MAIN CONSULTANT
ANCHOR ENVIRONMENTAL CONSULTANTS

THE ONRUS RIVER WETLANDS
(HEMEL EN AARDE VALLEY, WESTERN CAPE, SOUTH AFRICA)

WETLAND ASSESSMENT

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PREPARED BY

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1 INTRODUCTION

1.1 Background

The Onrus Wetland is located in the Onrus River catchment, which drains through the coastal town of Onrus into Walker Bay, some 7 km northwest of Hermanus. A long history of ongoing and escalating degradation of the wetland (Le Roux et al 2023) culminated in its near-complete destruction during the late-winter storms of 2023 and the associated passage of large volumes of sediment (primarily eroded peat soils) into the Onrus Lagoon and estuary downstream. Erosion of a section of the important scenic Hemel en Aarde Road between Onrus and Caledon also took place as a result of this flood, along with widespread damage to infrastructure including sewer pipelines.

In response to the flood damage and the obvious need to conduct large scale rehabilitation works within the catchment, the Overstrand Local Municipality (OLM) appointed Anchor Environmental Consulting (Pty) Ltd ("Anchor") to manage and conduct the rehabilitation design studies, authorisation processes and implementation works that are required in order to address, as far as possible, the impacts to the downstream ecosystems affected by upstream erosion and flooding, and to rehabilitate, as far as possible, the upstream watercourses (Onrus Wetland and others), so as to result in more sustainable ecosystem management.

In this context, Liz Day Consulting (Pty) Ltd ("LDC") was appointed by Anchor to provide input into this project from the perspective of wetland ecosystem assessment and rehabilitation design and management. LDC is an independent company that specializes in freshwater (i.e. inland) aquatic ecosystem assessment. The specialist's CV is attached as Appendix A.

1.2 Purpose of this report

This report has been compiled primarily to:

- Provide an adequate baseline assessment of the Onrus Wetland and its drivers to inform wetland rehabilitation and remediation plans for the Onrus Wetland;
- Provide a broader perspective to existing threats to wetlands and other watercourses in the Onrus River catchment, to inform future project planning and interventions.

1.3 Terms of reference

The terms of reference for this report were developed iteratively with Anchor, and allowed for the following specialist aquatic ecosystem input:

- A Baseline Study, to identify the *status quo* of the wetland at the time of assessment, including:
    - Desktop and literature review, including mapping from aerial and drone photography;
    - The wetland history, focusing on events over the past 10 years but including a summary of wetland formation, age and general background, drawing on aerial photography and literature;
    - Consideration of the history of flow releases from De Bos Dam, drawing on the hydrological analyses of SRK (2024);
    - Measurement / assessment of:
        - Soil hydraulic conductivity, soil moisture and organic carbon content;
        - Water quality (key characterising variables only);

    - Vegetation (main wetland plant communities)
    - Wetland condition (WET-Health)
    - Wetland ecosystem services
- Liaison with the project engineer (Mr Hans King) regarding the proposed engineering design and implementation methods for rehabilitation of the Onrus Wetland;
- Liaison with the appointed horticulturalist regarding plant species selection and propagation;
- Compilation of a Baseline Report with recommendations for Best Practice Implementation of rehabilitation measures;

1.4 Report informants

This assessment was informed by the following inputs and datasets:

- Multiple site visits, for catchment familiarisation, site walk-overs, general wetland assessments and soil and water quality sample collection and to discuss engineering plans, all conducted between May 2024 and August 2025;
- Consideration of high-resolution photogrammetry orthophotos of the Onrus wetland (2025) as supplied by Mr Hans King (project design engineer) as well as ages from Lidar surveys by Mr Nardus Bosman (Stellenbosch University), made available by Mr King;
- Liaison with specialists on the study team, namely:
    - Prof. Simon Lourenz (project hydrologist)
    - Mr Hans King (project design engineer);
- Liaison with the project management team, namely:
    - Ms Liezl de Villiers (Client: Divisional Manager: Environmental Management and Conservation, Overstrand Municipality)
    - Dr Barry Clark (Project lead: Anchor Environmental)
    - Ms Danielle Smith (Overstrand Municipality);
- Liaison with various people with direct experience / knowledge of the affected Onrus Wetland including:
    - Mr Jason Le Roux (Agricultural Research Centre)
    - Dr Alanna Rebelo (Agricultural Research Centre)
    - Mr Nardus Bosman (Stellenbosch University)
    - Various landowners encountered during site visits including Ms Matilda Roos (Volmoed);
- Liaison with key authorities, including:
    - Western Cape Department of Agriculture (Mr Rudolph Roscher, Mr Christie Cronje, Mr Grant Jephtas)
    - Breede-Olifants Catchment Management Agency (BOCMA) (Ms Elkerine Rossouw, Mr Fabion Smith, Ms Thembela Bushula).

