtain into a rain-meter system. The rain-meters are large bullet resistant glass tank-like containers, calibrated to show how many millimetres of rain have fallen during the shower. A rain-sensor drains the water into a temporary wetland and lets in percolate into the underground storage tank.

The third on site water system treats grey water from buildings through a stepped constructed wetland and displays the cleaned water in a jubilant motion activated display at one of the pedestrian entrances. Water from the rain-meter system; the grey water system and harvested surface runoff all contributes towards meeting the water needs of irrigation and buildings.

Other eco-system service strategies identified in the study are applied in the design. These include the protection of on site biomass along with the introduction of region appropriate planting; design for- and use of waste reducing materials and the integration of on site systems to enrich the experience.

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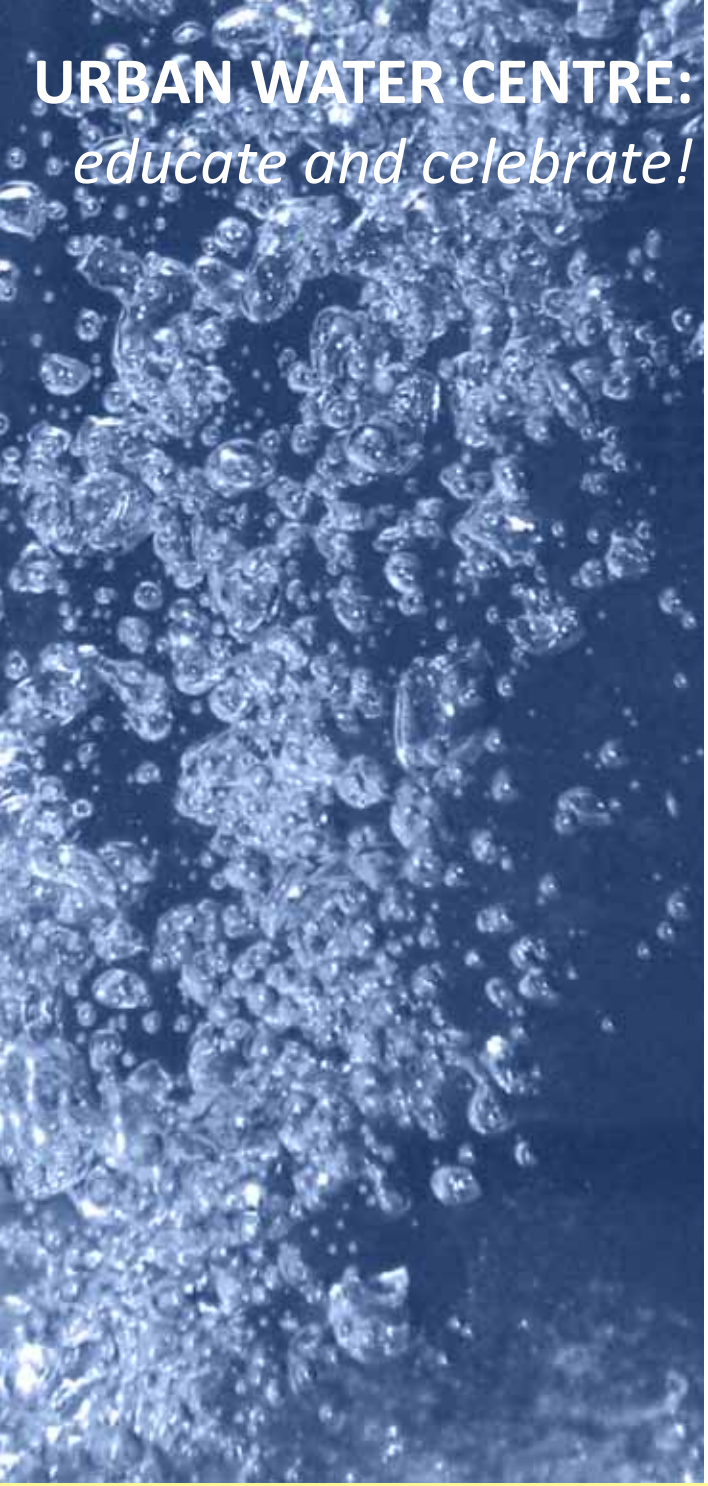

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Informing the Abstract

"Landscape Architecture is a design profession committed to a sustainable future by applying an integrated and holistic approach to living systems." (Institute of Landscape Architecture South Africa, 2007)

> "Green design is not simply about picking parts from a catalog[ue]. It is about ensuring that an ecological design intent is achieved." (Kwok, 2007, p. 1)

Green building rating tools sets criteria and measurements of quality that objectively evaluates how *green* a building is. The Green Star South Africa rating tool is based on the Green Star Australia system. (Green Building Council of South Africa, 2008).

The Sustainable Sites Initiative is an American organization that promotes the practice of sustainable site development and management. (Sustainable Sites Initiative, 2008)

Abstract

The world wide water crisis will soon become personal and water needs to be conserved in any way possible. The study aims to explore the role of water in urban landscape architectural design and to identify strategies that will conserve and optimise the use of water in the built environment. Creating awareness of all the on site water systems is a step towards educating the public on the importance of water and its role in green landscape architectural design.

Elaborating on the abstract

By using the Sustainable Sites Initiative (SSI) as a primer to establish possible relationships of parts and systems on a specific site, the author will attempt to elaborate on sustainable strategies that are applicable to Landscape Architecture in South Africa and the context of the City of Tshwane Metropolitan Municipality (CTMM).

Samevatting

Die wêreldwye water tekort raak almal, dit lei daartoe dat water besparing op alle gebiede nodig is. Die studie ondersoek die rol van water in stedelike landskapargitektuur. Strategië wat die gebruik en besparing van water op die hart het word ondersoek en geformuleer. Die publiek word ingelig oor die belangerikheid en plek van water in die stad en *groen* landskapargitektuur deur hul bewus te maak van die water verwante sisteme op die terrein.

Chapter layout

Chapter 1 introduces the site through discussing the relevance of the site in light of the identified theme. A possible program and design problem are discussed and an approach formulated. Possible clients are identified and the brief is set and delimited.

Chapter 2 sets the scene for the dissertation; global ecological and environmental problem are discussed through focusing on the water crisis. An exploration of world events that led to the rise of the green building industry in South Africa follows. The Green Star SA Office v1 is discussed in terms of the possible contribution of Landscape Architecture to a project's green status. The relevance of the study is discussed and possible outcomes are envisioned.

Chapter 3 aims to ground the dissertation through discussion of the problem statement and defines the hypothesis. Relevant topics and theories are discussed and interpreted.

Chapter 4 addresses the many uses, memories and aspects of water.

Chapter 5 addresses the context, site, design goals and objectives.

Chapter 6 discusses precedent studies and draws conclusions.

Chapter 7 explains the design development and tests it against the systems approach strategies.

Chapter 8 elaborates and explains the design solution through appropriate representational drawings and sketch plan, visualization of the strategies and integrating them into a physical whole.

Chapter 9 focuses on the technical report and design resolution.

Chapter 10 sees the project audited with the appropriate Green Star SA categories. The application of Green Star SA on Landscape Architecture is discussed. The project is concluded.

Bibliography and Addendum follows.

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CONTENTS_

LIST OF FIGURES_

URBAN WATER CENTRE: *educate and celebrate!* 4

review and reasoning_ 14

inform_ 22

grounding_ 32

water exploration_ 46

context and analysis_ 52

precedent studies_ 76

design development_ 88

design resolution_ 104

technical investigation_ 120

1

Introduction to the site through conceptual frameworks

The Apies River was one of the main reasons for the founding of Pretoria. The river historically formed the edge between the city and the adjoining farmlands that later became the suburbs of Sunnyside and Arcadia (Bolsman, 2001, p. 170). This natural boundary has been enhanced by the addition of Nelson Mandela Drive as main connectivity spine from Fountains Valley to the city centre. The combination of a main connectivity spine and the river channel fragments the city. Urban planning and open space planning schemes have tried to address this gap in the urban fabric.

A number of planning initiatives have addressed Nelson Mandela Drive and the Apies River. Figure 1 overlays these initiatives. These include among other: (Loots, 2007, pp. 10-11)

- Apies River Urban Design framework - 1999
- Tshwane Inner City Development Framework - 2004
- Tshwane Crossing (Kopanong) – 2005
- Mandela Development Corridor – 2005
- Tshwane Inner City Local Open Space Plan (LOSP) – 2007

FIGURE 1. OVERLAY OF MUNICIPAL FRAMEWORKS

The 1999 Apies River Urban Design Framework by Holm Jordaan provides a vision where "…the river [represents] a beautiful natural and cultural asset, bringing and breathing life, human joy and prosperity, which is accessible to all." (Holm Jordaan Group, 2001)

In 2009, in an urban design exploration, a group of Architecture students from the University of Pretoria, with whom the author collaborated, identified the Apies River as a vibrant linear spine for a public open space network in the future. This spine of public open space will include numerous soft green spaces, public squares along with passive and active recreation. The framework approaches the development of Nelson Mandela Drive as a series of nodes or 'buttons' that focuses on east-west integration, to figuratively button the rip in the urban fabric. Figure 2 diagrammatically illustrates cultural and institutional nodes along with active and passive recreation nodes. Selected projects in the nodes, of which this thesis project is part of, will be catalysts for future development along Nelson Mandela Drive.

The Apies River channel must be made safe and must provide the user of the city with a visual and emotional link with water and nature. The natural and cultural history surrounding the river must be celebrated through interventions that commemorate its history and educate the city user on the significance of the Apies River.

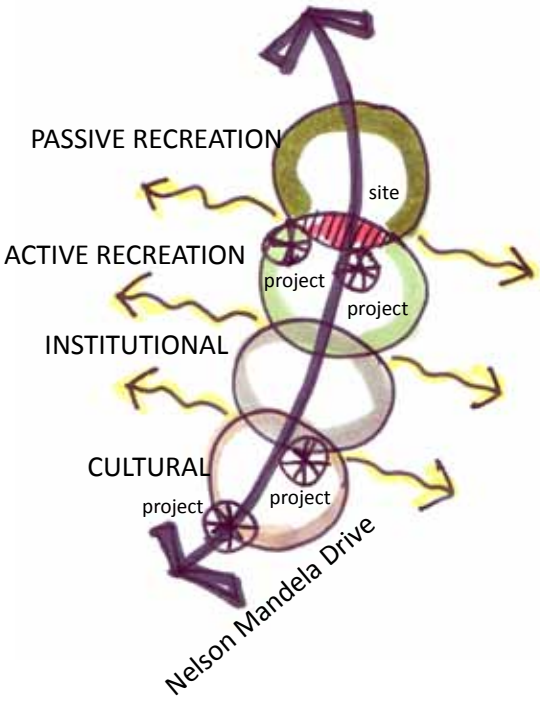


FIGURE 2. NELSON MANDELA STUDENT URBAN DESIGN FRAMEWORK

FIGURE 3. SITE AS LINK IN URBAN PEDESTRIAN MOVEMENT NOT TO SCALE

SITE SELECTION

The proposed site on Nelson Mandela Drive provides the following attributes:

- Relevant Business and Public Open Space zoning
- Identification of the site as a future local park by the Tshwane Inner City LOSP (Loots, 2007, p. 77)
- The channel thatbisects the Apies River
- The site has brown field status

The site lies within the passive recreation node that has been identified in the Nelson Mandela Student Urban Design Framework (figure 2).

CONTEXTUAL OVERVIEW

The site forms an important east-west pedestrian link in movement along open spaces in the city. It fills the gap between Lillian Ngoyi Square and the gardens of the Union Buildings as illustrated in Figure 3.

In the chosen study area (figure 4), the site lies central to educational, medical, commercial, cultural and institutional areas.

Primary and secondary users for the Urban Water Centre were identified.

Primary users:

- Students from two Tshwane University of Technology campuses and the Tshwane North College
- School children from Primary and Secondary schools in the immediate vicinity
- School children from the region for educational purposes (periodically)
- Researchers working at the Urban Water Centre
- Local residents that will utilize the site as a neighbourhood park

Secondary users

- Purpose bound pedestrians
- Business people on lunch
- Tourists and visitors from nearby facilities (proposed functions from M.Arch Prof students)
- Users of on site retail facilities

Design brief

The brief calls for the design of a public open space along Nelson Mandela Drive that connects the city users with the Apies River. The connection must be established through celebrating the river and water in the urban context and through experiences and learning opportunities. The role of water in green design and sustainability must be obvious. The project must include amenities for school children, students, pedestrians, business people and tourists that visit Nelson Mandela Drive as a cultural destination.

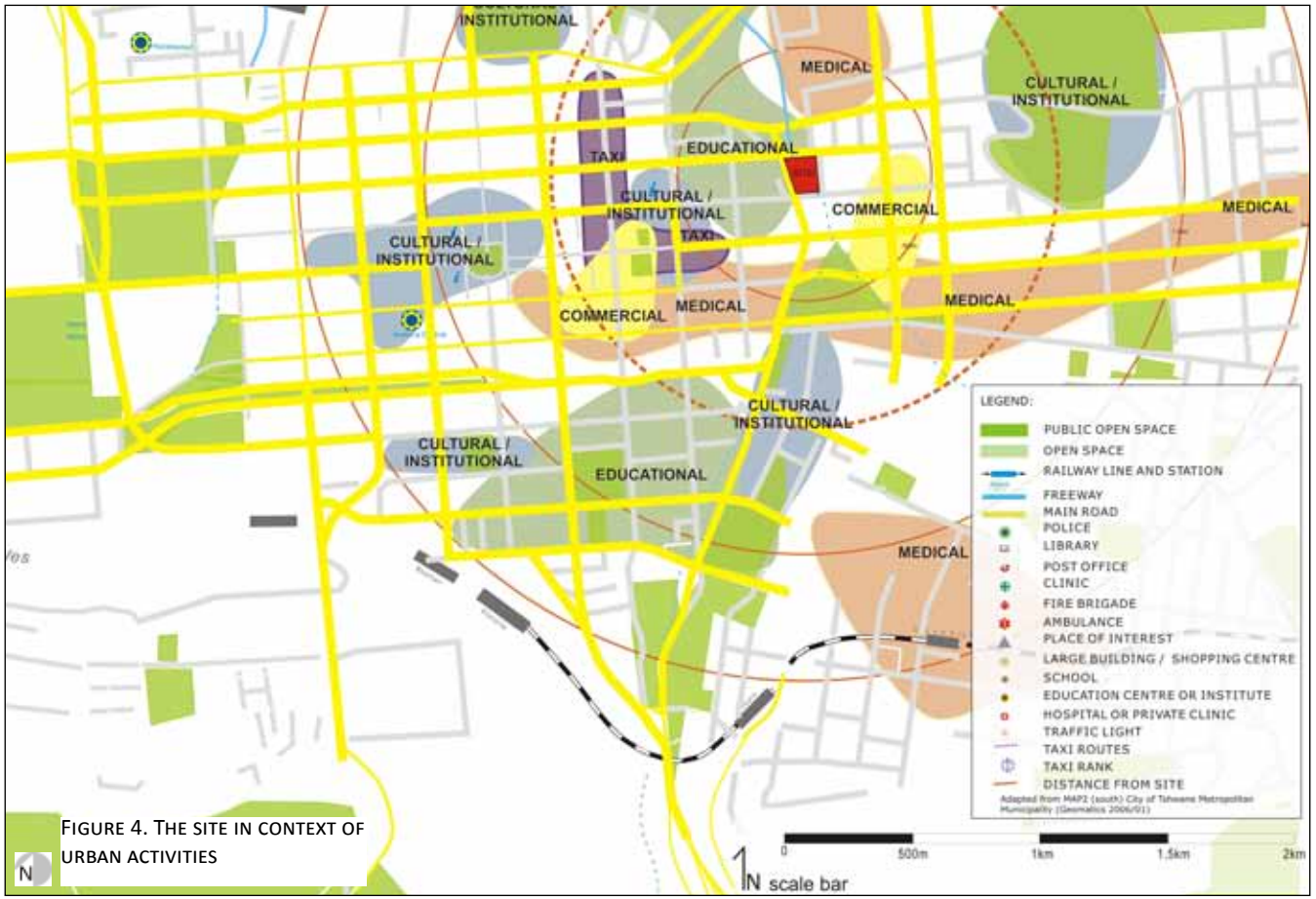


FIGURE 4. THE SITE IN CONTEXT OF URBAN ACTIVITIES

Design objectives

Design objectives will address the following citywide and Site specific issues:

Citywide

- Implement the vision of the Nelson Mandela Student Urban Design Framework (group work of the author 2009) for the Apies River with this project as a catalyst

Site specific

- Design a vibrant public open space that entices use throughout the day

- Enhance and protect the openness of the site
- Apies River
  - Establish a metaphysical connection between people and the Apies River
  - Retrofit the Apies River to improve safety
  - Utilize the base flow of the river and improve the quality of the water so it can be used for interaction and ecological experiences
- Expose the ecological, historical and cultural memory of the site by relating to what was on site, how it has changed and how it could be in the future
- Ecology
  - Utilizes the introduced system components to create diverse ecosystem components

A POSSIBLE PROGRAM

The project proposes an Urban Water Centre that

- Expresses and celebrates the natural and culture significance of water
- Shows the importance of rivers in nature and in the city
- Educates children and adults on water conservation, water management and water quality in urban environments
- Expresses the importance of water in sustainable resource management and open space design through making the on site water systems visible

The following program arises

- An information centre
- Educational facilities, including a multi- functional outdoor classroom
- The inclusion of visible on site water treatment through
  - Functional constructed wetlands
  - Rainwater harvesting, storing and cleaning
  - Storm water attenuation, use and infiltration
- Public park that:
  - provides spaces for students to rest, read and socialize
  - has safe and accessible play areas and facilities for kids that focus on encounters with water
  - provides for the needs of pedestrians, nearby residents and visitors
  - establishes a metaphysical connection between the city dweller and the river
  - Celebrates the Apies river and its history
  - Provides opportunity for meaningful contact with water
  - Celebrates the different qualities and emotions associated with water
  - is safe with adequate security and lighting at night
- An urban plaza bordered by retail facilities
- A pavilion with tuck shop for students, school children and visitors
- Restaurants that take advantage of the location
- Offices for a government water quality / conservation / research facility

Table 1 represents the project components along with their scale and area of expertise. Guidelines and massing for the Architectural and Interior Architectural components will be addressed.

Component	Sub component	Scale and area of expertise		
		Landscape Architecture	Architecture	Interior Architecture
Information centre				
Multi functional outdoor classroom / amphitheatre				
Research facilities				
Water management practices	Functional constructed wetlands for water cleaning			
	Rainwater harvesting use and storing			
	Storm water attenuation, filtration use and infiltration			
Public park	that provides spaces for students to rest, read and socialize			
	that has safe and accessible playground and facilities for kids that focuses on encounters with water			
	that provides for the needs of pedestrians and visitors			
	that establishes a metaphysical connection between the city dweller and the river			
Retrofitted river channel				
An urban plaza with economic activities				
A tuck shop for students, school children and visitors				
Restaurants that takes advantage of the location				
Offices for a government water quality / conservation / research facility				

TABLE 1 - PROJECT COMPONENTS

Client

This project is an integration of users and functions, and the clients must reflect this multifaceted approach. The traditional view of clients needs to change to a system of patrons that aim to uncover the potential of the city.

Possible patrons:

- CTMM parks division
- Department of Water and Forrestry (DWAF):
  - Directorate of Water Conservation, Catchment Management and Water Quality Management
  - Directorate of Water Utilization
  - Directorate of Working for Water
- Water Research Council
- Private companies that works towards the conservation of water and the promotion of appropriate green technologies
- Schools in the area that will use the park as playgrounds (Interviews with headmasters)
- Developers of Retail amenities

Assumptions

- The Nelson Mandela Student Framework is to be implemented
- The proposed Master Plan will be implemented
- All Erfs and Erf portions that are considered will be available to be purchased at market related prices by willing sellers
- Interventions along the Apies River will be approved by council along with water use licenses where applicable
- Architecture on the site will be assumed to achieve a Green Star SA rating

Study delimitations

- The author acknowledges that he is not an architect and will only provide concepts and guidelines for building footprint, height and use
- The author acknowledges that he is not a specialist in terrestrial or aquatic ecology and will only aim to implement general ecologically sound principles in order to inform his decisions in a systemic design approach
- The author acknowledges that he is not a civil engineer and will calculate basic flood and runoff volumes

Methodology

The study will be based on quantitative and qualitative research. The type of study requires sound and critical technical evaluation along with a subjective approach to human needs.

Table 2 sets out the research methodology.

Research type	*Typical source*	*Type of Information*	*Analysis approach*	*Interpretation*
Quantitative context and site analysis	GIS information from CTMM	Hydrological, cadastral and services information	• Overlays and assumptions	Opportunities and constraints
Intuitive site and context analysis	Observation and frameworks from council	Photographs, interviews, sketches, proposed development frameworks	• Intuitive interpretation • Collage	Interpret according to theory, draw diagrams
Qualitative theoretical research	Systems theory books and journal articles	Synopsis of theories and possible applications	• Investigate relevance to site, project program and local environment	Formulate and draw diagrams of strategies for application
Qualitative precedents studies	Journals, site visits	Written analytical and informative articles, Photographs, drawings	• precedents for each part of analysis where applicable • Trace to remove glamour, draw diagrams and cycles • Relate to theories	Spatial, relational and systems investigated

TABLE 2 - RESEARCH METHODOLOGY

Background

The Global Problem

- 70,78% of the earth's surface is covered by water (Engelbert, 2006)
- 2,8% of water on earth is fresh (35 million m^3) (WaterAid International, 2007)
- 30% of the fresh water (105 million m^3) is accessible
- 70% of the fresh water (73,5 million m^3) is used for irrigation and agriculture
- 22% of the fresh water (23,1 million m^3) is used for industry
- 8% is used domestically (8,4 million m^3) (UN Water, 2008)

In South Africa:

- 72% of fresh water is used for agriculture
- 17% for domestic use
- 11% for industry (EarthTrends, 2003)

Each person needs per day:

- 2 - 4 liters of water to drink
- 20 – 45 liters of water for cooking and cleaning
- 2000 – 5000 liters of water to produce daily food intake (UN Water, 2008)

Predictions are that by 2025, 1800 million humans will experience extreme water scarcity whilst 66% of people will have to deal with water shortages (UN Water, 2008).

The human body consists of between 65% and 90% water (New World Encyclopaedia, 2008), and the human brain between 77% and 78% (Chudler, 2009).

It becomes apparent that the water crisis will soon be personal and that water needs to be conserved in any way possible. This dissertation aims to identify strategies that will conserve and optimize the use of water in the built environment through raising awareness of water systems and cycles.

Relevance of the proposed site

The significance of the site can be ascribed to the presence of the Apies River that bisects it. Not only does the river have recreational, visual and environmental potential, but the river has historical value because the good water quality and quantity was one of the reasons that Pretoria was established in its current location.

The site forms part of an east-west pedestrian link as discussed in chapter 1 (figure 3).

On a north-south alignment the site forms part of a series of proposed public open spaces that uses the Apies River as a spine (Student urban design framework chapter 1 figure 2).

The Student Urban Design Framework (chapter 1) proposes an open space system that aims at bridging the gap that the concrete channel creates between the old core of the city and the suburbs of Sunnyside and Arcadia.

The bare site is a brownfield site but has the potential for major sustainable water interventions that will improve the quality of urban open space and social interaction in the city.

Worldwide changes

Water is only one of the resources that are wasted. Global climate change and environmental disasters are increasing awareness of the situation and are changing people's attitude towards nature and how resources are mismanaged and wasted.

Concepts like sustainable development have been on everyone's lips since the World Conservation Strategy of 1980 (Rosenberg, 2007). The Brundtland Commission has defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Rosenberg, 2007).

The 1992 Earth Summit in Rio de Janeiro (United Nations Department of Public Information, 1997) and the resulting action plans set the stage for future development.

The role players

It is evident that the crisis is global, on an economic and environmental level. International agencies, along with governments worldwide and environmental awareness initiatives in South Africa aim at informing and empowering the public on how to live more sustainably through principles such as 'Reuse, Reduce, Recycle and Respect' (Greenworks, 2008).

Although "Agenda 21, the Rio Declaration on Environment and Development, the Statement of Forest Principles, the United Nations Framework Convention on Climate Change and the United Nations Convention on Biological Diversity" (United Nations Department of Public Information, 1997) along with various national and local laws, legislations, bylaws, planning policies and initiatives attempts to inform people and improve the sustainability of society, the efforts do not have a large enough impact fast enough.

Sustainable development defined

Sustainability has been defined in the following ways

- "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs." (World Commission on Environment and Development, 1987, p. 43)
- "Living standards that go beyond the basic minimum are sustainable only if consumption standards everywhere have regard for long-term sustainability... and sustainable development requires the promotion of values that encourage consumption standards that are within the bounds of the ecological possible and to which all can reasonably aspire" (World Commission on Environment and Development, 1987, p. 44)
- "To a large degree, environmental management should be seen as a means of attaining the wider objectives of sustained economic growth and poverty alleviation" (World Bank, 1987)
- "Sustainable development describes a process in which the natural resource base is not allowed to deteriorate. It emphasizes the hitherto unappreciated role of environmental quality and environmental inputs in the process of raising real income and the quality of life" (Pearce, 1993, p. 8)
- "A style of development that, in each eco-region, calls for specific solutions to the particular problems of the region in light of cultural as well as ecological data and long-term as well as immediate needs" (Hettne, 1990, p. 186)

To summarize

Sustainable development manages resources and the environment in a way that addresses the basic needs of all people, while re-aligning consumer values and creating resource management strategies for each region in a way that does not diminish the future continuation of nature and man in a consistent way.

Sustainable development in South Africa

The approach of the South African government

On a national level in South Africa, "…the challenge of sustainable development means eradicating poverty via programs that engage all sectors. The South African economy also needs to grow in a more socially equitable way, where energy and resources are used in a more efficient manner, producing less waste." (Eco-Logic Publishing, 2007)

It seems that the government deems stimulating the economy and eradicating poverty as the main goals of sustainability in South Africa.

Figure 5 (Eco-Logic Publishing , 2007) diagrammatically illustrates the National Strategy for Sustainable Development. This can be interpreted that economy, socio-political systems and ecosystem services are all embedded in each other but that economy forms the core.

The *triple bottom line approach* stresses that sustainable development depends on the intersection of nature, society and economy.

The author is of opinion that a hierarchical approach must be followed. Governance should be the foundation of sustainability. The first level should be eco-system services as it supports all life forms. Economy (the second lev-

el) relies on ecosystem related resources, thus depending on nature and lastly a stable sociopolitical environment relies on eco-system services and a prospering economy. As the low levels in the hierarchy supports the upper levels, the lower levels can function without the levels above them, but not the other way around (as a good economy cannot thrive without natural resources, see figure 6).

The problem with Sustainable Development

Systems such the 'Sustainable Building Assessment Tool' (SBAT) in South Africa (CSIR, 2008) and 'Global Community Assessment Centre' (Politics and Justice without borders, 2004) have introduced means of measuring sustainability, but have not been widely accepted by the built industry or enforced through building standards by governments or local municipalities and have never had a focus or inclination towards Landscape Architecture.

Although sustainability lies at the core of Landscape Architecture, there are a landscape designs that disregard regional and site specific conditions (water, soil, climate, habitat and human use). These ignorant designs are resource intensive and are often green deserts.

The false perception that all landscapes are sustainable creates the illusion that a green rating tool for Landscape Architecture is unnecessary, which leads to ignorant designs.

The author is of the opinion that schools of Landscape Architecture in South Africa do teach sustainable principles, but mostly from a philosophical point of view and that strategies along with measurable outcomes are neglected. Thus an education of the public and a more focussed tertiary program could address this issue.

Green design

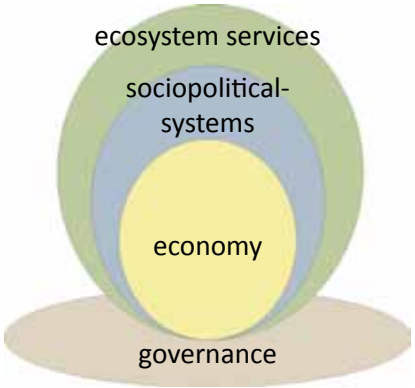


Figure 5. National strategy for sustainable development

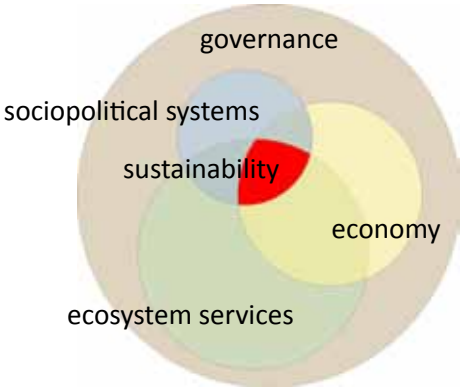


Figure 6. Proposed hierarchical levels in sustainability

Green is a term used in construction and product design that describes a product, material or system that aims at being more efficient or reducing an impact. *Green* can therefore still be unsustainable, although the product or material functions better than older technology in terms of efficiency and design (Squidoo, 2009).

Measuring *green*

Worldwide events after the 1992 World Summit that lead to the development of the '*green* industry' in South Africa

- 1993: The United States Green Building Council (USGBC) was founded and aims at transforming the American construction industry with a focus on green building solutions (US Green Building Council, 2008, p. 3)
- 1998: The Leadership in Energy Efficient Design (LEED) launched the first LEED project at the USGBC Membership Summit (U.S. Green Building Council, 2006, p. 11)
- 1999: The World Green Building Council (WorldGBC) was called to life by representatives from: U.S. Green Building Council; Representatives from Australia, Spain Green Building Council, United Kingdom Green Building Council, Japan Green Building Council, United Arab Emirates, Russia and Canada. The WorldGBC is an overarching body that works toward international standard of *green* building through support and the promotion of global best practice. (World Green Building Council, 2008)
- 2002: The Green Building Council of Australia (GBCA) came to life and aims to transform the property industry with green building initiatives through the design and life cycle of a building. (Green Building Council of Australia, 2009)
- 2003: Green Star Australia rating system was implemented, it "…considers a broad range of practices for reducing the environmental impact of buildings and to showcase innovation in sustainable building practices, while also considering occupant health and productivity and cost savings"
- 2003: The Sustainable Building Assessment Tool (SBAT) was developed in South Africa by the CSIR. It aims at relating sustainability to third world countries through a triple bottom-line approach. Looking at a building's physical sustainability as well as making a contribution to the surrounding systems(Gibberd, 2003)
- 2005: The Sustainable sites Initiative came to life and consist of a partnership between the 'American Society of Landscape Architects' (ASLA), 'Lady Bird Johnson Wildflower Center' and United States Botanical Garden (USBG). "The Sustainable Sites Initiative was created to promote sustainable land development and management practices that can apply to sites with and without buildings…" (Sustainable Sites Initiative, 2008) The SustainableSites Initiative aims at being incorporated into the LEED rating system in 2009 (Sustainable Sites Initiative, 2008)
- 2007: The Green Building Council of South Africa (GBCSA) was launched "to promote and facilitate green building practices through market-based solutions." (Green Building Council of South Africa). The GBCSA was born of 'Green Building for Africa' that stems from Agenda 21 (See Earth Summit 1992) and the 'Sustainable Building Assessment Tool' SBAT through the leadership of the 'Council for Scientific and Industrial Research' (CSIR). (Van Wyk, 2009)
- 2008: Green Star South Africa (Green Star SA launches a rating tool that is adapted from the Green Star Australia. The tool "…assesses the environmental performance of buildings on a range of issues including energy, water, materials and missions…" (South Africa: The Good News, 2008) "A lot of what we promote is just going back to the basics of good building

and design, such as orientation and using natural systems." (South Africa: The Good News, 2008)

Green Star SA

The following summary by Green Star SA (Green Building Council SA, 2008)

The objectives of Green Star SA

- Establish a common language and standard of measurement for green buildings
- Promote integrated, whole-building design
- Raise awareness of green building benefits
- Recognize environmental leadership
- Reduce the environmental impact of development

Green Star SA covers a number of categories that assess the environmental impact that is a direct consequence of a project's site selection, design and construction.

The nine categories

(Weighting added by the author from Green Star Office - V1)

• Management	9%
• Indoor Environment Quality	15%
• Energy	25%
• Transport	9%
• Water	14%
• Materials	13%
• Land Use & Ecology	7%
• Emissions	8%
• Innovation	bonus

(Green Star SA, 2008)

Thus a total of more than 100% is possible.
Research was done on the contribution that each of the elements mentioned above add towards *green* design and the elements were weighted accordingly.

Each category is subdivided into credits that make up the total value for the category. Each credit addresses an initiative that improves environmental performance.

Once all claimed credits in each category are assessed, a weighted percentage score is calculated and a four, five or six star rating is awarded.

To encourage the development and spread of innovative technologies, designs and processes that could improve buildings' environmental performance, an 'Innovation' category is included in each Green Star SA rating tool. The innovation category comprise of bonus points that make up a possible score of more than a hundred percent.

Possible Green Star SA certifications

- Four Star Green Star SA Certified Rating for"Best Practice"
- Five Star Green Star SA Certified Rating for "South African Excellence"
- Six Star Green Star SA Certified Rating for "World Leadership"

Design versus As Built Certification

A Design certification may be awarded at the end of the design phase of the project. The certification is specific only to what can be demonstrated at the design stage. The intent is that the building can then be marketed as Green Star SA certified building, having demonstrated the green building strategies to be included in the building. At the end of construction, a project may be submitted and be awarded an As Built certification, verifying the procurement and implementation of green building strategies.

Investigation of possible application to Landscape Architecture

Table 3 investigates the elements in the Current Green Star SA Office – V1 that can possibly be applied to Landscape Architecture (Green Star SA).

Category:	Title of Credit:	Applicable points vs. category points	% applicable	Weighted %
Management:		**10 / 14**	**71.5%**	**6.4 %**
	Green Star SA Accredited Professional	2		
	Commissioning clauses	2		
	Independent commissioning agent	1		
	Environmental management	2		
	Waste management	3		
Indoor Environmental Air Quality:		**4 / 28**	**14%**	**2%**
	External views (providing views)	2		
	Volatile organic compounds	2 /3		
Energy:		**6 / 30**	**20%**	**5%**
	Lighting power density	4		
	Lighting zoning	2		
Transport:		**9 / 14**	**64%**	**5.8%**
	Provision of car parking	2		
	Commuting mass transport	5		
	Local connectivity	2		
Water:		**10 /15**	**67%**	**9%**
	Occupant amenity water	5		
	Water meters	2		
	Landscape irrigation	3		

Table 3- Green Star Application

Conclusion

Table 3 shows that, 44,2% of the rating system can be achieved through Landscape Architecture. Through studying the Sustainable Sites Initiative, this dissertation aims to distil the essence of eco-system services, to formulate aims for sustainability in Landscape Architecture that focuses on the integral role of water in all systems. The design process will devise strategies for achieving these aims for the Tshwane region. The aims that are generated could be used to evaluate the Green Star SA rating system by and could be used to identify landscape related issues that can be addressed more thoroughly. It is however, larger than the scope of this dissertation to reformulate the Green Star SA rating system in terms of Landscape Architecture.

Materials:		**12 / 22**	**54.5%**	**7%**
	Recycling waste storage	2		
	Reused material	1		
	Concrete	3		
	PVC minimization	1		
	Sustainable timber	2		
	Dematerialization	1		
	Local sourcing	2		
Land use and ecology:		**9 / 9**	**100%**	**7%**
	Topsoil	1		
	Reuse of land	2		
	Reclaimed contaminated land	2		
	Change of ecological value	4		
Emissions:		**4 / 17**	**23.5%**	**2%**
	Watercourse pollution	3		
	Light pollution	1		
Innovation:		**5 / 5**		
	Innovative strategies and technologies	5		
	Exceeding Green Star SA benchmark	5		
	Environmental design initiatives	5		
Total applicability to Landscape Architecture:				**44.2% possible of all categories**

The possible role of Landscape Architecture in *green* design

When considering the professional team for development, the Landscape Architect's responsibility includes dealing with the following components

- Water use and storm water management along with the engineering professionals
- Appropriate plant material
- 'Hardscape' materials

These basic components need to be integrated into a design system that fulfils the needs of humans whilst protecting or enhancing the environment. Figure 7 explores the possible on site components that needs to be managed. The components functions in hierarchical levels with the top levels depending on the levels below. This approach translates Landscape Architecture into a management of resources on many levels and in specific ways to reach a the envisaged design intent.

The author is of the opinion that through a dedicated green measuring tool for Landscape Architecture (along with strategies for achieving them) the sustainability of Landscape Architecture can be demystified and made measurable. The author will not however attempt to propose a *green* rating tool for Landscape Architecture or amend Green Star SA.

Why reformulation is needed

It is the perception of the author that Green Star SA has a fragmented approach to evaluating projects. Although some of the criteria focuses on specific systems, for example Water (WAT – 3): Landscape Irrigation (Green Star SA), a check list approach seems to be followed and certain aspects can be chosen in isolation.

All sites are made up of physical, bio-physical and cultural systems. The designer needs to understand the specific on site systems in order to develop both with and alongside them. The essence of systems is organization and hierarchy with homologies, not superficial analogies. Von Bertalanffy (1971, p. 7) states that :

> "… the only way to study organization is to study it as a system; …treating organization as a system of mutually dependant variables."

The study will investigate systems that are applicable to Landscape Architecture in South Africa, with a specific focus on the City of Tshwane Metropolitan Municipality. Figure 7 illustrates the approach of the author to on site systems.

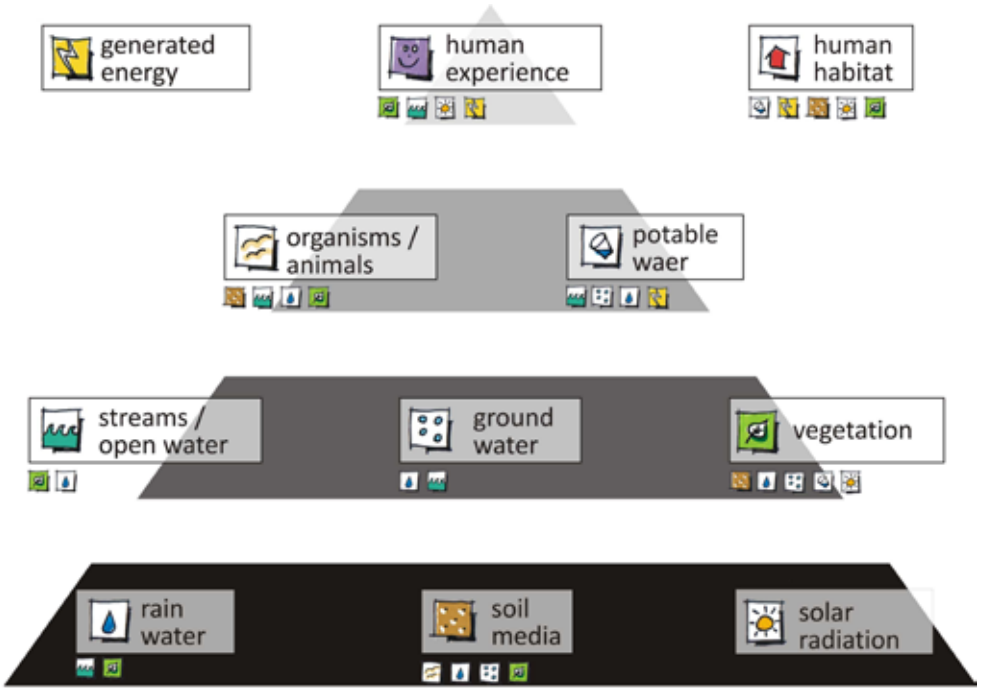


FIGURE 7. ON SITE SYSTEMS - EACH LEVEL DEPENDS ON THE LEVEL BELOW TO BE SUSTAINED

grounding_

3

Problem statement

How can the needs of nature and people be met by focusing on the role of water in green Landscape Architecture?

Sub questions

- Can the integration of the following aspects assist in the management of the South African water crisis?
  - Creative solutions for the treatment of watercourses
  - Storm water and storm water runoff strategies
  - Groundwater recharge methods
  - Irrigation design strategies
  - Plant selection and grouping
- What is the drive behind these strategies?
- Can a systems approach to site design help maintain the ecological function and improve biodiversity?

Hypothesis

An integrated and encompassing approach to water as a system is the base of green Landscape Architectural design.

The design of a Water Centre in Pretoria at an intersection of the Apies River and Nelson Mandela Drive can generate strategies for green Landscape Architecture through an intervention that addresses the Apies River channel, storm water runoff and rainwater.

By focusing on the role of water in ecosystem services, these aims can be distilled and strategies to achieve these aims can be formulated.

Relevance of ecosystem services

Chapter 2 concluded that a reformulation of Green Star SA is needed before it can be applied to Landscape Architecture. But how to achieve this reformulation?

From the investigation of site components (see figure 7 chapter 2) it becomes apparent that the way we live depends on nature for the resources we need.

The natural resources humans use are provided by ecosystems. Ecosystems can be defined as the "…dynamic complex of plant, animal and micro-organism communities and their nonliving environment, interacting as a functional unit." (Yara, 2007)

The resources from ecosystems are called ecosystem services. A study of ecosystem services could show how water supports ecosystems and thus help formulate strategies on how to deal with water in a way that will sustain these ecosystem services.

The Sustainable Sites Initiative (SSI) is a rating tool that works to protect and improve the services that ecosystems supply that man depends on. Thus to identify areas of improvement in the Green Star SA tool, the author will investigate the SSI.

Sustainable Sites Initiative

"A sustainable site links natural and built systems to achieve balanced environmental, social and economic outcomes and improves quality of life and the long-term health of communities and the environment. Sustainable landscapes balance the needs of people and the environment and benefit both" (Sustainable Sites Initiative , 2008).

The Sustainable Sites Initiative (see Chapter 2 – Measuring green for description) promotes site development and management strategies that can be sustained and is applicable on any site, whether it has a major building component or not (Sustainable Sites Initiative, 2008). The initiative provides guidelines and tools for all parties involved in design, construction and maintenance of sites that has landscape components. The strategies aim to address climate change, biodiversity issues and resource utilization (Sustainable Sites Initiative, 2008).

Aims of the Sustainable Sites Initiative

"Elevate the value of landscapes by outlining the economic, environmental and human well-being benefits of sustainable sites

- Connect buildings and landscapes to contribute to environmental and community health
- Provide performance benchmarks for site sustainability
- Link research and practice associated with the most sustainable materials and techniques for site development construction and maintenance
- Provide recognition for high performance in sustainable site design, development and maintenance
- Encourage innovation "
  (Sustainable Sites Initiative, 2008)

The need for a site-specific rating tool

The GREEN building industry is developing and is reducing the environmental impacts that buildings have on the environment and on specific sites. The Sustainable Sites Initiative recognizes the lack of an encompassing approach to sites and landscapes. The initiative recognize that the current building rating tools addresses some site aspects but states that sustainability in landscapes are not completely dealt with (Sustainable Sites Initiative , 2008).

The Sustainable Sites Initiative rating system aims at being integrated into the American LEED Green Building Rating system (Sustainable Sites Initiative, 2008).

Overview of the tool

The tool is structured around prerequisites and credits. Prerequisites are nonnegotiable benchmarks and credits are additional standards.

Ecosystem services

Nature provides man with what he needs to live; these needs are fulfilled by the services that ecosystems provide. The Sustainable Sites Initiative lists these services and addresses them through some of the prerequisites and credits. The author reviewed the ecosystem services matrix critically. The relevant aspects are summarized for ease of interpretation in Table 4. (Sustainable Sites Initiative, 2008)

Ecosystem services:	Number of *prerequisites* that protects and maintains ecosystem service vs. total prerequisites:	Number of *credits* that maintains or protects the ecosystem service:	Total amount of *components* that maintains or protect the ecosystem services:
Global climate change regulation	13 / 14	46	59
Local climate regulation	8 / 14	12	20
Air and water cleaning	14 / 14	23	37
Water supply and regulation	12 / 14	22	34
Erosion and sediment control	11 / 14	16	27
Hazard mitigation	7 / 14	11	18
Pollination	11 / 14	9	20
Habitat functions	11 / 14	23	34
Waste decomposition and treatment	12 / 14	18	30
Human health and well-being benefits	10 / 14	28	38
Food and renewable non-food products	13 / 14	16	29
Cultural benefits	9 / 14	22	31

Table 4- Summary of ecosystem service components by author

Interpretation

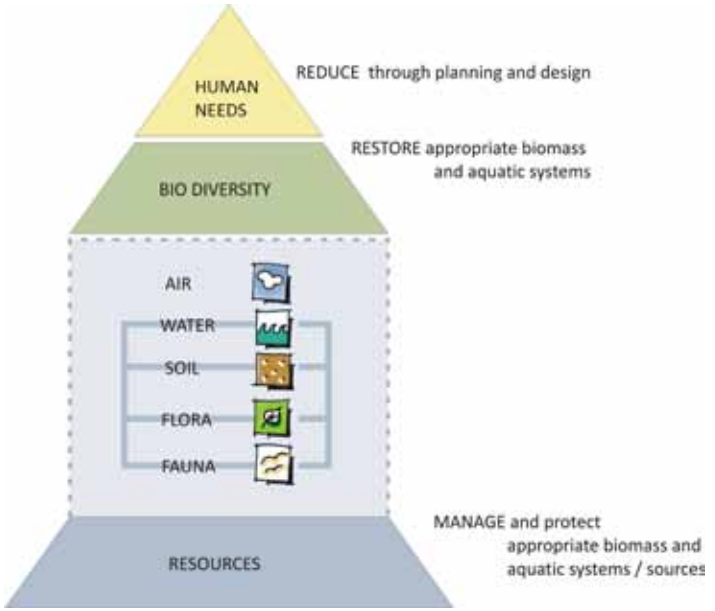
- The number of prerequisites (table 4 column 1) possiblysignifies the bare minimum parts needed to satisfythe needs of an ecosystem services
- The number of credits (table 4 column 2) are perceived to contribute to a richer and optimally functioning ecosystem service
- The total amount of components listed (table 4 column 3)seems to point to the amount of variables that should be considered for maintaining or recreating the ecosystem service it describes

Investigating the ecosystem services

The author will diagrammatically explore the prerequisites and credits mentioned above and distil the possible relationships of components of the system with each other and with other systems.
Figure 8 - 19 explores each of the ecosystem services distilled from the amount of prerequisites and credits mentioned in table 4.

In each diagram, the levels of the pyramid represent levels of hierarchy. Each level supports the levels above, thus the higher levels depend on the lower levels for support

Global climate change regulation



Legend figure 8 -19

FIGURE 8. Global climate change diagram - water is supports most of the resources provided by ecosystem services

Local climate change regulation

FIGURE 9: LOCAL CLIMATE CHANGE DIAGRAM - WATER IS AT THE CORE OF REGULATING THE LOCAL CLIMATE AS IT SUPPORTS THE MAIN SYSTEMS RESPONSIBLE FOR ON SITE CLIMATE

Air and water cleaning

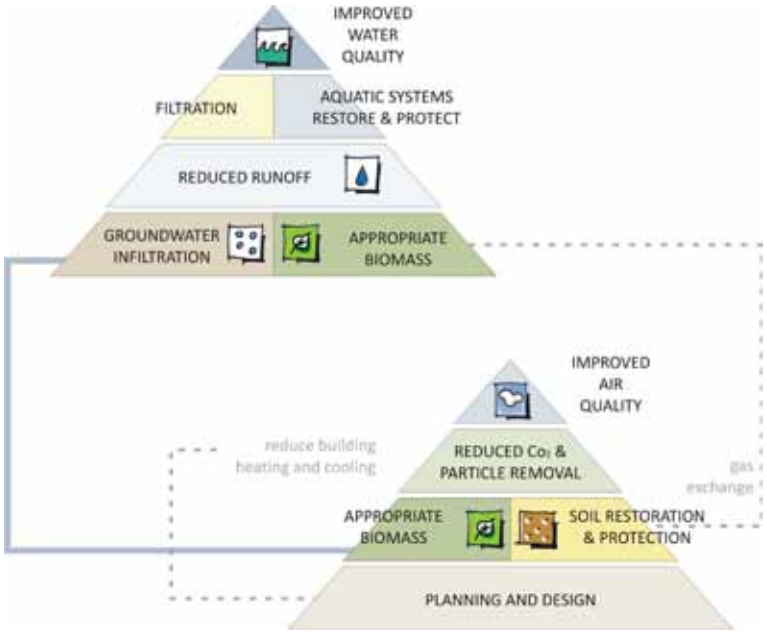


FIGURE 10. AIR AND WATER CLEANING - WATER SUSTAINS THE BIOMASS THAT FACILITATES AIR AND WATER CLEANING AND SUPPORTS HEALTHY SOIL THAT SUPPORTS BIOMASS AND AQUATIC SYSTEMS

Water supply and regulation

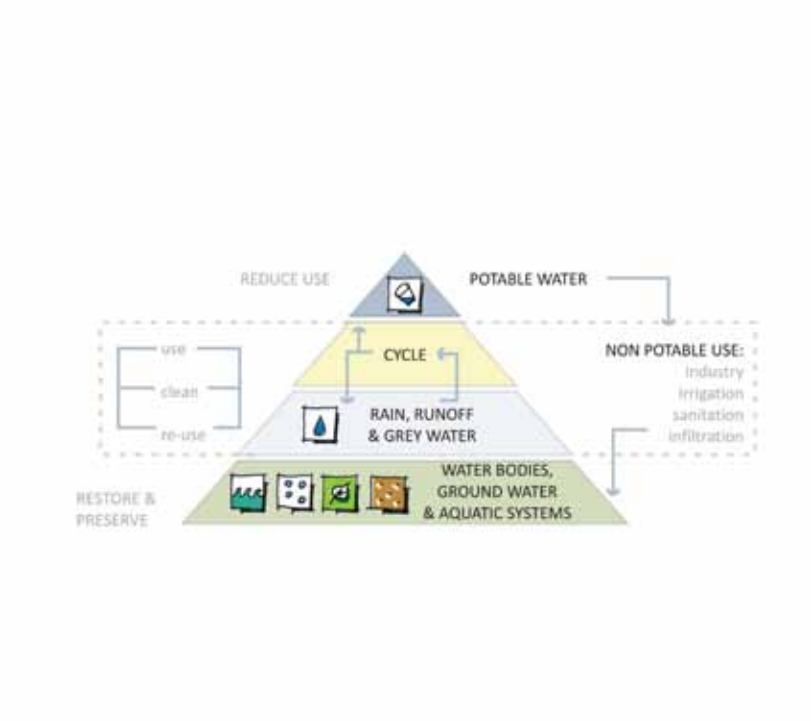


FIGURE 11. WATER SUPPLY AND REGULATION - REDUCING USE OF POTABLE WATER THROUGH OPTIMISING A SYSTEM OF ON SITE WATER USE AND RE-USE WHILE RESTORING AND PRESERVING WATER BODIES, GROUND WATER AND AQUATIC SYSTEMS

Erosion and sedimentation control

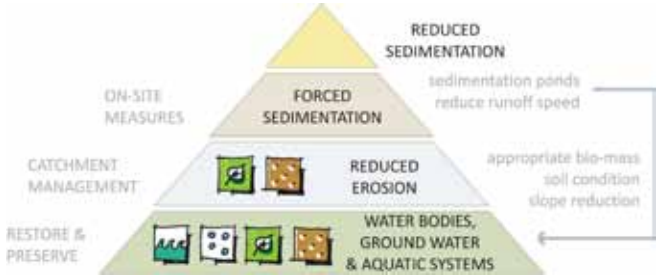


FIGURE 12. EROSION AND SEDIMENTATION CONTROL - THIS ECOSYSTEM SERVICE ADDRESSES DIFFERENT PARTS OF THE SOLUTION ON DIFFERENT SCALES, FROM NATIONAL TO CATCHMENT, TO SITE SPECIFIC. ALL MEASURES CAN BE APPLIED ON A LARGE OR SMALL SCALE.