1.5 Assumptions and limitations

This report has been compiled in response to catastrophic erosion of the Onrus Wetland in 2023. Its primary purpose is to assess the extant wetland and provide input into the design and implementation of wetland rehabilitation and remediation measures. There is high urgency for implementation, given the real risk of ongoing, event-driven erosion of vestigial wetland sediments and the environmental and other costs of their accumulation downstream. This means that this study has focused on collation of existing core wetland data and the findings of previous assessments that are relevant to this study. Wetland delineation for the main Onrus Wetland is coarse and based onpre-2023 wetland extent as seen in Google Earth imagery – the extant wetland is considerably smaller and most of the visible wetland vegetation is severely compromised and unlikely to be sustained beyond the short to medium term (see Section 4).

This assessment has not, moreover, included any detailed faunal or botanical assessment, relying instead on previous studies for background information while noting that the extent of recent (post 2023) wetland degradation is likely to have severely compromised habitat quality and accessibility for many wetland and wetland-associated fauna.

No attempts at dating of wetland sediments were included in this project, which relies for such background information n (albeit limited) available data in published literature, for comparable systems. Given that the project itself aims to stabilise the remnant wetland and improve current wetland function, these limitations are not considered significant.

Of more relevance to the rehabilitation plan itself are data limitations relevant to the actual proposed wetland rehabilitation / remediation works, in particular relating to available and required sediment volumes and quality, and the likely trajectory and associated fire risks of vestigial peat and associated palmiet reedbeds that have been separated from surface and subsurface flows as a result of major channel incision. A conservative approach has been taken in this regard.

1.6 Study area location and extent

Figure 1.1 shows the extent of the Onrus River Catchment as a whole, and its location within the Western Cape of South Africa. **Figure 1.2** shows the location of the Onrus Wetland itself, nested within this catchment.

Figure 1.1
Location of the Onrus River and Onrus wetland in the Western Cape, South Africa

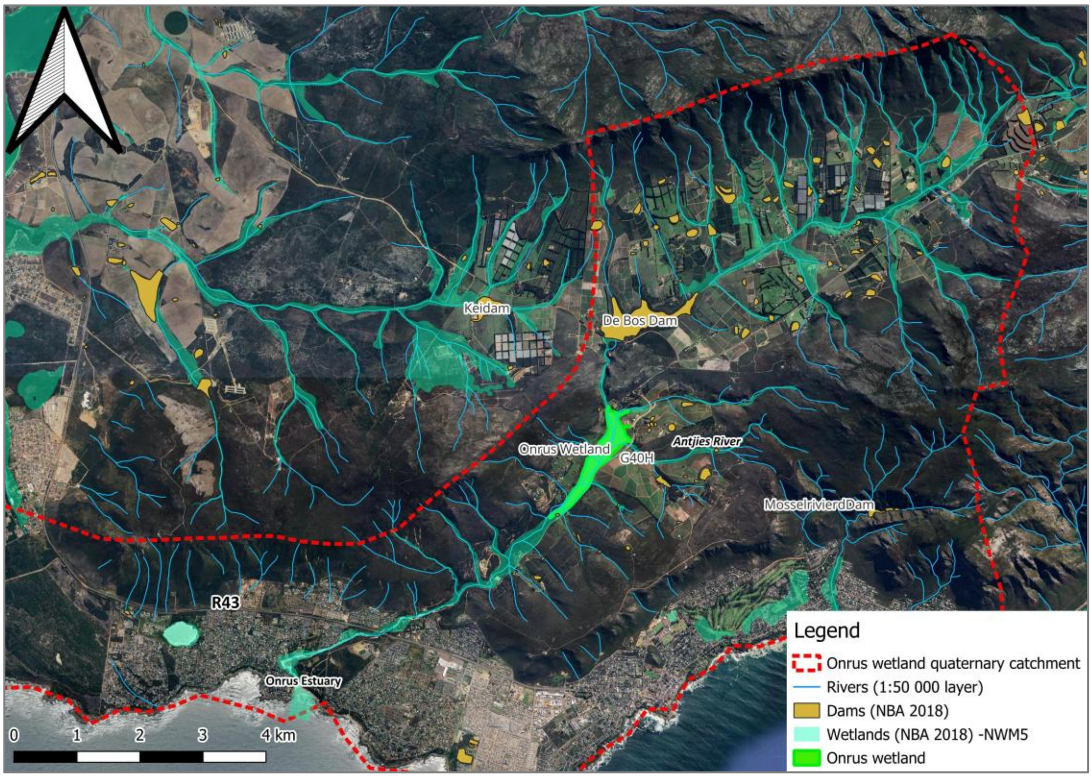

Figure 1.2
Onrus River and Onrus wetland in quaternary catchment G40H, shown in the context of other mapped wetland and river layers.

2 ASSESSMENT METHODOLOGIES

This section outlines important definitions that have guided watercourse assessments and commentary as well as methodologies for watercourse assessments that are presented in this report and used to inform recommended interventions.

2.1 Definitions

All references to wetlands and watercourses in this document are based on the following definitions, taken from the National Water Act (NWA) (Act 36 of 1998):

"**watercourse**" means -

(a) a river or spring;
(b) a natural channel in which water flows regularly or intermittently;
(c) a wetland, lake or dam into which, or from which, water flows; and
(d) any collection of water which the Minister may, by notice in the Gazette, declare to be watercourse, and a reference to a watercourse includes, where relevant, its bed and banks;

"**wetland**" means -

land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.