Hazard mitigation

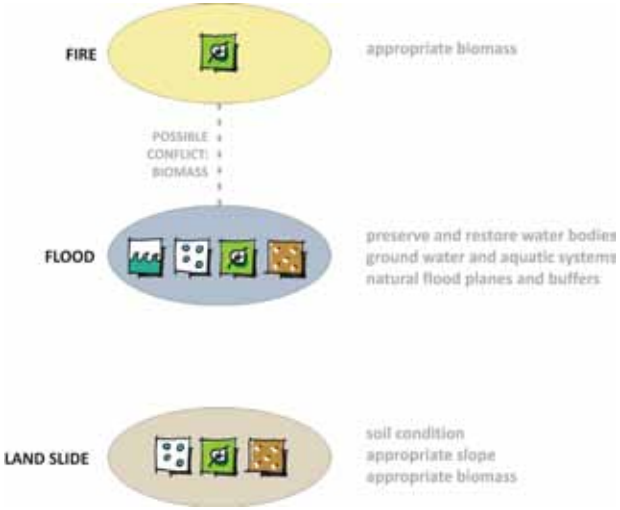


FIGURE 13. HAZARD MITIGATION - THE DESIGNER NEEDS TO TAKE THESE ISSUES INTO ACCOUNT; THEY ARE SITE SPECIFIC. THE MANAGEMENT OF NATURAL FLOOD PLANES AND BUFFERS ARE IMPORTANT, BUT CONFLICT MAY OCCUR, FOR EXAMPLE EXCESS BIOMASS ON SITE MIGHT POSE A FIRE HAZARD.

Pollination

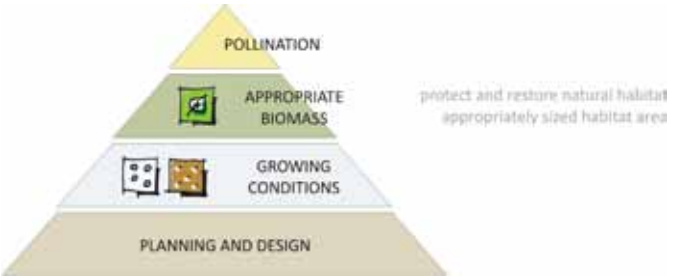


FIGURE 14. POLLINATION - WATER SUPPORTS THE SOIL AND BIOMASS FOR POLLINATION. SPECIALIST STUDIES NEEDED

Habitat function

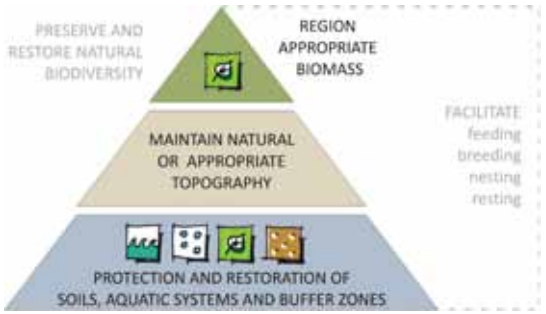


FIGURE 15. Habitat function - Water is part of the support of all life forms and part of the life cycles of many insects, fauna and flora. Feeding, breeding, nesting, resting (Breedlove: 2005)

Waste decomposition and treatment

FIGURE 16. Waste decomposition and treatment - Water supports systems where decomposition takes place and provides moisture for optimal decomposition conditions

Human health and well-being benefits

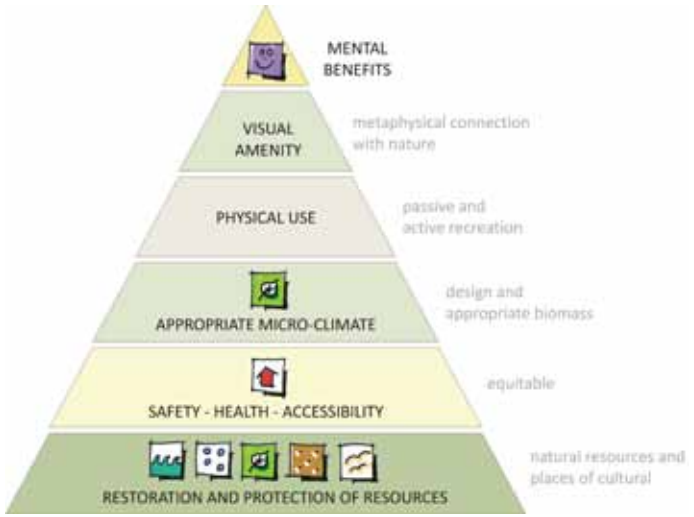


FIGURE 17. Human health and well-being benefits - resource management supports both the physical and mental benefits found in the landscape while water supports the resources

Food and renewable non-food products

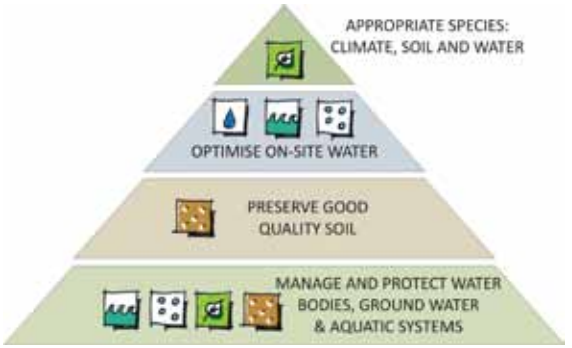


FIGURE 18. Food and renewable non-food products - Use on site Rainwater, runoff, groundwater and water bodies wisely, while reducing use of treated potable water

Cultural benefits

FIGURE 19. Cultural benefits - Water sustains and enhances resources while providing opportunity to create new cultural and socially significant spaces

Relating the Eco-system services

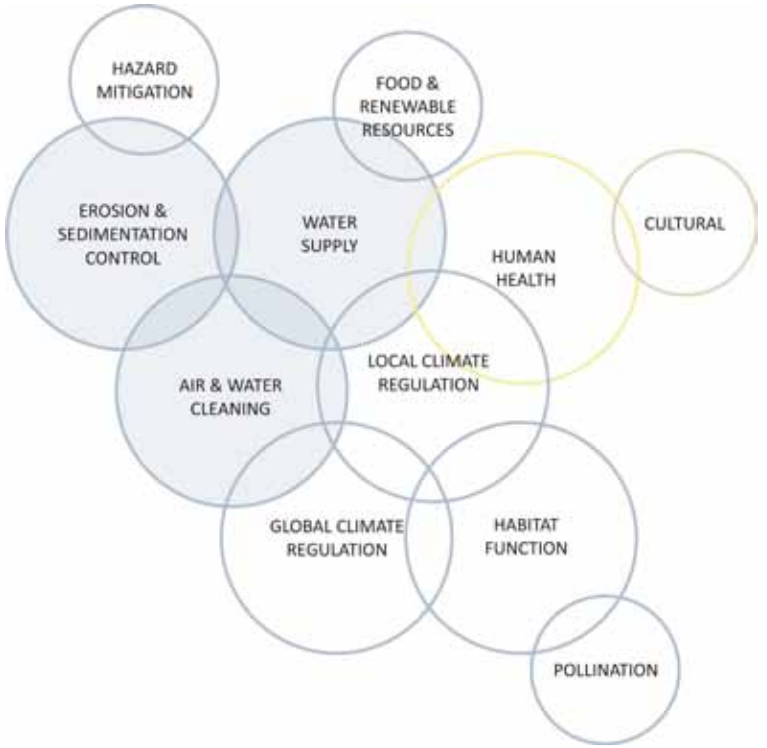


FIGURE 20. Eco-systems relation diagram

Figure 20 illustrates the role of water as the core of three of the eco-system services (blue fill). The connections with the other eco-system services are shown by over-lapping. A smaller circle indicates a perceived secondary or 'spinn-off' nature of the eco-system service

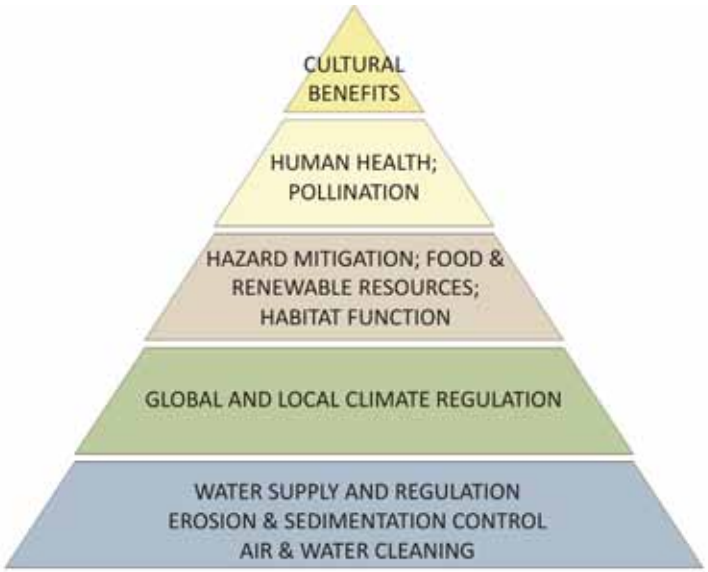


Figure 21. Hierarchical structure of core concepts

Conclusion from the SSI investigation

The most prominent themes from the ecosystem service analysis diagrams are

- Conserving water sources and the systems they support while optimising the use of on-site water and reducing the use of potable water
- Introducing and preserving existing natural and on site region appropriate biomass
- Using renewable- and waste minimising materials that does not pollute through manufacturing application or after installation
- Optimise human use and health benefits by integrating the on site systems to improve the experience of man's environment

The base of most of the ecosystem services are the protection of resources that includes aquatic and terrestrial systems along with on site biomass and associated soil conditions. Tied to these resources are groundwater, water bodies (streams, rivers, lakes, oceans), rainwater and site runoff. Figure 20 illustrates conceptually how the ecosystem services relate to one another.

Water appears to be the golden thread that links most of the systems; *therefore addressing the multifaceted topic of water as an integrated system will satisfy the majority of aims and criteria for green Landscape Architecture*.

The hierarchical structure (figure 21) that manifests from the relational diagram (figure 20) confirms the dependencies between on site systems, components and ecosystem services, proving that *green* design through the eyes of ecosystem services, functions as an integrated whole and cannot be measured or rated with a fragmented 'pick off a list' approach.

The prominent themes from the SSI investigation (listed above), will be used to shape the design approach and objectives as they are broad aims and not strategies. After the design is completed, the design strategies could be formulated into strategies that will contribute towards reaching the above mentioned aims.

The relevance of a General Systems approach

When we deal with eco-systems, we must approach what we introduce into them as systems. According to von Bertalanffy (1971, p. 38), systems are groups of interrelated components.

The influence of people on ecosystems have increased the complexity of systems; thus a holistic and generalist interdisciplinary approach seems to be needed to understand, manage, create and maintain them (von Bertalanffy, 1971, p. VIII).

This further strengthens the stance that a green rating system should for a large part focus on relationships. A study of General System Theory will revolutionize the approach to ecosystems in Landscape Architecture and their relationships to human users.

General Systems Theory

In the publication entitled General Systems Theory, Von Bertalanffy (1971, p. 36) makes the argument that there are certain general 'system laws' from mathematics that are relevant to any system of a specific classification (see open and closed systems below), no matter how specific aspects may vary. Von Bertalanffy states that:

> *"… the only meaningful way to study organization is to study it as a system of mutually dependant variables…" (1971, p. 7)*

Von Bertalanffy argues that analytical methods fails in explaining systems because they are limited and focuses on linear links and not on hierarchical order that depends on the interactions between parts (1971, pp. 16 - 17, 27).

The overarching aim of General Systems Theory should be the base for integrating natural and social science and that this integration may introduce exactness to non-physical fields in science (von Bertalanffy, 1971, p. 37).

Von Bertalanffy identifies two types of systems:

He states that closed systems stand alone and do not depend on an environment, where open systems "…maintains itself in a continuous inflow and outflow, a building up and breaking down of components, …never in equilibrium but maintained in a so called steady state…" (von Bertalanffy, 1971, p. 38). Open systems relate to the concept of metabolism where specific inputs are needed to generate the desired output.

Characteristics of open systems

- *Equifinality* is the ability of an open system to reach a certain state from many starting points. According to Von Bertalanffy on Dreish (1971, p. 39): "Equifinality… contradicts the laws of physics, and can be accomplished only by a soul-like vitalistic factor which governs the processes in foresight of the goal…"
- A *higher order* and more *complex organisation* are created by open systems. This is in contrast wit the laws of physics that aims towards dissipation (von Bertalanffy, 1971, pp. 39 - 40)

Application by the author

> *Landscapes for the most part are open systems, with inputs like rainwater and sunlight, using these in metabolic processes. Photosynthesis leads to the production of living matter (a higher order) that continues to increase in numbers and complexity. The principle of Equifinality becomes visible through landscapes that, on separate sites, can develop into similar though physically unrelated systems. Systems like these are guided by genetic*

qualities and needs of individual parts as guided by common limiting factors. This evolution of a system will lead to a somewhat predictable and common climax community.

The role of Information in General systems

Information is based on the concept of decisions; these decisions establish and measure the organisation in a system. Feedback of information in a system lets the system regulate itself. (von Bertalanffy, 1971, p. 41) (See figure 22) According to von Bertalanffy "…mechanisms of a feedback nature are the base of purposeful behaviour in man made machines as well as in living organisms, and in social systems." (1971, p. 43) Thus feedback helps to improve a system to reach a goal more easily. A repeated trial and error cycle will help a system adapt to a mode of the least conflict.

Organisation

The adaptive ability of a system that stems from the feedback of information leads to higher levels of organisation that can be identified by:

- *Growth* of a system is directly proportionate to the number of elements. The law of Malthus statesthat population growth is unlimited where the natality overshoots the mortality. Two scenarios are possible: exponential where there are no limiting factors and s-curve where there are limits (asymptote) to growth, e.g. resources. It is therefore imperative for all systems, weather natural, man made or human, to find the limiting factor in each system, evaluate it and amend it where possible or needed (von Bertalanffy, 1971, p. 60).
- *Competition* occurs where two systems are dependent on the same resource. (von Bertalanffy, 1971, p. 63).
- *Centralisation* in a system occurs where a single element or part of a system becomes irreplaceable; this leads to individualization and renders the system indivisible (von Bertalanffy, 1971, p. 71).
- *Equifinality* as discussed previously.

The author concludes

The designer should understand the hierarchical order and dependencies of system components. By manipulating the characteristics and components, the design intent enables a system to reach a state of equifinality.

Feedback loops are already used in many Landscape Architectural designs for example a floating ball valve that regulates a predetermined water level.

Landscape Architects need to understand growth in systems maturation and life cycles of individual plants and plant communities should be taken into consideration when designing.

Competition is something that occurs in all landscapes and are addressed to some degree already, for example the spacing of plants allows for each plant to mature to a full size without having to compete for space. Sunlight, water and nutrients are some of the other obvious sources of competition. This concept should be applied more extensively where less obvious resources is competed for. Each system will have unique critical resources that needs to be identified and taken into account.

Water is the resource that is most commonly the source of centralisation in Landscape Architecture.

Landscape Architects should avoid treating all resources as unlimited and work with sites as systems with finite on site resources.

As systems theory deals with components, relationships and integration of parts, it will contribute to the conceptual design of the on site water systems and shape the technical investigation.

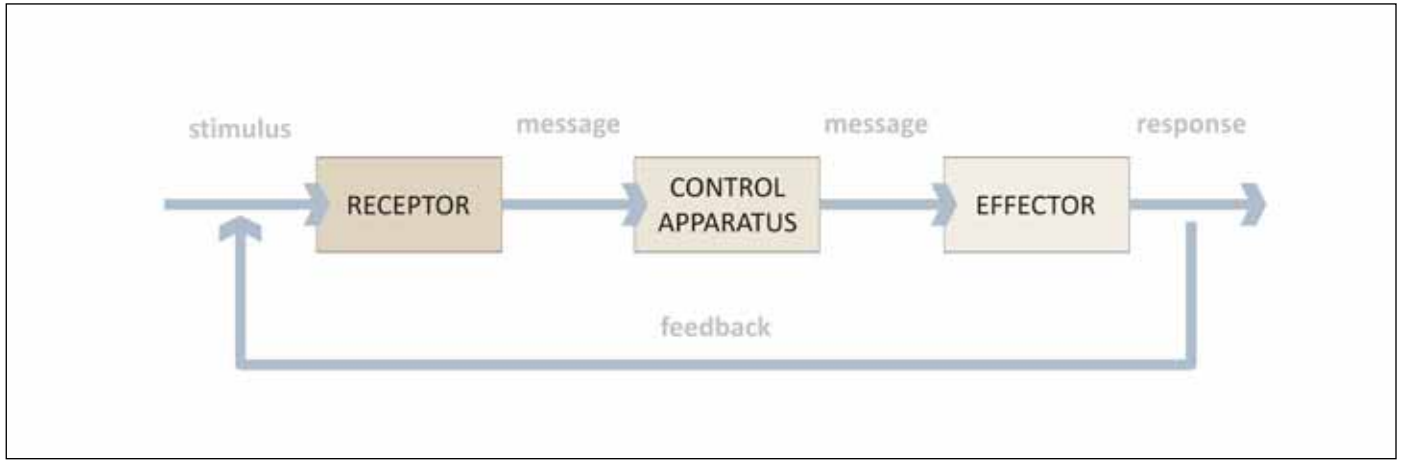


FIGURE 22. A FEEDBACK SCHEME - THE DESIGNER CAN INTRODUCE TECHNOLOGICAL COMPONENTS TO ACT AS RECEPTORS FOR EXAMPLE RAIN SENSORS, CONTROL APPARATUS LIKE BALL VALVES AND EFFECTORS LIKE AUTOMATED PARTS TO MANAGE ARTIFICIAL SYSTEMS

water exploration_

4

Our need

The human need for water is second only to the need for air. Maslow describes the four basic human needs as air, water, food and sleep (Wagner, 2009). The four elements of nature are air, water, earth and fire. Water and air are the physical needs we directly associate with water and water is the most tangible of the two and thus could be seen as one of the strongest links between man and nature (figure 22).

Besides the physical need for drinking water, humanity uses water in its many forms in more ways than we can imagine, thus shaping our world into a water dependant system. Memories associated with water evoke an array of feelings, reactions and different interpretations of water. Water has a prominent place in many cultures and societies where its use varies from religious symbolism to manufacturing processes in factories (memory collage figure 23).

To be able to continue using water and to keep these water related memories alive, water and its related natural manifestations must be protected as a resource through

preserving, enhancing and reintroducing natural and artificial ecosystems.

The proposed site has a collage of water related, tangible and intangible, attributes that renders it appropriate for a design that focuses on the aspects of water.
These aspects include:

- The Apies River channel
- The Apies River's historical importance in the establishment of Pretoria
- The potential for habitat restoration
- The river as a functional and visual resource
- Opportunity for rainwater harvesting and treatment as part of a integrated design from concept phase

Sites specific water related goals arise

- Zero storm water runoff from parts of the site
- No use of municipal water for irrigation
- Create an educative and experiential landscape that provides encounters with water in as many forms, phases and applications as possible.

Water exploration

The author explored ways to express some of the aspects, qualities and emotions associated water in Landscape Architecture (figure 24).

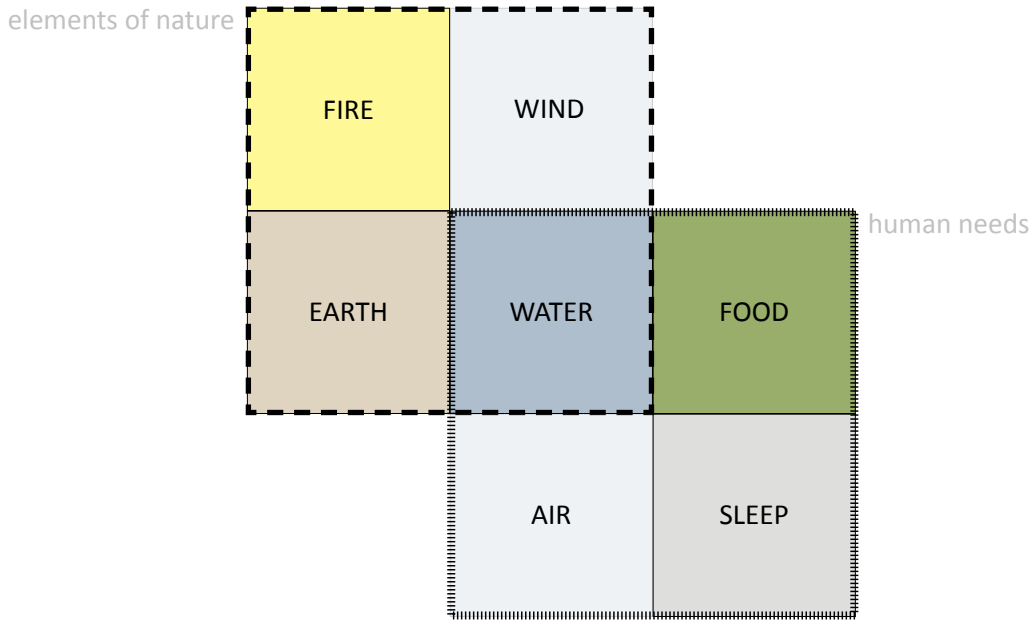


Figure 22. Human needs and the elements of nature- water becomes the most tangible link between nature and mankind



CLOUDS




RAIN






GROUND WATER



SPRINGS & HOT SPRINGS



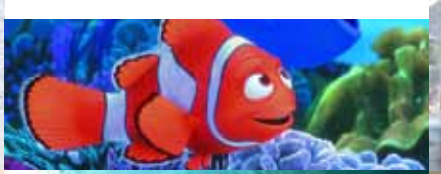
STREAMS & RIVERS


FIGURE 24: MEMORY COLLAGE

POOLS

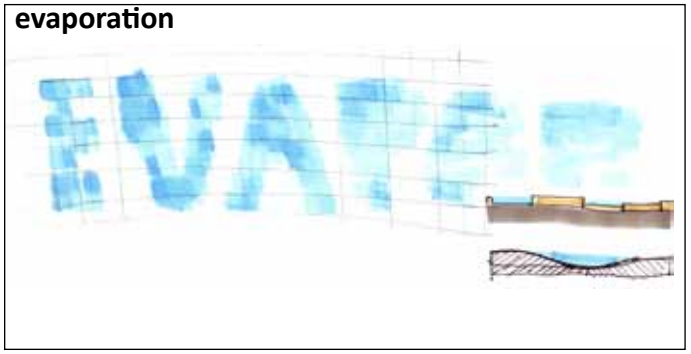
WATERFALLS

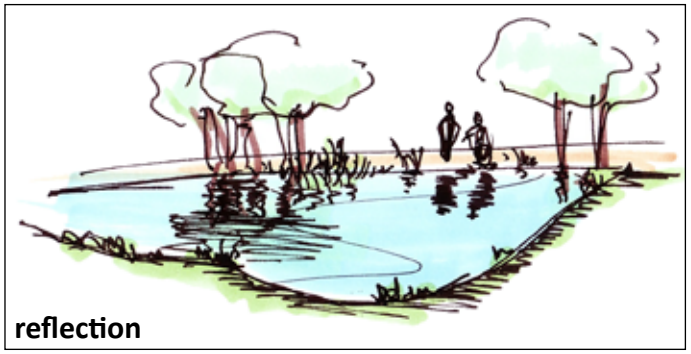
LAKES & DAMS

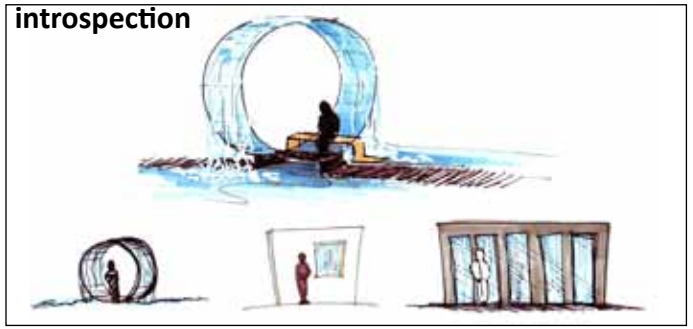


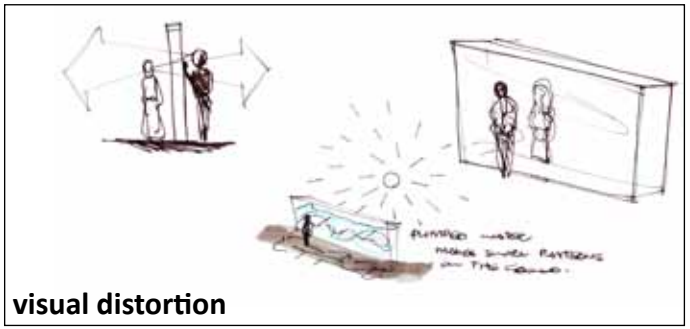
OCEANS

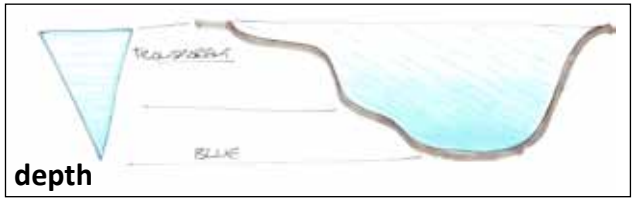
PLAY

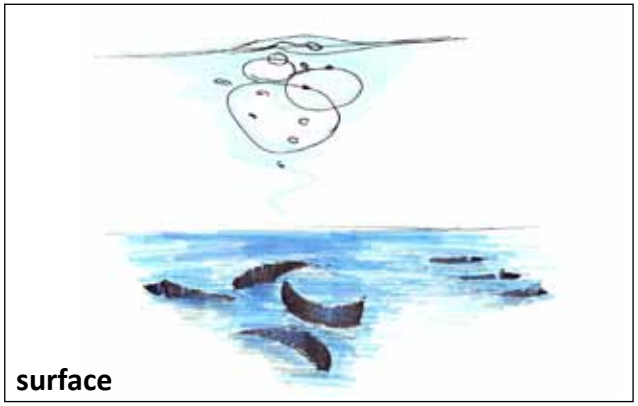












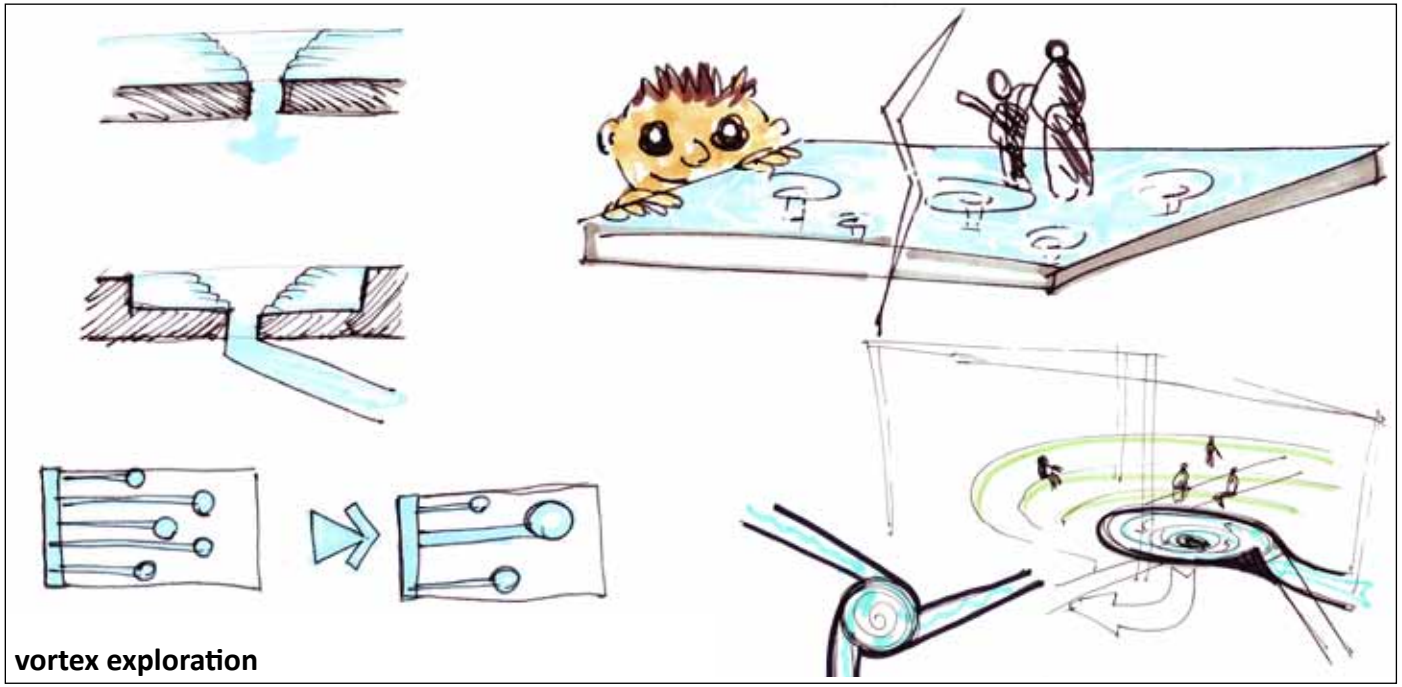
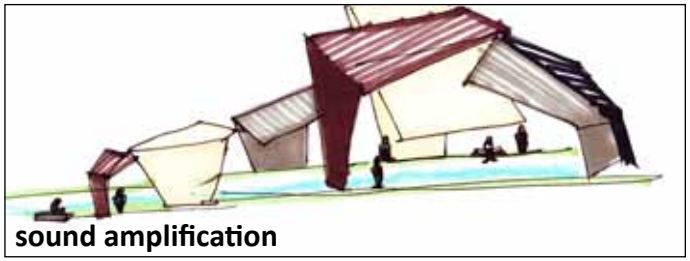
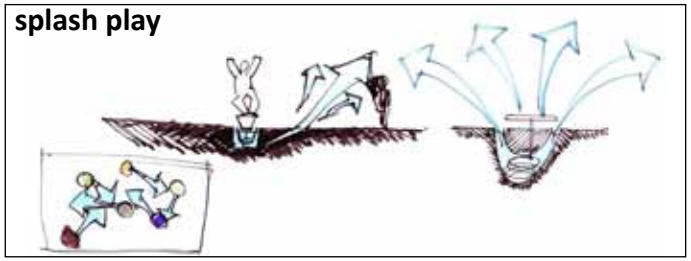


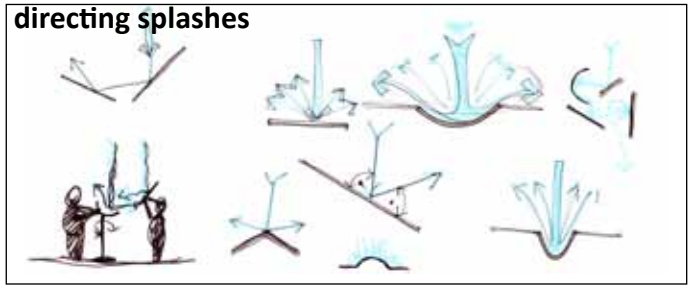
FIGURE 24. WATER EXPLORATION



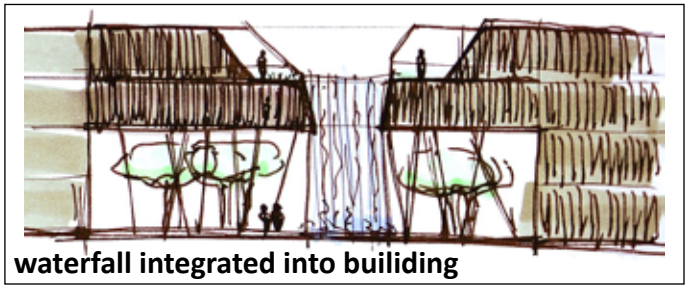
sound amplification

splash play

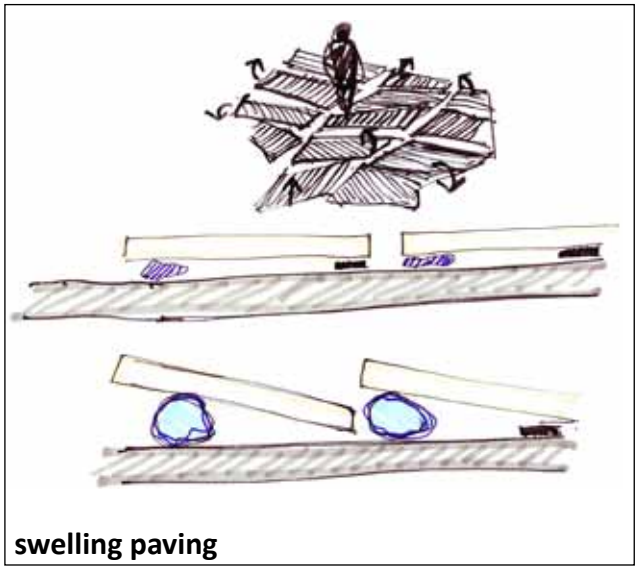




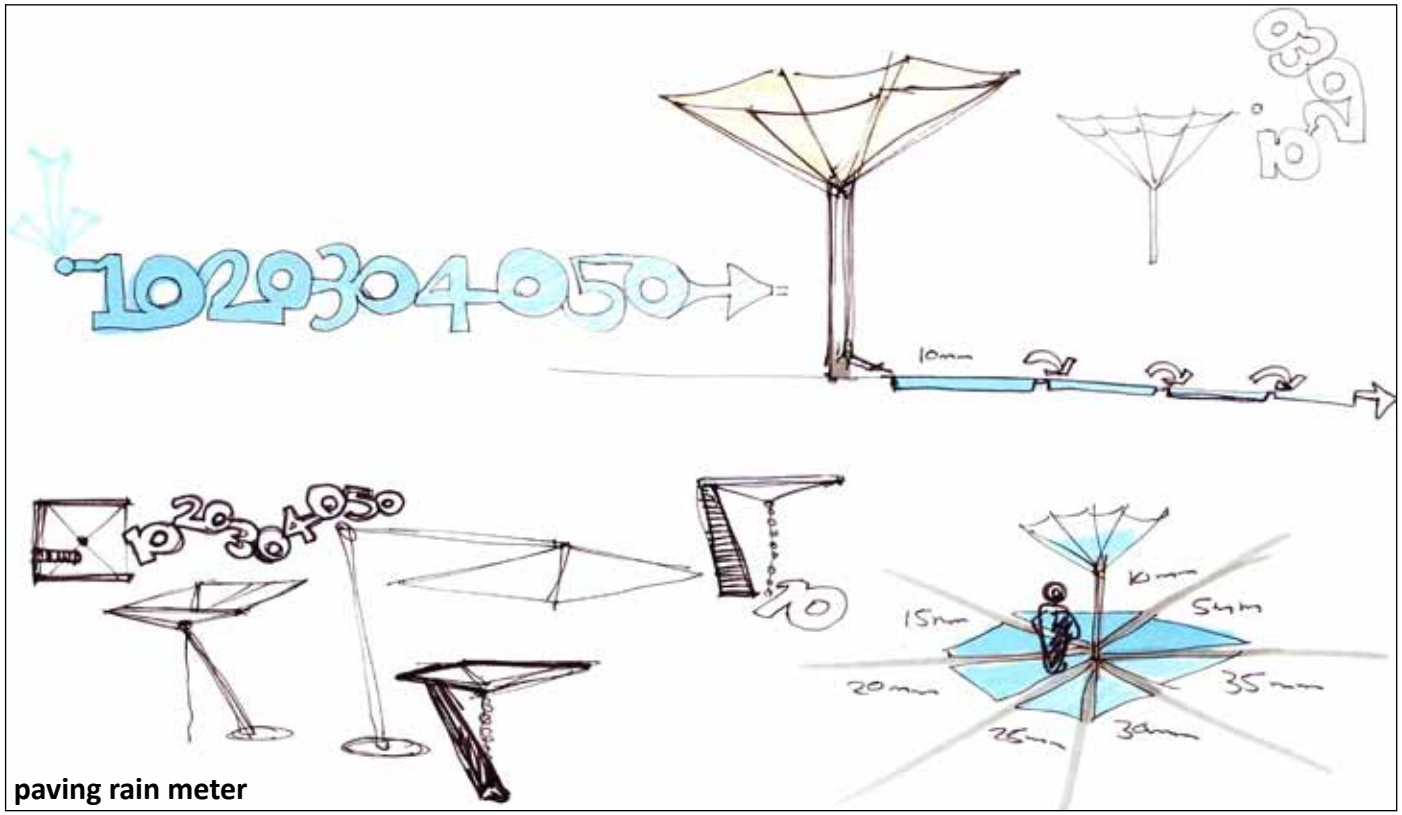
directing splashes



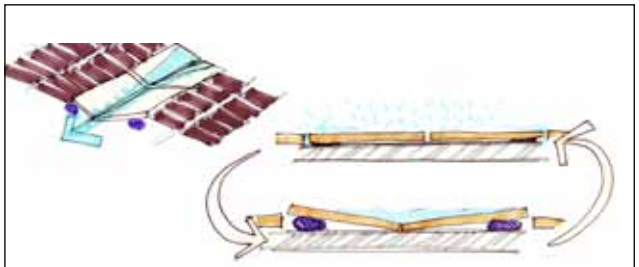
waterfall integrated into buiilding



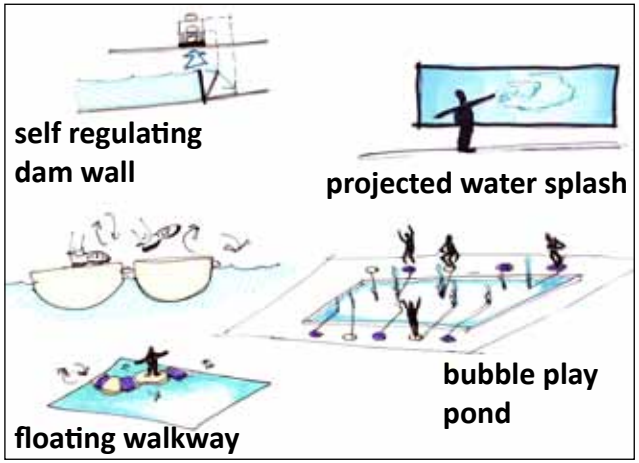
swelling paving



paving rain meter



self forming channel



self regulating dam wall

projected water splash

bubble play pond

floating walkway

context and analysis_

5

Historical context

The investigation of historical context focus on the Apies River. The river is discussed through focussing on the name of the river, the state of the environment in the early days of Pretoria and the physical attributes of the river.

The name

A Matabele tribe living in the river valley named the river Enzwabuklunga (orZwabuhlungu) which means 'painful' in reference to sharp edged dolomite stones in the river and at the fountains that hurt the women's feet when they fetched water from the river. Later on Tswana migrants called it Tshwane after a prominent chief of the time (van der Waal Collection). The current name was adopted from the prolific vervet monkeys that inhabited the area when the first settlers arrived in the Fountains Valley. (Bolsman, 2001, p. 170)

The environment

- The Apies River valley was home to a large population of lions that were hunted and exterminated; the vervet monkeys' habitat was destroyed and they were killed and captured; hyenas and jackals were also driven off (Bolsman, 2001, p. 170).
- One of the earliest settlers wrote: "The trees along

the Apies River made a beautiful pleasance, remark able for its scenery, and the place was blessed with a fine climate and an abundance of the purest water. In those days the central portion of the present city was covered by what we called bontbos, that is clumps and groups of trees with open space between, that gives the whole a parklike appearance, while mimosa [*mimosa sp.* are exotic invaders, thus the reference can be questioned] and the white flowered 'buffelpeer' [no known botanical name found], in spring filled the air with a sublime perfume" (Bolsman, 2001, p. 170).

- Trees in the valley included bushwillows *(Combretum sp)*, wild olives *(Olea europaea subsp. africana)*, stinkwood *(Celtis africana)*, wild currant *(Rhus pyroides)*, 'bontbos' and 'buffelpeer', with camel thorn *(Acacia erioloba)* on the ridges (Bolsman, 2001, p. 170).
- Rose hedges that separated the properties and decorated the parks gave Pretoria the nickname of the 'city of roses' before the time of Jacaranda trees (Bolsman, 2001, p. 182).
- In 1912 two rows of date palms were planted along the river (van der Waal Collection).
- In the book, Eugene Marais 'Versamelde Werke', Marais recalls that in the early Pretoria, grass grew lush everywhere in town, with dense clumps of thorn trees fountains valley to where Lion Bridge now stands and less dense thorn trees from there to the north. The river was densely vegetated with trees and shrubs.
- Pretoria was well known for its water, the river was a dolomite stream with crystal clear water and in the deep pools, and even thesmallest of stones could be seen on the river bed.
- The river banks were covered with ferns and cotton fields, varkblomme [assumed *'varkore'* or arum lillies: *Zantedescia sp.*] in all the streams. A quarter of the river was diverted to supply water to the farms and towns (Marais, 1984, pp. 757 - 759).

Figure 25 gives a glimpse of the Apies River valley in 1857, large expanses of grassland with clumps of trees was commonplace.

The river

- Around 1835 when the first Voortrekkers settled at Fountains Valley, approximately 25 million litres of water entered the Apies River on a daily basis (Bolsman, 2001, p. 170).
- During 1875 a water wheel and mill (figure 26) was built on the river bank west of Lion Bridge (Bolsman, 2001, p. 40).
- In 1858 a series of channels and shallow furrows was built that fed water to the farms and homesteads (Bolsman, 2001, p. 14).
- 1894 saw the completion of Lion Bridge on Church street (van der Waal Collection).
- Frequent flash floods gave the river the nickname 'the Mighty Apes' and led to the start of its channelization (figure 28) in 1909 from Rissik Street to Du Toit Street after the loss of lives, cattle and repeated damage to property. (Bolsman, 2001, p. 133) The channel was completed in the late 1930's (van der Waal Collection) (figure 28).
- The City Lake project was abandoned in the 1980's, a lake would have been built at Trevenna (van der Waal Collection).
- Nelson Mandela Drive was introduced along the Apies River, crossing it in several places and replacing some of the smaller streets to form a major connectivity spine from Pretoria southwards.

FIGURE 25. PRETORIA IN 1872 BY THOMAS BAINES SHOWS THE CURRENT DAY LION BRIDGE TOWARDS THE CITY CENTRE

FIGURE 26. FARM HOUSE IN PRETORIA [WITH WATER WHEEL] BY W.H. THRONE DATED 19 AUGUST 1887 SHOWS THE WATER WHEEL AND MILL ON THE BANKS OF THE APIES RIVER WEST OF LION BRIDGE

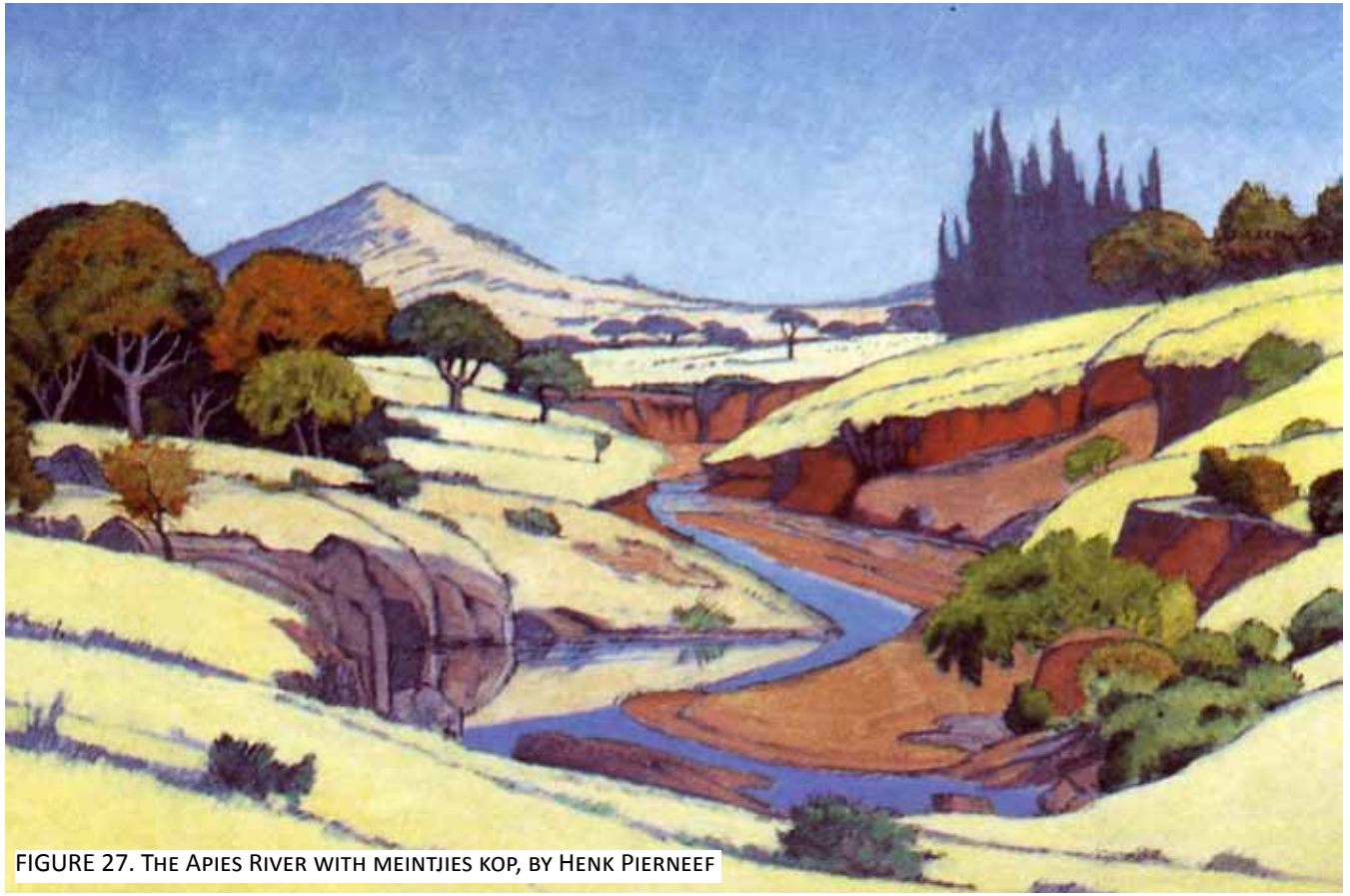


FIGURE 27. The Apies River with meintjies kop, by Henk Pierneef

FIGURE 28. Canalization of the Apies River by Pieter Wenning shows the channel with young palm trees that dates it after 1912

The historical descriptions paint a much different picture of Pretoria and the Apies River than what the current day city dweller experience. The author needs to focus attention on the possibility that the channelization of the Apies River was not due to human modification of the land cover, topography or the introduction of impermeable surfaces; the ecosystem seemingly had a naturally erosive and dynamic character (figure 27) that can be ascribed to a myriad of conditions.

The historical context gives cues to the type of planting would historically appropriate to use, and hints at the state of the river that was lost.

The current day context

A lot has changed since the 1800's, Pretoria has grown from its humble beginnings into on of the largest cities in South Africa. The Apies River that originally separated the farms from the town is now bordered by development on all sides.

Figure 29 locates the study area and the site in Pretoria.

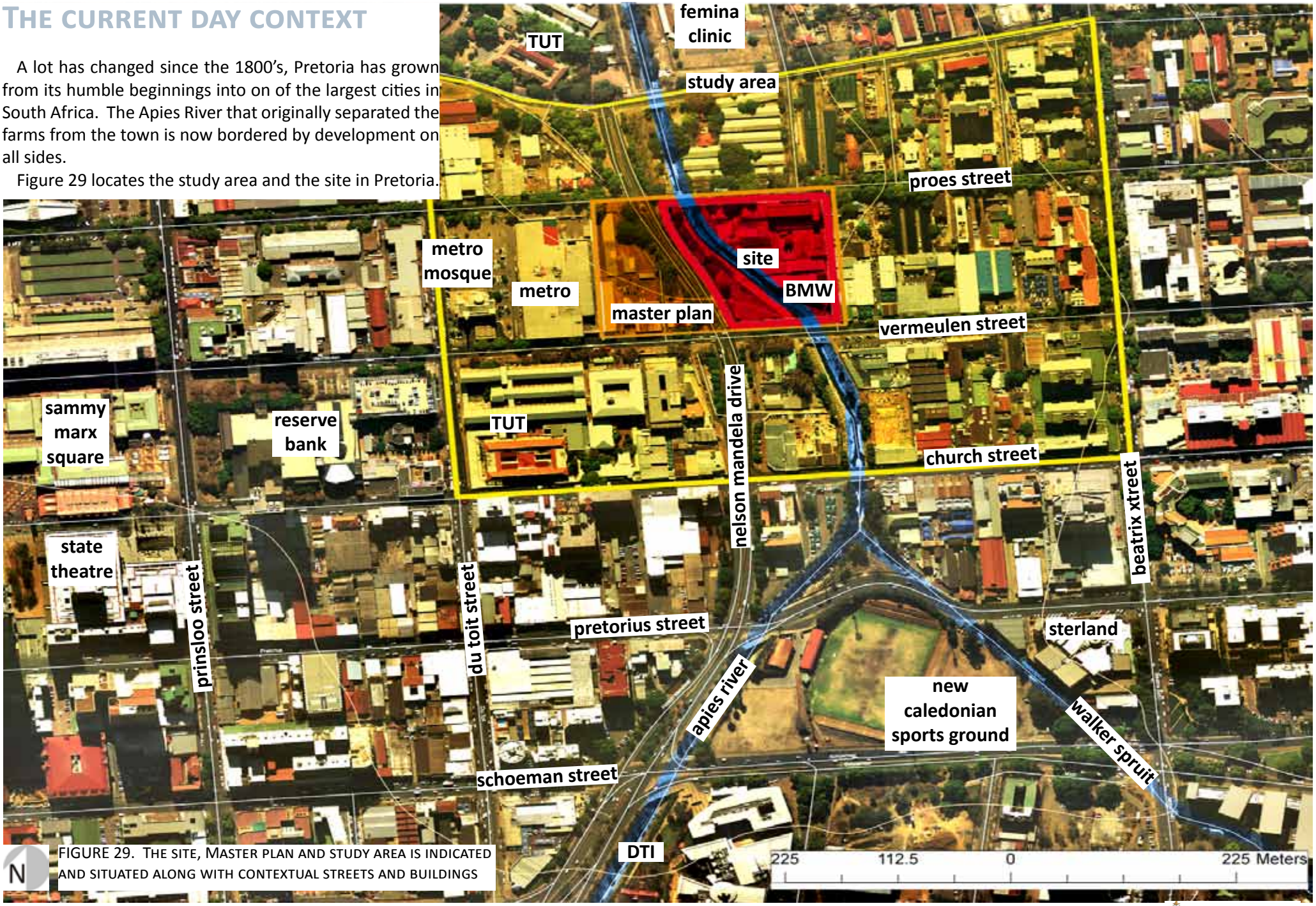
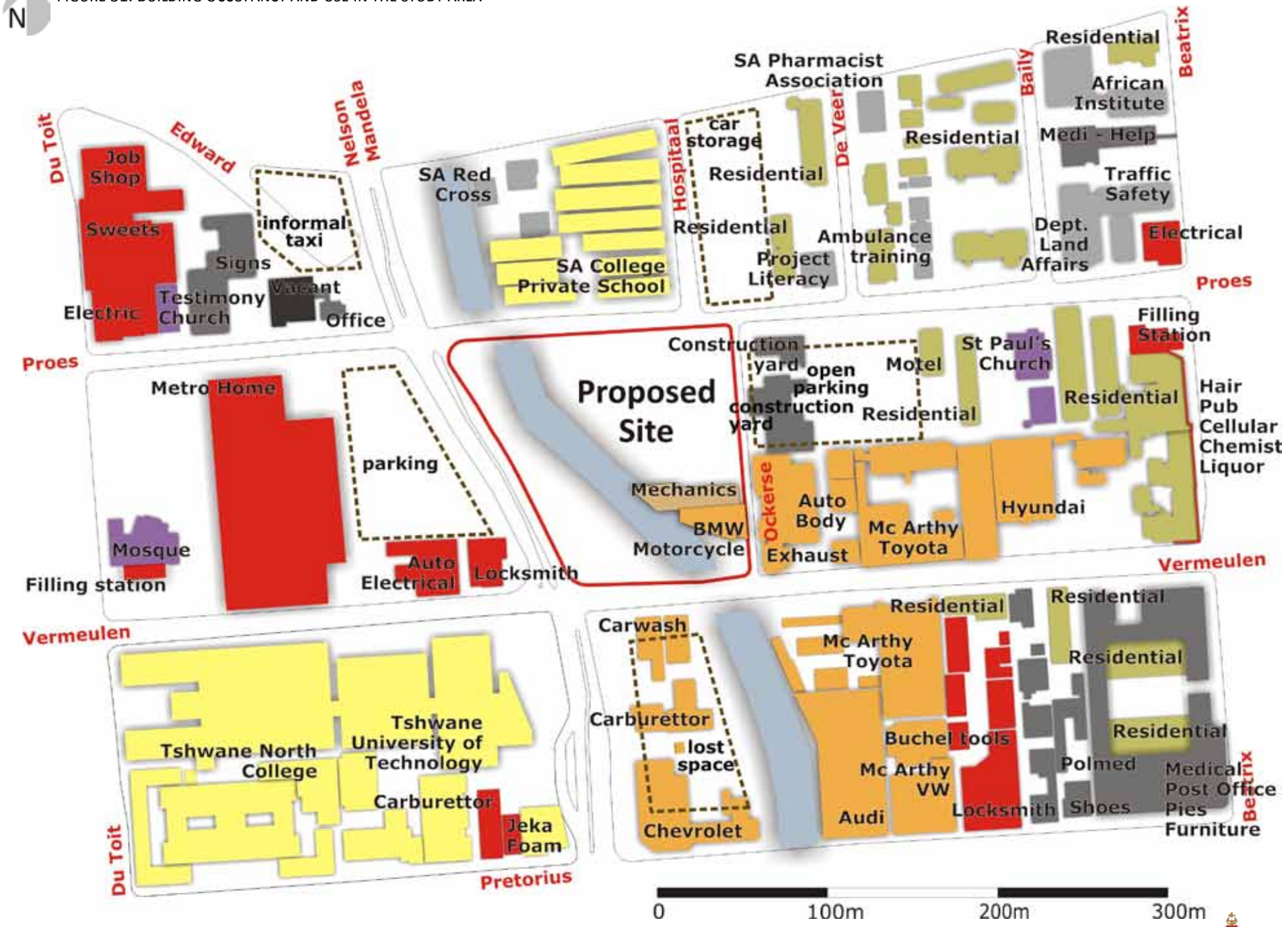


FIGURE 29. The site, Master plan and study area is indicated and situated along with contextual streets and buildings

Figure 30. Zones of use in the study area - The site is situated between educational, retail, and residential areas

FIGURE 31. BUILDING OCCUPANCY AND USE IN THE STUDY AREA



Zoning on site and consolidation

Figure 32 illustrates the on site zoning. The following zoning is applicable on site.