Government Notice (GN) 4167 of December 2023 furthermore defines:

"**Extent of a watercourse**" as:

(a) The outer edge of the 1 in 100 year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam; and

(b) Wetlands and pans: the delineated boundary (outer temporary zone) of any wetland or pan.

Peat is defined in the 2018 revised "Soil Classification: A Natural and Anthropogenic System for South Africa" as requiring more than 20% organic carbon.

Organic soils (also referred to as Champagne soils) are defined in the 2018 Soil Classification System as having a minimum organic carbon threshold of 10% (Soil Classification Working Group (SCWG) 2018).

Aquatic ecosystems are defined in Ollis et al. (2013)'s National Classification System for wetlands and other aquatic ecosystems as including

- Inland systems (i.e. watercourses (as defined above) comprising rivers, wetlands, springs and pans
- Estuarine systems (as defined above); and
- Marine systems.

This report is concerned only with **Inland aquatic ecosystems**, with a focus on the peat wetlands of the Onrus Wetland.

2.2 Water quality assessments

Water samples were collected on 10 January 2025 from three sites associated with the Onrus Wetland, namely WQ1, immediately upstream of the wetland (on Volmoed); WQ2, immediately downstream of the Camphill Road crossing; and WQ3 immediately upstream of the R43 road bridge. These samples were analysed at Aquatico Laboratory (Somerset West) for major nutrients and total suspended solids, while *in situ* measurements of electric al conductivity, pH and dissolved oxygen were also taken.

The analytical certificates and raw data are presented in **Appendix B**.

Figure 2.1 shows the locations of water quality sampling sites used to inform this report.

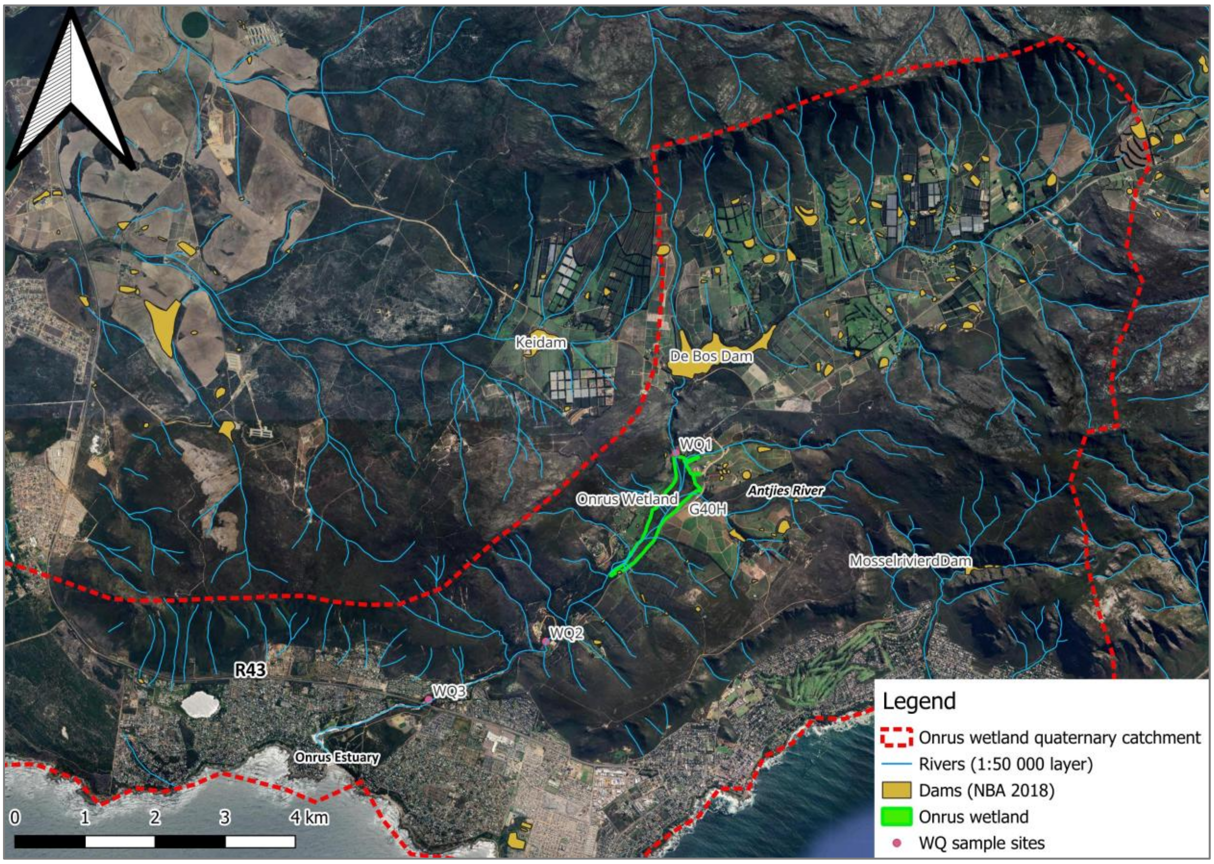

Figure 2.1
Locations of soil and water quality sampling sites. January 2025

2.3 Wetland soil assessments

2.3.1 Soil hydraulic conductivity

> **Hydraulic conductivity** is a measure of how easily water flows through a porous material such as rock or soil (Stibinger 2014).
>
> **Sorptivity** is a measure of the soil's ability to absorb water, primarily due to capillary forces.

Unsaturated hydraulic conductivity (HC), soil sorptivity and repellence were measured from *in situ* soils using a Mini Disk Infiltrometer from METER Group. HC was explored in 29 sites, each displaying one of three soil conditions, namely sand, exposed and unexposed organic soils /peat (see **Figure 2.2**). These measurements were taken over four separate site visits, 9th and 10th January and the 17th and 19th of March 2025, from sites between Madron Farm on the upstream end of the Onrus Wetland and the lower end of the wetland (**Figure 2.3**). Note that unexposed soils were difficult to locate, with soils throughout the wetland showing signs of desiccation, and with large-scale shifting of blocks of palmiet wetlands throughout the wetland, either as a result slumping into the incised valley bottom or from floodwater transport.

Actual infiltrometer measurements involved filling the infiltrometer's mariotte chamber with river water and placing the stainless-steel disk underlying the instrument on an area of flat, undisturbed surface of the selected soil, ensuring good contact between the two surfaces. The time taken for a known volume of water to infiltrate the soil was measured, using multiple measurements at intervals of 5 – 30 seconds, depending on the rate of infiltration. These measurements were repeated using 95% ethanol instead of water, to provide a measure of soil water repellence, based on Lichner et al. (2007)'s proposed index of soil water repellence, based on the respective sorptivities of 95% ethanol and water in soils. The excel models provided by METER were used to convert measured data into hydraulic conductivity and soil water repellence data, using Van Genuchten parameters for soil texture classes.

Figure 2.1
Examples of different soil conditions selected for sampling and analysis for TOC and HC analyses in the Onrus Wetland, January to March 2025.

		
Coarse, sandy soils	**Infiltrometer on exposed organic soils**	**Mainly unexposed soils – these were accessed by augering at least 40cm into the soil mass**

2.3.2 Soil sample analyses (physical properties, organic carbon and water holding capacity

Soil samples for analysis of soil physical properties and total organic carbon (TOC) were also collected at each site, for analysis at BEMLAB, Somerset West. Samples (500g – 900g wet weight) were placed in zip-lock plastic bags and [1]inundated with river water before sealing to prevent further oxidation of organic soils before laboratory analysis. Soil texture was analysed, as well as TOC, using the LECO method of analysis.

The analytical certificates and raw data for HC, TOC and soil texture are presented in **Appendix C,** along with a brief discussion of these data.

[1] Methodology followed in consultation with Mr J. Le Roux and is thus comparable in methodology at least with data presented for the Onrus wetland in Le Roux et al (2023).