Business 1 zoning

25m height
FAR 3.0
Coverage 80%
Uses:

- Business
- Dwellings
- Government
- Guest House
- Institution
- Light Industry
- Parkade
- Parking
- Instruction
- Public worship
- Refreshment
- Residential
- Retail
- Shop
- Social hall
- Sport Club
- Vehicle retail
- Veterinary

Figure 32. Zoning diagram

Public open space zoning

- Agriculture
- Market garden
- Picnic place
- Refreshment
- Recreation
- Sport club
- Telephone Masts

The intended program can be accommodated in the current zoning profile

Consolidation

Figure 33 shows the Erf's that needs to be consolidated before the master plan (to the left) and the site development (to the right can take place).

The shape of the erfs on the right hand side gives clues to where the Apies river had run at the time of subdivision.

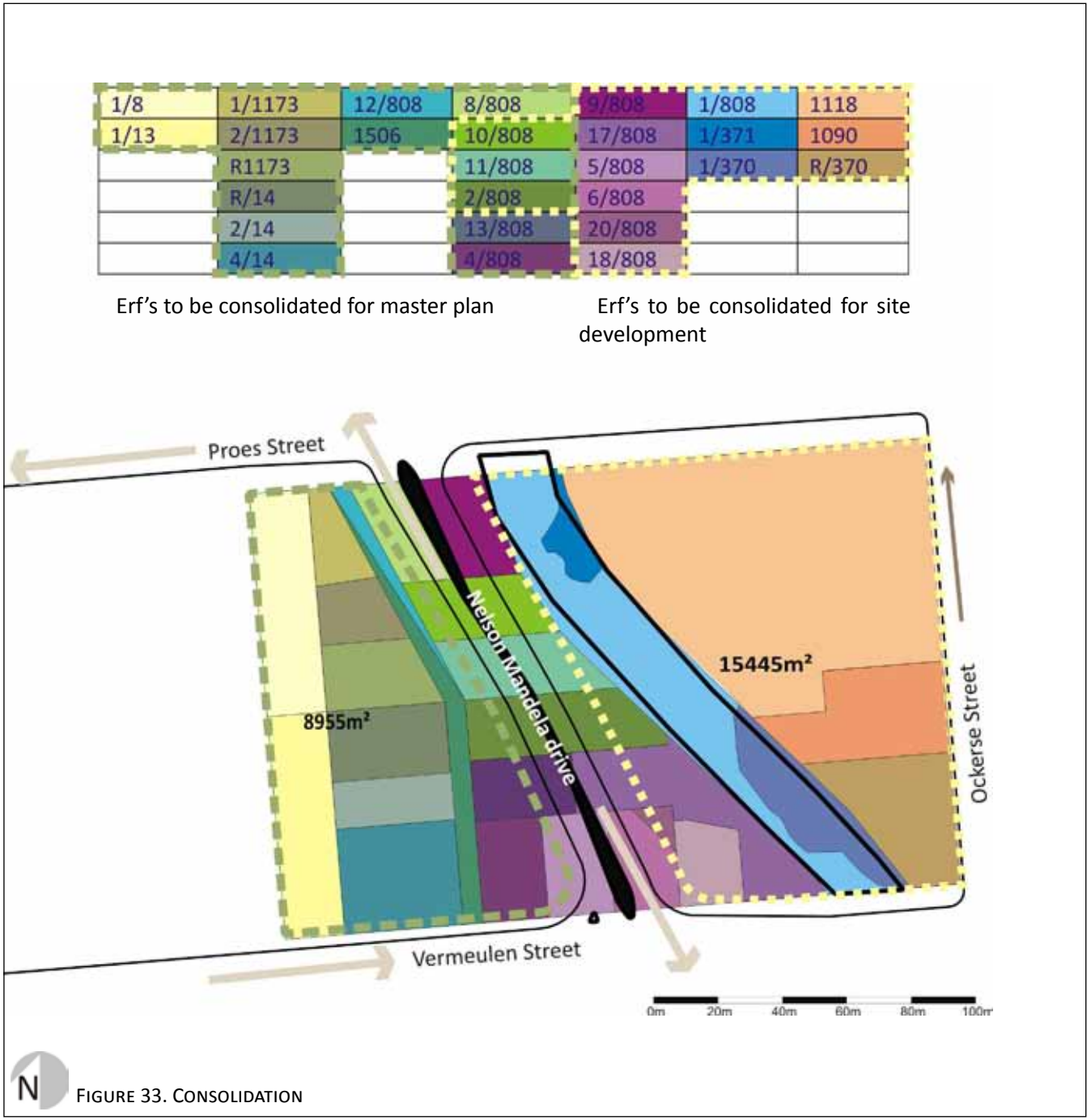


Figure 33. Consolidation

Figure 34. Water supply pipes at the Proes street bridge

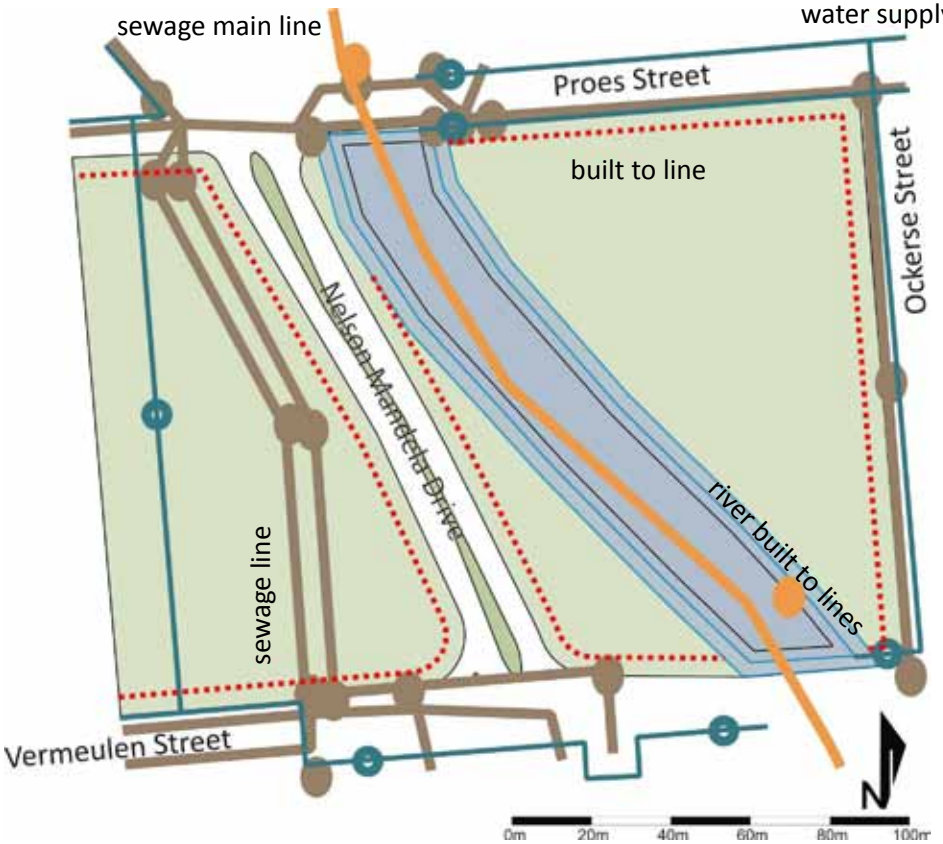


Figure 35. Restrictions and services - Built to lines, sewage and water supply lines are indicated. A main sewage line lies below the river channel

Restrictions and services

Built to lines from framework

- Business and Public Open Space - 5m
- Apies River channel - 70% of buildings 7m & 30% of buildings 3m from the channel

Built to lines from Tshwane Town-Planning Scheme

- Business and Commercial - 4,5m
- Public Open Space and undetermined - 5m

Height restrictions:

- 18 storeys and no more than 1381m above mean sea level

Parking requirements:

- Flats - 1/93m²
- Offices - 1/116m²
- Shops - 1/116m²
- loading space of 7,5m x 4,5m

(City of Tshwane Metropolitan Municipality, 2009)

State of the environment and site exploration

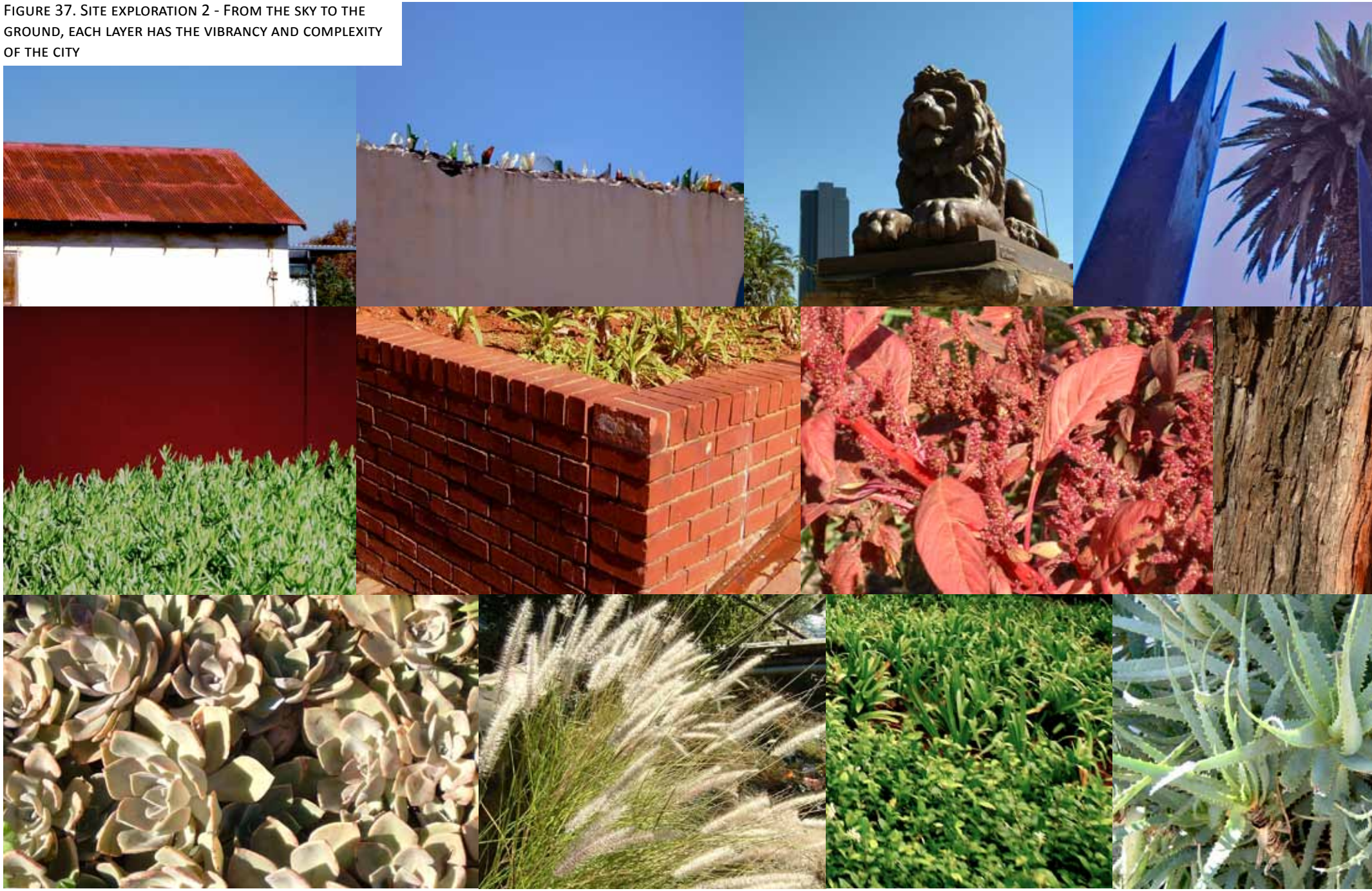
Figure 36 explores the state of the environment on and around the site, looking at textures, colours and use.

The effects of age, misuse and neglect are visible in surface finishes and general maintenance.

The site and surrounding area is rich with colour, texture and contrast. Cues for colours, textures and materials are abundant.

FIGURE 36. SITE EXPLORATION 1 - THE STATE OF THE SITE AND SURROUNDING AREA

Figure 37. Site exploration 2 - From the sky to the ground, each layer has the vibrancy and complexity of the city



Slope analysis

The site varies from extremely flat to extremely steep. Steep smooth concrete edges of the channel poses a danger. The north western part of the site and the channel has a slope 15% or steeper. The majority of the site has a slope of 0 - 5%.

Figure 39. VIEW NORTHWARDS INTO THE CHANNEL - The old rock wall on the right was built as an hydraulic structure and raises the ground level at the BMW motorcycle shop above the top of the channel

Figure 40. VIEW SOUTHWESTWARDS FROM THE PROES STREET BRIDGE - The level difference from the Proes street intersection towards the channel drops by more than 2.5m.

Figure 38. Inside the channel - Looking northwest

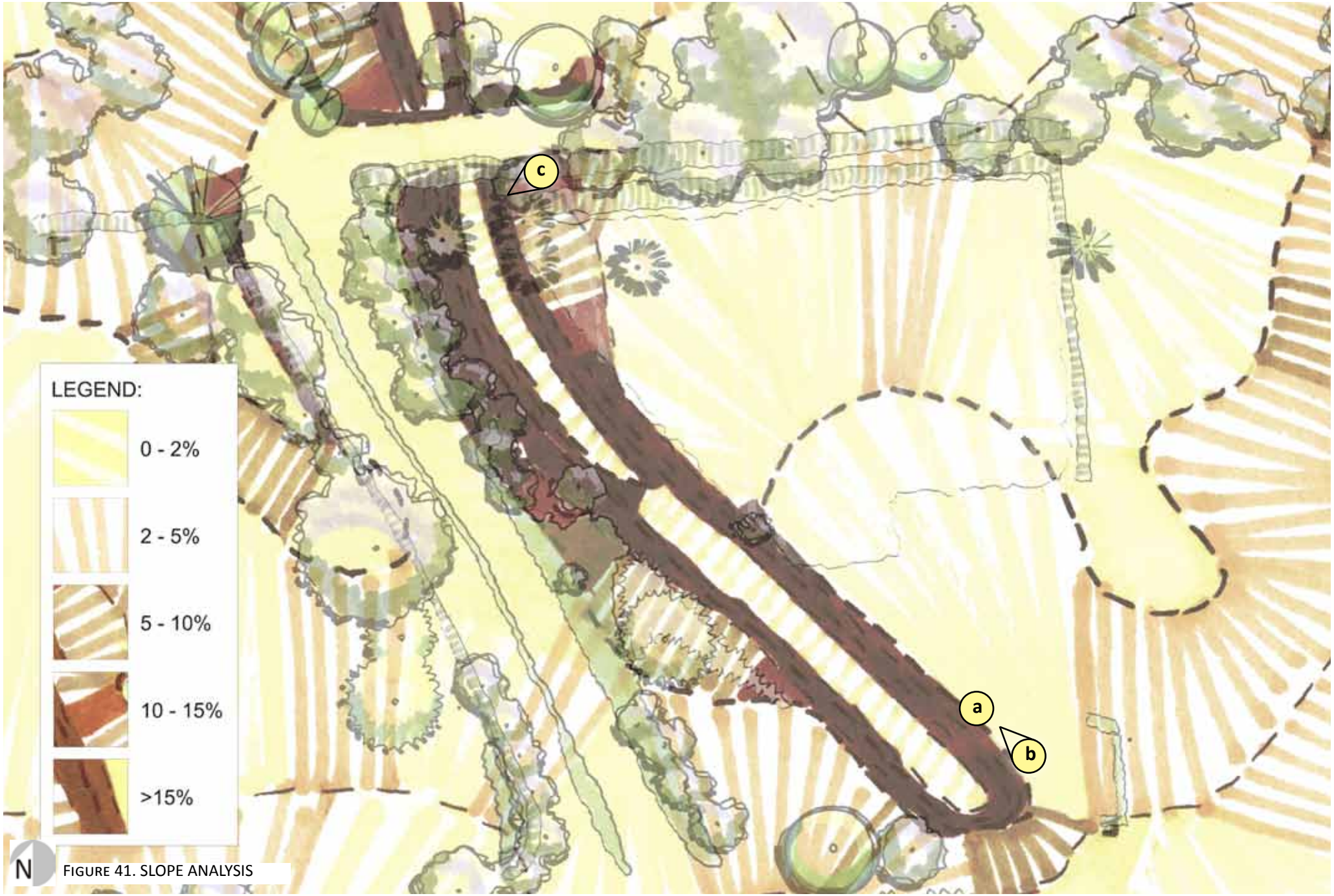


FIGURE 41. SLOPE ANALYSIS

Figure 42. View from corner Nelson Mandela Drive and Vermeulen Street eastwards - Formalised planting

On site vegetation

The site is covered in weeds for the most part due to extensive demolition after 2007 (figure 42 and 43).

Informal parking on the southwestern corner of the site leaves a large part of the site with bare compacted soil.

Grass has established in some areas while invaders and pioneer plants grow on the edge of the channel. The pedestrian edges, especially along Nelson Mandela drive are planted with a mix of indigenous and exotic vegetation (figure 46), while Jacarandas and exotic trees occur.

Trees on site

Jacaranda mimosifolia

Platanus x acerifolium

Phoenix canariensis

Invasive exotic shrub

Figure 43. Invasive creepers in the channel

Figure 44. Grass in cracks and joints

Figure 46. View from corner Nelson Mandela drive and Vermeulen street north

Figure 45. View from corner Nelson Mandela Drive and Proes Street eastwardly

FIGURE 47. ON SITE VEGETATION

Use and surface cover

There are two buildings on site, a BMW motorcycle shop (figure 48) on the southeastern corner of the site and a Autobody and mechanic shop (figure 49) that is in disrepair.

Homeless people to use the shady spots and soft vegetation to live in (figure 51).

No maintenance and informal parking (figure 50) leads to bare patches of compacted soil.

Figure 48. BMW motorcycle shop

Figure 49. Autobody and mechanic shop

Figure 50. Informal parking

Figure 51. Homeless people

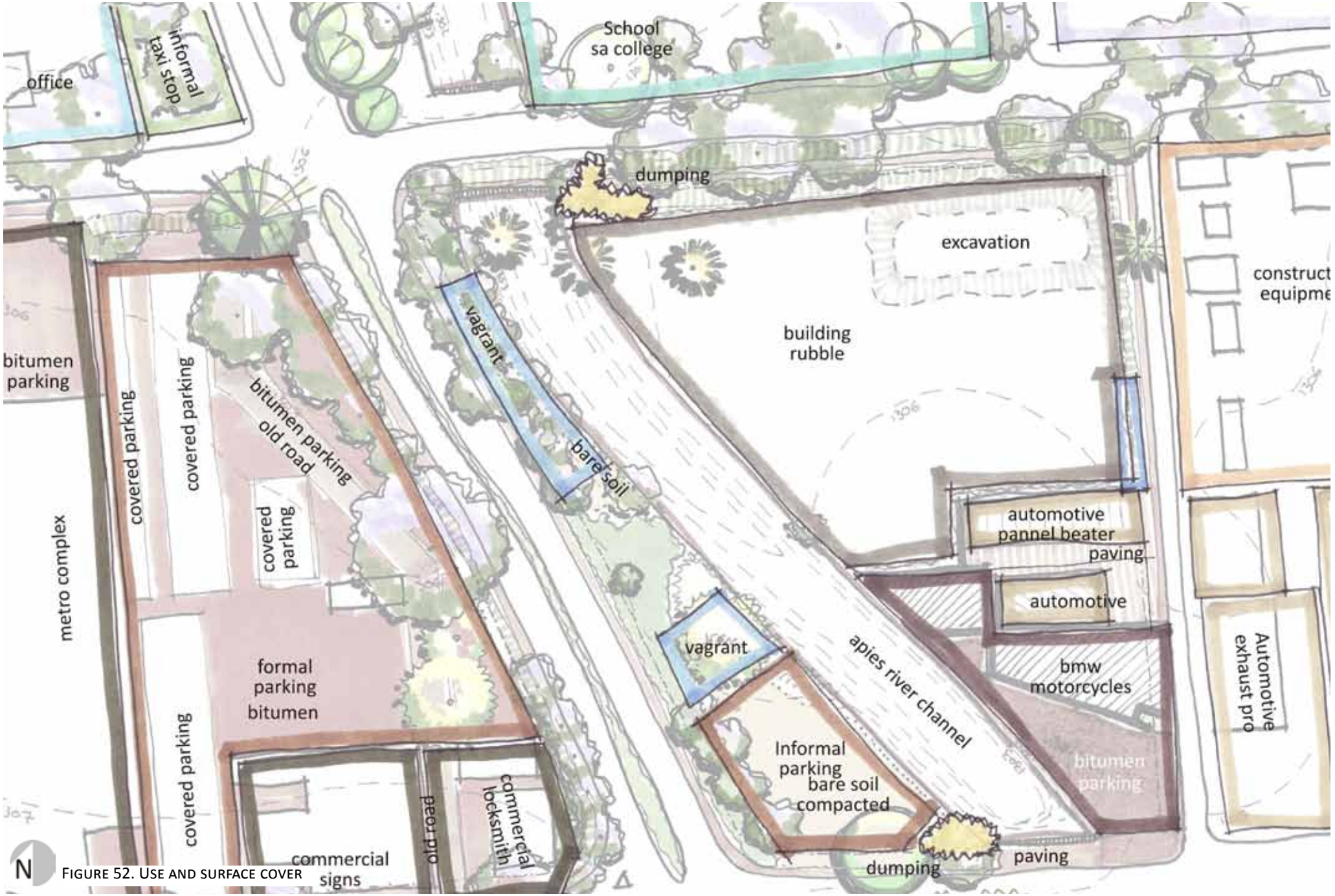


FIGURE 52. USE AND SURFACE COVER

Noise and danger

Nelson Mandela Drive and the surrounding streets are part of a major movement corridor in the city and generates a considerable amount of traffic noise.

Sounds from the nearby Metro mosque (figure 54) adds character to the site and a nearby informal taxi rank generates noise.

The steep edges of the Apies River channel and the seasonal floods pose serious physical dangers. The abandoned site and run down state of Ockerse Street (figure 53) on the eastern side of the site creates opportunity for criminals.

Figure 53. View of Ockerse street across the site

Figure 54. The mosque at metro

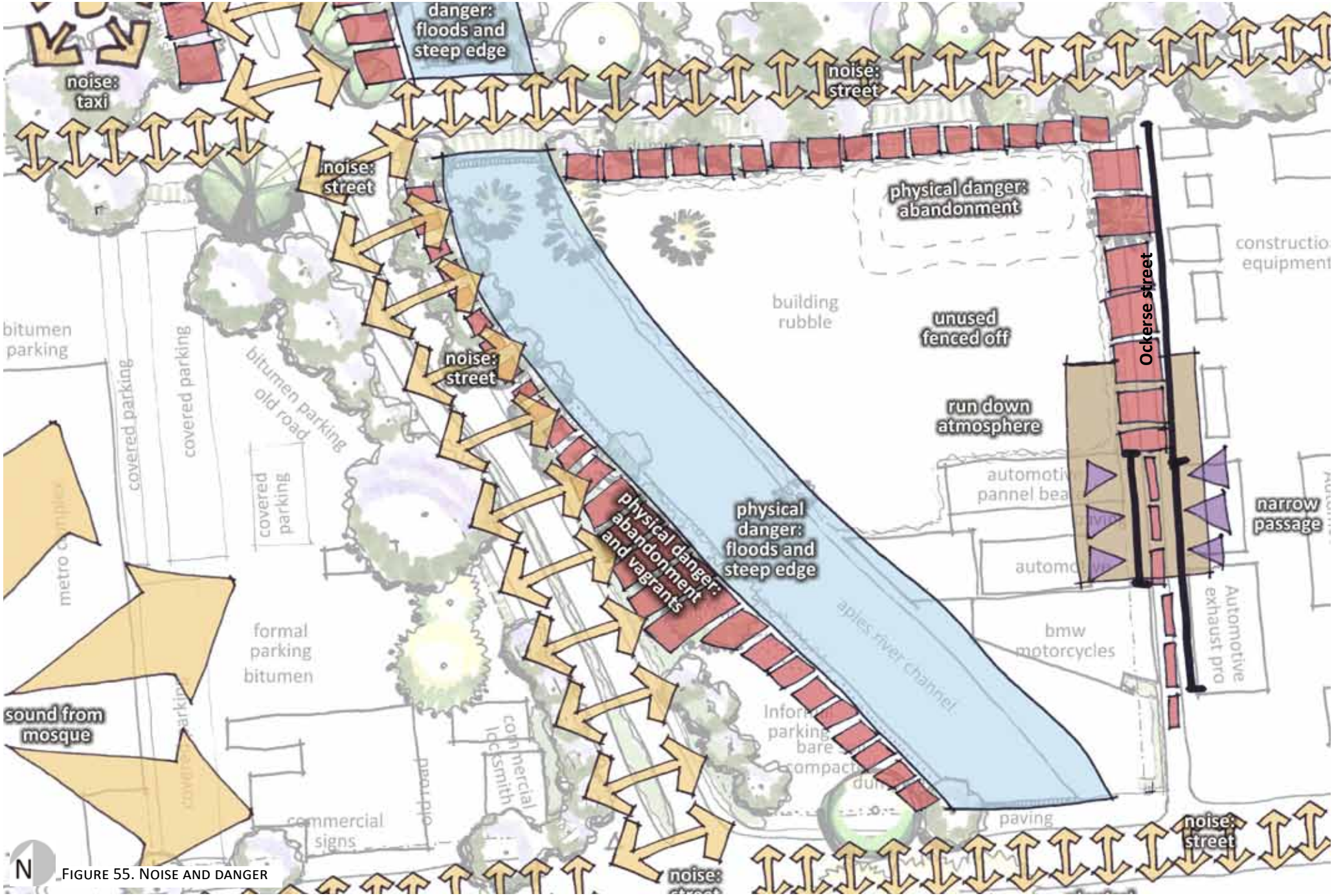


FIGURE 55. NOISE AND DANGER

Water Quality in the Apies River channel

"Tshwane's scarce water resources are under tremendous pressure, with water quality of streams deteriorating during its course through the Tshwane area, especially with relation to bacteriological quality.

The Apies River average faecal coliform [pollution by human waste] *count at Skinner Street is 6000/ml and 32141/ml at Onderstepoort (counts above 100 is risky for bathing and washing of laundry). The monitoring network needs to be expanded and specific measures implemented to improve water quality."* (City of Tshwane Metropolitan Municipality, 2005)

Figure 56. Skyline to the southwest from cnr. Proes and Ockerse Street

Conclusions from the context and analysis

The position of the site in the city, in terms of pedestrian movement and the need for open space in the city and study area, makes it ideal for green public open space.

The Apies River is a under-utilised resource both on site and in the rest of the city. The river has a rich history in its name, physical history and its core role in the establishment of the city. The social and ecological role that this river needs to play are issues that needs to be addressed.

Although the site is a brown field site, open space in the city is rare and needs to be conserved and the use thereof must be optimised. This combination of under-utilised resources holds a lot of potential to create a meaningful open space in the city.

The current openness of the site allows for views of the city centre skyline to the west (figure 56) and glimpses of the Union Buildings to the east (figure 57). These views are important as they link the site to the broader context of the city.

Most of the site is in a state of disrepair and mismanagement. Introducing context appropriate use will address the issues of inappropriate use, the danger associated with abandonment and destructive informal use.

Figure 57. Glimpse of Union Buildings from Nelson Mandela drive eastwards

Design goals and objectives

The design objective is to create a place of repose in the city, a breathing space. The grid of the city block collides with the river channel and divides the site in two parts. This haphazard intersection and bisection of the site needs to be addressed through a unification of the site. The concrete channel does not only divide the site, but it also divides the city. By unifying the site, a great step will be taken towards unifying the city. The open character of the site needs to be celebrated and protected. The scale of the city scale should be reduced on site to address human proportions.

These design objectives will be addressed through the following Citywide and Site specific issues:

Citywide

- Implement the vision of the Nelson Mandela Student Urban Design Framework (group work of the author 2009) through providing a network of social public open spaces along Nelson Mandela drive and the Apies River that is safe, accessible, and responds to the history of the river and the city;
- Outline and implement a basic catchment management plan along with envisioned projects along the Apies River in support of the frameworks and design.

Site specific

There are three major problems with the Apies River channel that should be conceptually addressed for the whole river and for the specific site:

- A small base flow year round which must be protected, cleaned and utilized for its potential of recreation and habitat restoration
- Dangerous flash floods that needs to be accommodated in controlled flood planes
- Harsh concrete channel that needs to be addressed and softened whilst maintaining the function of a collect an remove channel that the river has sadly been turn into

Design a vibrant public open space

- Create an appropriate on site micro-climate for pedestrians, students, school children and nearby residents
- Entice use throughout the day by providing opportunities for a wide variety of use, such as retail facilities, playground and tuck shop facilities for schools from nearby, both in lunch breaks and after school, restaurants and cafés that attracts patrons on weekends and evenings
- Enhance and protect the openness of the site through providing a building edge that focuses inwards towards the core of the site

- Expose the ecological, historical and cultural memory of the site by introducing a memory of where the river used to run (abstracted from the SG diagrams of the Erfs), by reintroducing vegetation that was removed (descriptions from historical records and books), by celebrating and using the existing flood control rock wall and on site buildings

Ecology

- Introduce constructed systems that supports components of ecology by focussing on water as a critical building block
- Incorporate the prominent themes from the ecosystem service analysis
    - Conserving water sources and the systems they support while optimising the use of on-site water and reducing the use of potable water
    - Introducing and preserving existing natural and on site region appropriate biomass
    - Using renewable- and waste minimising materials that does not pollute through manufacturing application or after installation
    - Optimise human use and health benefits by integrating the on site systems to improve the experience of man's environment

precedent studies_

6

Introducing the precedents

The precedents are classified according to themes they address

- *Relation* analyses organization and program: Greenlyn Village
- *Water* focuses on water systems: Water Master Planning
- *Digestive* examines modes of water cleaning: On Site Sewage Wetland and Vortex generator
- *Experience* explores the creation of uncommon encounters with water in the landscape: Weather Garden
- *Memory* looks at forgotten resources and the commemoration of change over time: Cape Town Foreshore Pedestrianisation
- *Reuse* reinterprets on site materials: Urban Outfitters Navy Yard Headquarters
- *Surface* explores the translation of the liquid properties of water into habitable space: Simcoe WaveDeck and Boreno-Sporenburg Bridges

RELATION_ORGANISATION AND PROGRAM

Greenlyn Village, Menlo Park, Pretoria, South Africa

Greenlyn Village (figure 58) was chosen as precedent because it was designed as a social hub with restaurants, cafés and a few shops centred around a constructed stream and a semi-public open space. Layout, spatial orientation and function were part of the criteria for selecting the precedent.

Description

The centre sits on a whole city block in a suburb. The design attempts to create a public space that includes restaurants, shops, businesses, fitness and gardening outlets all utilizing the attraction of an introduced 'naturalistic' water course with a dam, wetlands and aquatic bird species.

Spatial organization

Connectivity

The complex surrounds the water element on all sides and allows no direct view from the four streets that surround it. Tall fences, although visually permeable, isolates the complex from street activities to form an exclusive island. On the southern side of the development a wide parking and planting buffer (figure 59) along with a height difference and a retaining wall adds to the segregated atmosphere of the development (figures 59 and 60). Large expanses of monotonous lawn (figure 61) add distance between the pedestrian and the core of the development and fenced off service yards and entrances (figure 62) gives an inactive and dead façade to one side of the development.

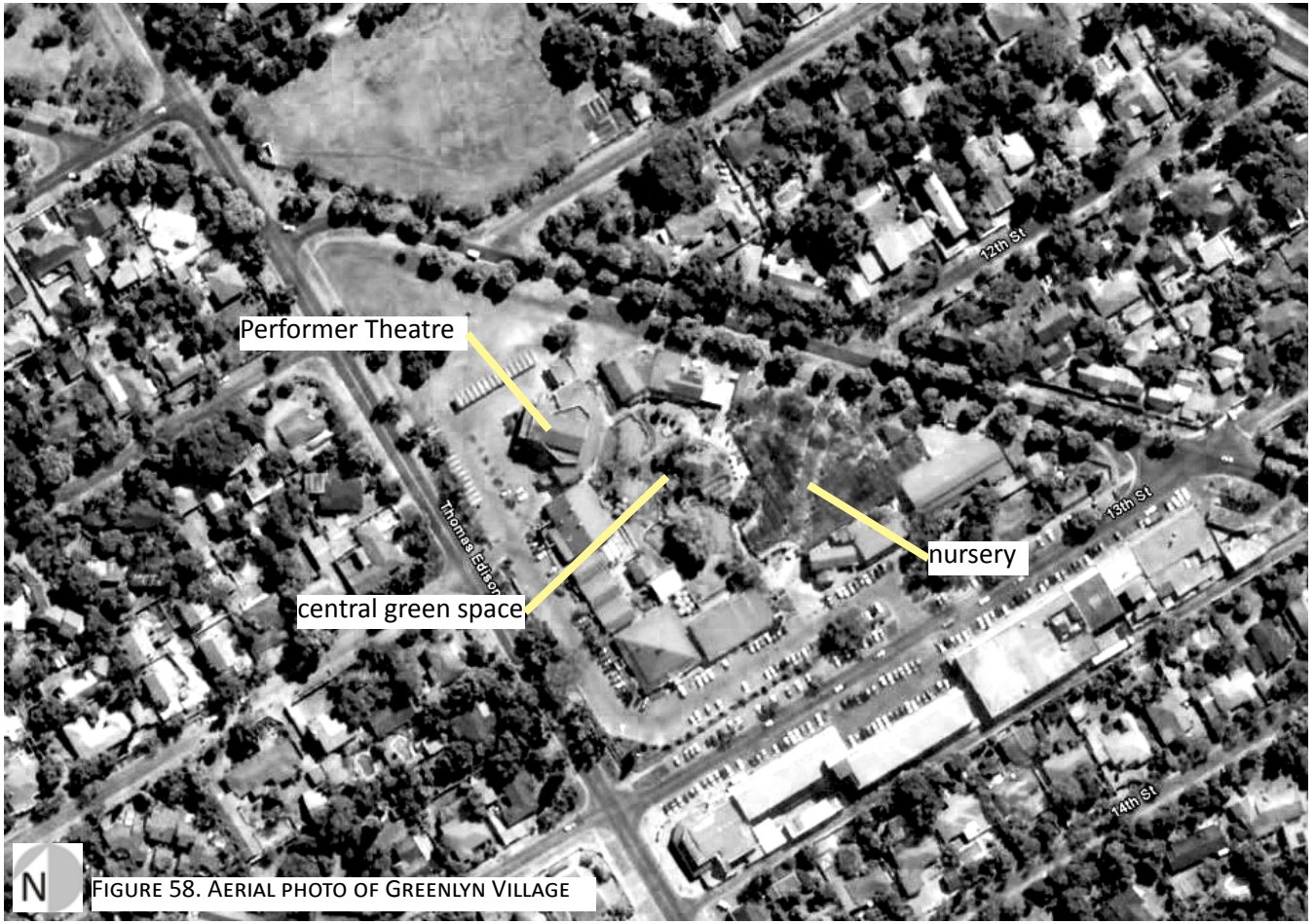


FIGURE 58. AERIAL PHOTO OF GREENLYN VILLAGE

Security

In spite of the high fence, the development experiences security issues like break-ins and robberies. The author is of the opinion that the exclusiveness of the design and the organization of the buildings to focus inwards and turn their back on the street adds to the safety dilemma.

Visual amenity and use of amphitheatre

Apart from the muddy water (figure 63), the water element has a calm and relaxing quality that has a lot of potential. The amphitheatre is hardly ever used except for shopkeepers on a smoke break (figure 64). The amphitheatre is a novel idea, but when it is not integrated functionally into the design it loses its integrity.

Economic viability

Some of the restaurants change ownership frequently which might lead to the conclusion that the project might not be as economically feasible as it was intended. This may be due to too many restaurants or the spatial configuration. The introduction of a green island in the heart of a suburb might also not be as significant as it would have been for example in the inner city where green space is a valued and scarce commodity.

Conclusion

- Pedestrians and motorist should be enticed with views of the attraction
- The development should be programmed to include all income groups
- Configure the spatial layout to prevent dead facades and unsightly service entrances from deactivating streets
- Details and construction should anticipate the effect of introduced or attracted wildlife on water systems and embankments
- Sedimentation ponds are needed in a systems where disturbance occurs on erodible banks

Figure 59. Large buffer and height difference between buildings and street

Figure 60. Wide buffer between buildings and street (looking towards 13th street)

Figure 61. Large expanses of fenced off lawn

Figure 62. Dead street interface

Figure 63. Muddy water and a distance between buildings and water element

Figure 64. Amphitheatre with the Performer theatre on the right

Water Master Planning

Heritage Middle School, Raleigh, North Carolina, USA

The school was selected as a precedent for its extensive rainwater and storm water harvesting system that integrates harvesting, cleaning and reusing.

Description

The school retrofitted nine sustainable strategies onto the buildings.

The strategies includes

- Rainwater harvesting from roofs
- Constructed wetland (figure 65)
- Solar geysers
- Photo Voltaic (PV) panels
- Day-lighting of interiors
- An energy efficient building shell (GreenNews, 2007, p. 3)

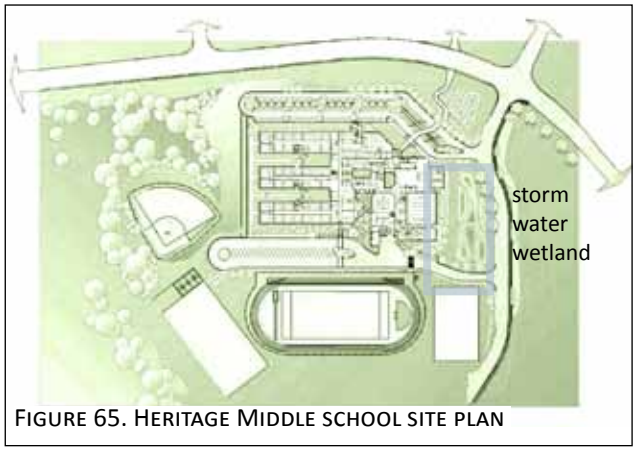


FIGURE 65. HERITAGE MIDDLE SCHOOL SITE PLAN


FIGURE 66. HERITAGE MIDDLE SCHOOL WETLAND

Rainwater collection system

From the roofs the water is collected in underground cisterns; water for flushing toilets is treated with chlorine. The system is diagrammatically explained to students and visitors. Low flow and conserving sanitary appliances are used throughout the facilities and harvested rainwater is used for irrigation.

Other strategies

Extensive lawn areas are replaced by regional planting and mulched areas. A constructed wetland is used for education and treats runoff from fields before it enters a nearby river. Pathways into the wetlands (figure 66) allow the study of wetland soil and gives access to the PV powered aerator that prevents mosquito breeding. (Kinkade-Levario, 2007, pp. 149-151)

Conclusion

- Raising awareness through signs and notices cultivates understanding of green strategies
- Integrating rainwater harvesting with irrigation and sanitary appliances saves on the use of potable water
- Native planting, mulching and reduction of conventional lawn area is needed in order to eliminate the use of potable water in irrigation
- Making systems visible and understandable gives the opportunity for education and exploration
- The rainwater harvesting process should be expressed visually for a richer educational experience

DIGESTIVE_CLEANING WATER

On Site Sewage Wetland

Sidwell Friends School, Washington, D.C., USA

The project was selected for the integration of different water systems on site. Sewage treatment on site allows for education and water use reduction and an extensive grey water recycling system.

Description

The on-site sewage treatment integrates with the other water related strategies on site and interlaces landscape and architecture to the enhancement of both. The visibility of the system adds richness and an educational aspect to the project (figure 67).

Technical

An underground treatment tank is the first step in sewage treatment, where after the effluent circulates in a subsurface manner through reed-planed terraces. Sand- and trickle filters treat the effluent further. The cleaned effluent is reused for all the toilets in the building. A closed system is formed where re-cycling supplies the system with adequate water (figure 68).

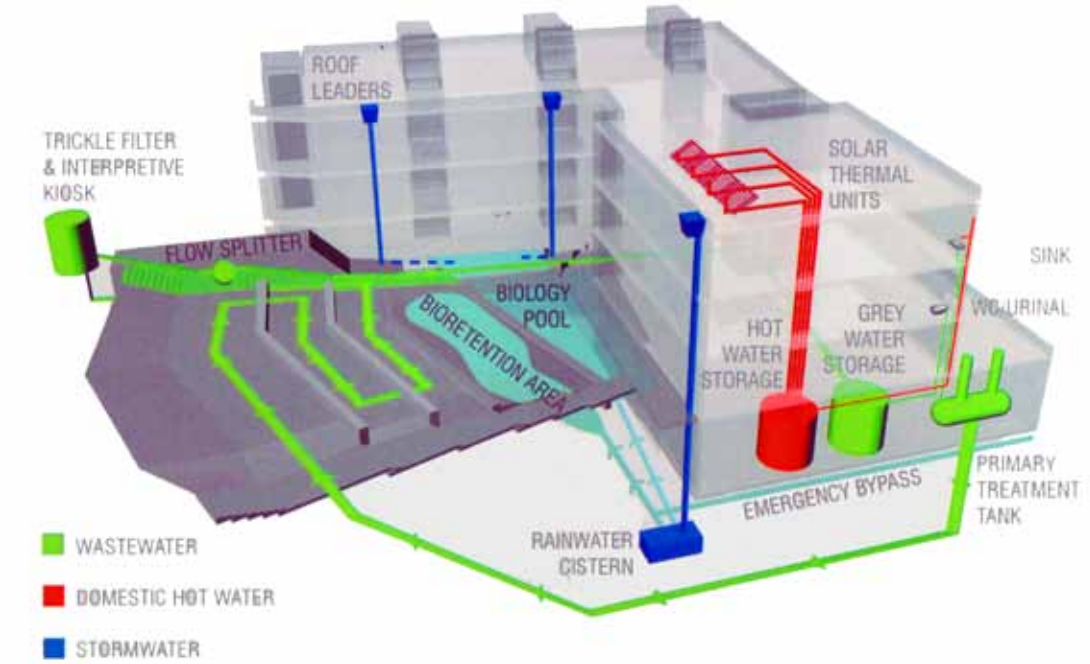
Figure 67. Sidwell friends - stepped wetland

Storm water runoff is collected in a rain garden and pond, the pond is topped up with harvested rainwater from cisterns in the basement. The rain garden doubles up as an overflow for the pond during heavy rain. The changing water levels of the system reflect the fluctuating annual rainfall of the region. (Margolis, 2007, pp. 112-113)

Conclusion

- Successful on-site sewage treatment can enhance the qualities of the landscape and add to an educational experience
- Different water systems can complement and complete each other and enhance the overall function and experience of water on a site
- A symbiosis between Architecture and Landscape Architecture is needed for integrated functional systems that work on various levels

Figure 68. Sidwell Friends - Water system



Vortex generator

Water Vortex Power Plant, Obergrafendorf, Austria

The project was chosen for the vortex it creates. The physical properties of the system guide the design of the vortex pool in the thesis project.

Description

The prototype is a gravitation driven water power plant that uses the rotation push of a water vortex. The system not only generates energy, but aerates the water as well.

> "The water vortex disseminate homogeneously contaminants in the water and increases the contact surface of the disseminate contaminants for microorganisms and water plants. So the biological water purification process will be accelerated." (Zotlöterer, 2007)

Technical data

- Water head of 1,3m (falling height)
- A flow rate of 1m³/s
- Diameter of the rotation tank is 5,5m
- Turbine turns at 25rpm
- Effectiveness of the turbine 80% at 3/3, 83% at 2/3 and 76% at 1/3 of the maximum flow rate
- Produced electrical power 8kW

(Zotlöterer, 2007)

Conclusion

- A vortex can be created by asymmetrically channelling a large amount of water through a shaped container (figure 69).
- Aeration and consequently cleaning of water can be achieved through a gravity fed vortex generator
- Water temperature is reduced by going through a vortex

Figure 69. Vortex power generator

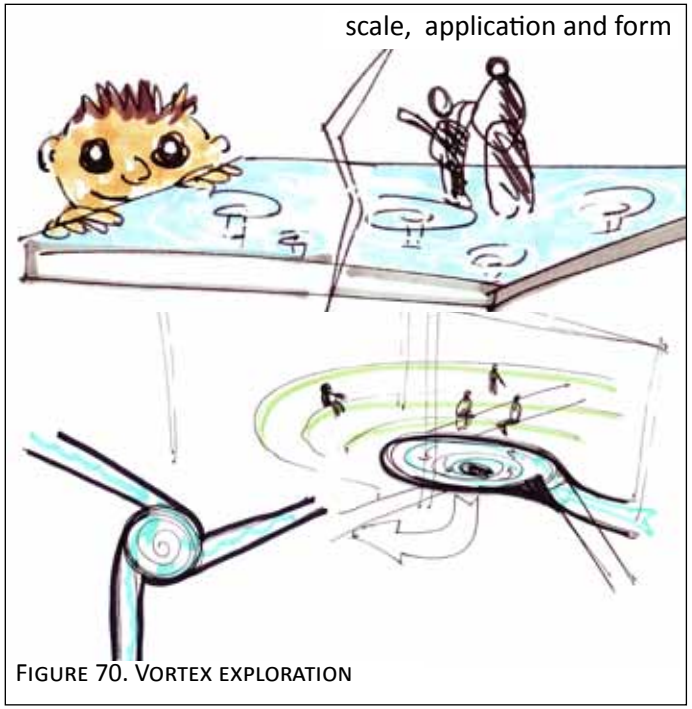


Figure 70. Vortex exploration

EXPERIENCE_UNCOMMON ENCOUNTERS

Weather Garden

Impression of Rain, Weather Garden, The Park Hyatt Hotel_Zurich, Switzerland

The simplicity and effectiveness of this project to communicate the event of a rain shower is inspiring.

Description

A stone garden is reinterpreted in the form of stone paving slabs that captures and holds puddles of rainwater to evaporate (figure 72). The slabs have been hollowed out individually (figure 71) to create unique puddle shapes and depth. Different evaporation rates highlight the "materiality of rainwater and its phase changing qualities" (Margolis, 2007, p. 146). The subtlety of the intervention poetically draws attention to the overlooked phases of water and the surface qualities of the regular streetscape. (Margolis, 2007, pp. 146-147)

Conclusion

The phases and aspects of water, for example evaporation can be celebrated by using low technology materials and principles.

FIGURE 72. RAINWATER PUDDLES

FIGURE 71. SLAB SHAPING

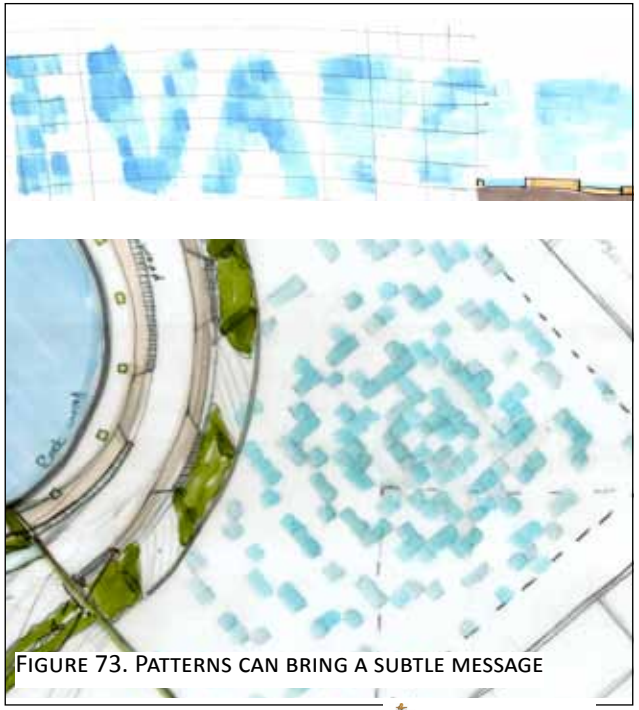


FIGURE 73. PATTERNS CAN BRING A SUBTLE MESSAGE

MEMORY_ FORGOTTEN RESOURCES AND THE COMMEMORATION OF CHANGE

Cape Town Foreshore Pedestrianisation, Cape Town, South Africa

Centre Island Adderley street

The Adderley street island (figure 74) reminds pedestrians and motorists of the spring water from Table Mountain that runs in pipes below the surface in Cape Town. By displaying the water in a “grachte” the observer is not only reminded of the natural resources that goes unnoticed, but of the ways water has been used in Cape Town historically.

Jetty Square

On Jetty Square (figure 75), skeletal shark sculptures by Ralph Borland reminds the user that the ground one stands on have once been below sea level. The installation thus comments on the impact man has on the environment. The interactive sculptures change orientation according to the wind direction and emits flute like sounds that is generated by the wind.

Conclusion

Reminding the public of what was lost or forgotten can be as simple as displaying something that lies hidden, or by paying homage lightheartedly through sculpture.

Figure 74. Adderley street island

Figure75. Jetty square

REUSE_REINTERPERATING ON SITE MATERIAL

Urban Outfitters Navy Yard Headquarters, Philadelphia, Pennsylvania, USA

Reduce, reuse, recycle and respect was the reasoning behind this reinvention of on site materials that would have been dumped in a landfill (figure 76).