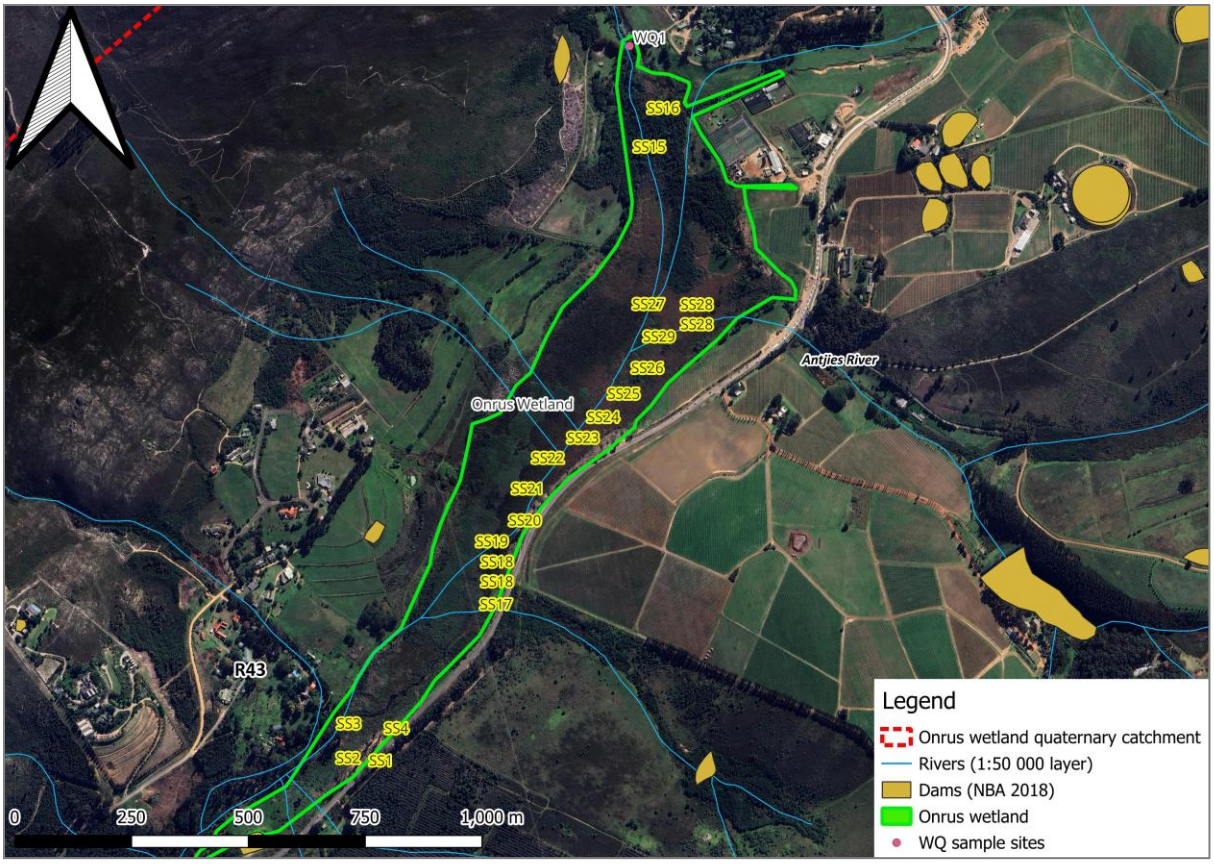

Figure 2.3
Soil samples Infiltration data with hydraulic conductivity(K), Van Ganutchen parameter(A), the value of the curve of cumulative infiltration vs square root of time and the repellence index. Overlay on GOOGLE Earth image prior to 2023 floods.

2.4 Assessment of trajectory of change in wetland condition: WET-Health assessment

Present Ecological State (PES) is a measure of the condition of a river or wetland, relative to its natural (or reference state) condition. The PES assessment protocol results in a score, reflecting the percentage similarity of the present state, to the assumed reference conditions. Depending on the score, one of six PES categories is assigned to each assessed wetland or part of a wetland.

The following categories are applicable in the present study (Macfarlane, Ollis, & Kotze, 2020):

- Ecological Category A: Natural (90-100%)
- Ecological Category B: Largely natural with few modifications (80-89%)
- Ecological Category C: Moderately modified (60-79%)
- Ecological Category D: Largely modified (40-59%)
- Ecological Category E: Seriously modified (20-39%)
- Ecological Category F: Critically modified (0-19%).

There are several methodologies for determining wetland condition or PES. In this study, the WET-Health methodology was utilized, using the Version 2 Level 2 assessment protocols (Macfarlane, Ollis, & Kotze, 2020). This methodology allows the determination of wetland condition with regard to four key components, namely Hydrology, Geomorphology, Water quality and

Vegetation. Together, the scores for these components yield a combined (overall) PES score and associated Ecological Category.

3 OVERVIEW OF THE ONRUS CATCHMENT

3.1 Water Management Area context

The Onrus River catchment comprises quaternary catchment G40H in the Breede-Olifants Water Management Area (WMA). This quaternary is included in the Department of Water and Sanitation (DWS)'s (then) Breede-Gouritz Catchment Classification, for which Resource Quality Objectives (RQOs) have been gazetted for rivers, estuaries, dams and groundwater resources (GN 1008 of September 2020). The Onrus River is not however included as a priority node in this classification, although the estuary is. Although the Onrus Wetland might well have been considered a priority **wetland** node, RQOs for wetlands have not to date been gazetted in this WMA.

3.2 General description of the catchment

The Onrus River is located in the Overstand Local Municipality in the Western Cape. It rises on the steep slopes of the Babilonstoring and Kleinrivier Mountains and flows in a south-westerly direction towards the coastal town of Onrus, entering the sea via a small estuary that discharges into Walker Bay in the Atlantic Ocean. The river has a relatively small catchment of around 55 km^2 and the main-stem river is approximately 16.5 km long from source to mouth (Heinecken and Damstra 1983). The main stem of the river flows through two distinct valleys, passing first through the high-lying Attacquas Valley (altitude of 600-1000m) and then, after narrowing through the Attaquas Gorge, which causes the distinct kink in the river's alignment in these reaches (**see Figure 1.2**), passing into the lower-lying Hemel en Aarde valley (altitude 200-400 m), in which the Onrus Wetland itself is located.

The flat slopes of the two valleys mean that the river is prone to the creation of wetlands, and flowed mainly as a valley bottom wetland, supporting extensive and ecologically important wetlands in places, including peatlands (. Severe erosion throughout the catchment has however significantly compromised the condition and ecological function of these wetlands in many areas, as outlined in Sections 3.3 and 4.

Although the river is fed by numerous seeps and minor watercourses, its only major tributaries comprise the Antjiesrivier, which enters the main stem in the upper reaches of the Hemel en Aarde Valley, and an unnamed tributary that enters about 100 m upstream (see **Figure 1.2**). Both of these rivers rise on the slopes of the Kleinrivier Mountains to the east.