Description

D.I.R.T. Studios reveals traces of previous production and use on site by conserving and reusing the in-situ concrete slabs. Reinforced and un-reinforced slabs was used in a 'crazy pave' configuration with compacted stone dust infill in-between (figure 77). All the demolition debris generated from the slabs have been used. (Margolis, 2007, pp. 114 - 116)

Conclusion

- Reusing on site materials can save money, reduce the load on landfill sites and be a reminder of the history of the site.
- Reusing materials in their current state reduces energy consumption. If all the concrete were to be crushed and used as aggregate, more energy would be used in the process.

FIGURE 76. CONCRETE CRAZY PAVE

FIGURE 77. CRAZY PAVE PROCESS

Surface_translating properties

Simcoe WaveDeck, Waterfront Toronto, Canada

This inspiring project pushes the boundaries of the conventional approach to surfaces and blends the boundaries between sculpture and Landscape Architecture in an effortless way. The user is brought closer to the idea of water and the water's edge simultaneously.

Description

West 8 Urban design and Landscape Architecture translates the shoreline of Ontario's lakes and the 'cottage experience' of life on the lakes into undulating WaveDecks in the harbour (figure 78). These decks facilitate access to the harbour and act as informal gathering spaces (figure 80).

Technical

The decks are supported on custom made curved steel beams, clad with wood and decked afterwards (figure 79).

Conclusion

Manipulation of the ground plane not only adds sculptural qualities, but also forces the user to interpret the surroundings in another light.

Figure 79. Wave deck construction

Figure 78. Wave deck view 1

Figure 80. Wave deck view 2

Pedestrian bridge, Borneo-Sporenburg, Amsterdam, The Neatherlands

This bridge by West 8 Urban design and Landscape Architecture is turned into a sculpture that facilitates an enriched experience of crossing the water. The bridge creates an identity for the development and become landmarks.

Description

A series of pedestrian bridges by West 8 Urban design and Landscape Architecture connects residential blocks on the Amsterdam docks (figure 81).

Conclusion

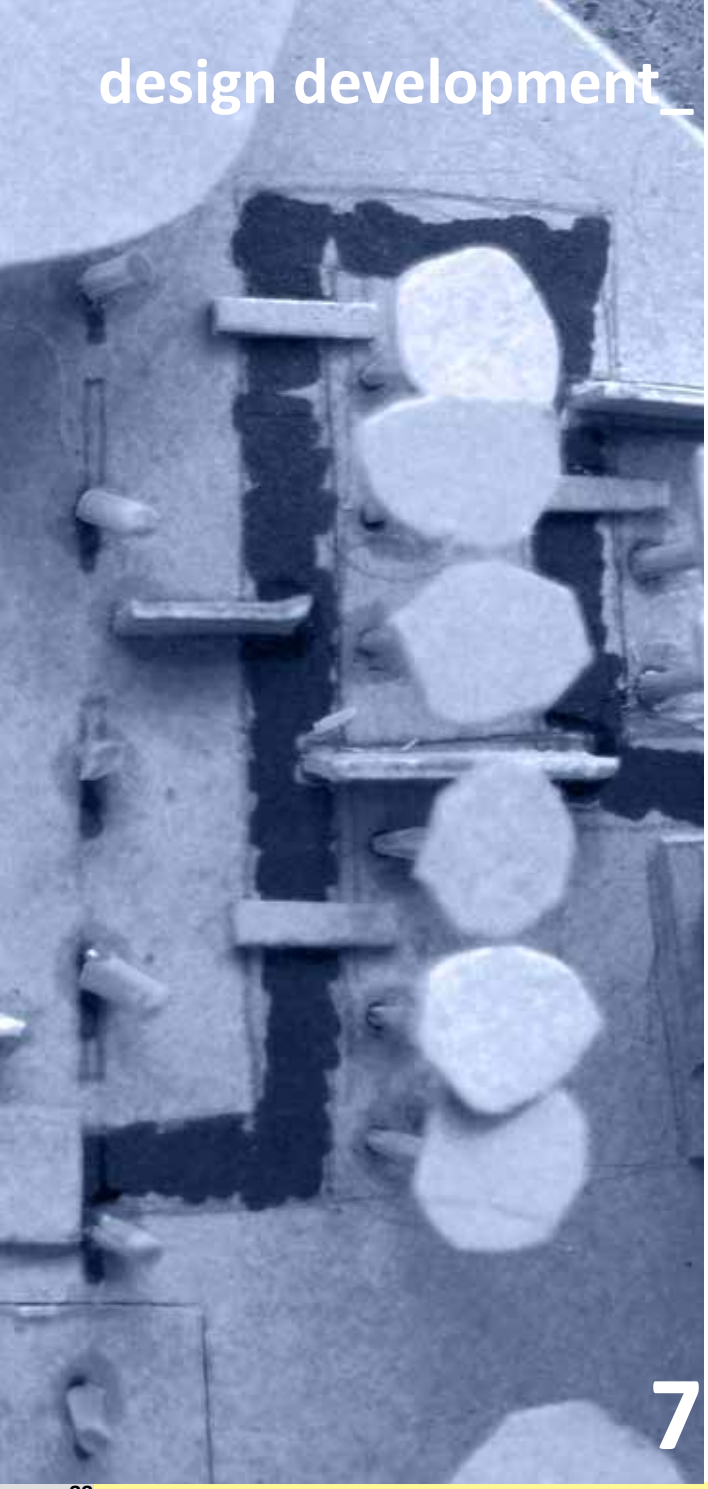
The forms of these bridges might seem frivolous and excessive but it calls for a level of intuitive interpretation and it questions the norm of walking surface.

From the precedents

The components of systems should be integrated into place making objects and the built fabric; thus each component has more than one function. Systems should complement and complete each other, working corroboratively towards site design goals. Systems should be designed to be as self explanatory as possible so that users will intuitively sense something about their working at a glance and on closer inspection understand the design intent. Awareness is the first step towards understanding that leads to education.

The limiting factors that certain system resources impose on other systems should be taken into account and used as control devices to form a designed feedback loop (for example water limits on planting area).

Figure 81. Bridge perspective



design development_

7

Clues and cues

The first cue towards site selection was the large piece of open ground in the city, and the presence of the Apies River channel on site. The width and depth of the concrete channel cuts the site in two unevenly sized parcels. This site longs for unification and use; it brims with potential and the promise of a so-called river.

The presence of the river led to a design focusing on meaningful encounters with water in urban environments. The harsh state of the river and the lack of connection between the river and the city dweller pushed for an intervention that would try to reconnect people to the Apies River, to what it was, what it is and what it could be. The openness of the site creates a place of repose in city, the large volume of open space needs to be protected, celebrated and enhanced.

Design generators

There are three main form givers to the design

- The physical shape of the concrete channel
- The metaphysical line where the river used to run
- The collision of the city grid with the grid of the concrete channel

From observing the study area and interviews with schools in the area it became clear that open space for playing and relaxation in the surrounding area was limited and insufficient. The residential area to the north of the site is dominated by high rise residential units and lacks safe green public open space.

From here the design development flows...

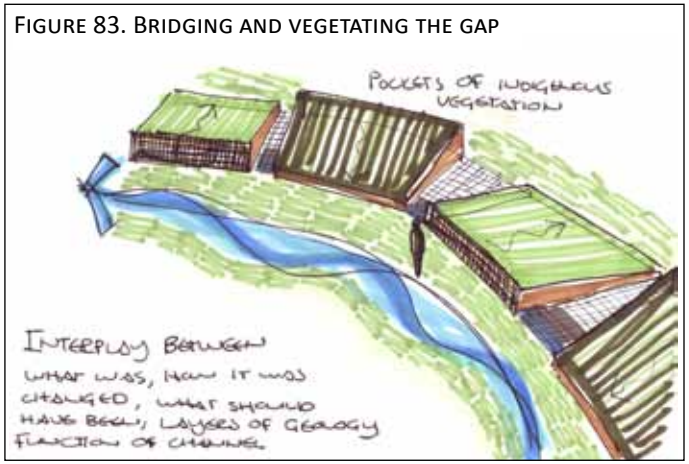
Concept site plan

The concept plan (figure 82) covered the channel with habitable space. The aim was to bidge the gap and unify the site. The base flow would be on the surface while the channel below would accommodate the flash floods. The green wedges (figure 83 and 84) would act as seating and vegetated pockets. Crossing the site diagonally was an important form giver.

Covering the channel so extensively is not financially feasible and peak runoff that push against a covered top would create disastrous floods as the dynamic of a covered channel varies greatly from the current state.

Figure 82. Concept plan 1 (March 09)

Figure 83. Bridging and vegetating the gap



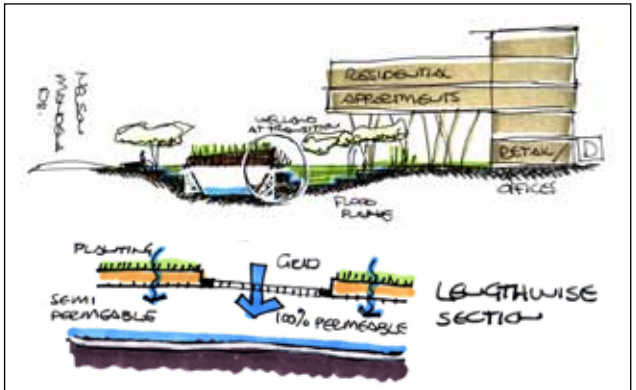


Figure 84. Exploring concept 1 (March 09)

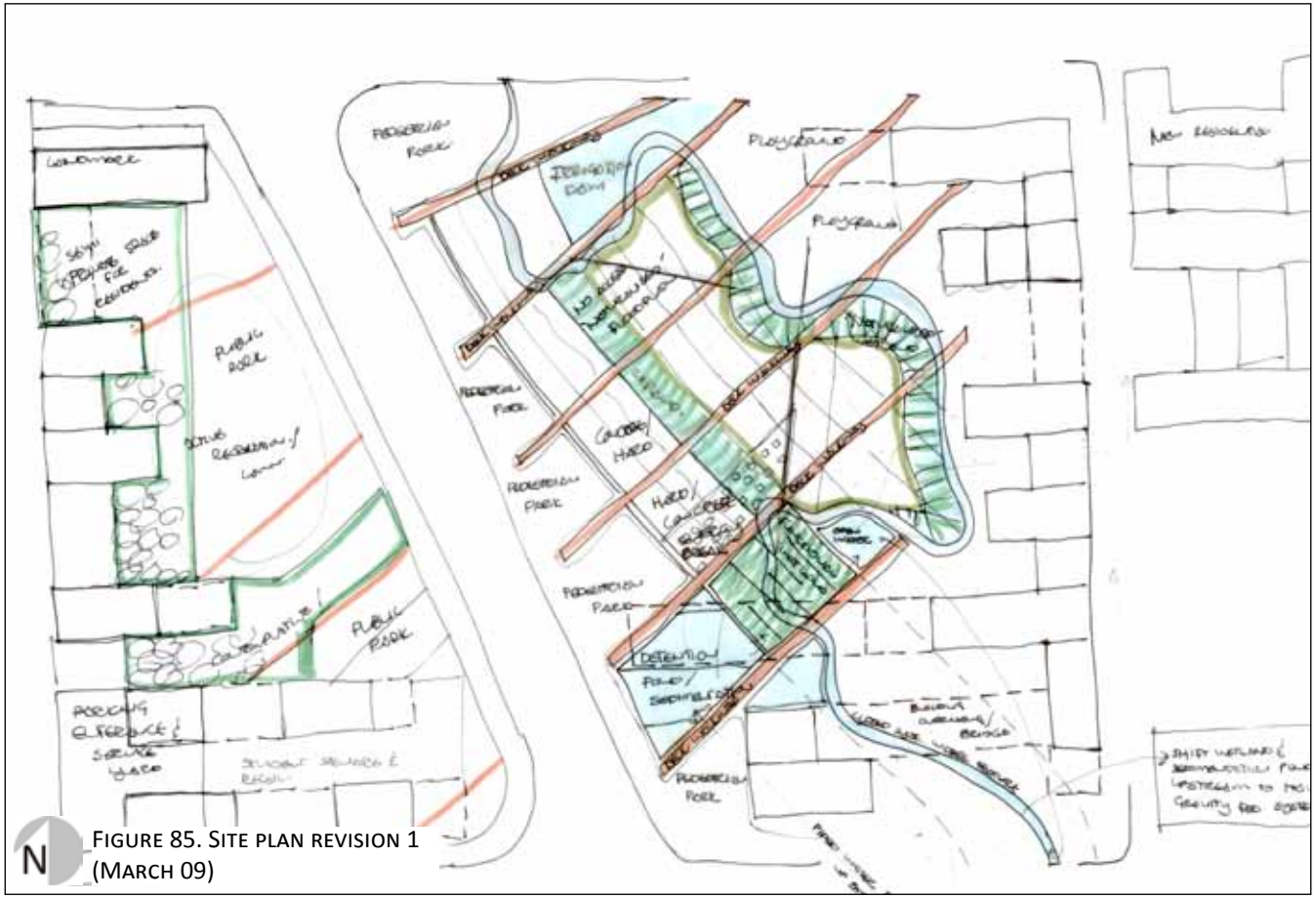


FIGURE 85. SITE PLAN REVISION 1 (MARCH 09)

FIGURE 86. SITE PLAN REVISION 2 (MARCH 09)

SITE PLAN REVISION 1

Revision 1 of the site plan (figure 85) started to address the master plan area. The site west of the project site forms part of the master plan area and addresses the need for more green open space. The site on the western side of Nelson Mandela Drive becomes a spill-out park that would be quiet and contemplative while the project site would be a hub of activity and excitement.

Ecological aspects such as flood plane restoration and wetland construction became important at this stage as well.

SITE PLAN REVISION 2

Revision 2 (figure 86) programmed both sides of Nelson Mandela Drive. Relevant supporting buildings was suggested. The channel crossing is placed strategically. The base flow of the Apies River follows a naturalistic stream on ground level outside the channel. The concept of inflatable dam walls gives opportunity of have a full channel.

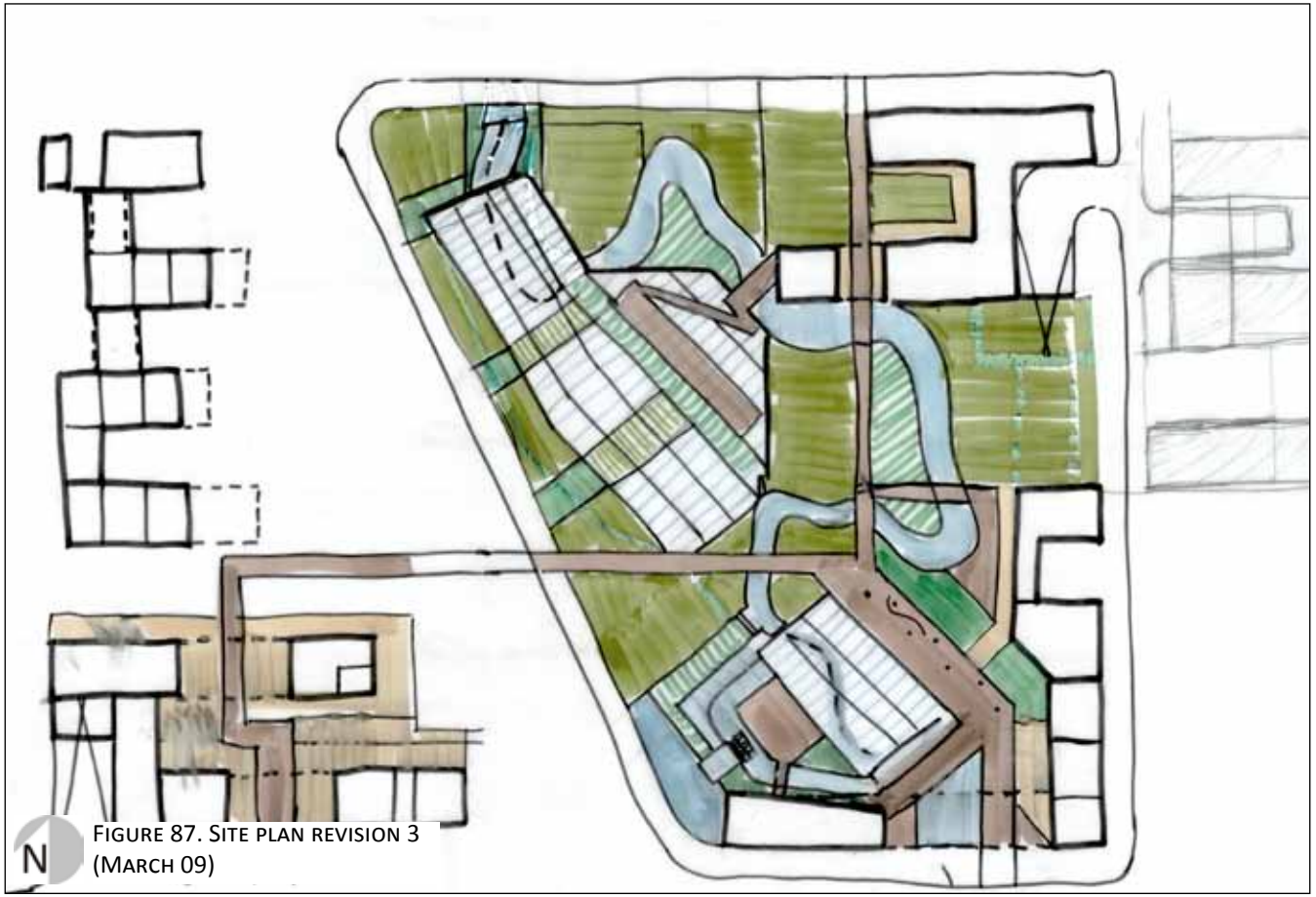


Figure 87. Site plan revision 3 (March 09)

Site plan revision 3

Revision 3 (figure 87) refines the design from revision 2. The base flow crosses the channel on grade and the 'deemed idealistic' idea of inflatable dam fade to the background. A amphitheatre (figure 88) is cut in the side if the channel to be connect with the river and the anticipated volume of water.

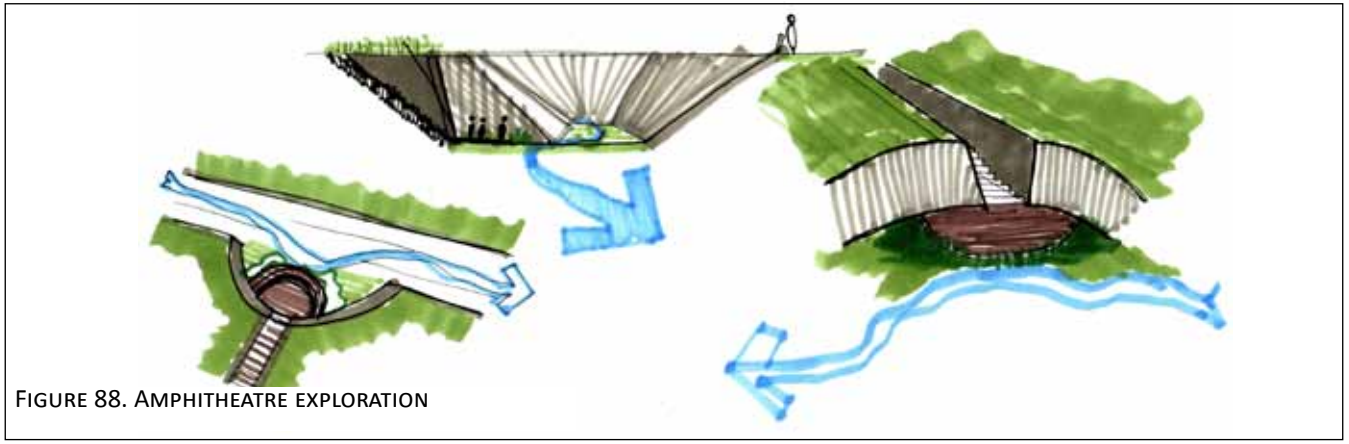


Figure 88. Amphitheatre exploration

Figure 89. Site plan revision 4

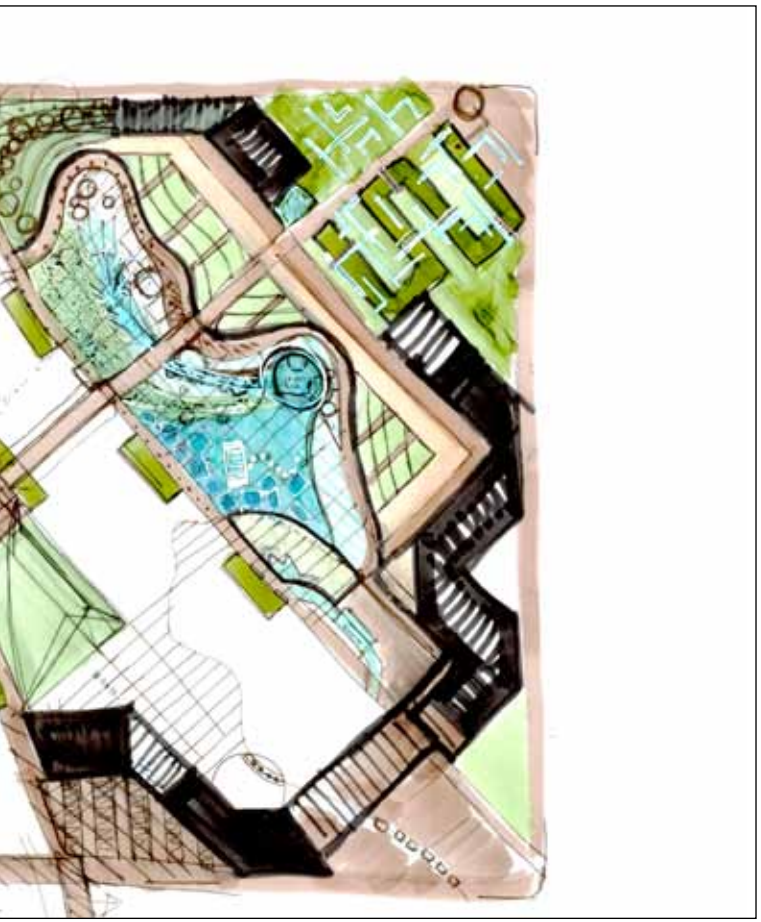
Site plan revision 4

Revision 4 (figure 89) discards the amphitheatre concept due to control and flooding issues. A water wheel is introduced to the project to lift the base flow from the channel.

Figure 90. Site plan revision 5

Site plan revisions 5 & 6

A major breakthrough (figure 90 & 92) was reached through changing the grid of the proposed buildings. The open centre of the site was now enveloped by buildings that responds to the angle of the channel. The search for a soft connection between people and the river continued through the exploration of cantilever grass planes. Concepts that explores the energy of the floods and the memory of the old river was introduced (see figures 91 and 93).



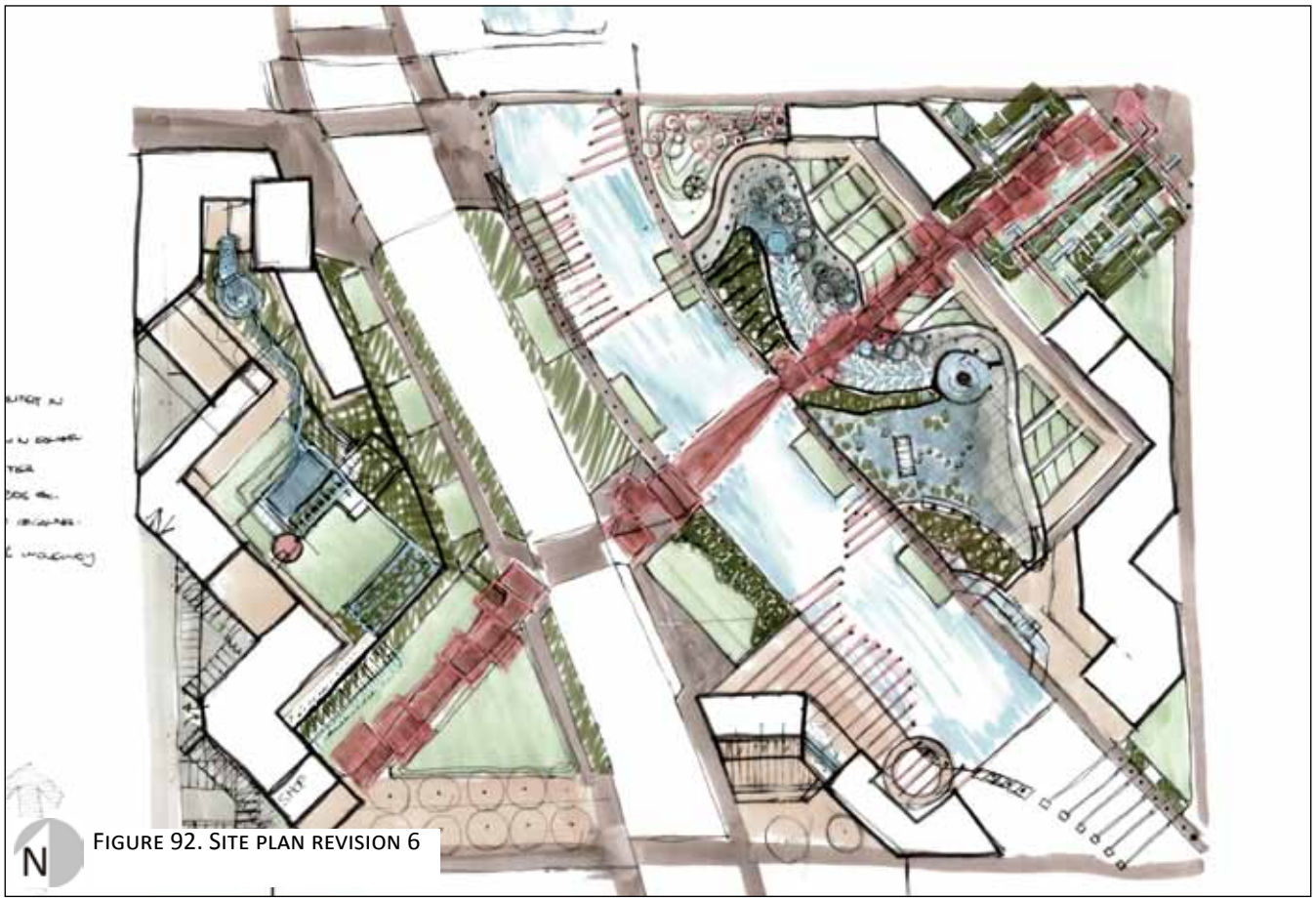
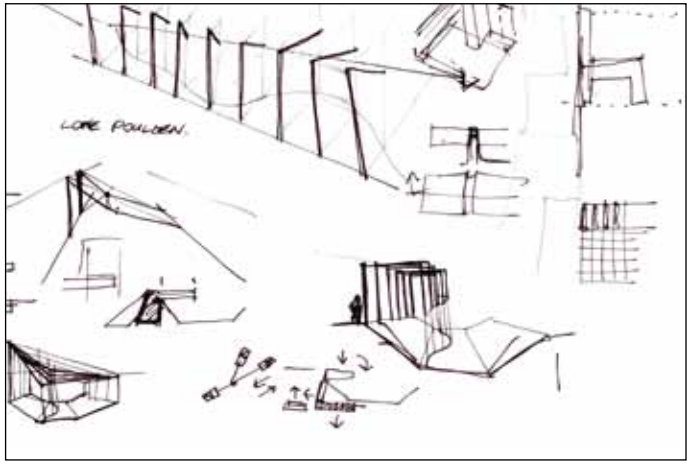
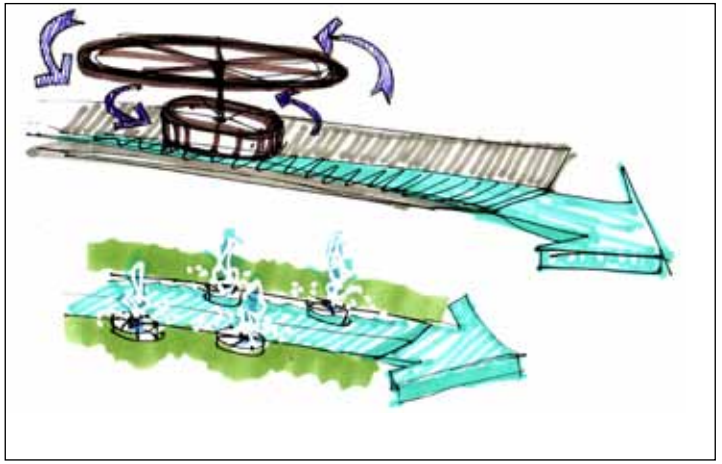


FIGURE 92. SITE PLAN REVISION 6





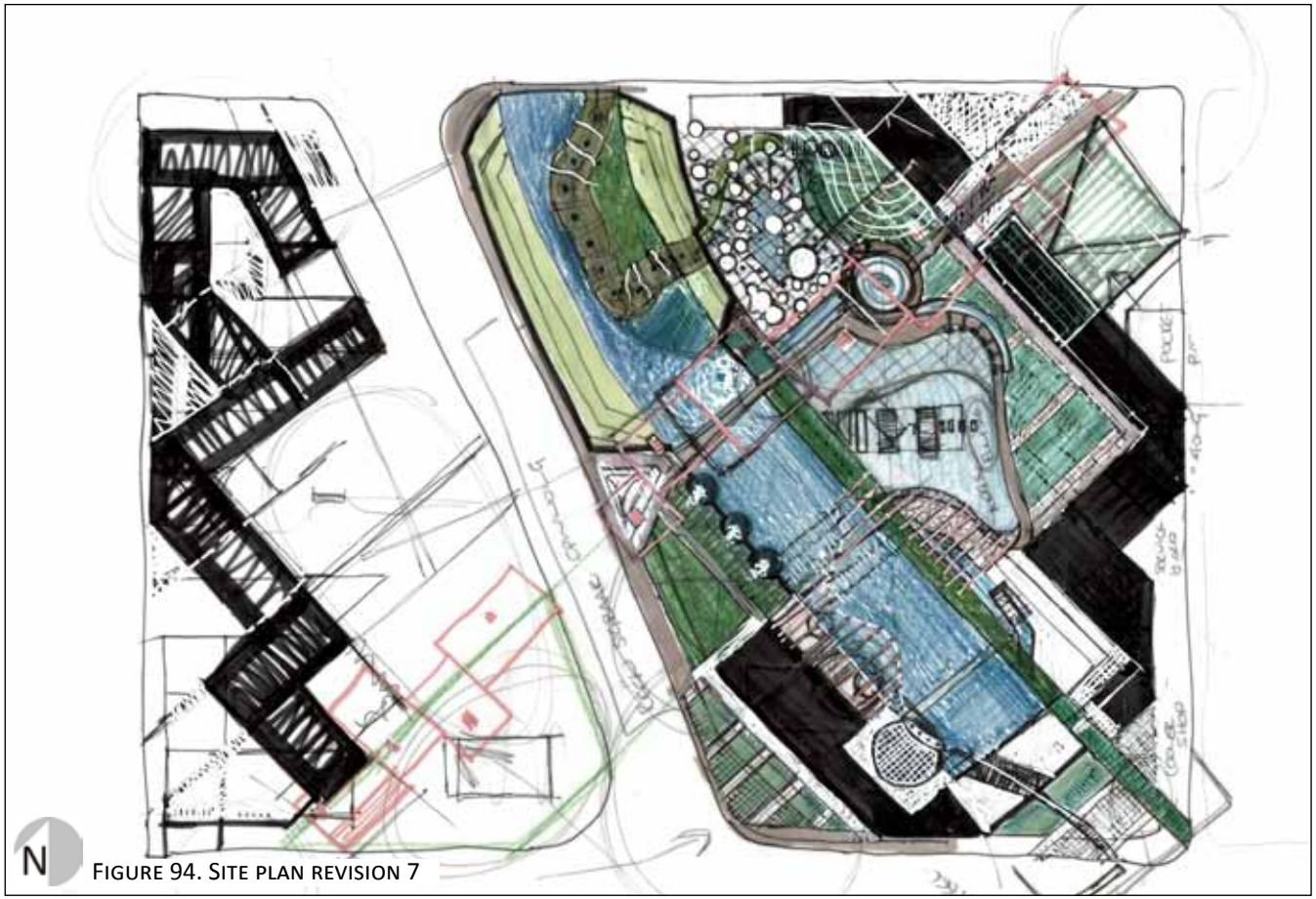


Figure 94. Site plan revision 7

Site plan revisions 7, 8 & 9

Revision 7, 8 & 9 introduces vertical elements on the pedestrian bridge, treats the line of the old river as element rather a physical stream and fragments and abstracts the line. The vortex pool becomes the centre of the site. The the idea of recycling concrete from the river channel was adopted.

A myriad of interactive play concepts littered the site and fragmented the design.

Revision 9 (figure 96) started the process of simplification.

Forrest of dead invader trees

Figure 95. Site plan revision 8

Figure 95. Site plan revision 9

Abstraction and *parti* diagram

From these explorations the interplay of the old line where the river used to run needed to be abstracted, as awkward curves complicated the spatial arrangement on site. The line became a representation, not a physical path (figure 97).

At this stage a *parti* diagram was drawn to solidify the design approach (figure 97).

The *parti*

Parti can be described as an expression of the core concept of a design in a diagram (Frederick, 2007, p. 15).

The line of the concrete channel becomes something solid, rigid and stereotomic, suggesting the physical. The representational line of where the river used to run becomes something intangible and metaphysical, relating to the memory of the river and tectonics.

The intersection of the physical and metaphysical, the concrete and the memory change both the elements, the concrete channel becomes more liquid and the line of where the river used to run becomes more solid.

A new site grid is established perpendicular to the concrete channel (figure 97). This comments on the change of grid between Sunnyside and the city centre, thus acknowledging the impact of the river on the city. The new grid is accentuated by a single crossing of the Apies River channel via a bridge, addressing the important pedestrian link across the site.

The *parti* is applied to every level of design in a simplified form where a solid mass is intersected by a light, curving element.

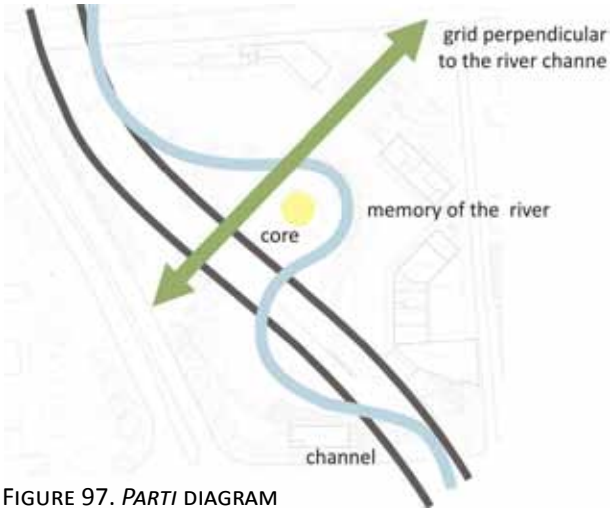


Figure 97. *Parti* diagram

Designing for on site water

The on site water systems (see chapter 8) are all integrated and works towards

- expressing the types of on site water and creating awareness around natural and artificial water systems
- celebrating water in the urban environment through a variety of experiences and creating opportunities for interaction
- eliminating the use of potable water for irrigation and reducing the need for potable water use in sanitary appliances
- establishing region appropriate biomass on site

Integrating theory with on site water systems

Figures 98 and 99 are the conceptual function diagrams that explain the integration of the on site water systems through the use of General Systems Theory.

The systems directly address the water related goals that were identified from the ecosystem service analysis diagrams, and address the appropriate regional biomass aims indirectly via the connectedness discussed in chapter 3.

Site plan revisions 10, 11 & 12

Revisions 10 through 12 (figure 100 - 102) focuses on abstracting the line further and finding the form for a pedestrian bridge and constructed wetland by the water wheel.

Figure 102 simplifies the play area and introduces a much needed kick about lawn.

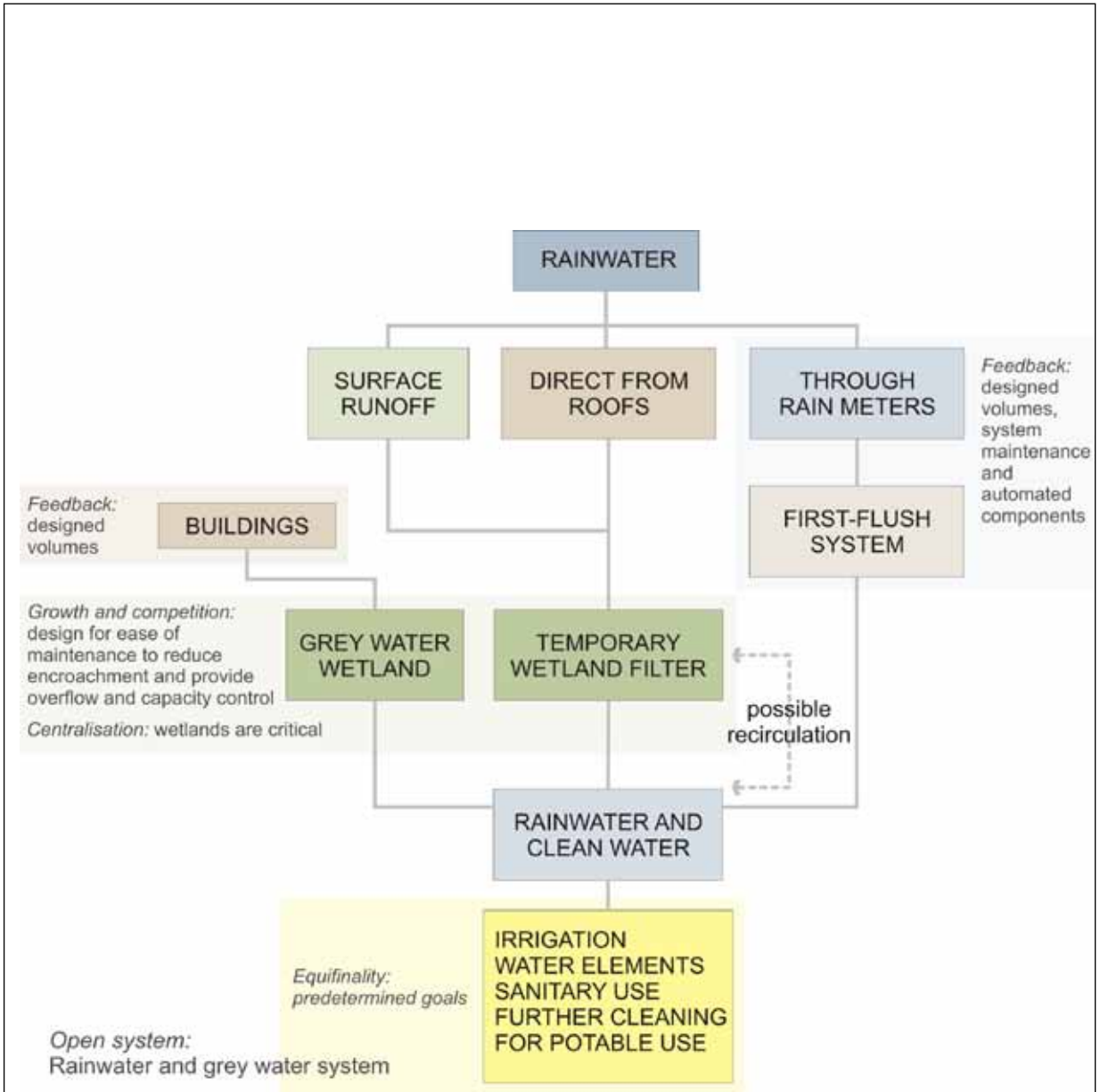
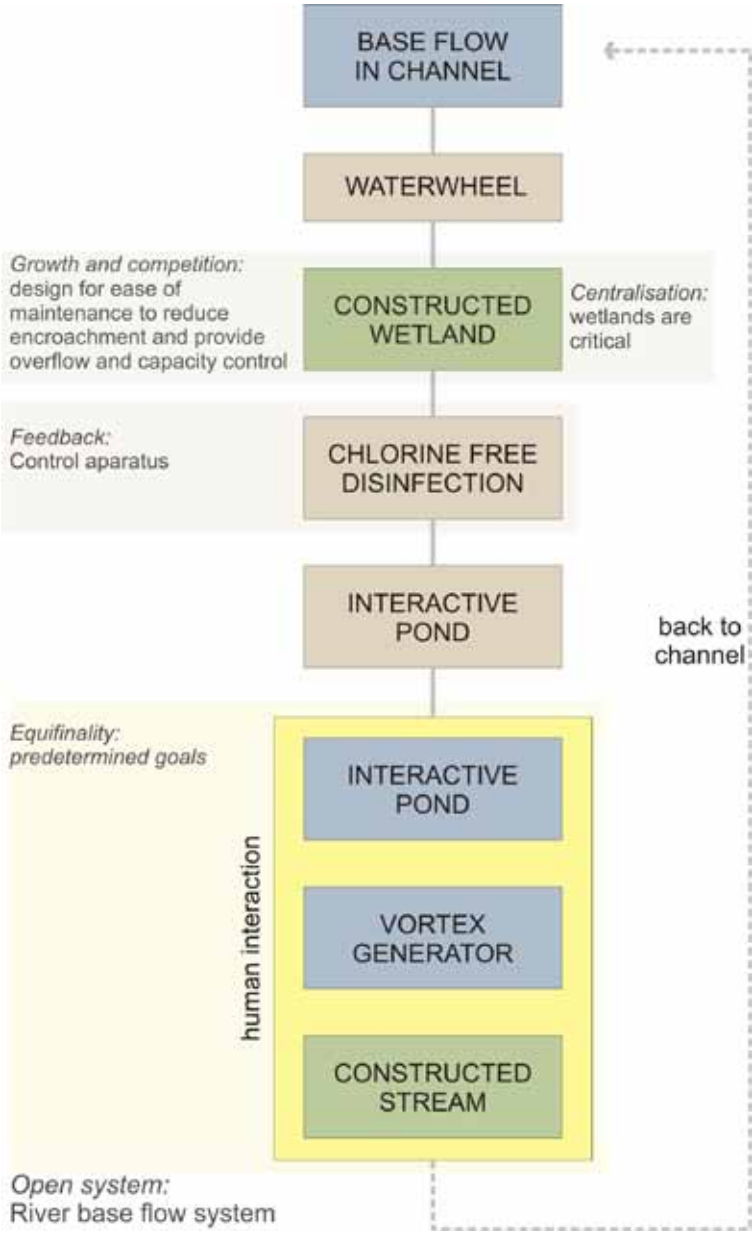


FIGURE 98. RAIN AND GREY WATER SYSTEM RELATED TO GENERAL SYSTEMS THEORY

FIGURE 99. RIVER BASE FLOW SYSTEM RELATED TO GENERAL SYSTEMS THEORY



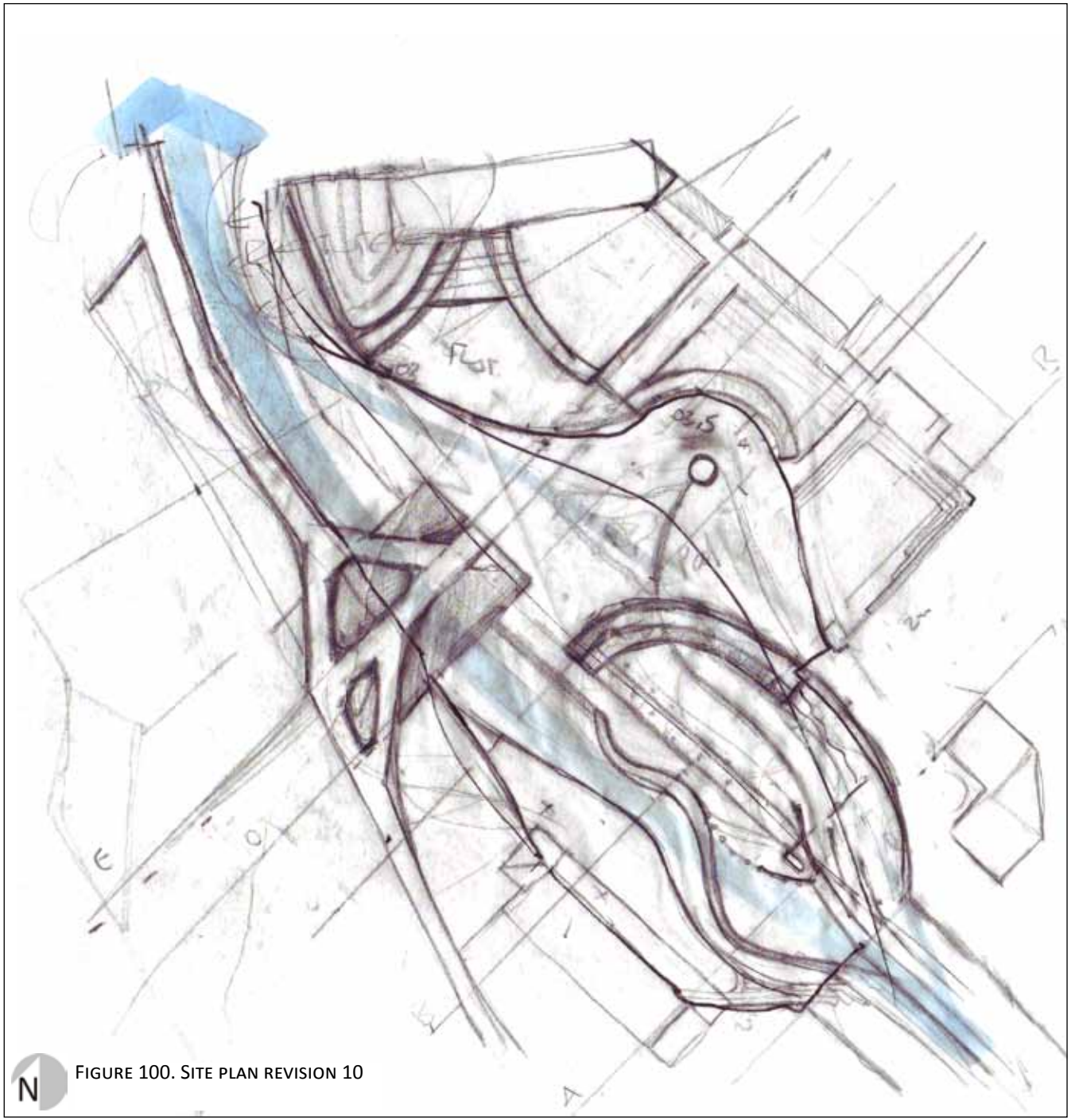


FIGURE 100. SITE PLAN REVISION 10

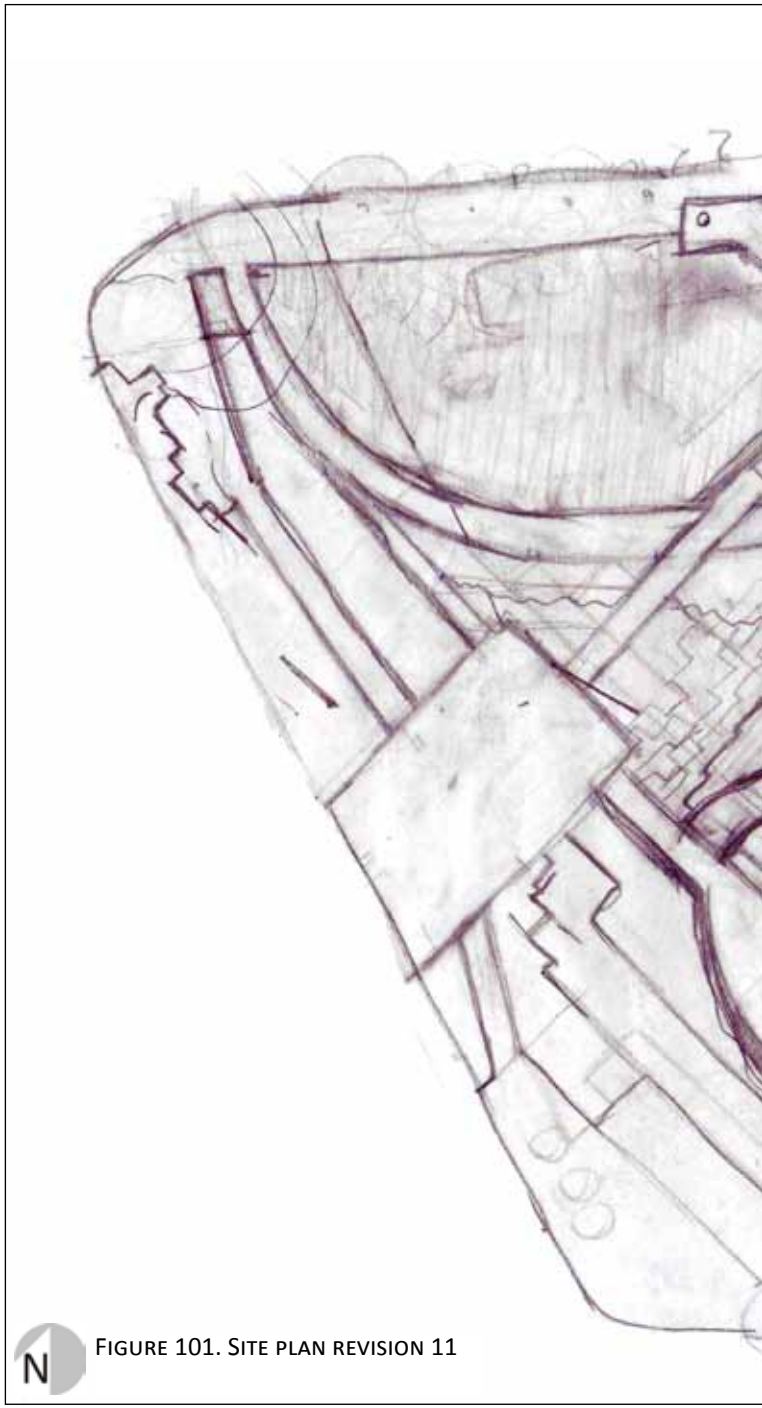


FIGURE 101. SITE PLAN REVISION 11

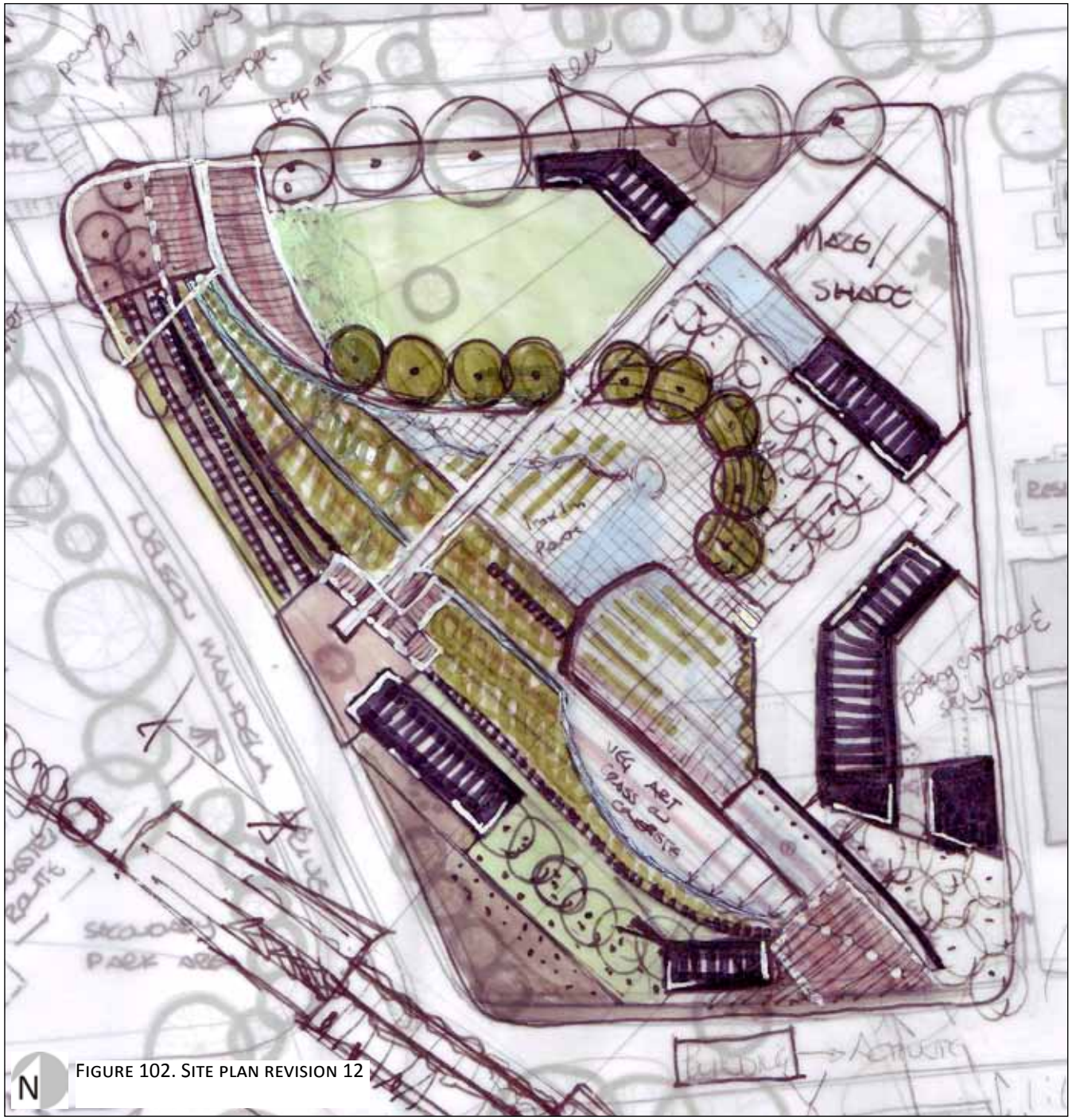


FIGURE 102. SITE PLAN REVISION 12

Site plan revision 13 & 14

Revision 13 and 14 (figure 103 and 105) sees the grey water wetland integrated into the water system and the pavilion introduced. The pavilion encourages passive surveillance and gives school children and resident a sense of ownership. The raindrop plaza subtly echoes a splash of water while wave like decks communicate the volume and energy of water. The rain meter maze creates opportunity for residents, people on their own and small groups to sit relax in more intimate spaces.

The amende channel mimics the habit of wild grass that establishes itself in joints and cracks in the current river channel by providing recesses and soil media. The lines created by these joint suggests the waving action of grass in the wind. This refers back to the grassland habitat that was lost with the settlement of Pretoria and the channelization of the Apies River (figure 104).

Figure 103. Site plan revision 13

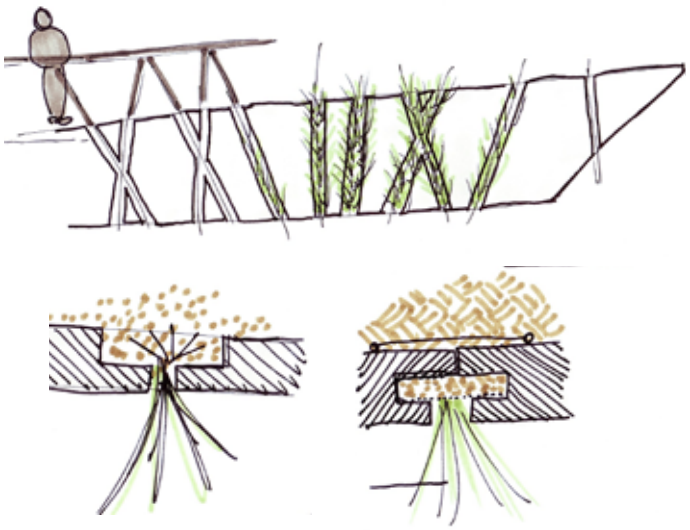


Figure 104. Precast retaining wall panels

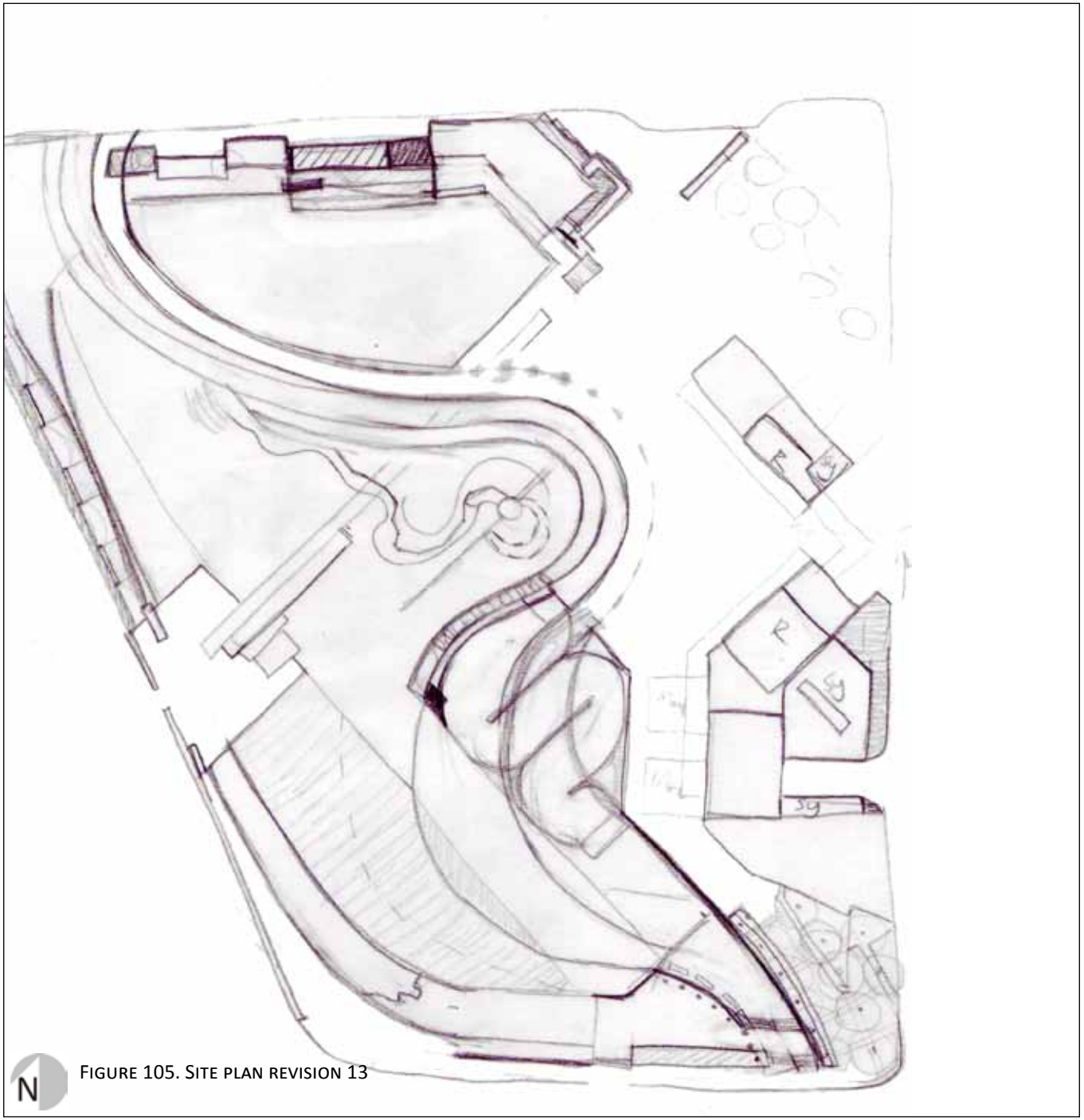


FIGURE 105. SITE PLAN REVISION 13

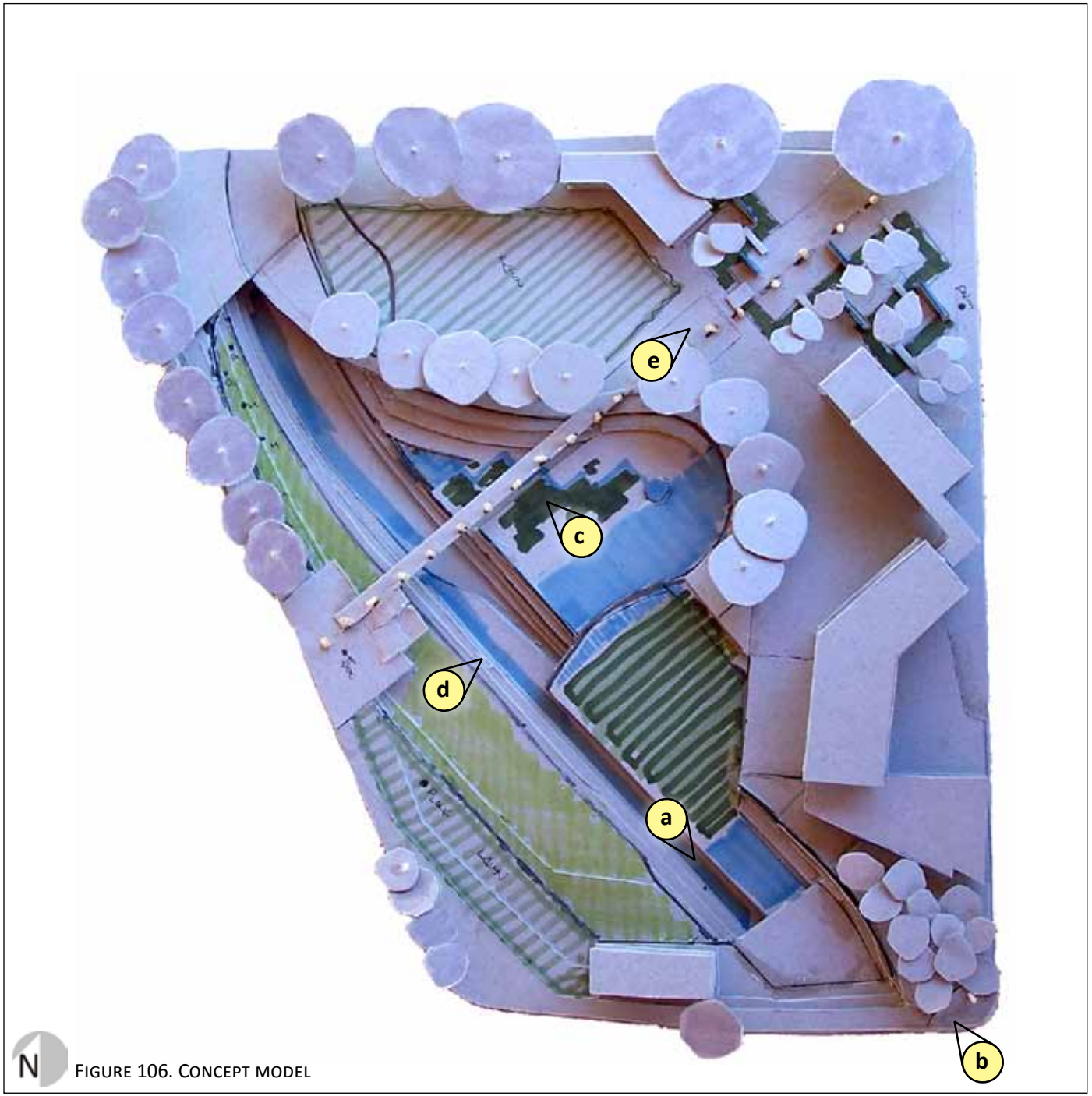


FIGURE 106. CONCEPT MODEL

Exploration through model building

The design called for an intervention in the river channel, this was done through lowering and widening the channel. This led to steep edges around the channel that needed to be solved. The model building exercise helped solve these steep edges around the channel (figure 106).

The tangible model allows the designer to sculpt lines, but more importantly spaces.

The following areas were specifically addressed

- The historical rock wall introduced a level difference that needed to be acknowledged, this was done though a series of steps that separates the pedestrians and the cafe (figure 107 and 108).
- Figure 109 explores the clearance height below the bridge and the series of steps where a retaining wall was originally envisaged.
- The level difference at d (figure 110) between the level that the water wheel can lift water to and the need for a minimum slope led to the investigation of a series of ramps.
- The spatial qualities of the rain meter maze and the verticality of the rain meters led the author to discard the other vertical elements. the spaces in between the rain meters relate to a human scale and proportion that is sometimes missing in public open space (figure 111 and 112).

Figure 107. View towards cafe deck

Figure 108. Vermeulen street entrance towards BMW

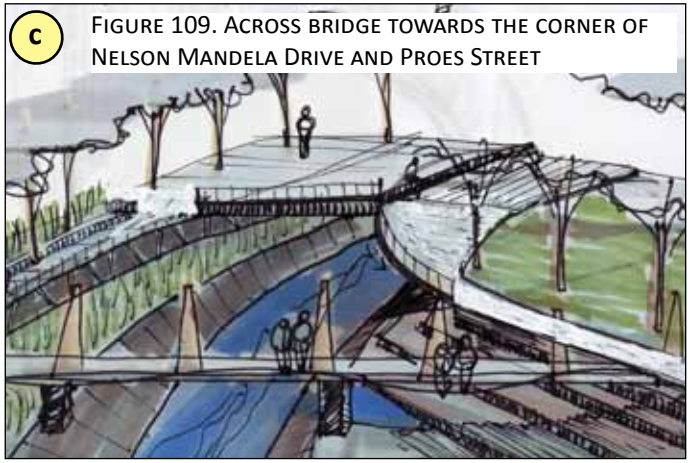


Figure 109. Across bridge towards the corner of Nelson Mandela Drive and Proes Street

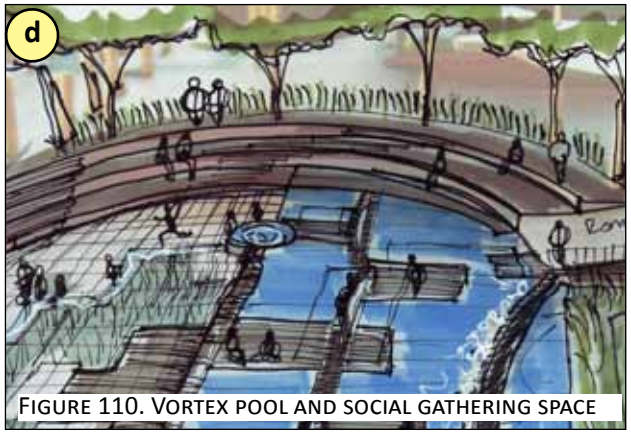


Figure 110. Vortex pool and social gathering space

Figure 111. Rain meter maze towards cnr. Proes and Ockerse street

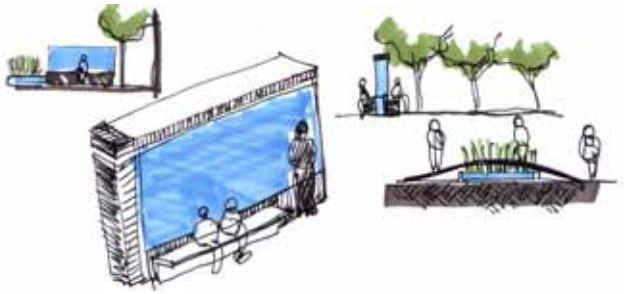
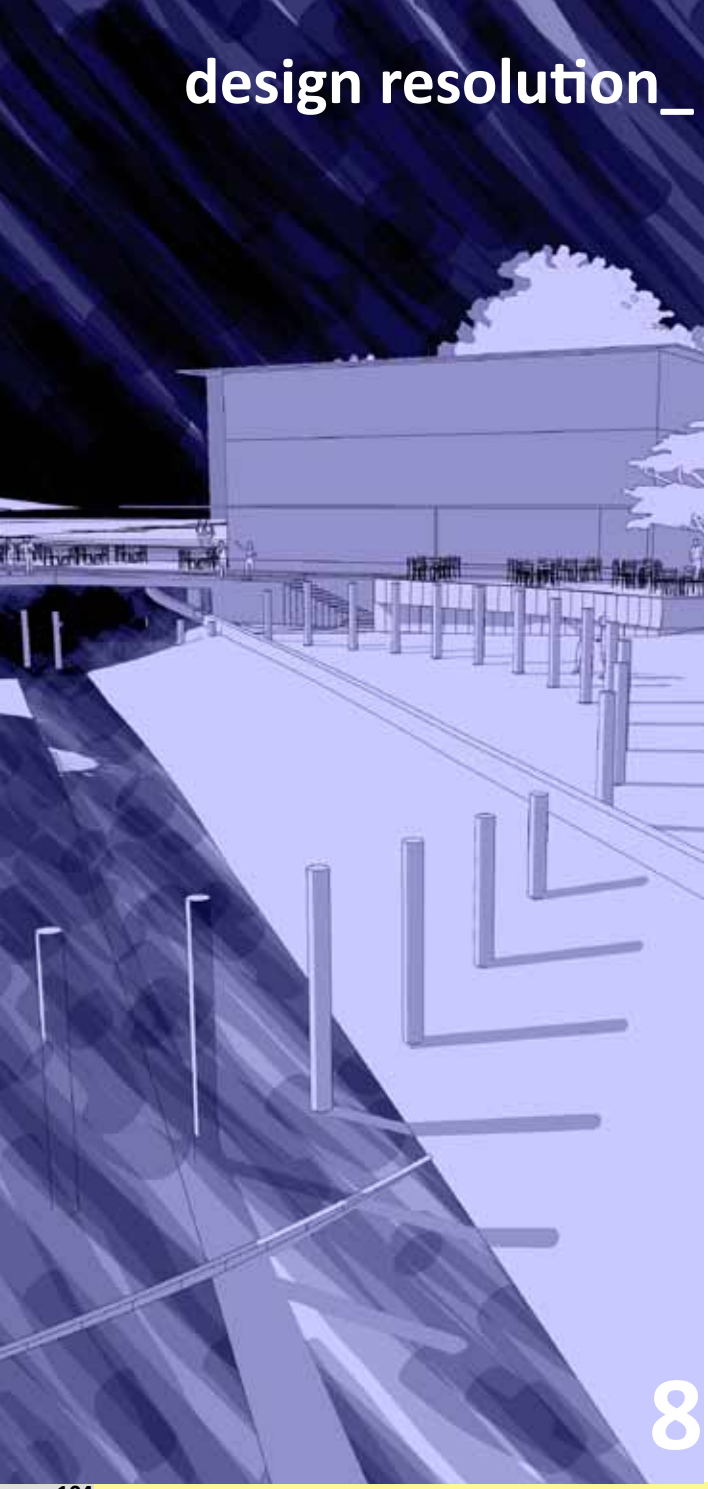


Figure 112. Rain water maze 'rooms'



City wide design objective

Catchment management plan

Water quality and quantity (flood control) problems in the Apies River can only be addressed through proper management of the catchment.

According to Vosloo (1990) on De Meire & Van de Putte, the aims of a catchment management plan includes:

- Flood control through reducing peak discharge
- Water quality control: reducing erosion and sedimentation; remove floating debris with screens and filters; remove suspended materials through ponds and wetlands; remove solutes through wetlands
- Utilise amenity value of aquatic systems through ensuring a controlled volume of water and managing levels of water contact
- Optimise production and employment in the catchment

Figure 113 delineates the relevant catchment area for the Apies River on site.

In the context of the Apies River, the associated catchment area, and the Nelson Mandela student framework

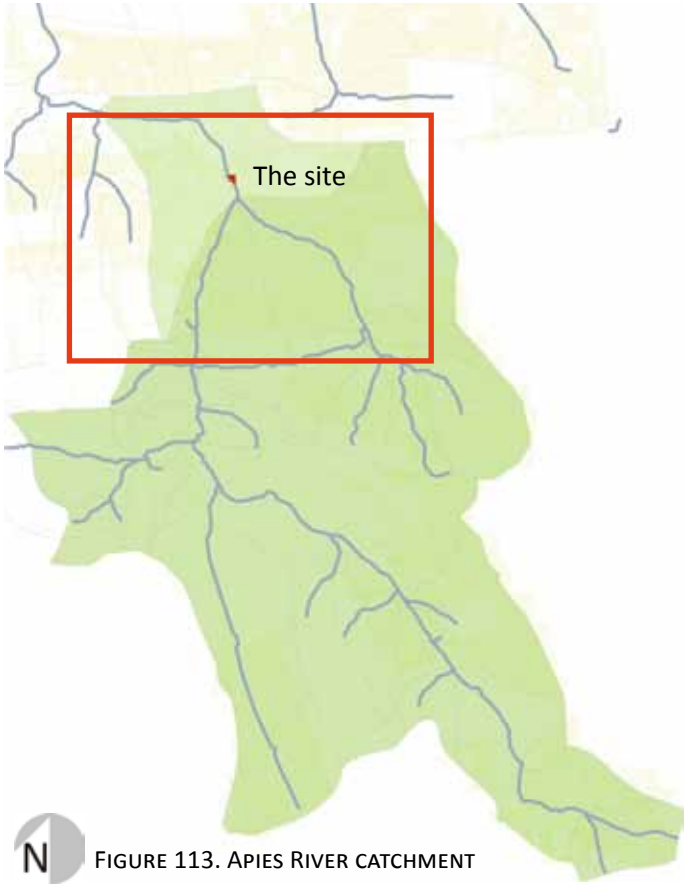


FIGURE 113. APIES RIVER CATCHMENT

the proposed project cannot function as a stand alone entity.

The proposed Urban Water Centre is a pilot project for amending the Apies River channel and connecting people to the river.

Figure 114 identifies a series of projects along the channel to be implemented. The different projects addresses ecological, social and recreational functions that should be taken into account in the context of the river and proposed frameworks.

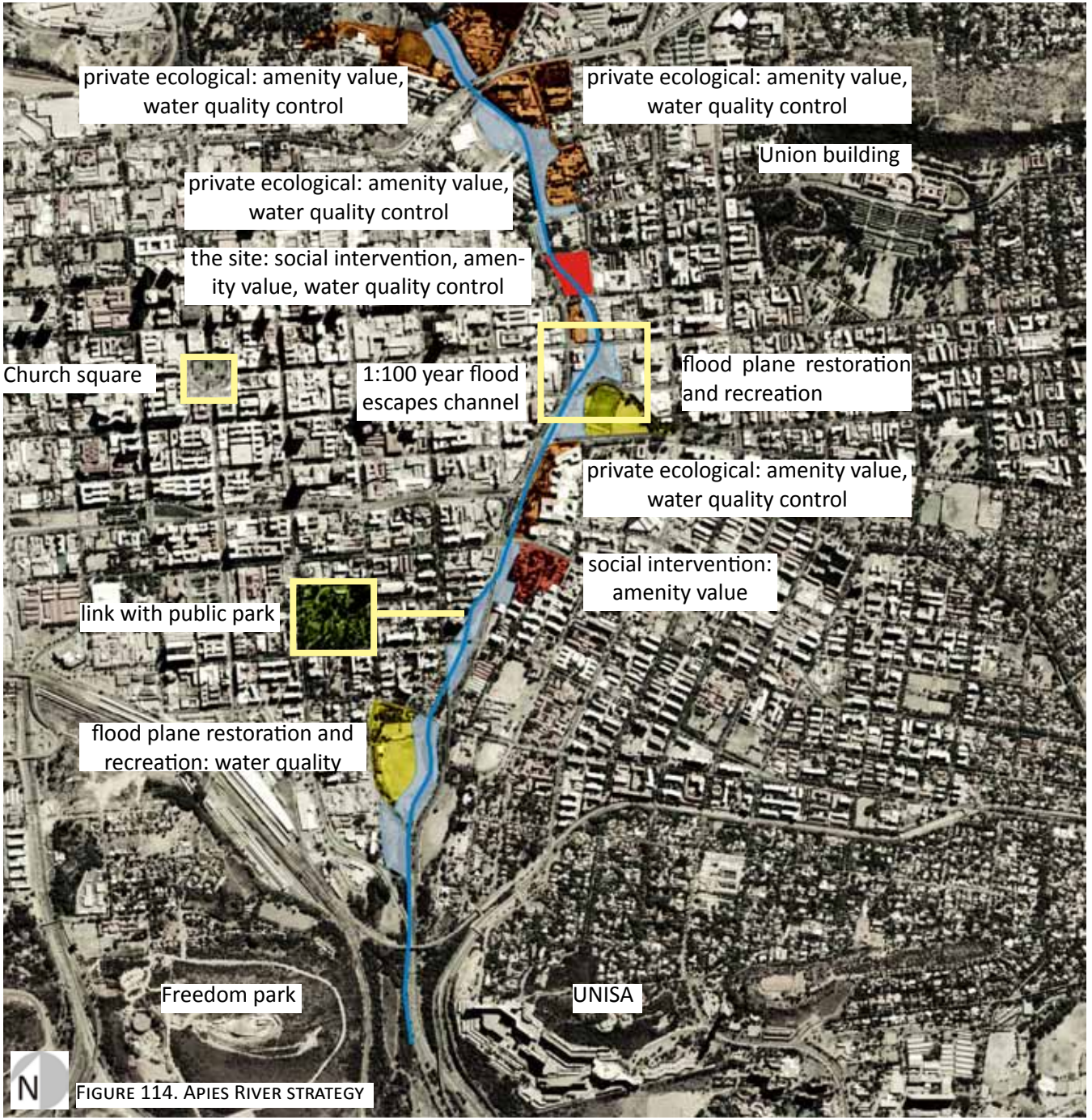


FIGURE 114. APIES RIVER STRATEGY

Sketch plan

The site provides for school kids, students, pedestrians, residents and lunch goers.

Figure 115 illustrates how the site relates to the context. The design will be explored in light of each user and the areas each will frequent.

Figure116 shows the sketch plan.

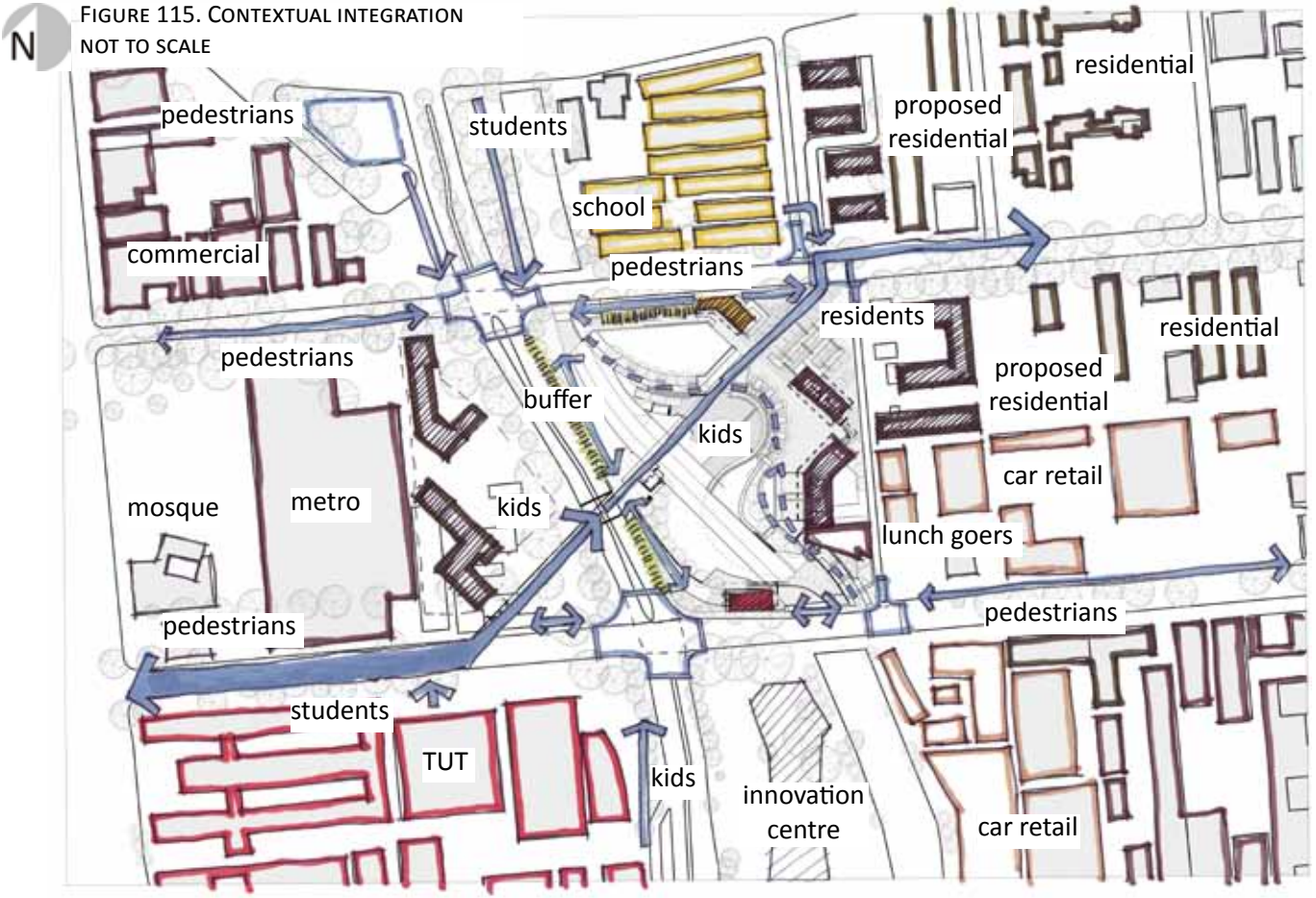
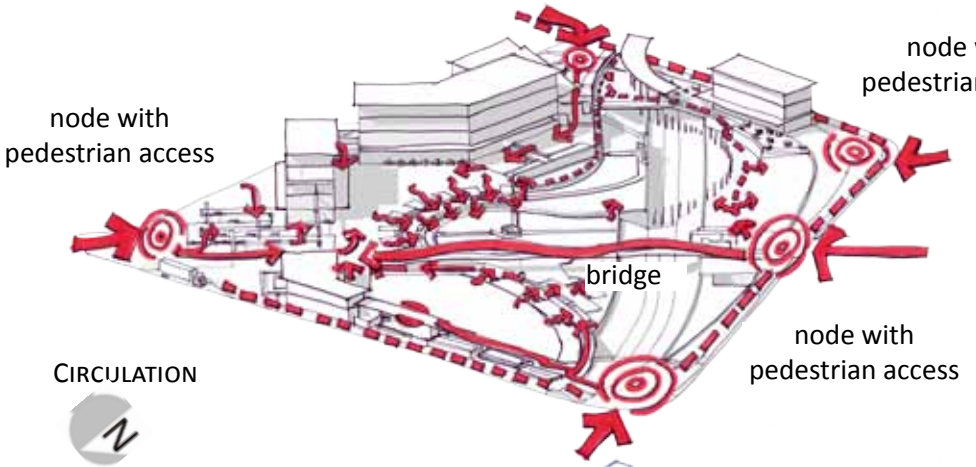
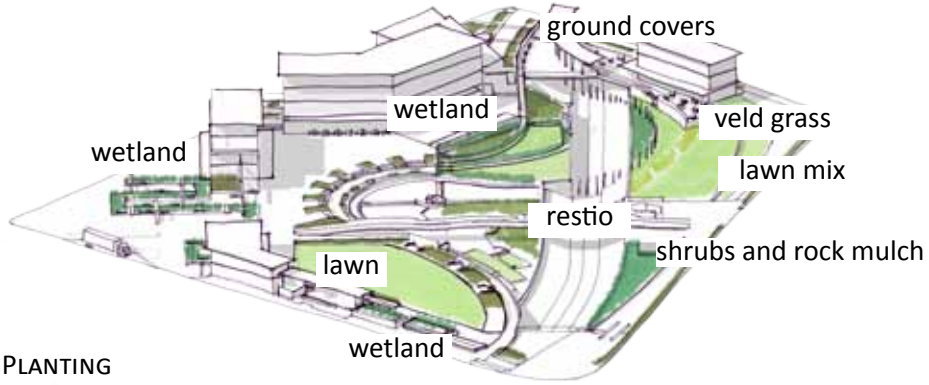


FIGURE 115. CONTEXTUAL INTEGRATION
NOT TO SCALE

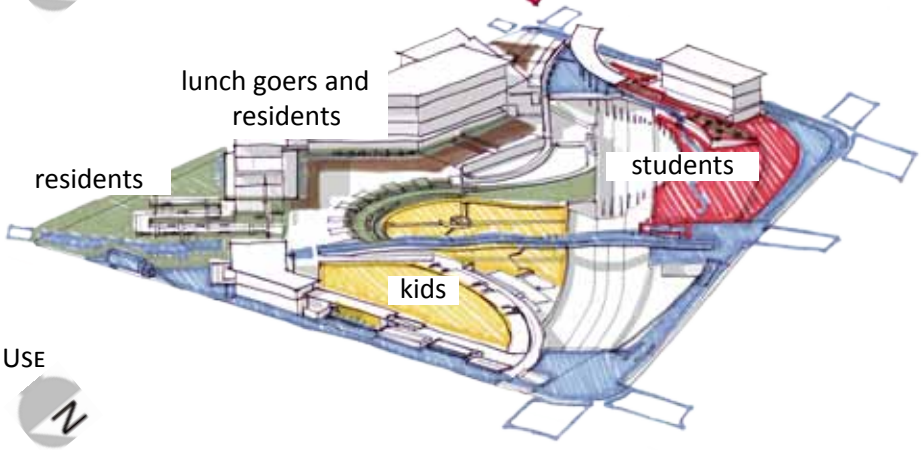
FIGURE 116. SKETCH PLAN - SCALE 1:1000



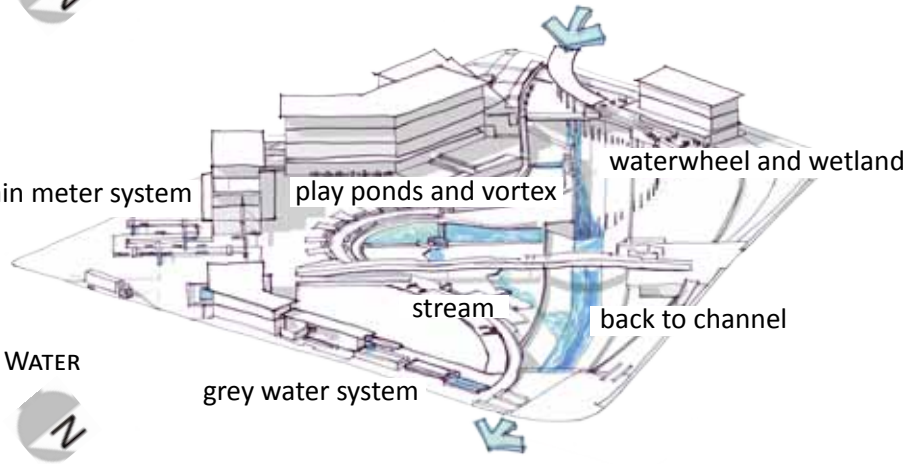
CIRCULATION



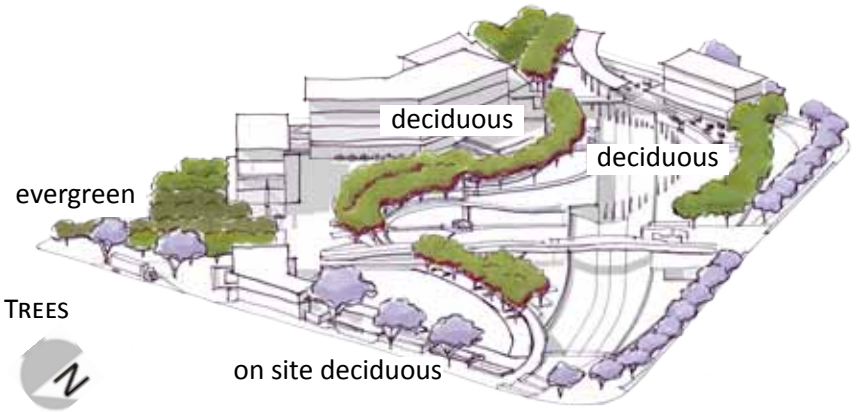
PLANTING



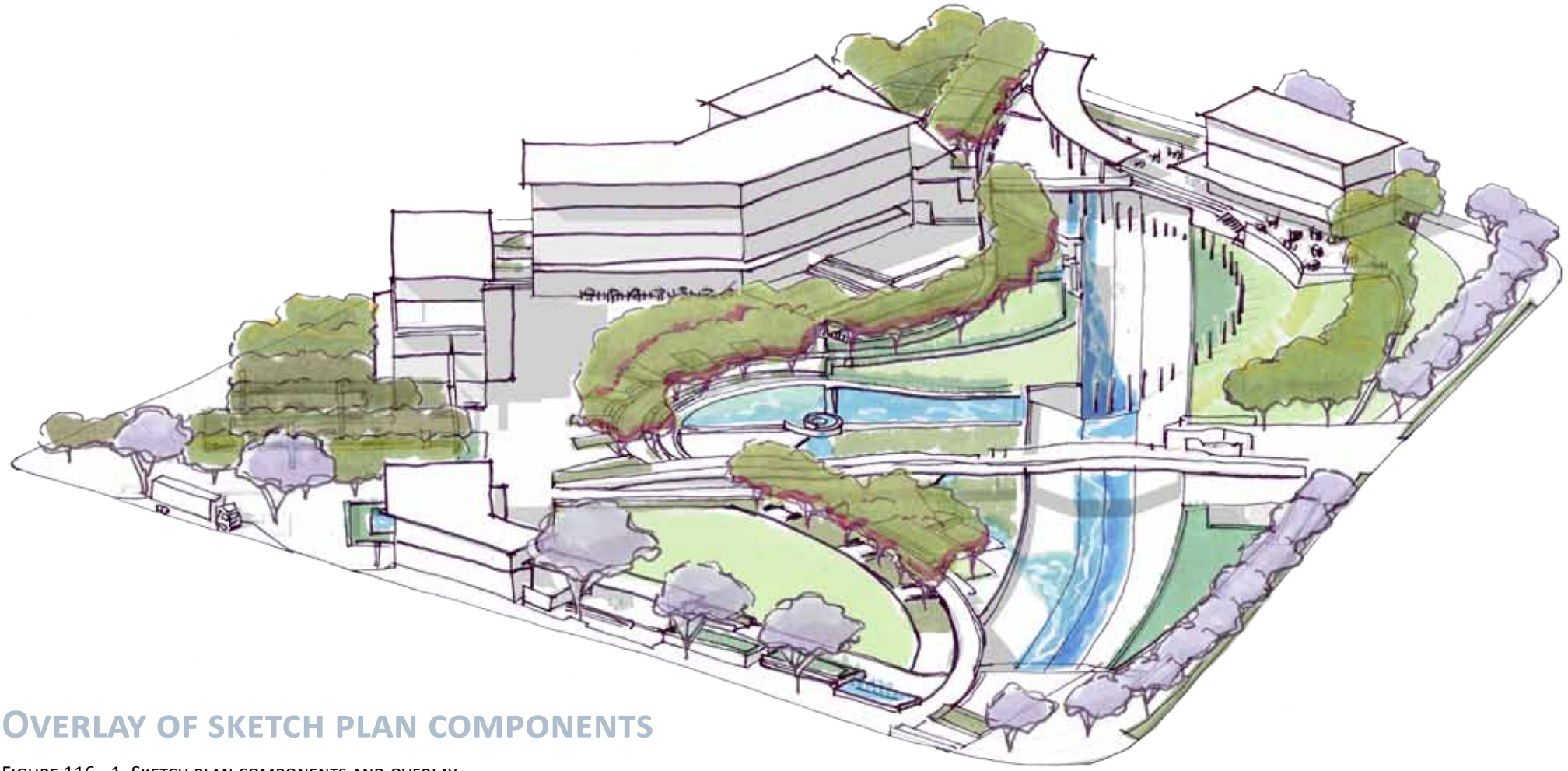
USE



WATER



TREES



Overlay of sketch plan components

Figure 116 - 1. Sketch plan components and overlay
not to scale

School children

The class of school kids from next door will come running down the path, everyone want to be the first one to see how much it had rained last night! They will be amazed at how much water you can get from one roof. A clever boy will nudge his friend and show him the patterns on the ground, he will explain that water refracts light and that is where the patterns come from (figure 118). The kids' teacher would not be far behind, she will bring them here every lunch break (interview with headmaster), they can play and use the tuck shop while she has a cup of tea at the pavilion while watching them (figure 119).

After school the kids will rush to the water spouts and play ponds that fills up and swirls away through the vortex! The children will feel the cool, clear water of the river on their hands and feet and discover crabs, insects and water plants in the constructed stream (figure 120).

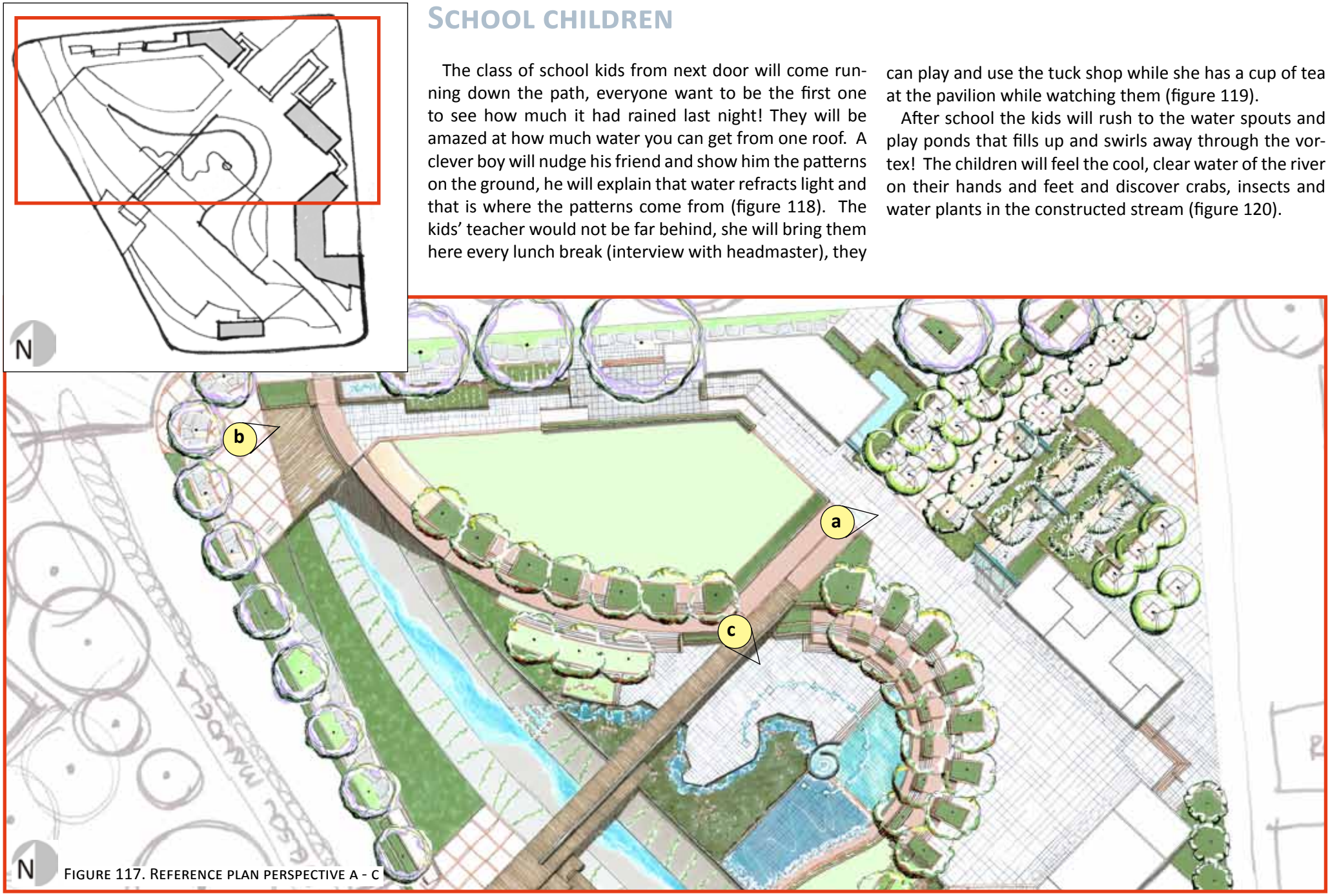


Figure 117. Reference plan perspective a - c

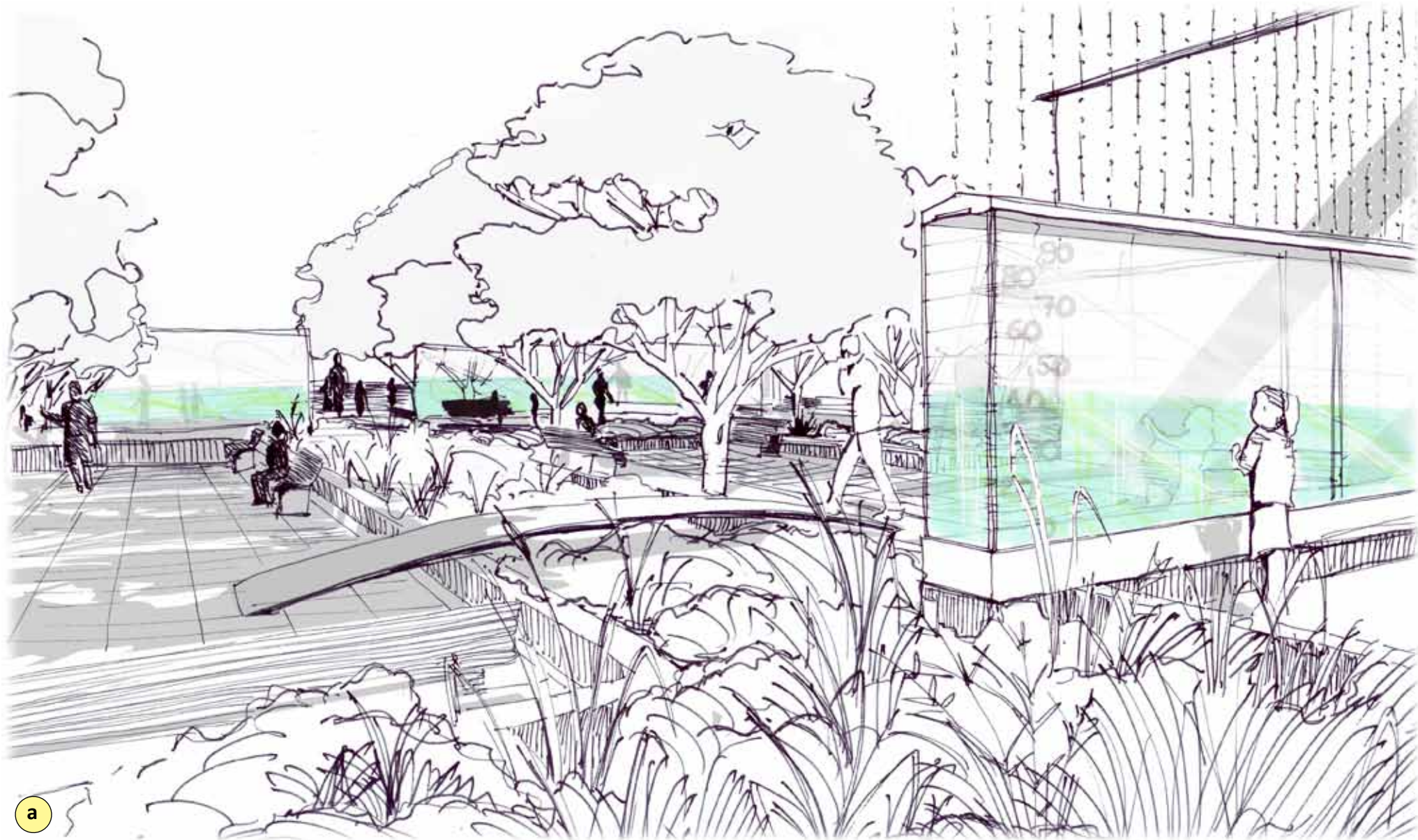


FIGURE 118. RAIN METERS AND RAIN CURTAIN

FIGURE 119. GREY WATER WETLAND WITH PLAY LAWN AND PAVILION

C

FIGURE 120. VORTEX PLAY

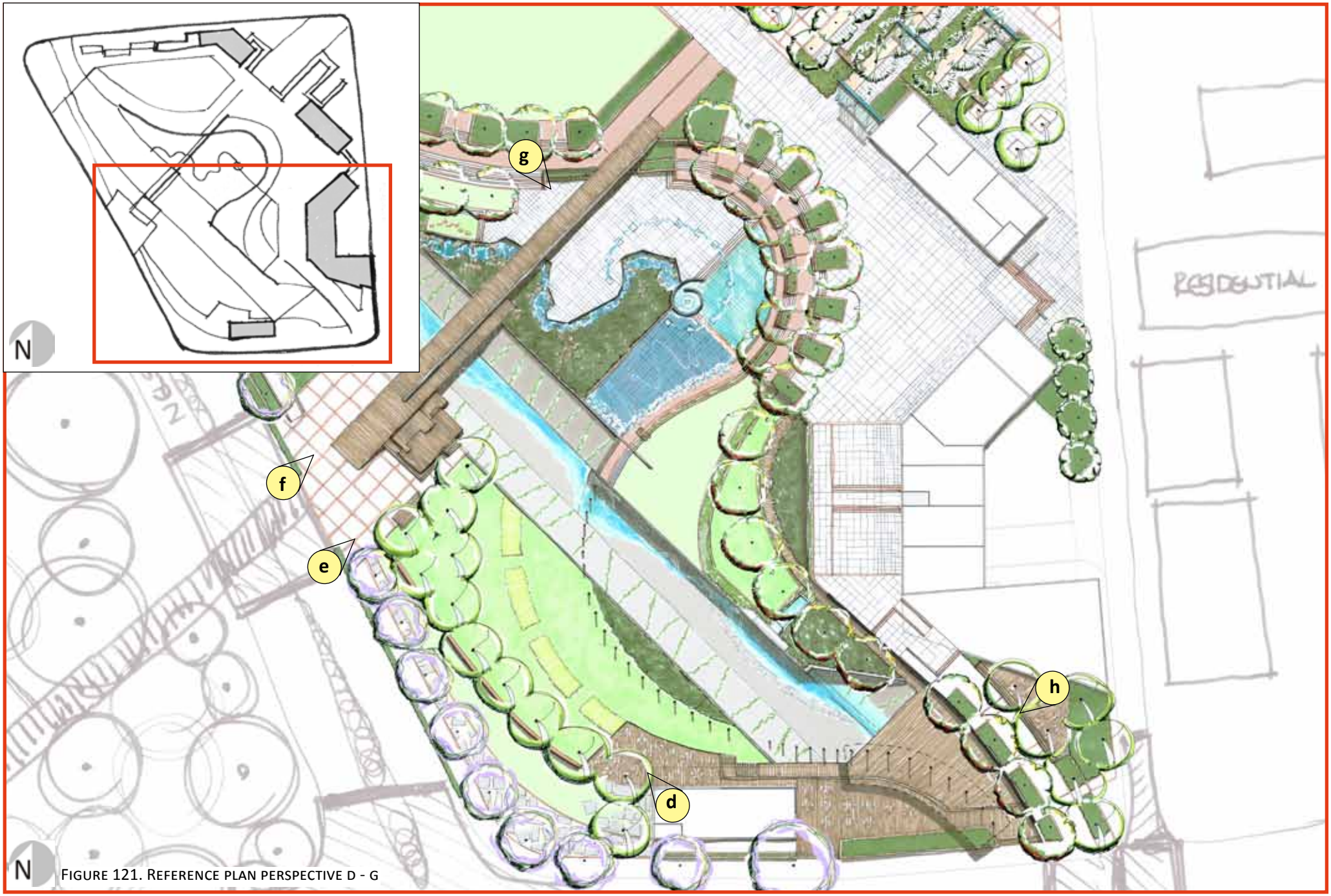


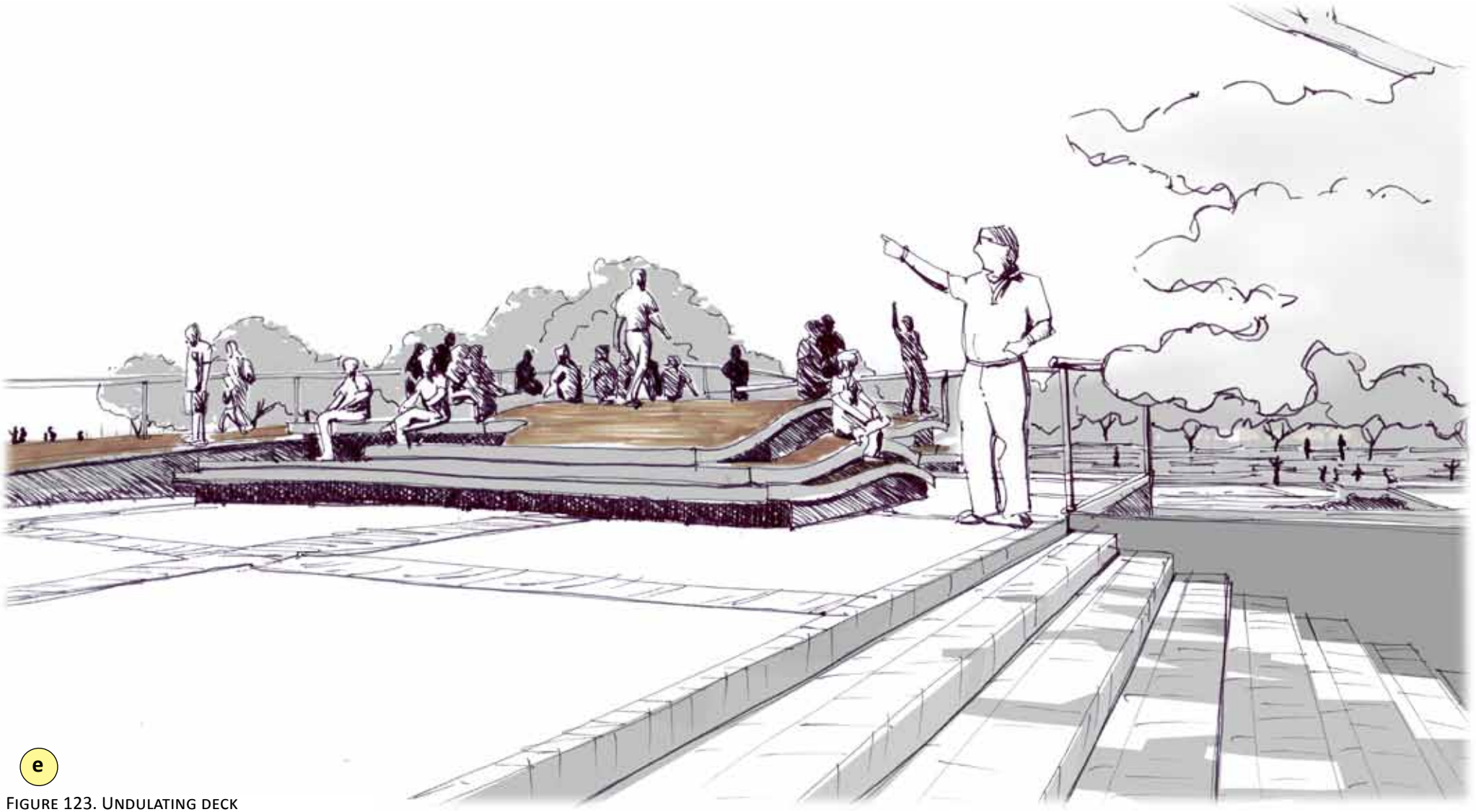
FIGURE 121. REFERENCE PLAN PERSPECTIVE D - G

Students

A group of friends, all students from the close by TUT campuses will come and lounge on the lawn, later they will have a have a drink and a meal at the cafe and debate going back to class, a few will leave for class a couple will stay to 'study' in the cool shade of a tree, all the while hearing the rhythmic slush of the water wheel in the background (figure 122).