While the steep mountain slopes of the catchment largely comprise natural vegetation with invasion by alien vegetation in places, particularly along some of the watercourse ravines (as modelled in SRK 2024), the flatter valleys and coastal plains have been highly transformed by development, mainly comprising agriculture in the upper and middle reaches of the catchment and urban development in its lower reaches, close to the coast. Invasion by alien vegetation is also extensive in the catchment, and particularly dense along many sections of the river, with *Acacia mearnsii*, (black wattle), *Eucalyptus* sp. (gums), *Pinus* sp. (pine), *Popularis cf. canescens* (poplar) and *Hakea sericea* (silky hakea) being particularly prevalent (see **Figure 3.1**).

Although there are multiple in- and off-channel dams in the catchment as a whole, the only in-channel dam on the main stem of the Onrus River is the De Bos Dam, which supplies water to the towns of Hermanus, Onrus, Vermont, Hawston, Sonesta and Sandbaai as well as to other local water users (Heinecke and Damstra 1983). Constructed in 1976 in the narrow Attacques Kloof (Massie and Clark 2016), this dam has a storage capacity of 6.3 million m^3, and an annual supply capacity of approximately 3.3 Mm^3 (Du Plessis 1995, cited in SRK 2024). SRK (2024) notes that compensation releases of approximately 0,5 million m^3/a are supposed to be released to supply irrigators downstream of the dam, together with a supplementary environmental release of 1.6 Mm^3 per annum (0.066 m^3/s) (Massie and Clark 2016 cited in SRK 2024). No data confirming the above environmental releases were available at the time of writing this report.

The De Bos Dam is located upstream of the Onrus Wetland. This wetland has formed downstream of the confluences of the unknown major tributary and the Antjiesrivier, where the Hemel en Aarde Valley widens out, giving rise to the establishment over time of extensive wetland habitat, classified as peatland by Grundling et al (2021).

Downstream of the wetland, the river passes through a narrow kloof and then meanders across the coastal plain before discharging into its estuary at the coast. Severe erosion of the river in its reaches through the kloof has taken place, particularly during the 2023 floods, which saw sections of the abutting Hemel en Aarde and Camphill Roads being seriously damaged and eroded in places.

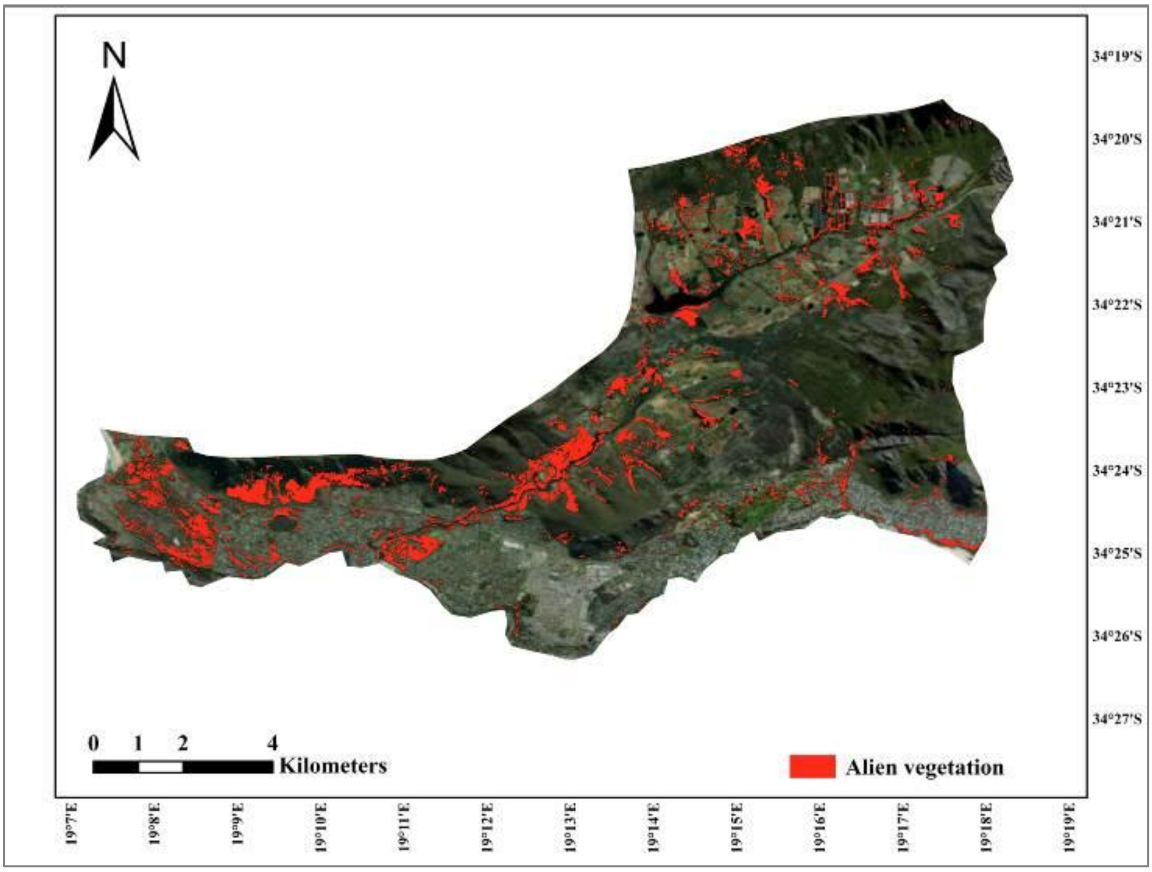

Figure 3.1
Extent of alien invasion (all species) in the Onrus River catchment
(Figure after SRK 2024, "traditional classification technique)