Later on that year the same group will be sitting on the wave-like bridge and deck, because it will definitely be a favourite spot of theirs to watch people and the days go by. During winter, when the river is reduced to a trickle, the only reminder of the volume, power and motion of the Apies River will be the undulating deck they sit on.

Figure 122. Cafe deck, lawn and seating wall



e

FIGURE 123. UNDULATING DECK

Residents and pedestrians

A tired by pedestrian from Arcadia will catch a breath in a shady spot beneath a tree while waiting for a bus or taxi, and meet a resident from close by who is on his way to the corner shop for his daily milk and bread. They will exchange greetings and go their separate way after lingering a while on the deck that overlooks the park with it's ever changing vortex pool, jubilant fountains and laughing kids.

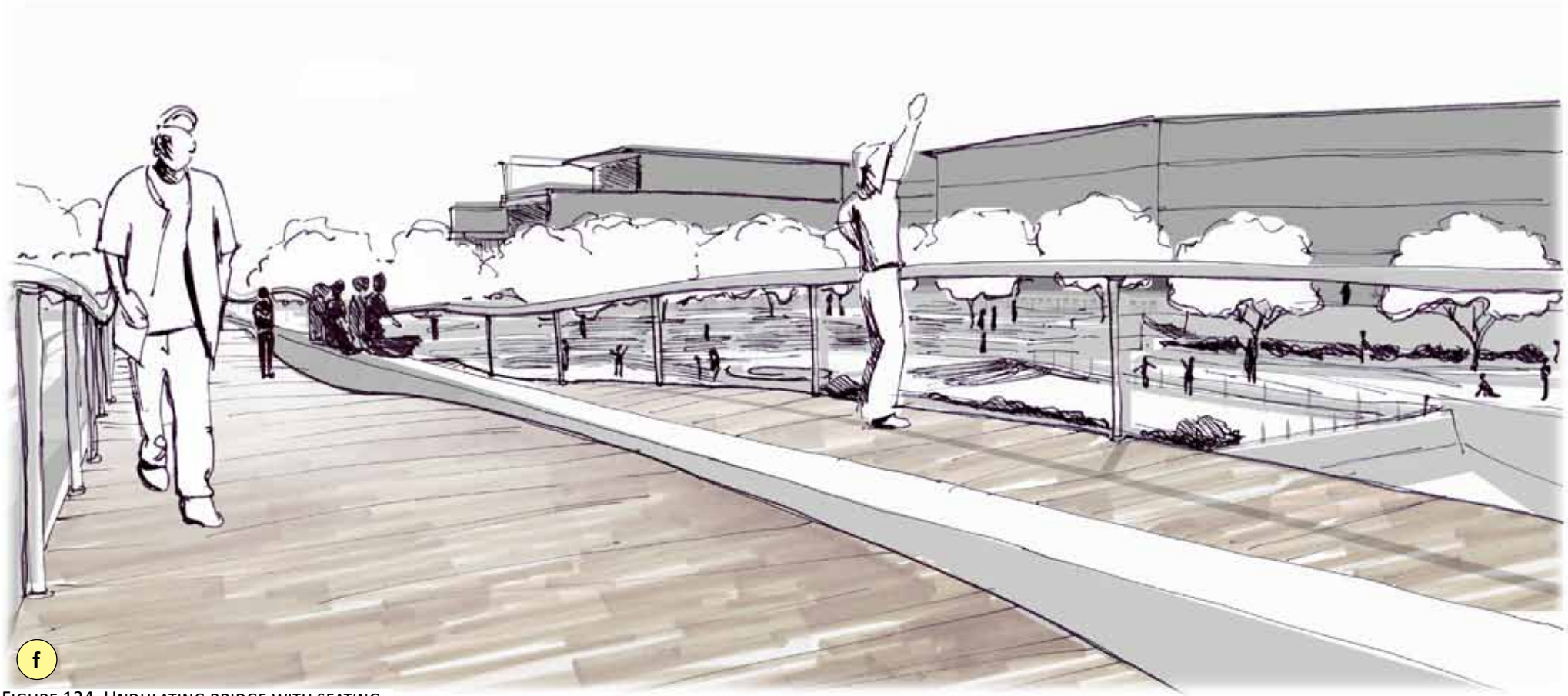


Figure 124. Undulating bridge with seating

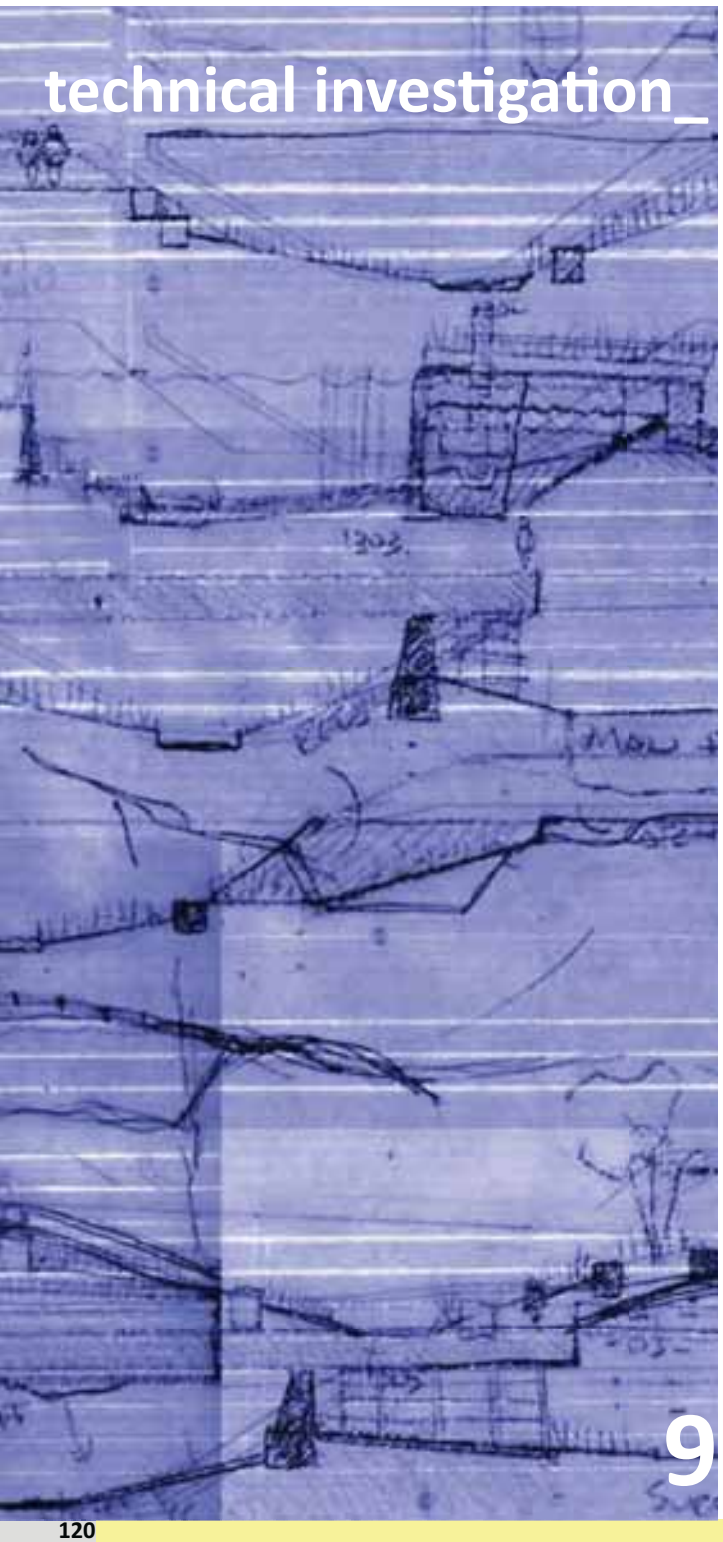
FIGURE 125. SOCIAL HEART OF THE CENTRE

Lunch goers

On their lunch meeting, two business woman will be sitting at a classy restaurant, having a glass of white wine. They will gaze at the park, and remember how they loved playing in a mountain stream, or on their favourite beach. The sound of children playing will make them smile, and the steady turn of the water wheel will give them a sense of assurance that all is well in the world. Unknowingly, they will both make a mental note to bring their lunch packet here next week, maybe they'll even cool their tired feet in the play pond, and have some candy floss...

Figure 126. View from the BMW garage restaurant conversion

technical investigation_



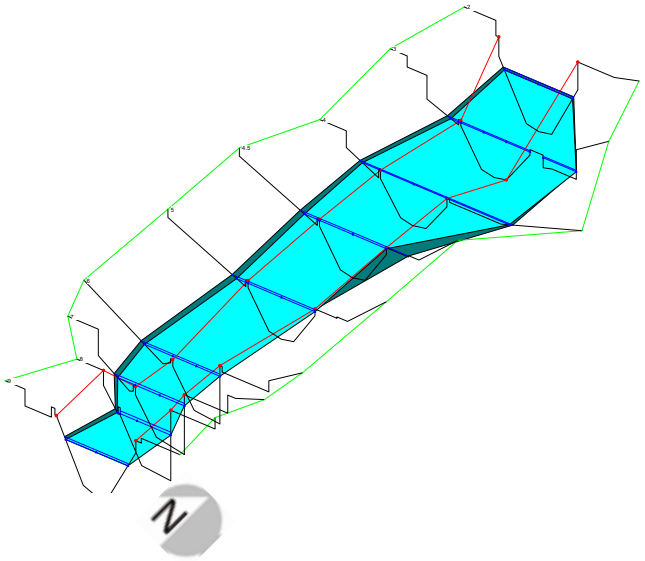
9

Introduction

The technical investigation includes:
- Flood plane alteration
- The river base flow system
- The rain meter maze system
- The grey water system

Water from the rain meter maze, the grey water system and surface runoff collection are all included in the site water budget.

Further investigation includes:
- Planting strategy
- Material palette



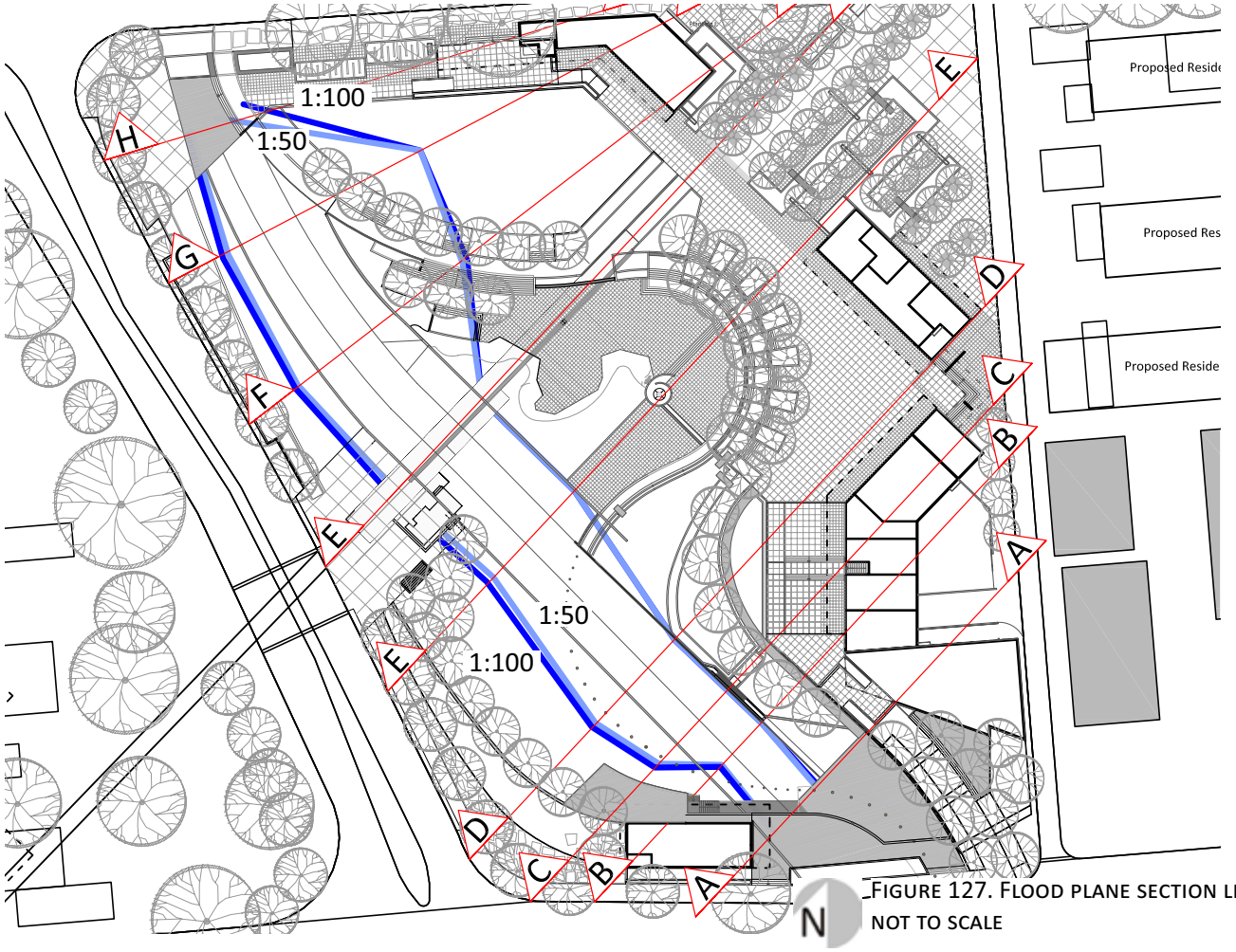


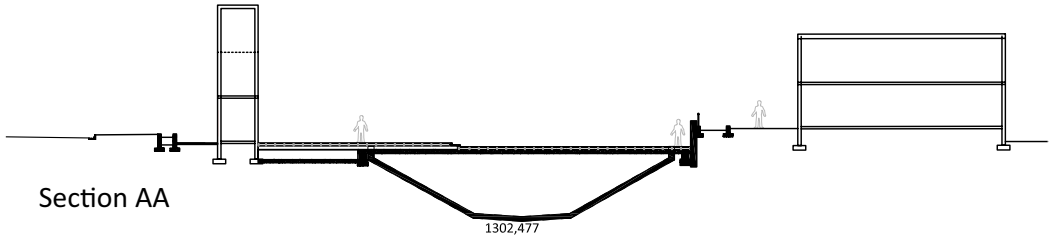
FIGURE 127. FLOOD PLANE SECTION LINES
NOT TO SCALE

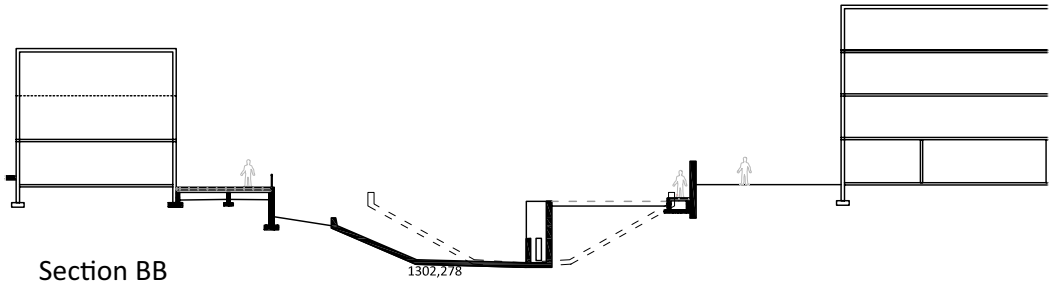
FLOOD PLANE ALTERATION

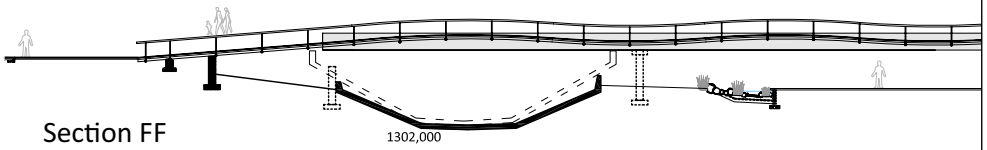
Figure 127 shows the section lines and projected flood lines.

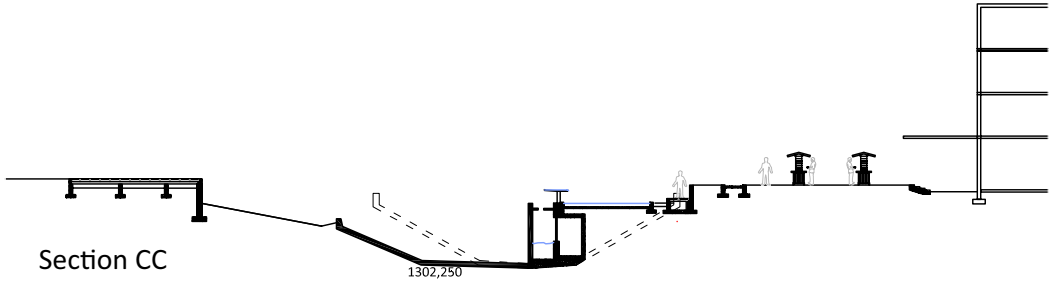
Figure 128 illustrates sections AA - HH through the amended channel. The channel section were used to project flood lines:

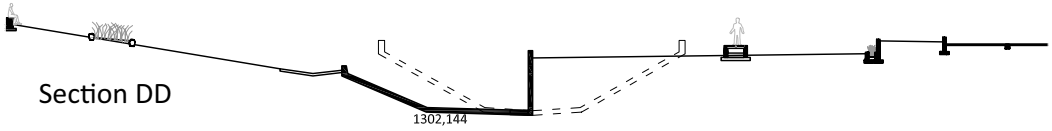
"Hydraulic modelling done with Hec-RAS software (v4.0 Beta). Computation done on variable cross-sections, with steady flow conditions, assuming sub-critical main channel flow." (Etsebeth: 2009)











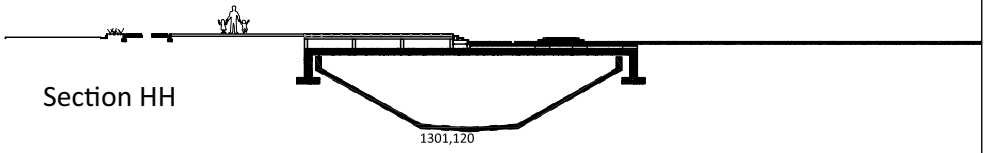


FIGURE 128. FLOOD PLANE SECTIONS AA - HH

The river base flow system

The first and most extensive system is the river system that uses some of the Apies River base flow (see figure 129).

Water is lifted from the channel with a waterwheel, where after it is purified in a constructed wetland (see table 6 for size calculation) and a chlorine-free disinfecting process.

After disinfection has taken place, the water is displayed in a pond that partially drains through a gravity driven vortex generator.

The vortex generator aerates and cools down the water while adding movement; sound and a sense of the passage of time to the system.

From the vortex, water flows into a constructed pebble lined stream that children can play in and experience stream ecology.

The pebbles and vegetation refers back to the Apies River before it was lined with concrete. From the stream the water rejoins the channel.

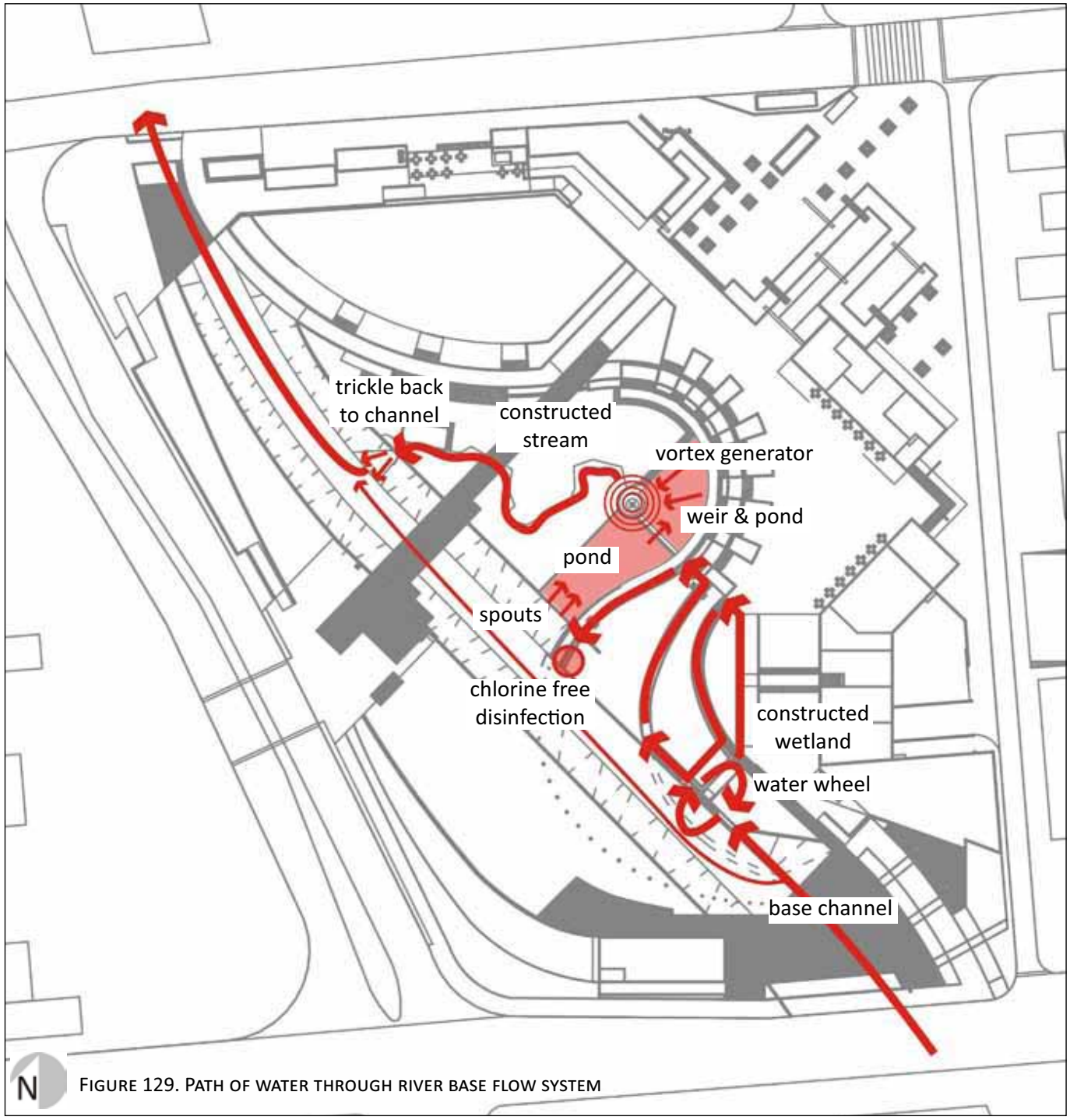


Figure 129. Path of water through river base flow system

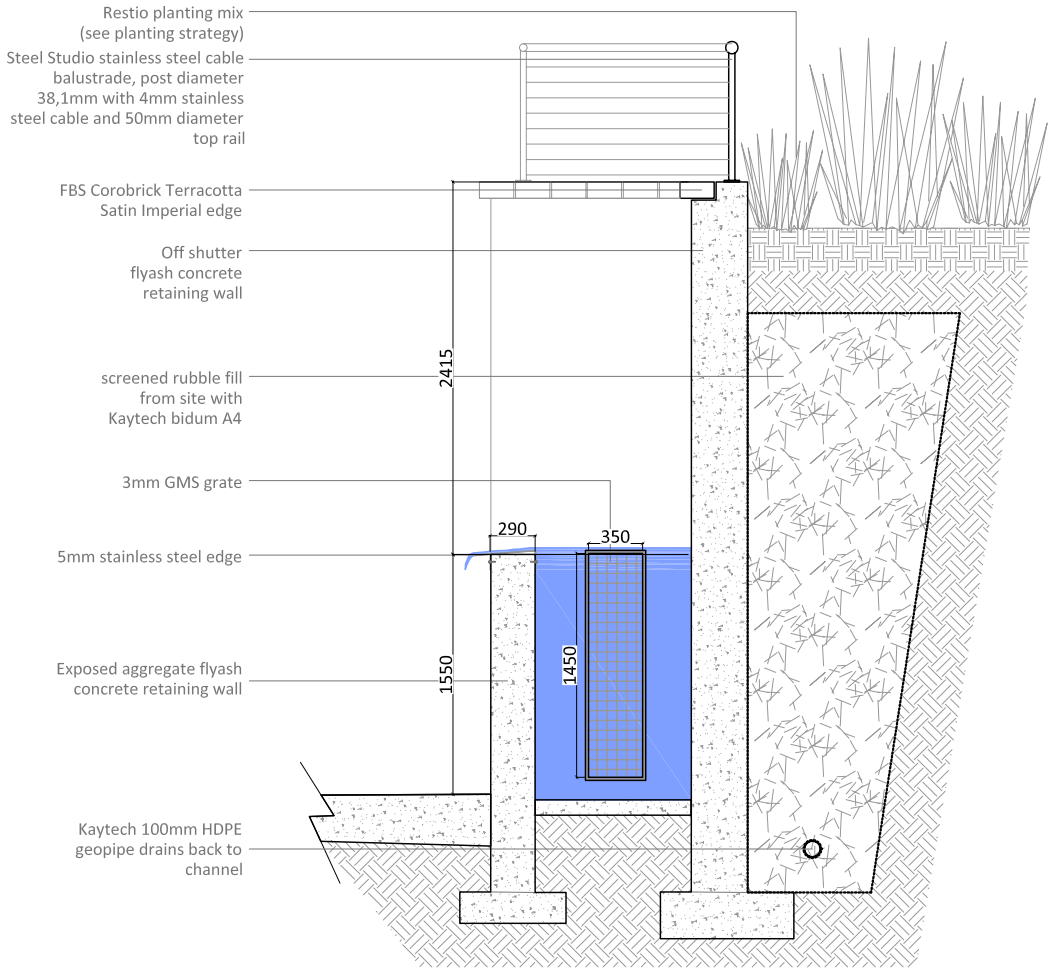
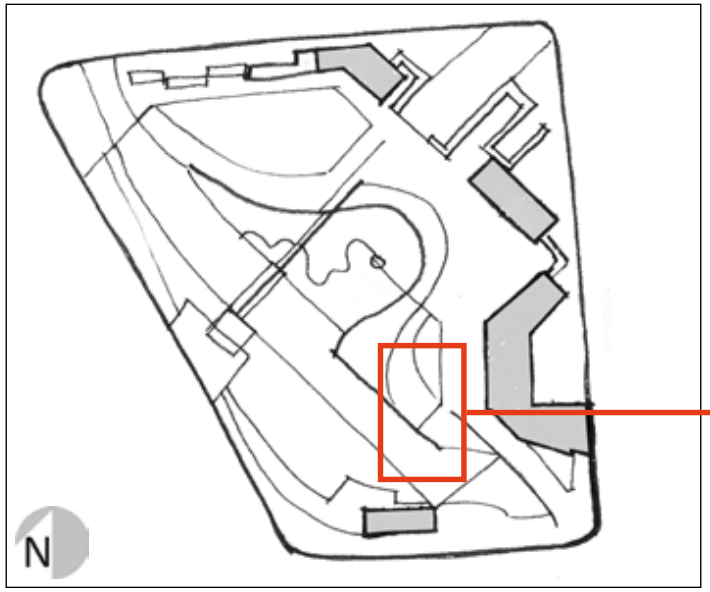


FIGURE 130. SECTION II - BASE CHANNEL
SCALE 1:50



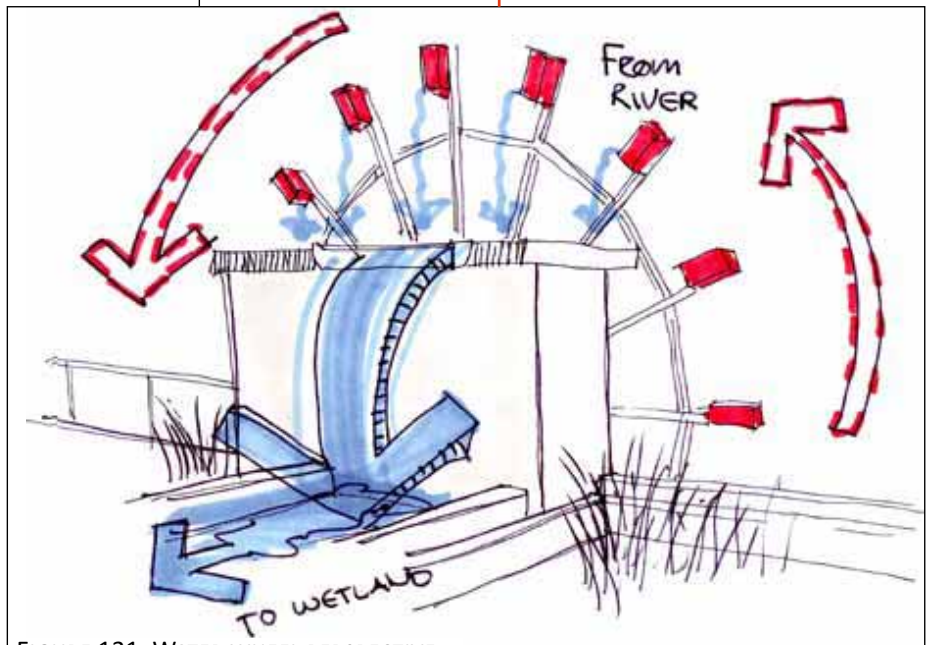


FIGURE 131. WATER WHEEL PERSPECTIVE
NOT TO SCALE

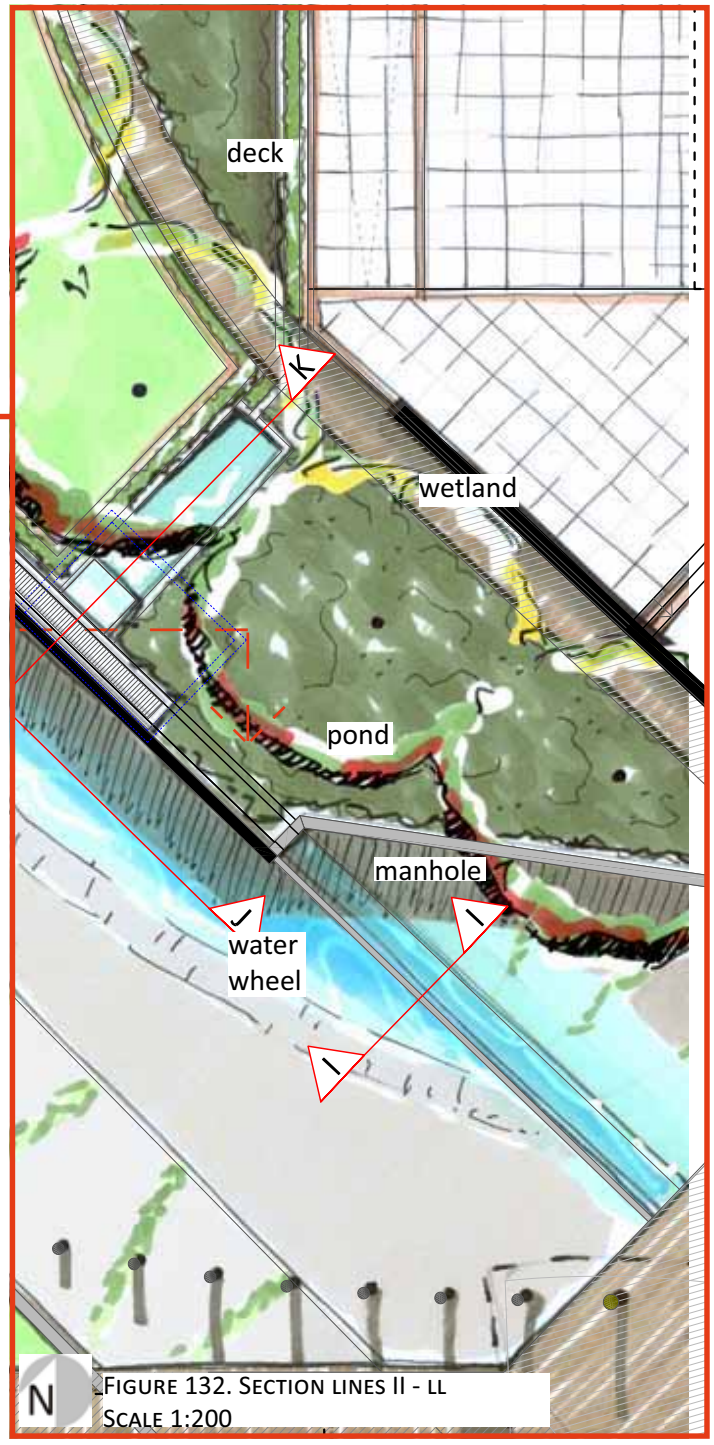
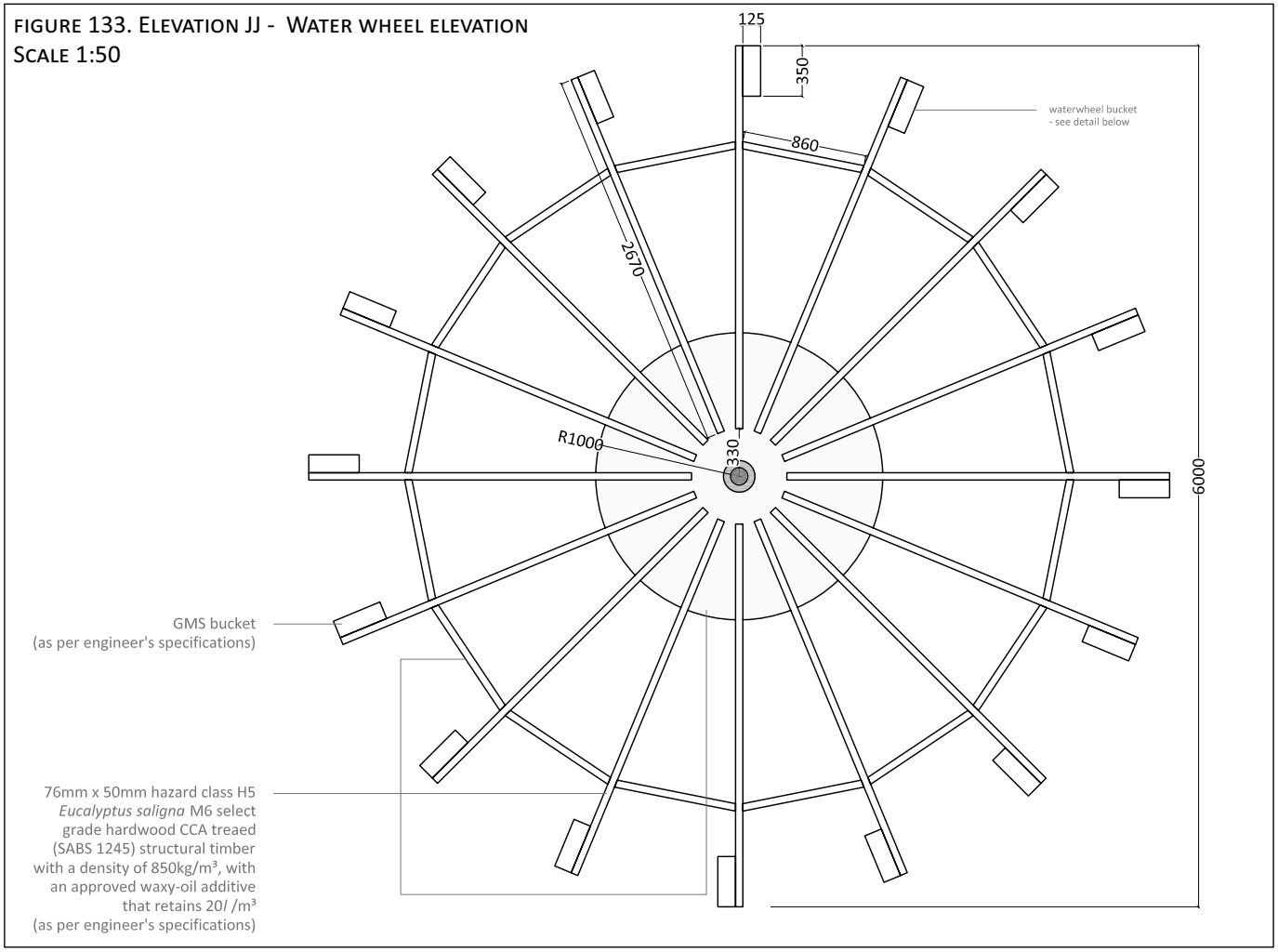


FIGURE 132. SECTION LINES II - LL
SCALE 1:200

FIGURE 133. ELEVATION JJ - WATER WHEEL ELEVATION
SCALE 1:50



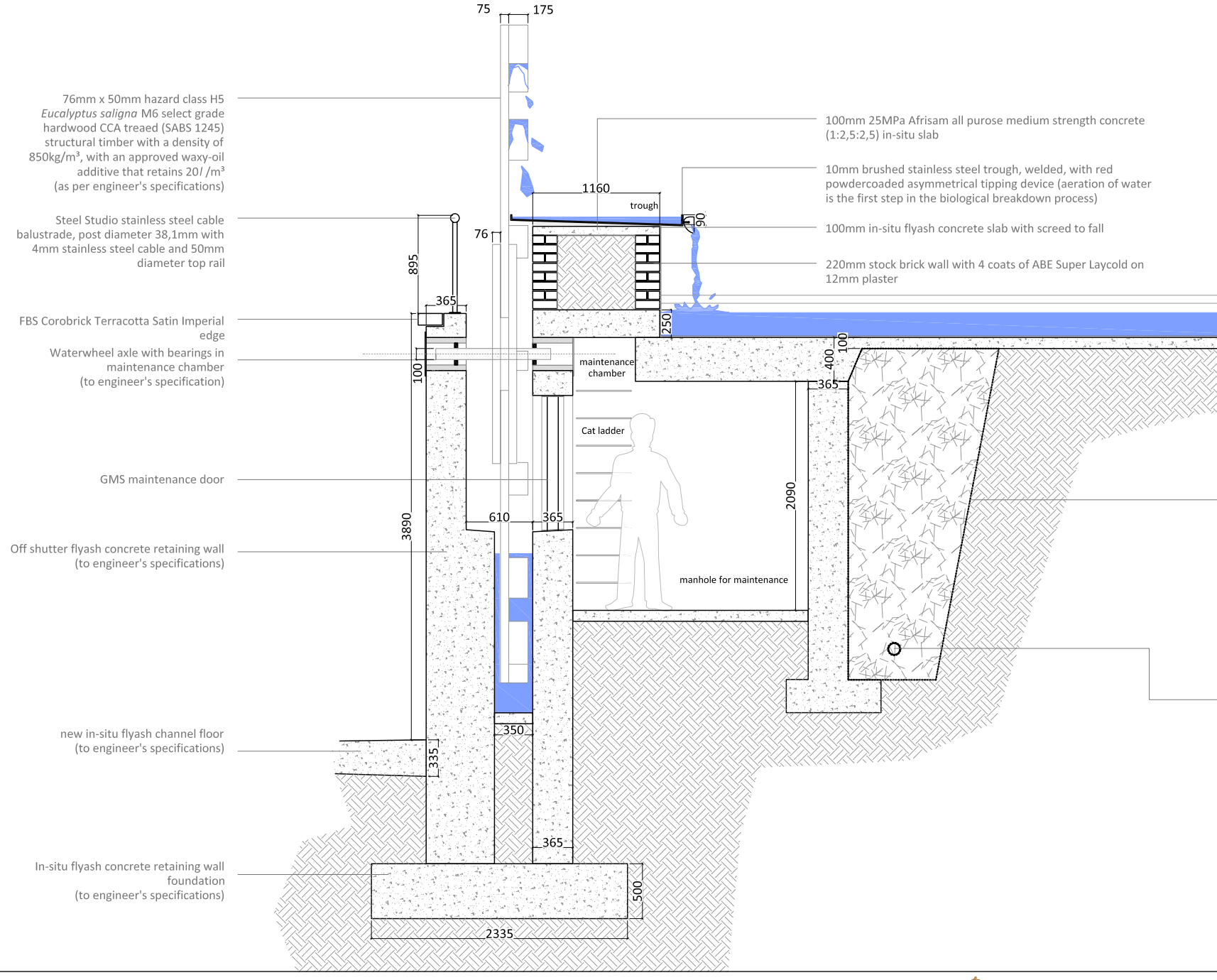
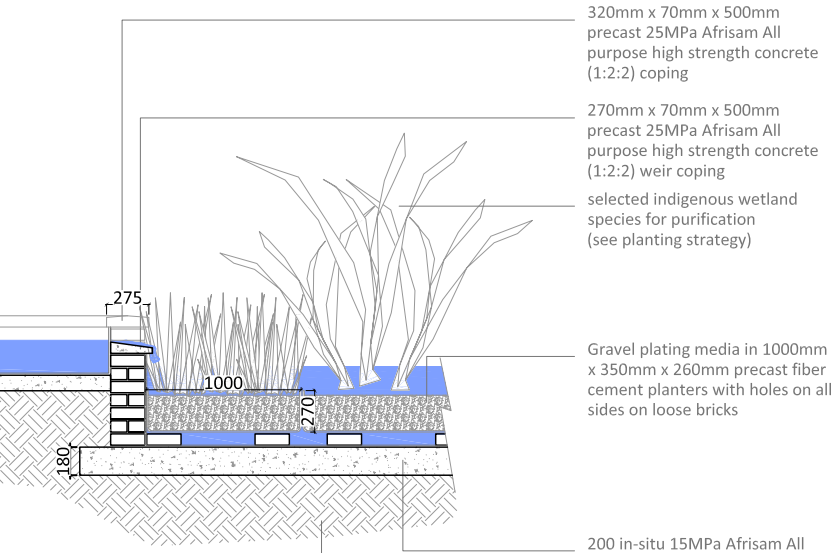


FIGURE 134. SECTION KK - WATER WHEEL AND MANHOLE
SCALE 1:50



320mm x 70mm x 500mm precast 25MPa Afrisam All purpose high strength concrete (1:2:2) coping

270mm x 70mm x 500mm precast 25MPa Afrisam All purpose high strength concrete (1:2:2) weir coping

selected indigenous wetland species for purification (see planting strategy)

Gravel plating media in 1000mm x 350mm x 260mm precast fiber cement planters with holes on all sides on loose bricks

200 in-situ 15MPa Afrisam All purpose low strength concrete (1:3,5:3,5) slab with 4 coats of ABE super laycold

In situ soil compacted to 93% Mod AASTHO

Kaytech bidum A4 with screened rubble from site

Kaytech 100mm HDPE geopipe drains back to channel

river wetland							
component	channel width	*Q*	*A*	*P*	*n*	*S*	*y*
a	0.4	*0.008*	*0.0736*	*0.768*	*0.1*	*0.0025*	*0.184*
b	0.118	*0.001*	*0.00861*	*0.522*	0.021	*0.0025*	*0.073*
Q total		**0.009**					

TABLE 6- RIVER WETLAND CHANNEL SIZE CALCULATIONS

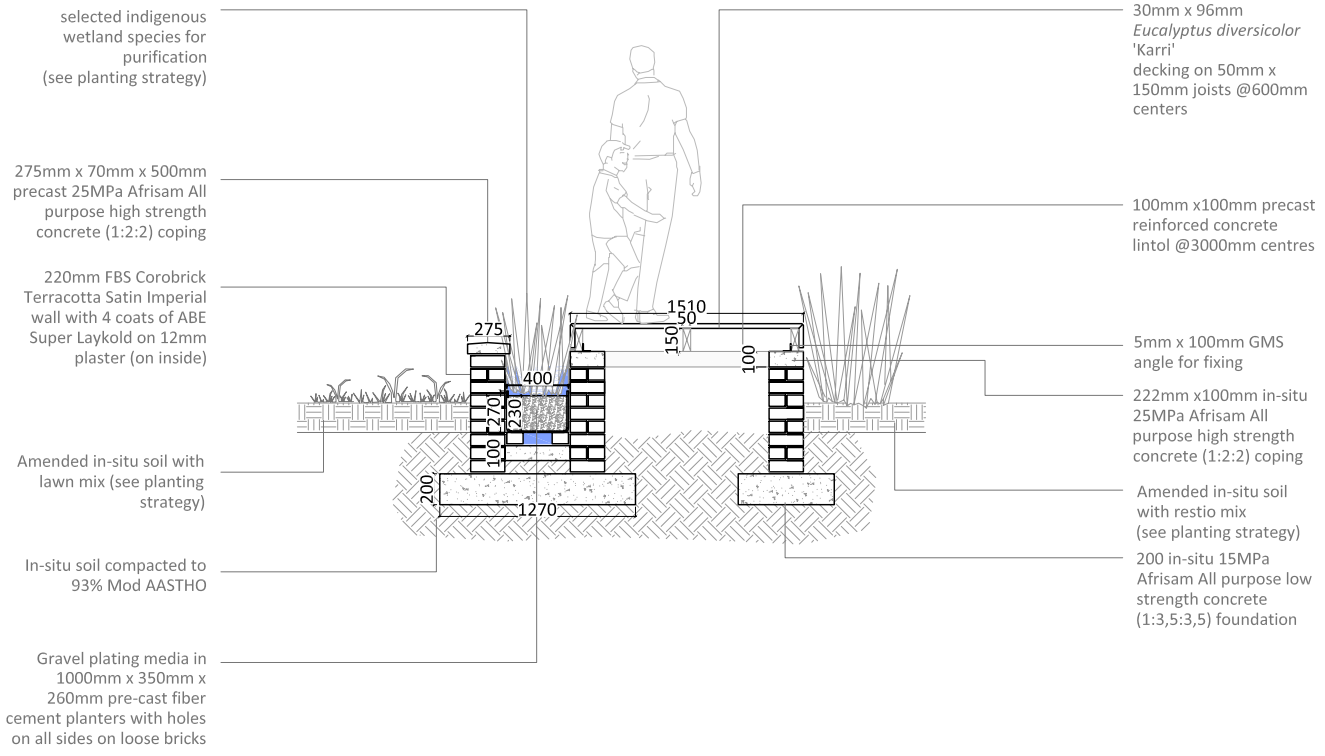
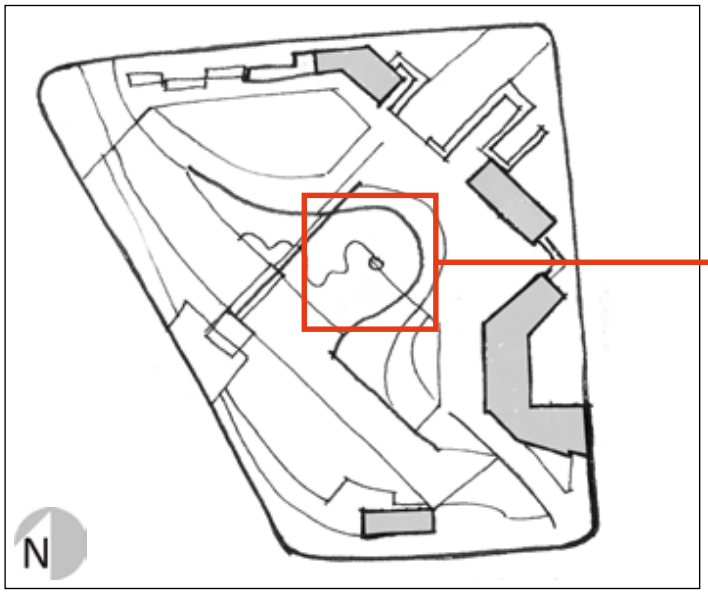