3.3 Geology

The Babilonstoring Mountains and the northern slopes of the Kleinrivier Mountains that dominate in the upper catchment are composed of quarzitic Table Mountain Sandstone and bands of hard Bokkeveld shales (Heineken and Damstra 1983). The previous citation notes that these hard rocks erode slowly, resulting in a slow rate of sediment production.

However, as noted in SRK (2024), the steep slopes on both sides of the Onrus River valley make the system susceptible to rapid hydrological responses and extreme events. This is borne out by the images in Figure 3.2, which show that, notwithstanding the hard rock formations of the upper catchment, major storms in 2023 resulted in the formation of multiple debris flows off even relatively intact mountain slopes, contributing large sediment loads into the Onrus River via its mountain tributaries (see **Figure 3.2**).

The higher-lying Attacquas Valley comprises a local intrusion of Cape Granite, while the bed of the Onrus River consists of Table Mountain Sandstone (Heineken and Damstra 1983), with the Peninsula Formation of this group being exposed in the peatland itself (Umvoto 2020). The Onrus Wetland itself is assumed to be perched above this layer (see Section 4 for a more detailed discussion).

Figure 3.2
Major sediment flows down the Babilonstoring Mountains following major storms in 2023. Inset: Sediment accumulation in the upper reaches of the Onrus River, resulting in large-scale habitat disturbance

3.4 Geohydrology

The Onrus Wetland is underlain by rocks of the Peninsula Formation, which are exposed in the peatland itself (Umvoto 2020) (see Section 3.3). The deep fractured Peninsula Aquifer (formed by the Peninsula Formation) is targeted by the Overberg Municipality for municipal supply as well as by some farmers within the Hemel en Aarde Valley (Umvoto 2024). Two of the three wellfields used for municipal water supply comprise the Camphill and the Volmoed Wellfields, both located close to the Onrus Wetland and targeting the semi-confined to confined Peninsula Aquifer along the damage zone of the NE-SW orientated Attakwaskloof Fault and (Volmoed Wellfield only) NW-SE orientated Fernkloof Fault. Abstraction from the Peninsula Aquifer is monitored, and Umvoto (2024) suggest no impact on surface aquatic ecosystems as a result of abstraction of water from the deep aquifer.

3.5 Climate

Climate is a major driver of wetland formation and a significant consideration in practical rehabilitation planning. Basic climatic data are therefore relevant to this assessment. SRK (2024) presents average monthly and annual rainfall, drawing on the 48-year rainfall record for the catchment. These data show that:

- Rainfall peaks in the winter months (June, July and August – June and July have the highest average monthly rainfall of 80 mm)
- Rainfall is lower in summer (lowest annual monthly rainfall in December and January) but monthly averages are all above 20 mm;

- Mean Annual Precipitation (MAP) for the 48-year record was 613 mm while the Mean Annual A-Pan equivalent Evaporation (MAE) is more than twice the MAP at 1 318 mm
- Rainfall exceeds potential evaporation in only three months of the year, on average.

In addition to the above, the Overstrand area, like many areas of South Africa (review in Xulu et al 2023), is also subject to occasional extreme "cut-off low" (COL) pressure weather systems, that at times bring torrential rainfall to the area, including the 2023 and 2024 storm events that precipitated the present project (Umvoto 2024). As COLs occur in westerly waves where cold frontal systems are located, they occur throughout the year over South Africa, though with an autumn (March–May) maximum and a secondary peak during the austral spring from September to November. In spring, COL rainfall is more intense and widespread over the region (Xulu et al 2023).

3.6 Catchment vegetation

The 2024 South African Vegetation Map of SANBI (2006-2024) shows that natural vegetation in the Onrus catchment would have comprised mainly Overberg sandstone fynbos, with extensive Elim ferricrete fynbos dominating the Attacquas and Hemel en Aarde valleys through which the main stem of the Onrus River flows. Areas of Hangklip sand fynbos occur in the lower reaches of the catchment, west and east of the river course, while Agulhas limestone fynbos vegetation has been mapped in the south eastern part of the lower catchment. Of these vegetation types, both Elim ferricrete fynbos and Overberg sandstone fynbos, through which the Onrus River itself flows, have been classified as Endangered ecosystems in CapeNature (2024), while the other two vegetation types mapped are listed as Critically Endangered.