FIGURE 135. SECTION KK - SECTION AND ELEVATION LL OF RIVER WETLAND AND DECK WALKWAY
SCALE 1:50



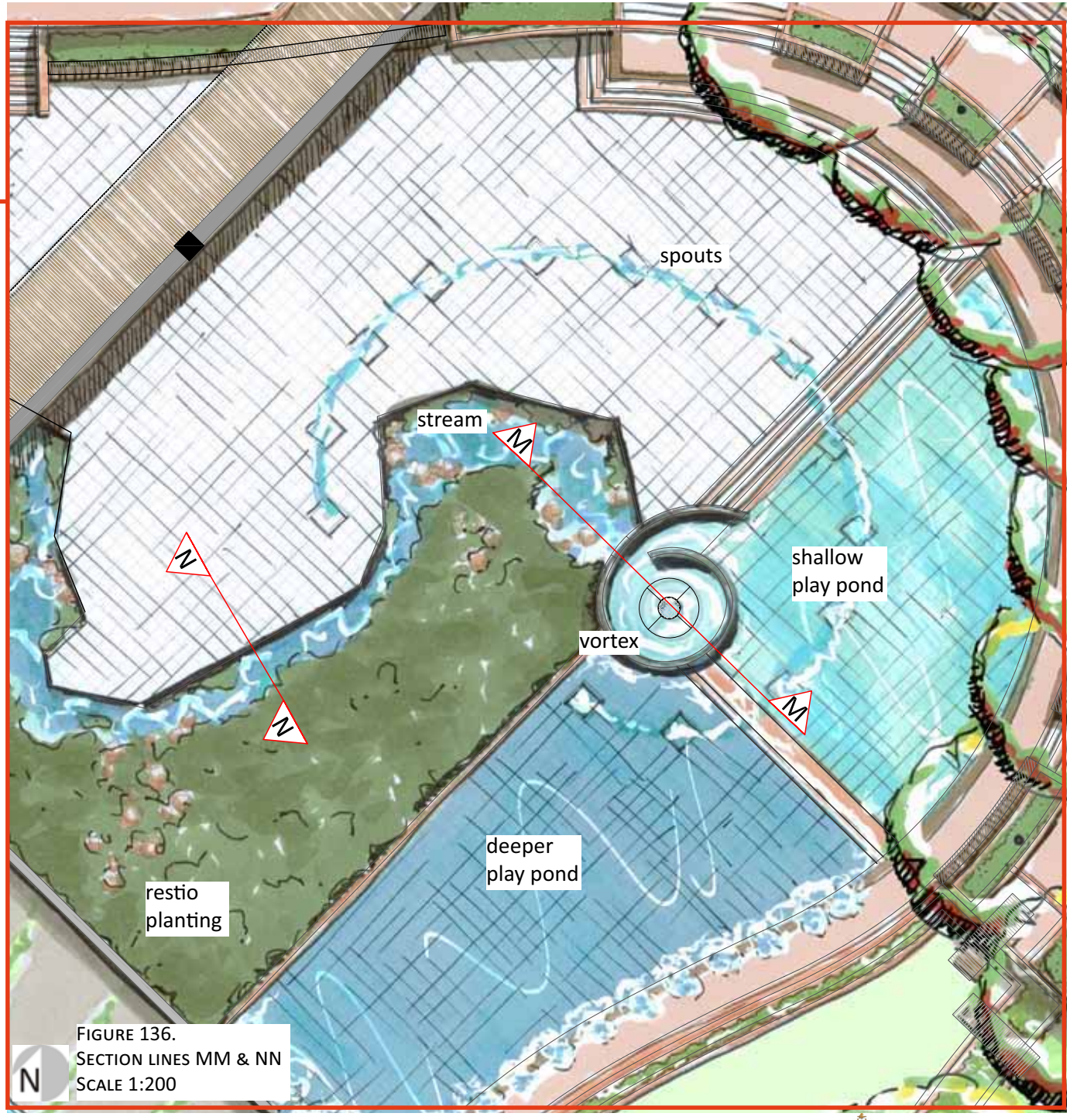


FIGURE 136.
SECTION LINES MM & NN
SCALE 1:200

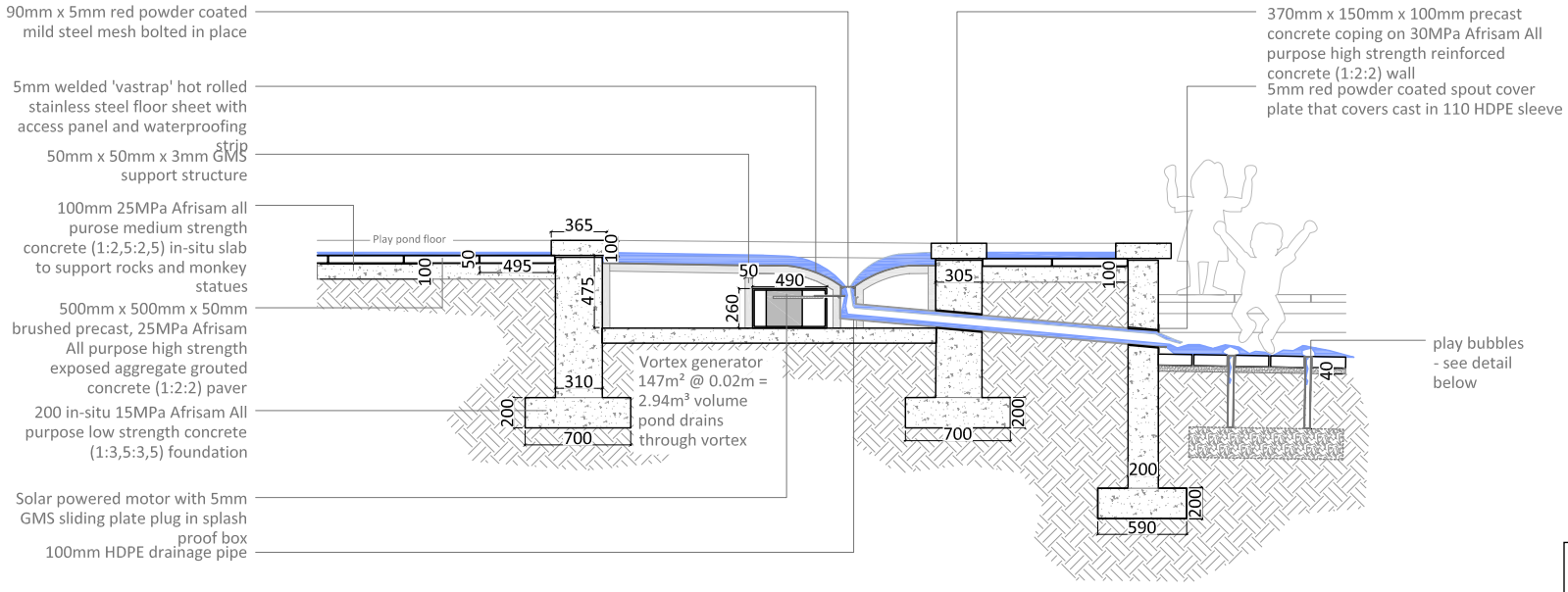


FIGURE 137. SECTION MM - VORTEX GENERATOR
SCALE 1:50

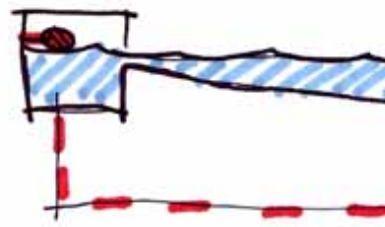


FIGURE 138. VORTEX DIAGRAM

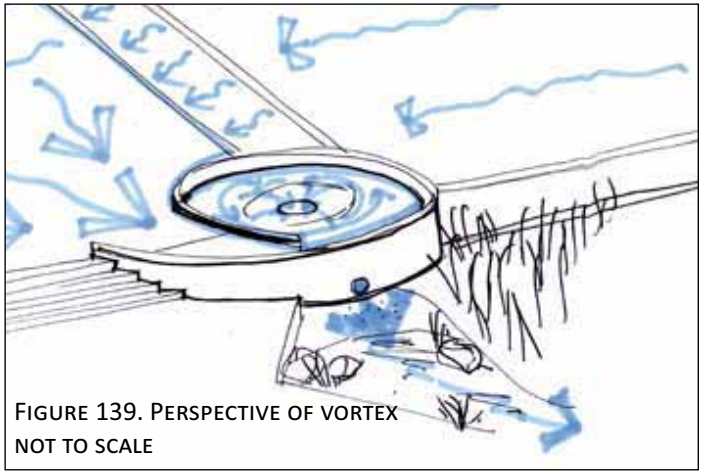


FIGURE 139. PERSPECTIVE OF VORTEX
NOT TO SCALE

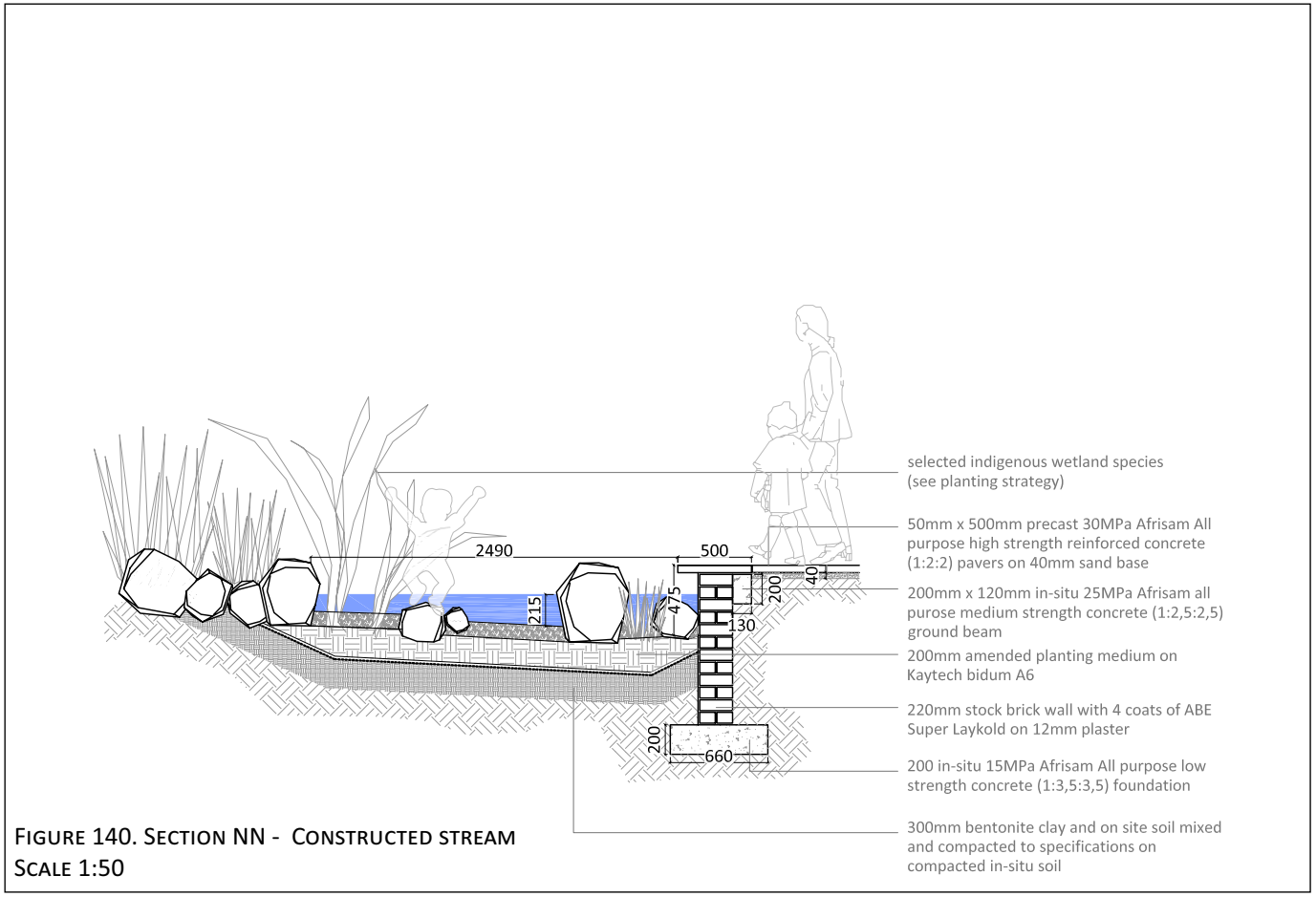
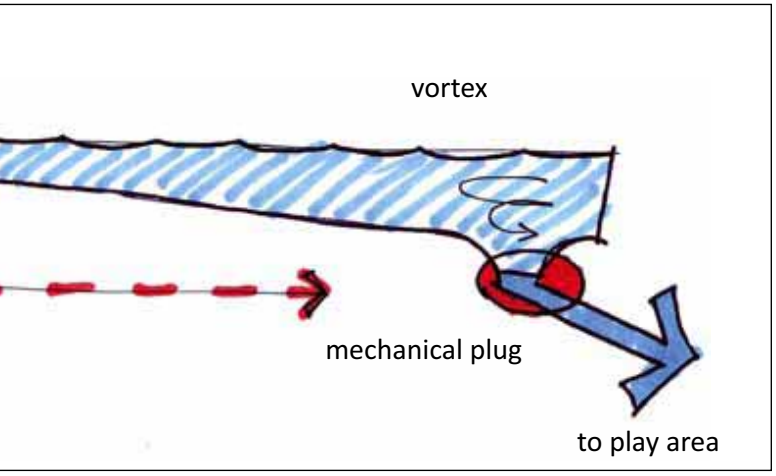


FIGURE 140. SECTION NN - CONSTRUCTED STREAM
SCALE 1:50



Water budget

The water budget is tied to the Rainwater harvesting plan, irrigation areas and grey water harvesting system as illustrated in figure 141. Tables 7 to 8 quantifies the water budget.

Figure 142 identifies the two systems (east and west of the channel) and the surfaces used for rainwater and runoff harvesting

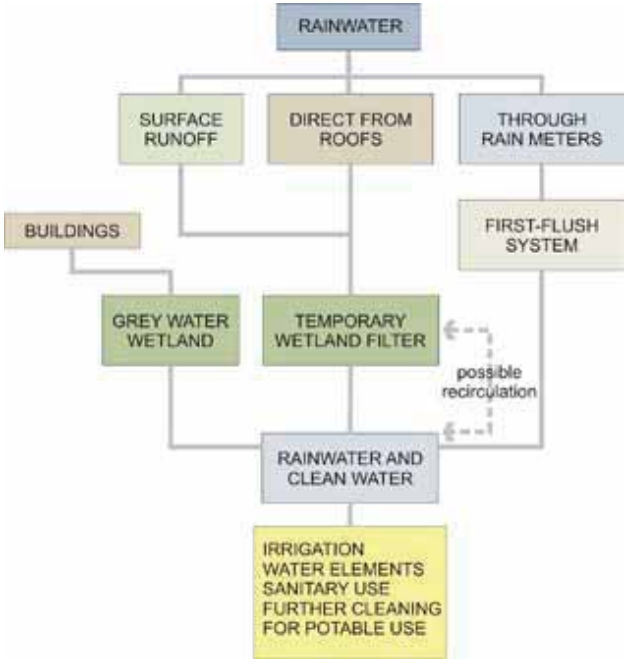


Figure 141. Water budet diagram

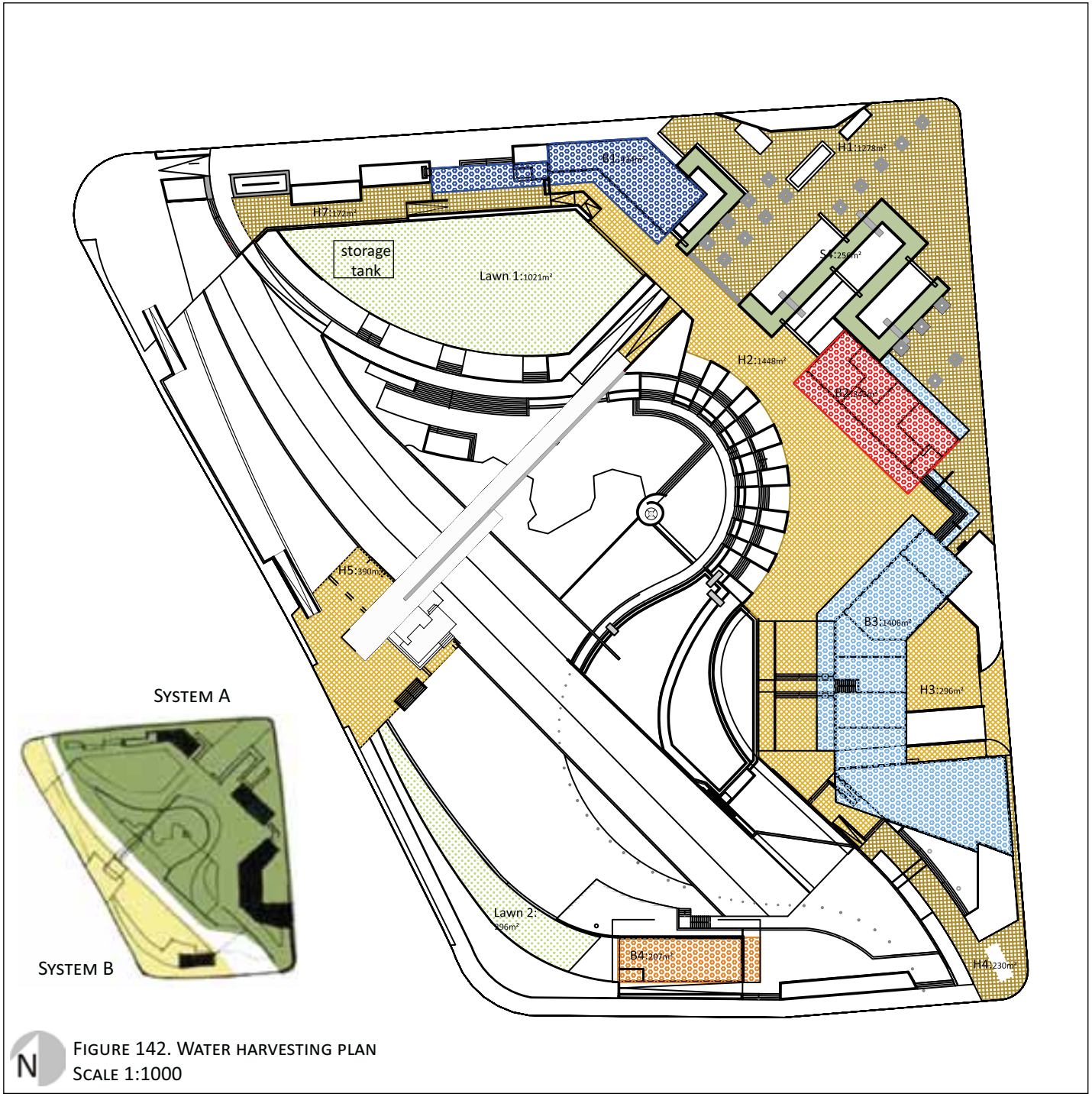


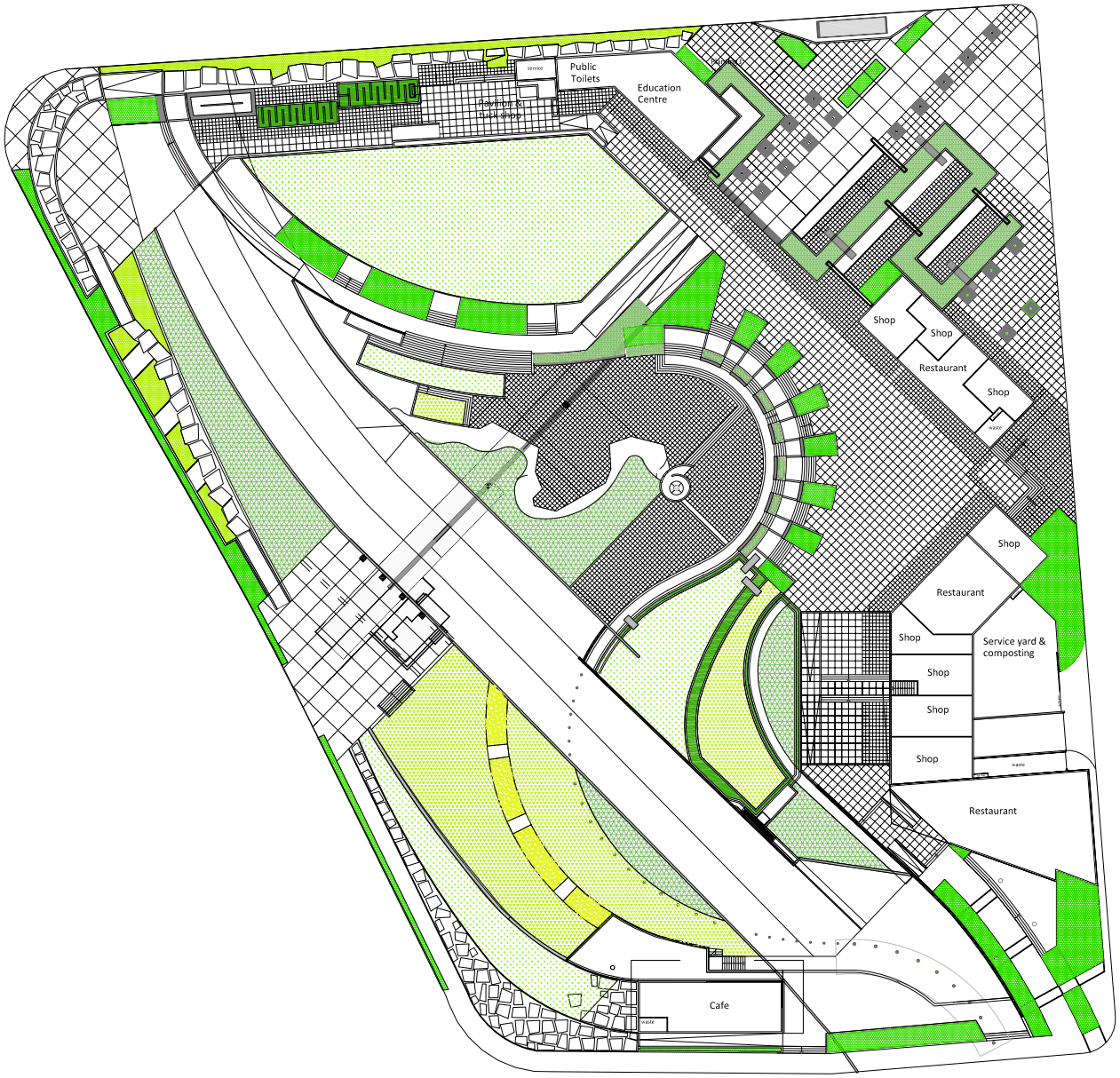
Figure 142. Water harvesting plan
Scale 1:1000

	Rainfall	Building roofs c value = 0.9			Paving c value = 0.8					Lawn c value = 0.3			Use				
Month	average	B 1 (m^2)	B2 (m^2)	B3 (m^2)	H1 (m^2)	H2 (m^2)	H3 (m^2)	H4 (m^2)	H7 (m^2)	L1 (m^2)	L2 (m^2)	Month In	Month Need	Month Need	Month Need		Balance
m	*(m)*	*336*	*1063*	*207*	*1278*	*1406*	*296*	*230*	*248*	*1024*	*256*		*Lawn*	*Veldgrass*	*Planting*	*total use*	
												m^3	*1609*	*1266.00*	*1725.00*		
January	0.136	41.13	130.11	25.34	139.05	152.97	32.20	25.02	26.98	41.78	10.44	**625.03**	178.20	0.00	76.42	*254.61*	370.41
February	0.075	22.68	71.75	13.97	76.68	84.36	17.76	13.80	14.88	23.04	5.76	**344.69**	166.53	0.00	71.42	*237.95*	106.74
March	0.082	24.80	78.45	15.28	83.84	92.23	19.42	15.09	16.27	25.19	6.30	**376.86**	178.20	0.00	76.42	*254.61*	122.24
April	0.051	15.42	48.79	9.50	52.14	57.36	12.08	9.38	10.12	15.67	3.92	**234.39**	43.24	12.66	37.09	*92.99*	141.40
May	0.013	3.93	12.44	2.42	13.29	14.62	3.08	2.39	2.58	3.99	1.00	**59.75**	44.55	12.66	38.21	*95.42*	-35.67
June	0.007	2.12	6.70	1.30	7.16	7.87	1.66	1.29	1.39	2.15	0.54	**32.17**	43.24	12.66	37.09	*92.99*	-60.82
July	0.003	0.91	2.87	0.56	3.07	3.37	0.71	0.55	0.60	0.92	0.23	**13.79**	44.55	12.66	38.21	*95.42*	-81.63
August	0.006	1.81	5.74	1.12	6.13	6.75	1.42	1.10	1.19	1.84	0.46	**27.57**	44.55	12.66	38.21	*95.42*	-67.84
September	0.022	6.65	21.05	4.10	22.49	24.75	5.21	4.05	4.36	6.76	1.69	**101.11**	43.24	12.66	37.09	*92.99*	8.12
October	0.071	21.47	67.93	13.23	72.59	79.86	16.81	13.06	14.09	21.81	5.45	**326.30**	178.20	0.00	76.42	*254.61*	71.69
November	0.098	29.64	93.76	18.26	100.20	110.23	23.21	18.03	19.44	30.11	7.53	**450.39**	172.97	0.00	74.18	*247.14*	203.25
December	0.110	33.26	105.24	20.49	112.46	123.73	26.05	20.24	21.82	33.79	8.45	**505.54**	178.20	0.00	76.42	*254.61*	250.92
Year total		*203.82*	*644.82*	*125.57*	*689.10*	*758.12*	*159.60*	*124.02*	*133.72*	*207.05*	*51.76*	3097.57				*2068.77*	*1028.80*

TABLE 7- SYSTEM A: HARVESTED RAINWATER AND IRRIGATION NEEDS BALANCE

	Rainfall	Efficiency			Area			
Month	average	roofs*	gravel roof*	lawn*	B4	H5	L2	Month In
	monthly (m)		paving*		*207*	*390*	*296*	m^3
January	0.14	0.90	0.80	0.30	25.34	42.43	12.08	**79.85**
February	0.08	0.90	0.80	0.30	13.97	23.40	6.66	**44.03**
March	0.08	0.90	0.80	0.30	15.28	25.58	7.28	**48.14**
April	0.05	0.90	0.80	0.30	9.50	15.91	4.53	**29.94**
May	0.01	0.90	0.80	0.30	2.42	4.06	0.03	**6.51**
June	0.01	0.90	0.80	0.30	1.30	2.18	0.62	**4.11**
July	0.00	0.90	0.80	0.30	0.56	0.94	0.27	**1.76**
August	0.01	0.90	0.80	0.30	1.12	1.87	0.53	**3.52**
September	0.02	0.90	0.80	0.30	4.10	6.86	1.95	**12.92**
October	0.07	0.90	0.80	0.30	13.23	22.15	6.30	**41.68**
November	0.10	0.90	0.80	0.30	18.26	30.58	8.70	**57.54**
December	0.11	0.90	0.80	0.30	20.49	34.32	9.77	**64.58**
Year total								**394.58**

TABLE 8- SYSTEM B: HARVESTED RAINWATER



Planting legend

- Manicured lawn
- Lawn mix
- Veld grass species
- Formalised planting
- Restio species
- Wetland species

N

FIGURE 143. WATER IRRIGATION AREAS
SCALE 1:1000

Irrigation areas

Figure 143 sets out the irrigation areas and table 9 the corresponding need. The manicured lawn will be irrigated with 25mm per week during summer and 6,25mm during winter. The lawn mix will receive no water during summer and 10mm per week during winter (the lawn mix areas area part of the groundwater infiltration scheme). The formalised planting and restio mix will be watered 10mm per week during summer and 5mm per week during winter.

All of the irrigation needs are met by the rain and runoff harvesting system.

Table 10 describe the anticipated building use, classification and water use per day. Tables 11 (next page) sets out the summary of the water budget along with a estimated water related cost saving of 30,71% per annum.

Month	Months	Weeks	Lawn	need	m³ need	no mow lawn	need	m³ need	Planting	need	m³ need
				m / m²	/week	mix	m / m²	/month		m / m²	/week
January	1	4.43	1609	0.025	178.20	1266	0	0	1725	0.01	76.42
February	1	4.14	1609	0.025	166.53	1266	0	0	1725	0.01	71.42
March	1	4.43	1609	0.025	178.20	1266	0	0	1725	0.01	76.42
April	1	4.3	1609	0.00625	43.24	1266	0.01	12.66	1725	0.005	37.09
May	1	4.43	1609	0.00625	44.55	1266	0.01	12.66	1725	0.005	38.21
June	1	4.3	1609	0.00625	43.24	1266	0.01	12.66	1725	0.005	37.09
July	1	4.43	1609	0.00625	44.55	1266	0.01	12.66	1725	0.005	38.21
August	1	4.43	1609	0.00625	44.55	1266	0.01	12.66	1725	0.005	38.21
September	1	4.3	1609	0.00625	43.24	1266	0.01	12.66	1725	0.005	37.09
October	1	4.43	1609	0.025	178.20	1266	0	0	1725	0.01	76.42
November	1	4.3	1609	0.025	172.97	1266	0	0	1725	0.01	74.18
December	1	4.43	1609	0.025	178.20	1266	0	0	1725	0.01	76.42
					1315.66			75.96			677.15
Year total											2068.77

Table 9- Total irrigation need

Use	*SABS*	*description*	*floors*	*area*	*occupants*	*water /person*	*per day*	*total*
				m²		*PP10.4*		
Offices	G1	rain garden	2.6	639.6	42.64	90	3837.6	
		block	3	738	49.2	90	4428	8265.6
Education	A3	education centre	1	246	49.2	90	4428	4428
Restaurants	A1	rain garden	1	246	246	20	4920	
		north facing	1	246	246	20	4920	
		old bmw	1.3	319.8	319.8	20	6396	
		café	2	492	492	20	9840	26076
Shops	F2		1	246	24.6	9	221.4	221.4
Public toilets			1	1	650	9	5850	5850

Month	Days	Offices	Education	Restaurants	Shops	Public toilets	Total month
		8265.6	4428	26076	221.4	5850	
January	31	256233.6	137268	808356	6863.4	181350	1390071
February	29	239702.4	128412	756204	6420.6	169650	1300389
March	31	256233.6	137268	808356	6863.4	181350	1390071
April	30	247968	132840	782280	6642	175500	1345230
May	31	256233.6	137268	808356	6863.4	181350	1390071
June	30	247968	132840	782280	6642	175500	1345230
July	31	256233.6	137268	808356	6863.4	181350	1390071
August	31	256233.6	137268	808356	6863.4	181350	1390071
September	30	247968	132840	782280	6642	175500	1345230
October	31	256233.6	137268	808356	6863.4	181350	1390071
November	30	247968	132840	782280	6642	175500	1345230
December	31	256233.6	137268	808356	6863.4	181350	1390071
							16411806
Total in m³							16411.806

Grey water (estimated at 10% of effluent)	1641.1806

Table 10- Building use, occupation and water need

Total harvested:	Irrigation need:	Buildings need:	with 10% water saving devices
5134.46	2068.77	16411.806	
Total water need		**18480.57**	**16632.52**

Cost of 1 m^3 water	R 9.02
Yearly cost without harvesting	*R 150 025.30*
Yearly cost with harvesting	R 103 712.51
Yearly saving of harvesting	**R 46 312.79**
% saving per year	***30.87***

Table 11 - Water balance and saving per annum

This leads to

- using no potable water for irrigation
- using less water for sanitation
- reducing the impact on down stream systems by reducing site runoff
- saving money

(the author notes that the buildings on site needs more water than the landscape)

The rain meter maze system

The second on site water system addresses rainwater. Rainwater from one of the on site buildings is harvested and displayed in a rain-meter garden.

Water from roof B2 (see table 12) is used for the rain meter maze system. A first-flush device intercepts the first dirty water where after it drizzles down a rain-curtain into a rain meter system (see figure 144).

From the first rain meter tank, underground pipes with openings on the same level, controls the water level in all the tanks, thus all the tanks are equally full (figure 146).

Each tank has an overflow slot that lets water from rain events of more that 90mm drain into the temporary wet-land.

After each rain event, the water is kept in the tanks until the next event. Solar powered pumps circulate the water and UV light reduces algae growth.

A rain sensor triggers the drainage system as a shower approaches so that the new event can be captured and celebrated. Figures 144 to 147 explains the phases of the rain meter maze system.

The rain-meters are large bullet resistant glass tank-like containers, calibrated to show how many millimetres of rain have fallen during the shower.

A rain sensor drains the water into the temporary wet-land and lets it percolate into the underground storage tank.

Section OO and PP (figure 149 and 151) illustrates the system further.

Table 12 - Water from B2 and rain meter tank capacity

From roof B2

meter capacity (m^3)	area of meters (m^2)	height (m)
from roofs - first-flush		
29.82	20.39	1.46

calibration

Calibration

10mm rainfall event:	height / 9 (for 10mm intervals)	0.16

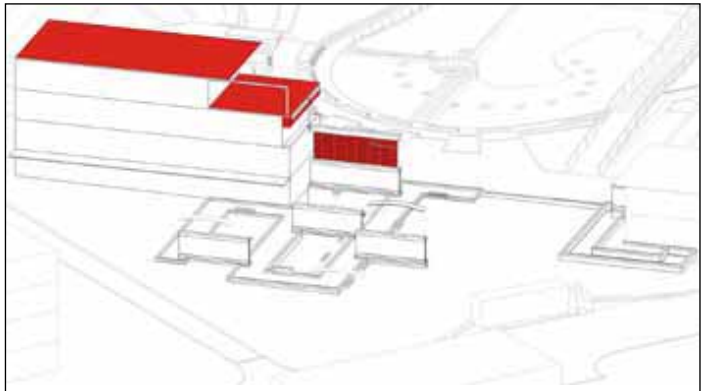


FIGURE 144. CATCH AND CONVEY

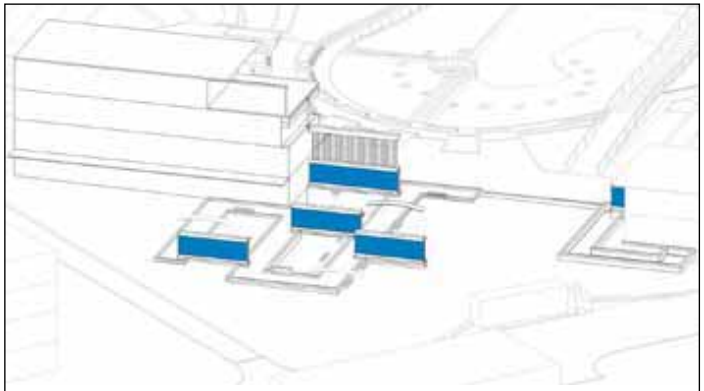


FIGURE 146. DISPLAY

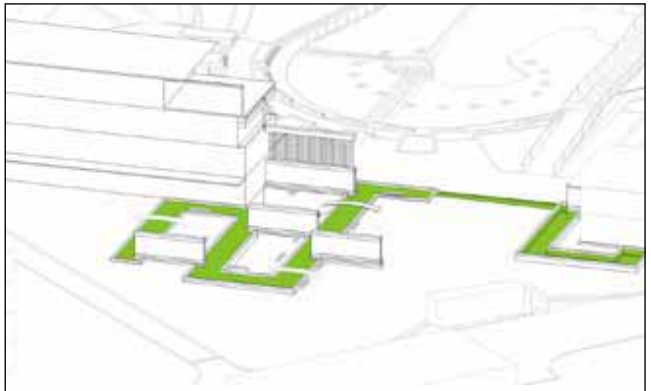


FIGURE 148. FILTER

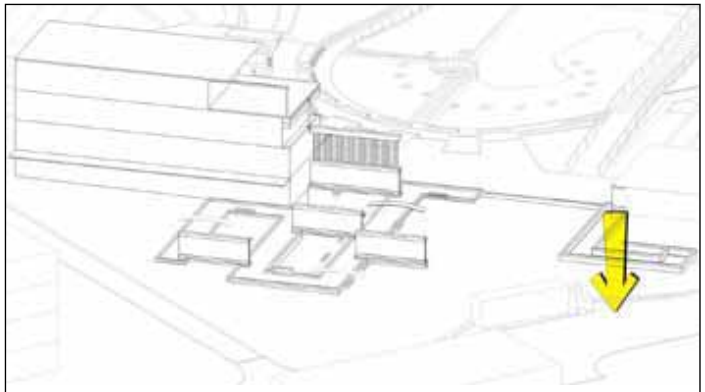


FIGURE 145. DRAIN TO STORAGE

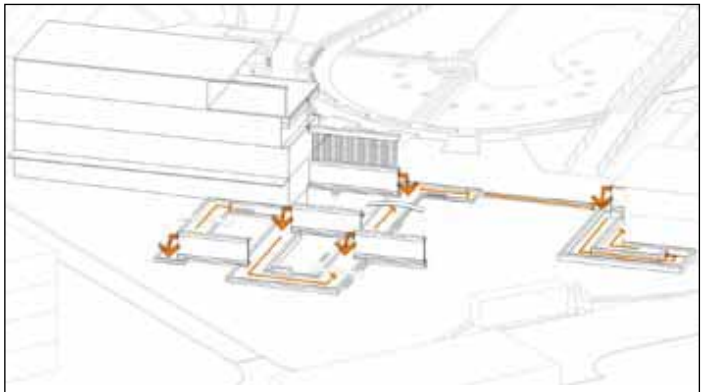


FIGURE 147. FLUSH AND PREPARE FOR NEXT SHOWER

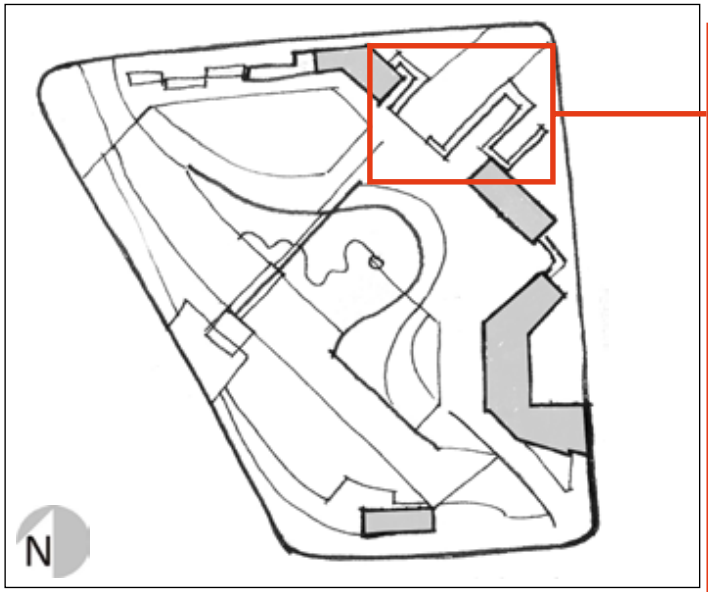


FIGURE 148. SECTION LINES OO & PP
SCALE 1:200

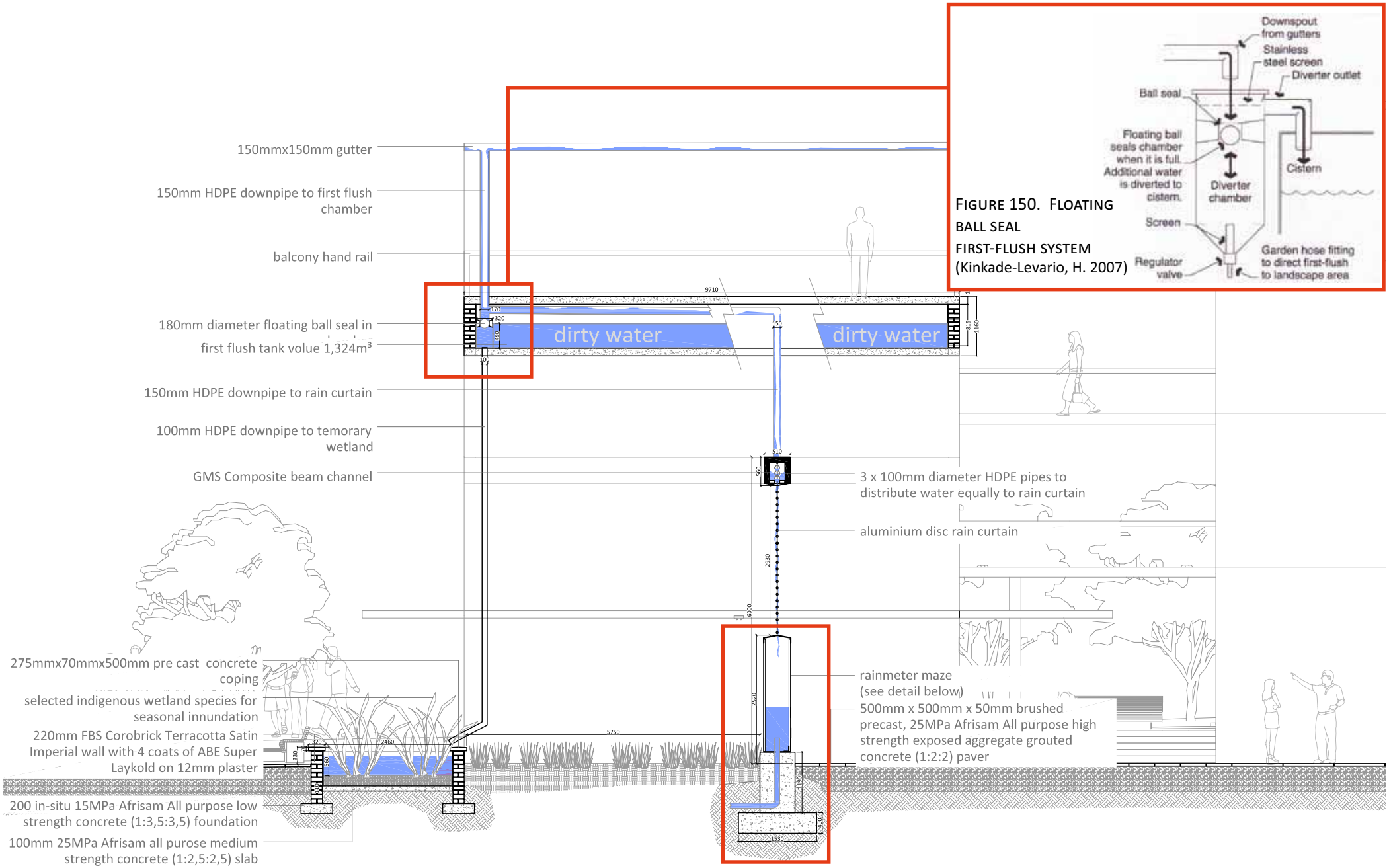


FIGURE 150. FLOATING BALL SEAL FIRST-FLUSH SYSTEM (Kinkade-Levario, H. 2007)

FIGURE 149. SECTION OO - RAIN DISPLAY SYSTEM
SCALE 1:100

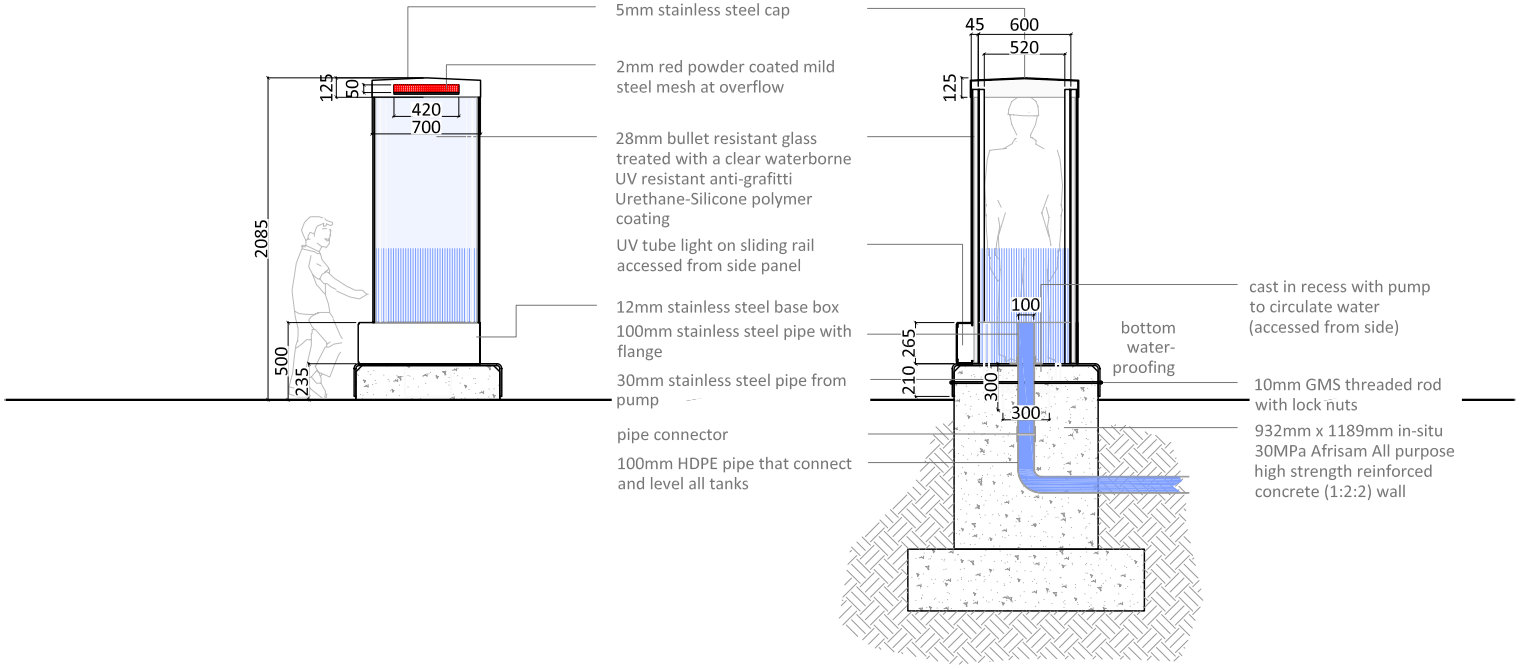


FIGURE 149 -1. RAIN METER DETAIL SECTION AND ELEVATION
SCALE 1:50

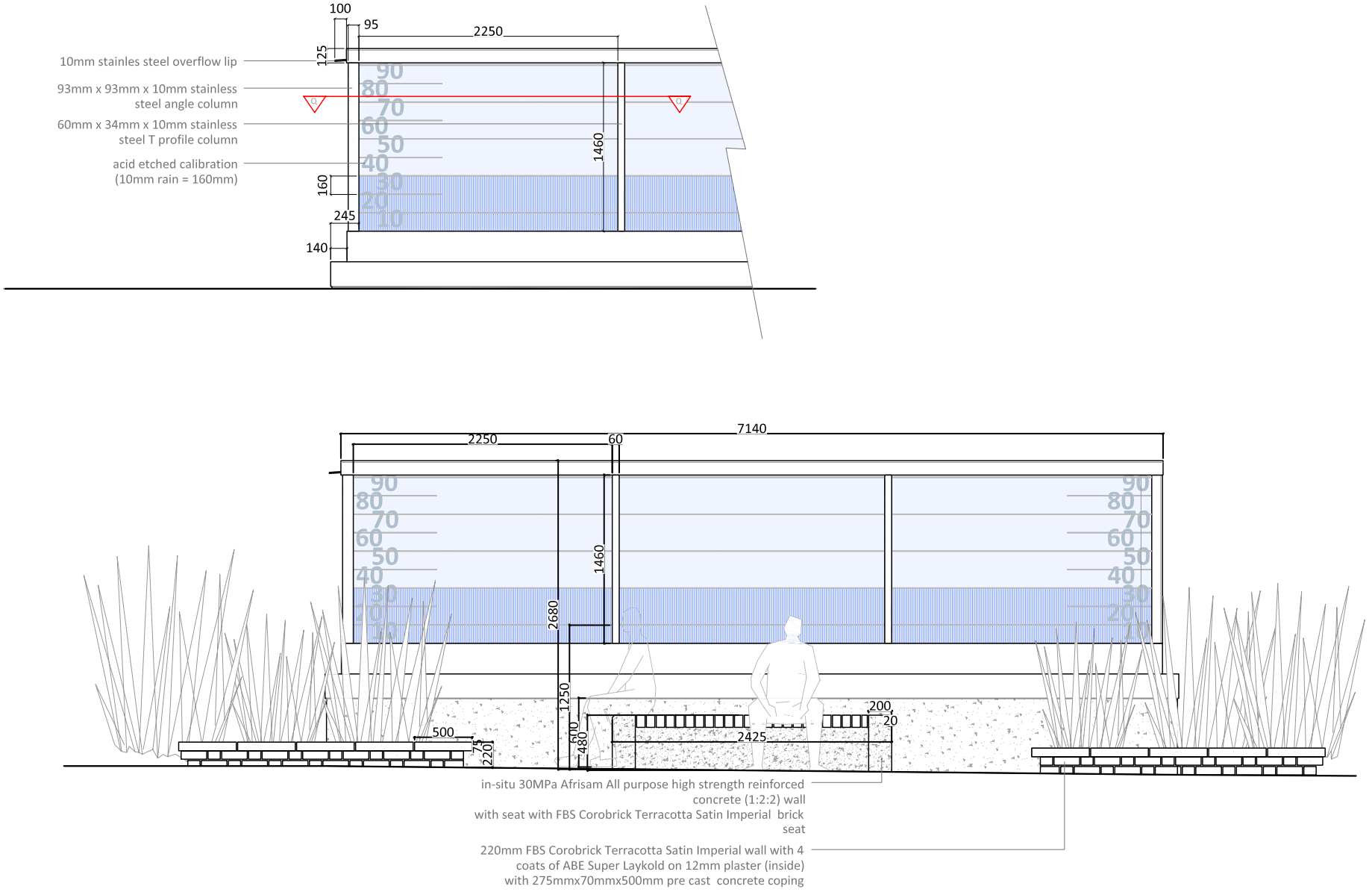


FIGURE 149 - 2. RAIN METER SIDE ELEVATION AND RAIN METER WITH BENCH INTEGRATION
SCALE 1:50

The grey water system

The third on site water system treats grey water from buildings through a stepped constructed wetland and displays the cleaned water in a jubilant motion activated display at one of the pedestrian entrances.

Water from all the taps and basins in the buildings are treated through the grey water wetland. For the biological processes in the wetland to be effective, the water needs to be in the system for a minimum of two days, thus 3283 litres over 2 days gives a flow rate of Q=0,019 (see table 13).

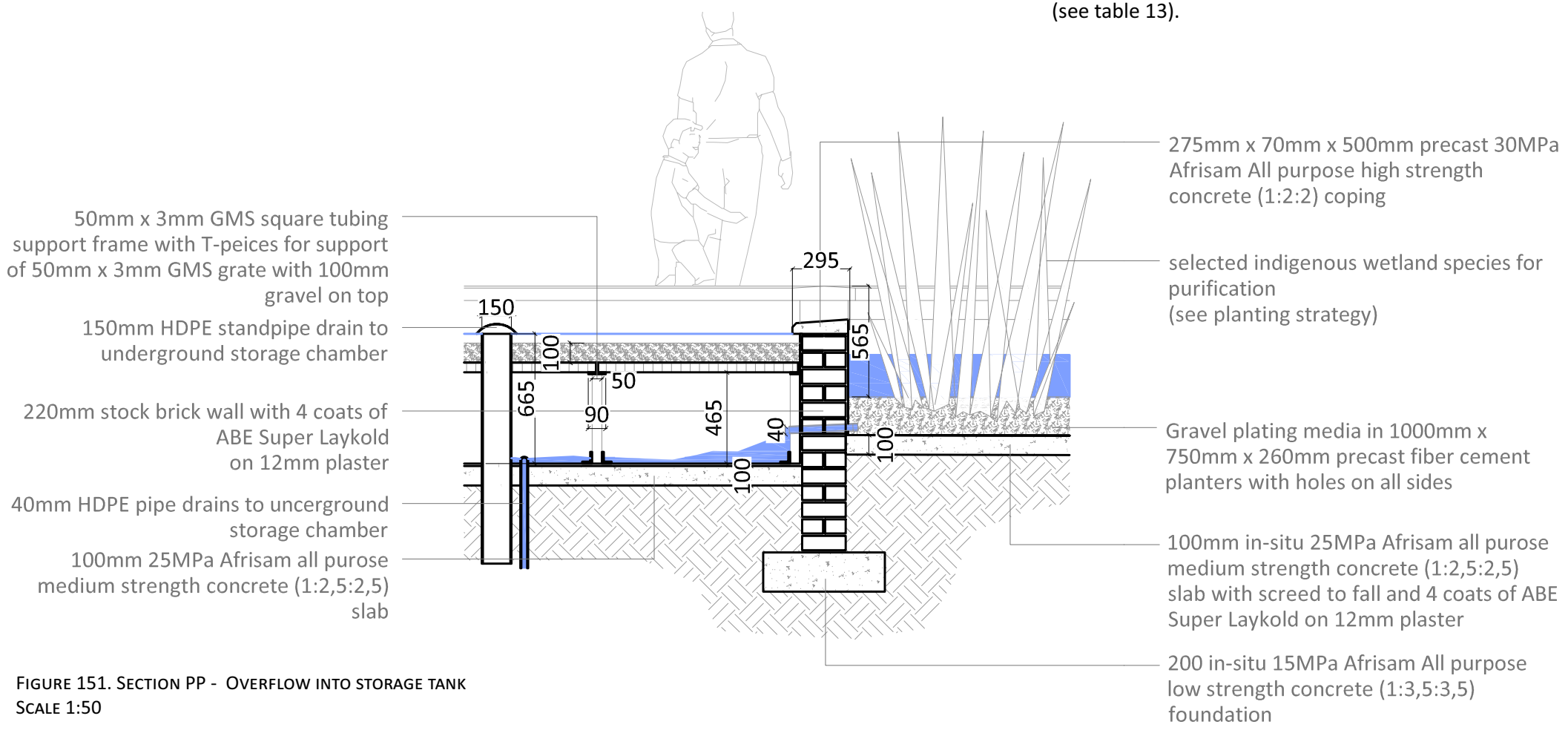
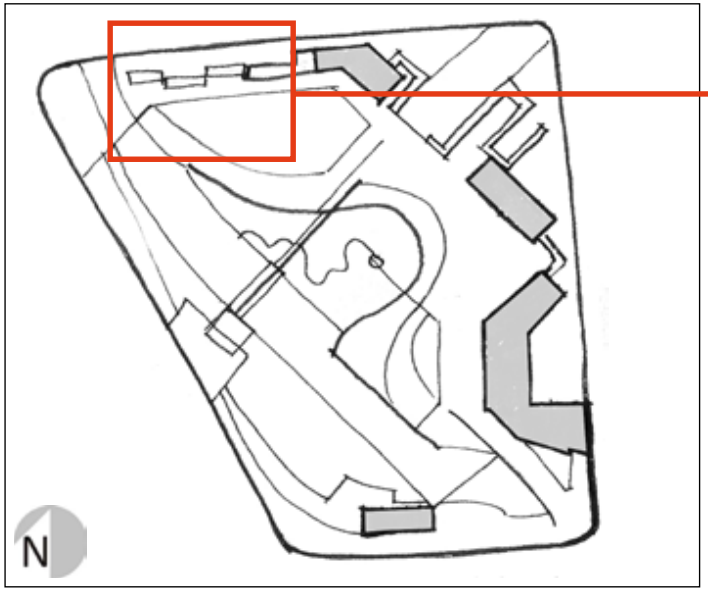


Figure 151. Section PP - Overflow into storage tank
Scale 1:50

grey water wetland							
component	channel width	Q	A	P	n	S	y
	0.775	0.019	0.04263	0.522	0.021	0.0025	0.055

TABLE 13 - GREY WATER WETLAND CHANNEL SIZE CALCULATION



Water from the rain-meter system; the grey water system and harvested surface runoff all contributes towards meeting the water needs of irrigation and buildings.

FIGURE 152. SECTION LINES QQ & RR
SCALE 1:200

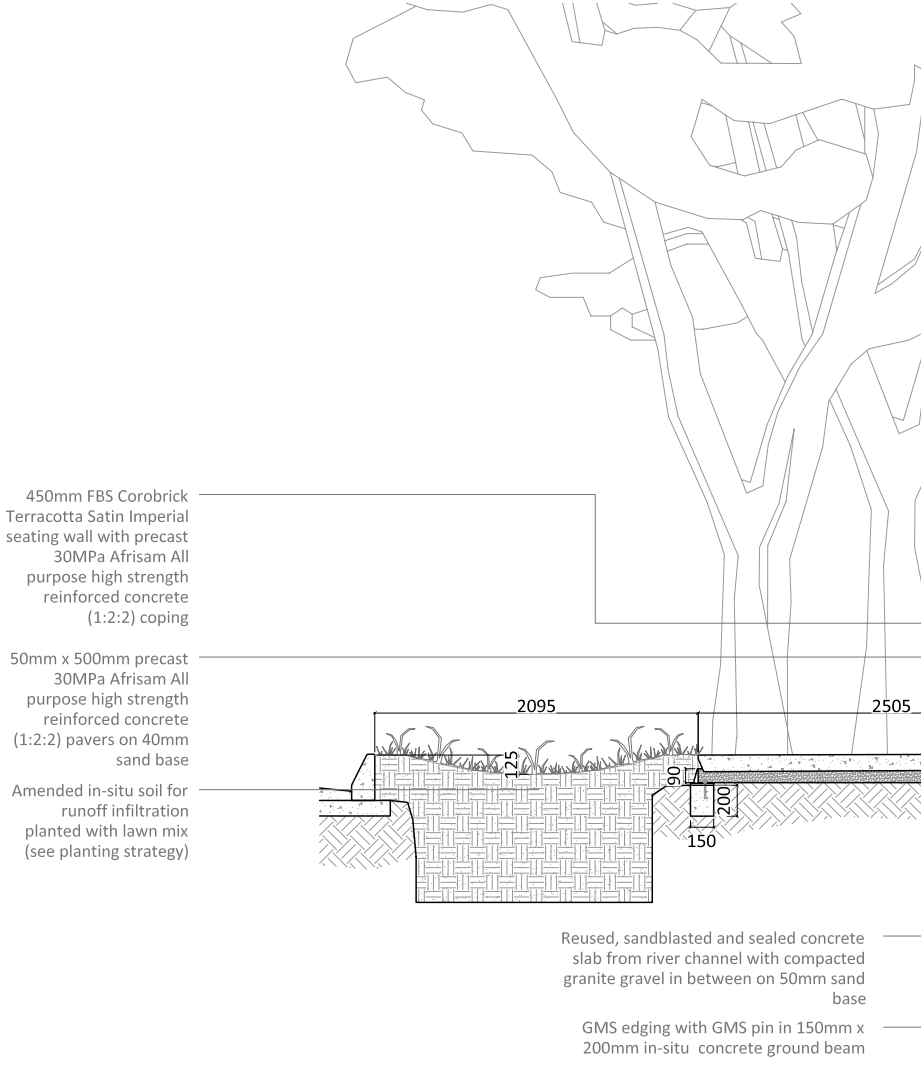
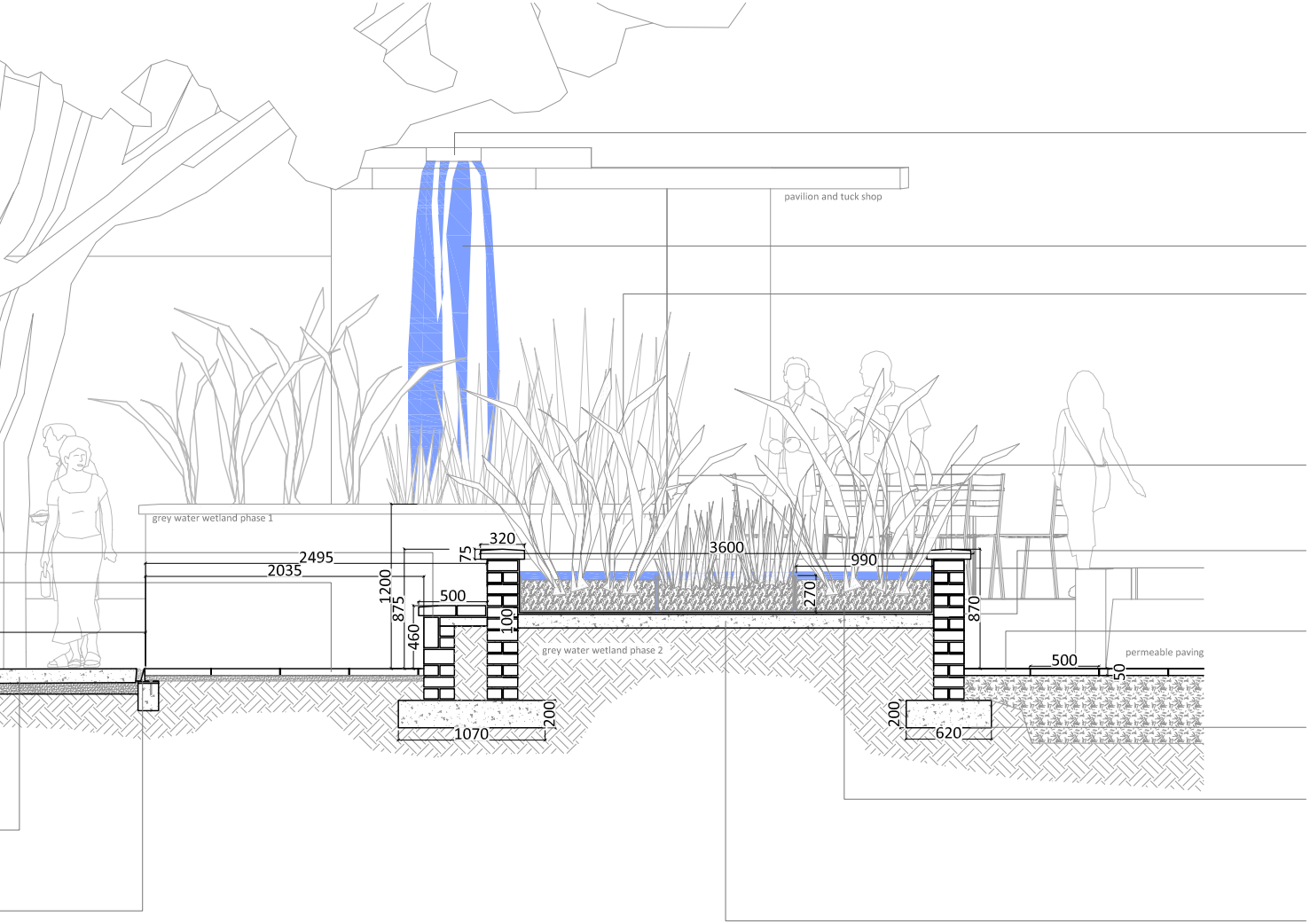


FIGURE 153. SECTION QQ - GREY WATER WETLAND
SCALE 1:50



Red powder coated mild steel asymmetrical tipping device decants grey water into wetland

grey water being aerated, pumped from gravel and sand filter

selected indigenous wetland species for purification (see planting strategy)

320mm x 75mm x 500mm precast 30MPa Afrisam All purpose high strength concrete (1:2:2) coping

220mm FBS Corobrick Terracotta Satin Imperial wall with 4 coats of ABE Super Laykold on 12mm plaster (on inside)

500mm x 500mm x 50mmm brushed precast, 30MPa Afrisam All purpose high strength concrete (1:2:2) paver on 500 compacted on site rubble

200 in-situ 15MPa Afrisam All purpose low strength concrete (1:3,5:3,5) foundation

Gravel plating media in 1000mm x 750mm x 260mm precast fiber cement planters with holes on all sides

Screed to fall

100mm 25MPa Afrisam all purose medium strength concrete (1:2,5:2,5) slab

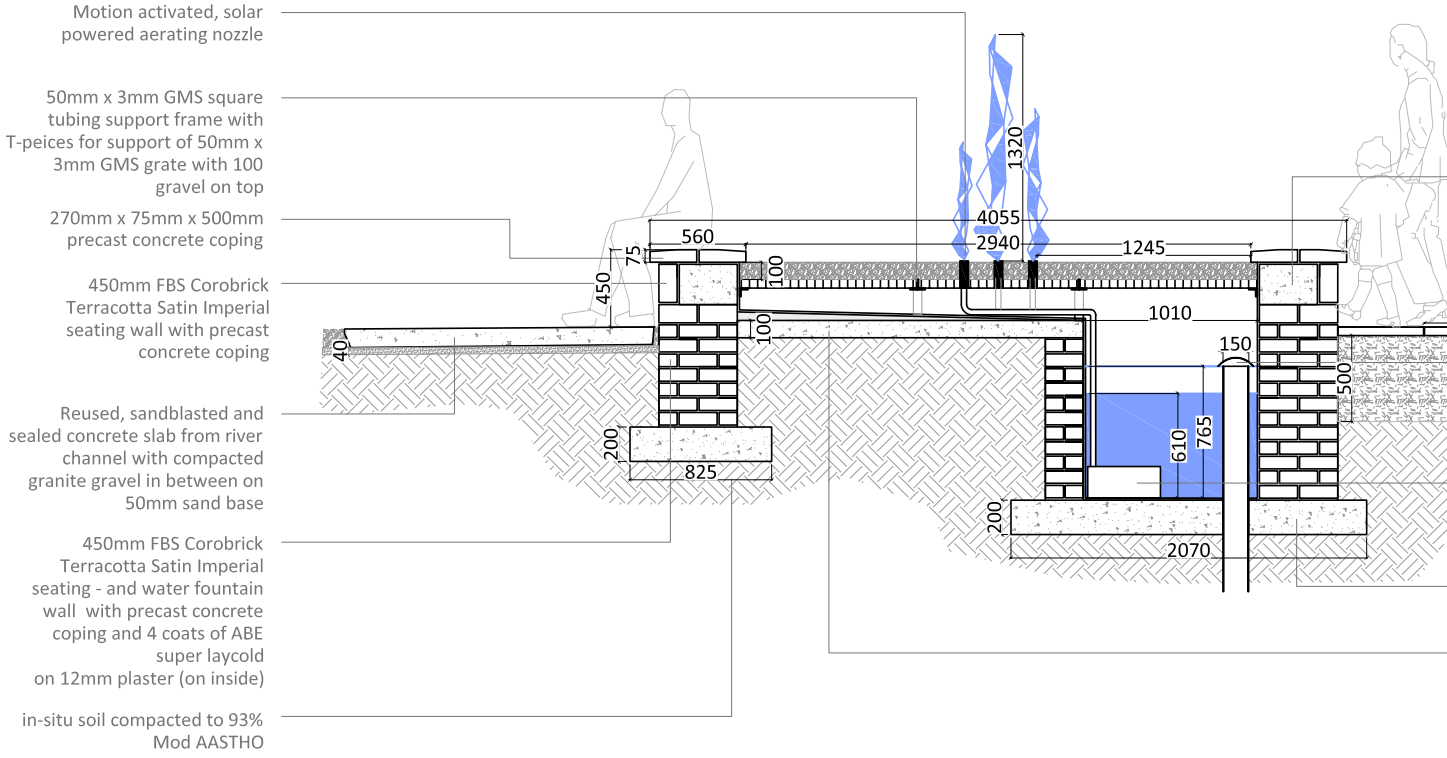
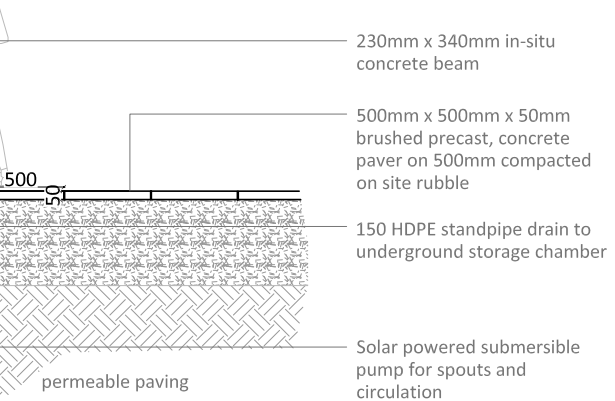


FIGURE 154. SECTION RR- GREY WATER FOUNTAIN
SCALE 1:50



230mm x 340mm in-situ concrete beam

500mm x 500mm x 50mm brushed precast, concrete paver on 500mm compacted on site rubble

150 HDPE standpipe drain to underground storage chamber

Solar powered submersible pump for spouts and circulation

2070mm x 200mm in-situ concrete foundatin

100mm in-situ concrete slab with screed to fall and 4 coats of ABE Super Laykold on 12mm plaster

Planting approach

Ecological intent

From the design goals and objectives (chapter 5), the following ecological objectives was identified

- Introduce constructed systems that supports components of ecology by focussing on water as a critical building block
- Incorporate the prominent themes from the ecosystem service analysis
  - Conserving water sources and the systems they support while optimising the use of on-site water and reducing the use of potable water
  - Introducing and preserving existing natural and on site region appropriate biomass

Appropriate biomass

From the historical analysis of the Apies River (see chapter 5), the following appropriate tree and plant species have been identified

- Bushwillows *(Combretum sp)*
- Wild olives *(Olea europaea subsp. africana)*
- White stinkwood *(Celtis africana)*
- Wild currant *(Rhus pyroides)*
- Ferns (Asplenium aethiopicum, Blechum australe and Cyathea dregei are appropriate according to van Jaarsveld (2000 p. 126 - 131)
- *Zantedescia sp.*

According to *Vegetation of South Africa, Lesotho and Swaziland* (Low & Rebelo, 1998 p. 39) the site is classified in the Rocky Highveld Grassland as part of the Grassland Biome.

Vegetation is dominated by grass species, forbs and trees. The use of veld grass in urban applications are limited due to the accumulation of biomass, the seasonal fire hazard and sensitivity towards trampling. A few species will be planted in manageable areas to serve as a reminder of what we have lost.

Selected forbs identified in *Vegetation of South Africa, Lesotho and Swaziland* will be used where appropriate.

All other plants selected are listed in 'Waterbesparende Inheemse Tuinmaak - 'n streeksgids tot inheemse tuinmaak in Suid-Afrika' by Ernst van Jaarsveld. In his publication van Jaarsveld addresses gardening in South Africa by grouping indigenous plants together that are appropriate for each region of South Africa. The groupings are based on suitability regarding climate and water conserving for each region. The site is located in his classification of the *highveld garden*.

On site biomass

All of the Jacaranda trees on site will be utilised and some will be moved to form a continuous edge along the streets. Restricting the use of Jacaranda trees to the street edge not only defines the edge but also maintains and enhances the historical value of Jacaranda trees as part of the heritage of the city.

Indigenous groundcovers will be replanted on site while exotic groundcovers will be used in the on site composting system.

Planting design as a system

Vegetation depends on soil, water and light. The soil on site mostly lies bare, compacted and polluted by rubble. An extensive soil rehabilitation plan needs to be drawn up (it is not within the scope of this thesis to do so). Part of the problem can be addressed by the proposed on site composting facility in that forms part of the service yard behind the shops.

Appropriate water strategies have been devised and covered earlier in chapter 9. Further water saving can be achieved by mulching. Using rocks or gravel as a mulch not only retains moisture in the soil but also reduces the presence of weeds and invasive species and stabilises the soil as well.

Planting groups

Manicured lawn

Cynodon transvaalensis 'florida'

Formalised planting

A selection of the following groundcovers

- *Sphenostylis angustifolia* (Low & Rebelo, 1998 p. 39)
- *Geranium incanum*

Some of the following perennials

- *Asparagus virgatus*
- *Barleria obtusa*
- *Diascia integerrima*
- *Europs tysonii*
- *Haplocarpa scaposa*
- *Plectranthus grallatus*
- *Senecio seminiveus*

(van Jaarsveld, 2000 p. 126 - 131)

Lawn mix

LM or *Dactyloctenium australe* (average height of LM lawn is around 200mm high) used as a continuous surface that will not be regularly mowed. Some of the following bulbs and forbs will be scattered throughout.

When needed, a brush cutter can be used in between emerging plants. These scattered bulbs and forbs will include some of the following

- *Senecio venosus*
- *Xerophyta retinervis* (monkey tail)
- *Crassula lanceolata*
- *Scilla nervosa*

Above mentioned are specific to Rocky Highveld Grassland vegetation (Low & Rebelo, 1998 p. 39)

- *Boophane disticha*
- *Chlorophytum krookianum*
- *Crocosmia aurea*
- *Dierama adelphicum*
- *Eucomis autumnalis*
- *Eucomis bicolor*
- *Gladiolus dalenii*
- *Haemanthus sp.*
- *Hypoxis hemerocallidea*
- *Moraea huttonii*
- *Nerine bowdenii*
- *Scadoxus puniceus*
- *Watsonia pillansii*

(van Jaarsveld, 2000 p. 126 - 131)

Wetland species

Herbaceous species with roots in water

- *Crinum bulbispermum*
- *Cyperus latifolus*
- *Cyperus papyrus*
- *Echinochloa cabana*
- *Phragmites australis*
- *Scilla natalensis*
- *Typha capensis*
- *Zantedescia sp.*

Herbaceous species on edge of wetland

- Juncus kraussli
- Juncus effuses
- Hermarthria altissima
- Cynodon dactylon
- Kniphofia uvaria

(Wyatt, 1997 p. 3 - 11)

Veld grass mix

Rock or gravel mulching will contribute to control and space the following grass species

- *Cymbopogon valdis*
- *Hyparrhenia hirta*
- *Melinis nerviglumis*
- *Themeda trianrda*

(van Jaarsveld, 2000 p. 126 - 131)

Plectranthus sp

Geranium incanum

Diascia sp

Typha capensis

Zantedescia aethiopica

Sphenostylis angustifolia

Cyperus papyrus

Juncus effusus

Asparagus viragtus

Celtis africana

Xerophyta retinervis

Eucomis autumnalis

Scilla nervosa

Crocosmia aurea

Combretum erythrophyllum

Melinis sp

Cyathea dregei

Materials

Red face brick relates to the history of the Kirkness brickworks in Groenkloof, Pretoria.

Wooden decking (Ecucalyptus diversicolor 'karri') is widely associated with waterside activities and will strengthen emotive link with the river.

The extensive use of concrete connects with the river channel and the finishes hints at the erosive quality of water. The concrete will be brushed, sandblasted or off shutter while the aggregate will be exposed in some applications. Square concrete flagstones used throughout links with the rigid grid of the city.

Bullet proof glass will be used for the rain meter tanks along with stainless steel and powder coated black and red mild steel.

Handrails will be stainless steel.

exposed aggregate concrete

bullet resistant glass

wood

red face brick

wooden seating

off shutter concrete wall

red brick paving

Eucalyptus saligna decking

sandblasted concrete

10

Green Star SA audit

The investigation of a possible application of Green Star SA on Landscape Architecture (see chapter 2) has shown that 44,2% of the rating tool can be applied.

The author concluded in chapter 3 that water appears to be the golden thread that links most on site systems and eco-system services; therefore all *green* aspects of the project was conceptually approached through investigating the role of water in every part.

From this the technical investigation of the project (see chapter 9) focussed on the three on site water systems: river system, rain and runoff system and grey water system. Where detail lacks in other technical aspects of the design, an informed assumption was made.

The self assessment audit (table 14) rates the project 37%. The score can now be divided by 44,2% to relate it back to the landscape applicable categories. Thus the project scores 83,7% which would be a six star rating.

Comparing Green Star SA Office V1 with the outcomes of the Sustainable Sites Initiative (SSI) investigation

Main themes form the SSI includes

- Conserving water sources and the systems they support while optimising the use of on site water and reducing the need for potable water
- Preserving existing natural and on site region appropriate biomass
- Using renewable- and waste minimising materials that does not pollute through manufacturing, application or after installation
- Optimise human use and health benefits by integrating the on site systems to improve the experience of man's environment

Through the Green Star SA Office V1 rating process and the study of eco-system services (listed above), the author found that the Green Star SA rating system addresses most of the themes from the SSI investigation.

The positive result of the audit might not be as accurate as one would hope because a lot of assumption had to be made with regard to basic building information that was required and estimated.

From the comparison

The author believes that converting the Green Star SA rating tool into a fully fledged landscape rating tool is well within reach. In the envisaged tool, there should

be an fundamental relationship between the 'Water' and 'Land Use & Ecology' categories as water is a basic building block in terrestrial ecology; this link does not exist in the current Green Star SA Office V1 rating tool.

An integration of the human use and health benefits with storm water and other systems into this category would be advisable.

Green Star SA - Office Design v1

Credit Summary

Urban Water Centre

Category	Title	Credit No.	Points Available	Points Achieved	Points to be Confirmed	Percent of Available Points Achieved	Weighting	Weighted Score
Management								
	Green Star SA Accredited Professional	Man-1	2	2	0			
	Commissioning Clauses	Man-2	2	2	0			
	Building Tuning	Man-3	2	2	0			
	Independent Commissioning Agent	Man-4	1	1	0			
	Building Users' Guide	Man-5	1	1	0			
	Environmental Management	Man-6	2	2	0			
	Waste Management	Man-7	3	3	0			
	Airtightness Testing	Man-8	1	na	0			
		TOTAL	**14**	**13**	**0**	93%	9%	**8.4**
Indoor Environment Quality								
	Ventilation Rates	IEQ - 1	3	na	0			
	Air Change Effectiveness	IEQ - 2	2	na	0			
	Carbon Dioxide Monitoring and Control	IEQ - 3	1	0	0			
	Daylight	IEQ - 4	3	na	0			
	Daylight Glare Control	IEQ - 5	1	na	0			
	High Frequency Ballasts	IEQ - 6	1	na	0			
	Electric Lighting Levels	IEQ - 7	1	na	0			
	External Views	IEQ - 8	2	2	0			
	Thermal Comfort	IEQ - 9	2	na	0			
	Individual Comfort Control	IEQ - 10	2	na	0			
	Hazardous Materials	IEQ - 11	1	1	0			
	Internal Noise Levels	IEQ - 12	2	na	0			
	Volatile Organic Compounds	IEQ - 13	2	#VALUE!	0			
	Formaldehyde Minimisation	IEQ - 14	0	na	0			
	Mould Prevention	IEQ - 15	1	na	0			
	Tenant Exhaust Riser	IEQ - 16	1	na	0			
	Environmental Tobacco Smoke (ETS) Avoidance	IEQ - 17	1	na	0			
		TOTAL	**26**	**4**	**0**	15%	15%	**2.3**
Energy								
	Conditional Requirement	Ene -	0	na	0			
	Greenhouse Gas Emissions	Ene - 1	20	0	0			
	Energy Sub-metering	Ene - 2	2	na	0			
	Lighting Power Density	Ene - 3	4	1	0			
	Lighting Zoning	Ene - 4	2	na	0			
	Peak Energy Demand Reduction	Ene - 5	2	na	0			
		TOTAL	**30**	**1**	**0**	3%	25%	**0.8**
Transport								
	Provision of Car Parking	Tra - 1	0	na	0			
	Fuel-Efficient Transport	Tra - 2	0	na	0			
	Cyclist Facilities	Tra - 3	3	0	0			
	Commuting Mass Transport	Tra - 4	5	5	0			
	Local Connectivity	Tra - 5	2	2	0			
		TOTAL	**10**	**7**	**0**	70%	9%	**6.3**
Water								
	Occupant Amenity Water	Wat - 1	5	0	0			
	Water Meters	Wat - 2	2	na	0			
	Landscape Irrigation	Wat - 3	3	3	0			
	Heat Rejection Water	Wat - 4	4	na	0			
	Fire System Water Consumption	Wat - 5	0	na	0			
		TOTAL	**14**	**3**	**0**	21%	14%	**3.0**

TABLE 14 - GREEN STAR SA SELF ASSESSMENT

Category	Title	Credit No.	Points Available	Points Achieved	Points to be Confirmed	Percent of Available Points Achieved	Weighting	Weighted Score
Materials								
	Recycling Waste Storage	Mat - 1	2	2	0			
	Building Reuse	Mat - 2	0	na	0			
	Reused Materials	Mat - 3	1	1	0			
	Shell and Core or Integrated Fit-out	Mat - 4	1	na	0			
	Concrete	Mat - 5	3	1	0			
	Steel	Mat - 6	0	na	0			
	PVC Minimisation	Mat - 7	1	na	0			
	Sustainable Timber	Mat - 8	2	1	0			
	Design for Disassembly	Mat - 9	0	na	0			
	Dematerialisation	Mat - 10	1	0	0			
	Local Sourcing	Mat - 11	2	1	0			
		TOTAL	**13**	**6**	**0**	46%	13%	**6.0**
Land Use & Ecology								
	Conditional Requirement	Eco -	0	0	0			
	Topsoil	Eco - 1	1	1	0			
	Reuse of Land	Eco - 2	2	2	0			
	Reclaimed Contaminated Land	Eco - 3	2	2	0			
	Change of Ecological Value	Eco - 4	4	2	0			
		TOTAL	**9**	**7**	**0**	78%	7%	**5.4**
Emissions								
	Refrigerant / Gaseous ODP	Emi - 1	1	na	0			
	Refrigerant GWP	Emi - 2	2	na	0			
	Refrigerant Leaks	Emi - 3	0	na	0			
	Insulant ODP	Emi - 4	1	na	0			
	Watercourse Pollution	Emi - 5	3	3	0			
	Discharge to Sewer	Emi - 6	4	0	0			
	Light Pollution	Emi - 7	1	1	0			
	Legionella	Emi - 8	1	na	0			
	Boiler and Generator Emissions	Emi - 9	0	na	0			
		TOTAL	**13**	**4**	**0**	31%	8%	**2.5**
						Sub-total weighted points achieved:		**36**
Innovation								
	Innovative Strategies & Technologies	Inn-1	5	1	0			
	Exceeding Green Star SA Benchmarks	Inn-2	5	0	0			
	Environmental Design Initiatives	Inn-3	5	0	0			
		TOTAL	**5**	**1**	**0**	(Innovation is not weighted)		**1**
						Total weighted points achieved:		**37**

Minimal standards for Green Star SA certification not met.

The GBCSA does not endorse any self-assessed rating achieved by the use of Green Star SA - Office v1. The GBCSA offers a formal certification process for ratings of Four Stars and above; this service provides for independent third party review of points claimed to ensure all points can be demonstrated to be achieved by the provision of the necessary documentary evidence. The use of Green Star SA - Office v1 without formal certification by the GBCSA does not entitle the user or any other party to promote the Green Star SA rating achieved.

Weighted Score	Rating
45-59	Four Star
60-74	Five Star
75+	Six Star

Conclusion

Themes from the abstract, hypothesis and problem statement

- The role of water in urban Landscape Architecture
- Water as the base of *green* Landscape Architecture
- Awareness and conservation of on site water
- Context specific strategies based on ecosystem services as described in the SSI and the formulation of aims and strategies
- Managing the South African water crisis through strategies that addresses watercourses, storm water, irrigation and planting on individual sites
- The contribution of a systems approach to site design in the maintenance of ecological function and adding to biodiversity

Findings

The need for water is shared by people and industry around the world, and it is this basic need (see chapter 4) that draws people to water. Water is one of the building blocks of nature and ecosystems (see chapter 3), but urban environments alienates the urbanite from nature.

Landscape Architecture that provides meaningful encounters with water in a green *way, addresses more than a physical element, but reminds man of his dependency on nature.*

All possible projects and sites around the world, whatever the climate or use might be, are influenced by or dependant on water. Rain is the most common source of water, although sometimes overlooked as a resource and runoff is treated as an inconvenience. While rivers and water bodies are scarce resources, most of the sites humans use generates some waste water. Thus the themes of waste water and rainwater is universal, and core strategies for utilising and managing them are universal as well. Because of the critical role of water in our lives and the ecology that supports us, awareness needs to be heightened regarding the qualities, uses and importance of water. This awareness is raised through creating memorable experience with water. The wave-like bridge and seating deck reminds of the volume, power and motion of water. The tank-like rain meters educate us on rainfall volumes and frequency, while creating anticipation around rain events and ultimately combines all of this in a relaxing, interesting and inviting space. Small groups or individuals can enjoy these spaces that are enriched by the way water refracts light and distorts images. The water wheel adds motion activity and sound to the site and tells us of the energy of water that can be utilised. The play ponds that fills up and drains through the vortex creates an ever changing scene where children and adult alike can feel the cool, clear water of the river on their hands and feet and discover crabs, insects and water plants in the constructed stream that drains into the channel.

These vivid experiences are created through the introduction of three visible on site water systems, namely the river base flow system, rain meter maze system and the grey water system (see chapter 9). The path of water through each system can be observed and will be elaborated on through informative signage.

Focussing green *design purely on technical and economic approach to on site water neglects the role of water in social and environmental systems. Thus while basic strategies for water harvesting and conservation are universal, each site needs to express the cultural, historical and emotional aspects of on site water (see chapter 8) through relevant and exciting designs that evoke meaning, introspection and celebration.*

Consequently this thesis utilises water as a fundamental component of urban Landscape Architecture and capitalise on the physical and emotive

qualities of water. The design creates places of reflection and introspection through shaded seating areas that overlooks the pools and constructed stream. The energising and life giving aspects of water is celebrated in joyfully animated motion activated water fountains.

Water thus becomes a recreational catalyst, an educative tool, a building block for ecology and a money saving resource.

The site design contributes towards managing the South African water crisis through realising that problems with river water quality should be addressed on a catchment and site specific scale. Balancing planting design, planting area and irrigation needs to create an optimal water budget, treating water as a vital and precious resource that needs to be conserved and used wisely.

The systems approach that the author investigated led to an understanding of the complex components that creates functional systems. The river base flow system, the rain meter maze system and the grey water fountain system contributes towards reaching the design intent. For example, the river base flow system's design intent was to let people interact with the river water. This aim is simple in concept, but challenges like getting the water out of the channel, improving the quality of the water and addressing the different properties of water called for a very intricate system.

Understanding the critical parts of the system and what it depends on led to achieving the design intent.

The investigation of the SSI ecosystem service matrix led to the conclusion that water supports the following overarching aims (see chapter 3):

- Conservation of water sources and the systems they support while optimising the use of on site water and reducing the use of potable water
- Introducing and preserving existing natural and on site region appropriate biomass
- Using appropriate materials
- Optimising human use and health benefits by integrating the on site systems to improve the experience of man's environment

These aims become overarching ideals that are integral to the design approach and must become part of the mind-set of the designer.

Strategies formulated through the design exploration

- *Design a rainwater and runoff harvesting system that supplies in the total irrigation and on site water feature needs*
- *Use surplus water for sanitation purposes*
- *Design planting areas and irrigation as a system where availability of water influences surface area sizes and plant material selection*
- *Use region appropriate plant material and group plants with similar water needs together*
- *Protect, use and re-use on site trees and plant material where appropriate*
- *Re-use on site materials*
- *Use materials sourced from invasive species (gum poles from the Apies River valley, see chapter 8)*
- *Use renewable materials*
- *Use materials that does not pollute through manufacturing process, installation or after installation*
- *Integrate rainwater and storm water harvesting systems into the spatial experience of the site to provide an emotional link between the user and nature that sustains us*

Themes from the design brief and objectives

- Create a repose in the city where the influence of the river on the city grid is celebrated
- Address the division of the city through unifying the site
- Enhance and protect the openness of the site
- Address and utilise the small base flow, accommodate flash floods while softening the channel
- Entice use throughout the day
- Expose the ecological, historical and cultural memory of the site
- Utilize the introduced system components to create diverse ecosystem components

Findings

The design deals with city scale challenges and protects the openness of the site. This is done by providing a building edge that focuses inwards towards a large green core of the site. The green core functions as a series of social interaction spaces. The alignment of the buildings speak to the change in grid from the old city core to the suburbs due to the Apies River. The introduced grid responds to the rigid concrete channel and the pedestrian link (see chapter 1) follows this grid diagonally across the site. The rigid grid of the city is portrayed in the paving design where square blocks are aligned to the new grid. The paving grid also comments on the different scales in the city. A 3x3 meter grid in the paving signifies large public open spaces while 1x1 meter pavers are used for main circulation zones and 0.5x0.5 meter pavers are used in places designed for smaller gatherings and use of individuals.

The environmental, historical and cultural significance of Apies River were introduced via celebrating the memory the river. An abstracted line where the river used to run (from the SG diagrams of the Erfs, see chapter 7) intersects and influences the concrete channel and comments on the physical changes made to the river. By the reintroduction of vegetation that was removed with the building of the channel (descriptions from historical records and books) one is reminded of the environmental conditions that existed around the river. An old flood control rock wall is celebrated as a form giver at a pedestrian entrance at the corner of Vermeulen Street and Ockerse Street. The existing building of the BMW motorcycle shop will be converted into a restaurant and integrated into the proposed built fabric of the site.

Use throughout the day is enticed by:

- *Providing opportunities for kids to play after school and in lunch breaks (interview with headmaster of SA Private School)*
- *Creating spaces for students to laze around, read and socialise*
- *Supplying pedestrians with appropriate space to rest, use the tuck shops and retail facilities*
- *Luring residents from the surrounding suburbs to the park through creating a green space to relax and play in*
- *Opening restaurants and cafe's that cater for different income groups and tastes*

Integrating Green Star SA, the SSI investigation and General Systems Theory into a design project

Figure 155 explains the design process that was followed; it indicates when and how each component of theory and investigation steered and influenced the design and thought processes.

The theoretical investigation led to an informed design process that culminated into the integration of the social, emotional and experiential needs of the user with the economic, technical and environmental aspects of *green* Landscape Architectural design.

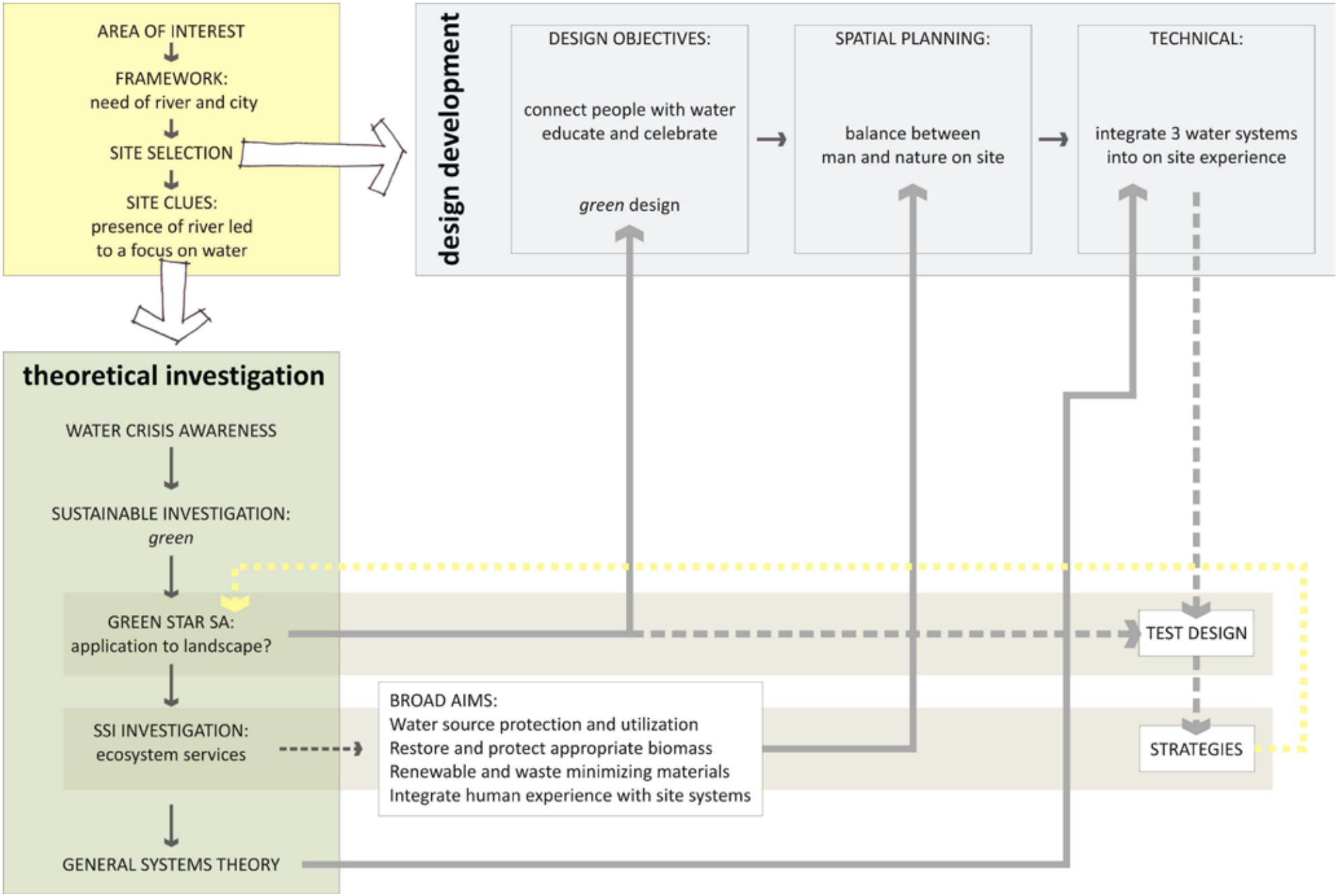


FIGURE 181. DESIGN INTEGRATION

the end

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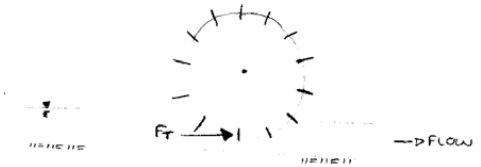
TEORETIESE BENADERING: WATER VERPLASING DEUR WATERWIEL

KONSEP ONTWERP

- DOEL: WATERVERPLASING OF ENERGIEVERPLASING NA POTENSIËLE ENERGY (HOOGTE) DEUR KINETIESE ENERGIE (VLOEI) TE GEBRUIK
- METODIEK: BESKOU WATERWIEL AS STATIES/DINAMIESE LIGGAAM EN EVALUEER KRAGTE → TOEGEPAS ≠ REAKSIE.

TOEGEPASTE KRAG

DIE ENIGSTE TOEGEPASTE KRAG IN DIE VRY-ROTERENDE STELSEL, IS DIE VLOEIKRAG VAN DIE KANAALVLOEI OP DIE WIEL, F_T



VOLGENS MOMENTUM VAN VLOEI,

$$F_T = \rho . Q . (V_2 - V_1)$$

WAAR DIE KRAG UITGE-OEFEN DEUR DIE WATER GEGEE WORD AS DIE PRODUK VAN DIE DIGTHEID ($1000 kg/m^3$), die vloei (m^3/s), EN DIE SNELHEIDSGRADIENT (m/s).

AANGESIEN HIERDIE WAARDE DEUR KANAAL HIDROLIKA GEMANIPULEER KAN WORD, IS DIT MINDER KRITIES

REAKSIE KRAG

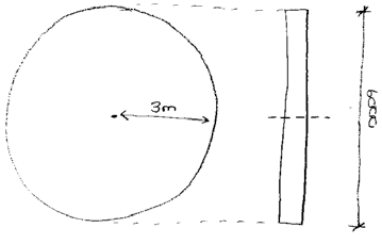
DIE VOLGENDE REAKSIEKRAGTE WORD VERWAG:

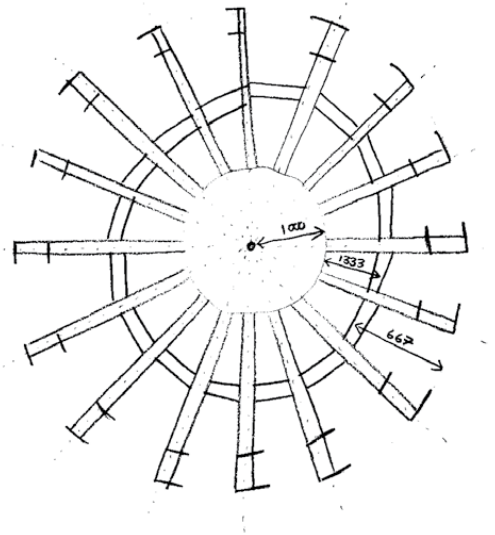
1. WEERSTAND TEEN WIELROTASIE - WRYWING OP AS — GENEEM AS 0 (VRYROTEREND)
2. MASSA VAN WIEL - GEGEE IN VERHOUDING WAAR $F = m.a$ (NEWTON)
3. MASSA VAN WATER IN BAKKIES - GEGEE AS $F = m.a$ (NEWTON)

DUS:

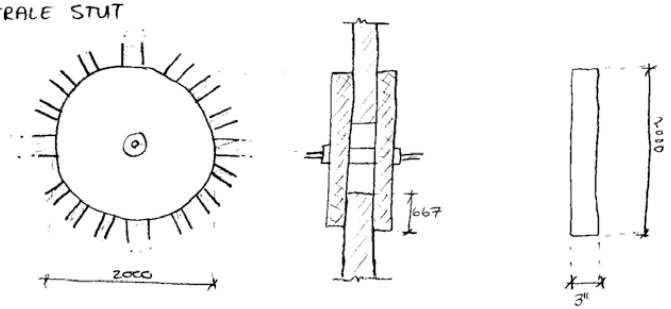
WIEL ONTWERP

DIE VOLGENDE WORD VOORGESTEL AS EERSTE BENADERING, EN IS AANPASBAAR

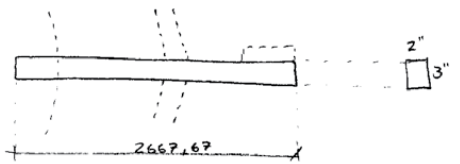




AS / SENTRALE STUT

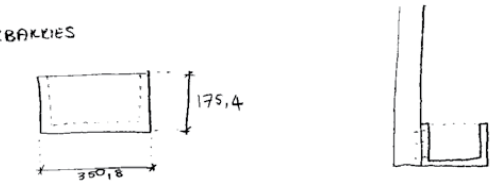


SPEKE



DWARSBALKE

WATERBAKKIES



④ STRUCTURAL TIMBER @ $\rho = 850\ kg/m^3$ OR SIMILIAR

BEREKENINGS

BEPAAL TOEGEPASTE, F_T, EN REAKSIEKRAGTE, F_{Ri}, EN NEEM MOMENTE OM SENTRALE AS, 'O'

NEEM $F_T = 1\ kN$

F_{Ri} → MASSAKOMPONENT VAN INDIWIDUELE DELE + MASSA KOMPONENT VAN WATER

$$\therefore \Sigma M_o = (2)(-99,33)(3000\cos 67,5°) + (2)(-99,33)(3000\cos 45) + (2)(-99,33)(3000\cos 22,5°) + (2)(-99,33)(3000) + (1000)(3)(1000)$$

$$= 1502\ N/m$$

→ HIERDIE IS DIE TOEGEPASTE ROTASIEKRAG OP DIE WIEL SE AS VIR DIE TYD WAT DIE WIEL IN KONTAK IS MET WATER

DIE VERHOUDING TUSSEN TOEGEPASTE MOMENT ("TORQUE") EN GEPAARTGAANDE VERSNELLING WORD GEGEE AS:

$$\Sigma M_o = I.\alpha$$

WAAR I → TWEEDE MOMENT VAN AREA / TRAAGHEID
α → HOEKVERSNELLING IN rad/s^2

$$I = \Sigma r_i^2 . m_i$$

$$= (16)(1,67)^2(0,0103)(850) + (16)(2,33)^2(0,0034)(850) + (16)(2,85)^2(0,0085)(850) + (10)(2,85)^2(0,01125)(1000)$$

$$= 2403,06\ kg/m^3$$

$\therefore$ DUS $\Sigma M_o = I.\alpha$

$$1502\ N/m = 2403,06\ kg/m^3 . \alpha$$

$$\therefore \alpha = 0,625\ rad/s^2$$

EN $a = \alpha . r$

$= (0,625)(3)$

$= 1,875\ m/s^2$ (VERSNELLING VAN INDIWIDUELE WATERBAK, GEMBLIKLIK)

$$s = \frac{2\pi r}{16} = 1,18m$$

④

BASIESE BEWEGINGSVERGELYKINGS : (1ST BEGINSELS)

$v^2 = u^2 + 2as$, met $u = 0$ (Beginsnelheid)

$v^2 = 2as$

$= 2(1,875)(1,18)$

$v = 1,486 \text{ m/s}$

∴ WATERWIEL VERVOER $0,0085 m^3$ water teen $1,486 m/s$ oor $1,18m$

$v = u + at$, met $u = 0$

$v = at$

$t = v/a = 0,793 s$

∴ $0,0085 m^3$ IN $0,793 s$

$Q_{gelewer} = 10,72 \ l/s$

2009/09/16
To: Tobias Mahne

REPORT BACK: WATERWHEEL CONCEPT DESIGN.

1. PURPOSE

The purpose of this report is to provide feedback on the concept design for a waterwheel in the Apies River

2. CONCEPT

The waterwheel will utilise kinetic energy from the force of flowing water, to translate water to a given elevation. This will be accomplished by converting the available kinetic energy to potential energy through applying a torque to the waterwheel, i.e. turning the waterwheel.

3. WHEEL DESIGN

For the purpose of this concept design and explanation, the wheel shall be as follows:

4. STATICS

In order to determine all the relevant forces acting on the waterwheel, and created by the waterwheel, it is necessary to create an imaginary control volume, within which all the forces can be quantified. These forces will be separated into *applied forces*, and *reaction forces*. Applied forces are those which act externally unto a system. Reaction forces are those forces *caused* by the applied forces.

4.1. APPLIED FORCES

The following applied forces are applicable:

- The force applied unto the waterwheel by the flow of water in the base channel, F_T;
- The weight of the waterwheel, m_1;
- The weight of the water in the buckets of the waterwheel at any time, m_2;

The first *applied* force is that cause by the obstruction in the free-flowing water channel (base channel). This force can be calculated by utilising the principle of momentum. Momentum is basically defined by the following relationship:

$$Momentum = m \cdot v$$

where

m = mass of object
v = velocity of object

The force caused by a sudden change in momentum, is simply the change in momentum. If the mass of the object does not change, then the force is calculated by the change in velocity. For water, this can be described as:

$$F_T = \rho \cdot Q \cdot (v_2 - v_1) \qquad (1)$$

where

F_T = momentum force, in N
ρ = density of water, in kg/m³
Q = flow rate, in m³/s
v_1 = initial velocity, in m/s
v_2 = end velocity, in m/s

In this case, the parameters are found to be:

ρ = 1000 kg/m³
Q = 1,148 m³/s
v_1 = 2,262 m/s
v_2 = 2,51 m/s
and therefore $\mathbf{F_T}$ = **1210 N** *(from 1)*

Since the weight of the waterwheel, m_1, is located symmetrically around the axis of the waterwheel, it was found to be inconsequential to the force analysis. This will be shown later.

The volume of each bucket is 0,01133m³, or 11,33l. Of this volume, approximately 75% will be filled with water. Thus, the weight of the water, m_2, is

$$\mathbf{m_2} = (0{,}75)(0{,}01133)(1000)(9{,}81)$$
$$= \mathbf{83{,}36\ N}$$

4.2. REACTION FORCES

All the applied forces results in a rotation force (torque) being applied around the axis of the waterwheel. This force can be found by taken the sum of the all the moments of the applied forces around the axis (because the weight of the wheel is symmetrical around the axis, its moment is equal to zero):

$$\sum M = \sum(F.d)$$
$$= 1498\ \text{N.m}$$

Thus, the rotation force *caused* by the applied forces, is **1 498 N.m.**

5. DYNAMICS

In order to determine the available discharge from the waterwheel, the rotation speed of the wheel needs to be calculated.

Because the reaction moment around the axis is known, the angular acceleration can be calculated as follows:

$$\sum M_0 = I \cdot \alpha \qquad (2)$$

where

M_o = total moment around axis, in N.m
I = second moment of area, in kg/m³
α = angular acceleration, in rad/s;

In its turn, the second moment of area, I, is defined as:

$$I = \sum r_i^2 \cdot m_i$$

and is calculated as

I = 2403,06 kg/m³

Note that this is a constant value for the given weight characteristics of the waterwheel. Should the design or construction materials change, this value will change with it.

Now the angular acceleration can be calculated from (2), and is found to be:

α = 0,625 rad/s

The corresponding acceleration of the water buckets is:

a = α.r
= 1,875 m/s²

With each bucketful, the wheel will turn

s = (2.Π.r)/16
= 1,18 m

Now, by basic movement equations, we find that the velocity of the wheel will be

v = 2,51 m/s

The discharge is therefore:

Q = v.V
= (2,51).(0,75).(0,01133)
= 9,03 l/s

6. BASE CHANNEL DESIGN

Discharge can be calculated with the following equation:

$$Q = \frac{1}{n} \cdot \frac{(A)^{\frac{5}{3}}}{(P)^{\frac{2}{3}}} \cdot S^{\frac{1}{2}}$$

where

Q = discharge, in m³/s
n = Mannings roughness coefficient;
A = cross-sectional area, in m²
P = wetted perimeter, in m
s = slope, in m/m

Therefore a channel of 1,45m x 0,35m will discharge 1,148 m³/s with a velocity of 2,51 m/s at a slope of 1:200.

7. MATERIALS

For this concept design, structural timber with density of 850 kg/m³ was used. If any other material is to be used, it should be kept in mind that any increase in total weight will require more base channel flow, as the second moment of area is increased (I value). With structural design, alternative materials such as aluminium, steel or composites could effectively be used to obtain the same value of function.