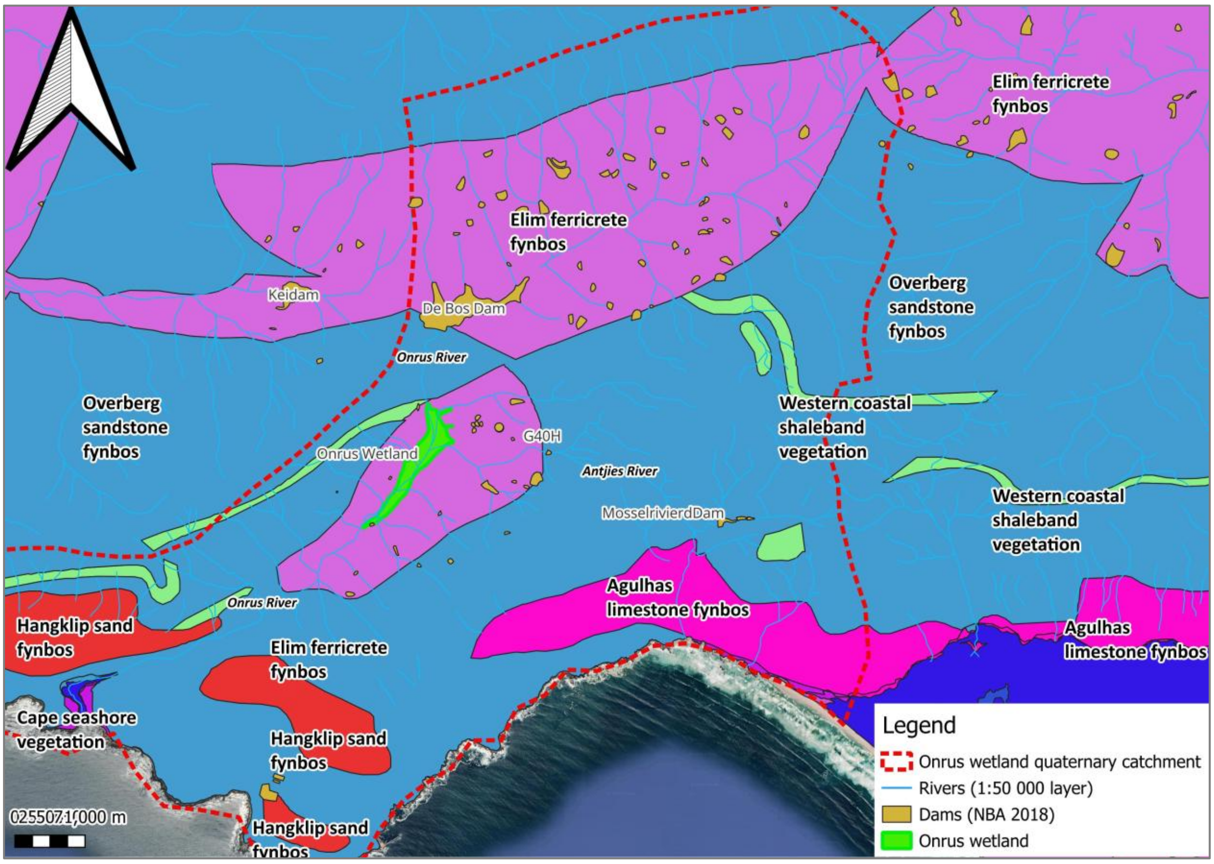

Figure 3.3
Vegetation of the Onrus Catchment. Data from SANBI (2006-2024).

SRK (2024) modelled alien vegetation extent in the Onrus catchment and showed that woody alien vegetation predominates along drainage features in the catchment (see **Figure 3.1**) and moreover has increased some ten-fold between 2018 and 2024, being estimated to cover some 8.6 km^2 of the catchment in 2024 - almost 16% of the total catchment area. This report further showed that current land use, including current alien vegetation distribution and estimated irrigation abstractions results in a in a 20% reduction in runoff in the catchment, compared with natural vegetation land use.

In addition to affecting base stream flow, woody alien invasion in the catchment, particularly along watercourses, has other significant impacts including:

- Impacting indigenous wetland and riparian vegetation by shading and thus increasing watercourse susceptibility to erosion during floods – Palmiet is particularly susceptible to shading;
- Facilitating channel incision during floods, by creating dense stands along the edges of watercourses, preventing flood overflows and increasing bed and bank erosion;
- Drying out peatlands by water uptake and thus increasing their susceptibility to fires and erosion;
- Increasing flood damage to infrastructure such as roads and bridges as well as watercourse bed and banks as a result of the creation of debris dams – that is, when logs, branches and felled or dislodged alien vegetation accumulates against barriers such as bridges and culverts, causing water to back up behind the structure and overflow along alternative and often damaging pathways.

3.7 Mapped aquatic ecosystems

Figure 3.4 shows inland aquatic ecosystems in the Onrus River catchment, as mapped in the National Wetland Map (version 5) (Van Deventer et al 2019). The data suggest that most of the main stem of the Onrus River comprises naturally unchanneled valley-bottom wetlands, that open into the Onrus River Estuary in the lower reaches of the river. This classification (after Ollis et al 2013) is concurred with in reported assessments such as Le Roux et al (2023) and as ground-truthed in the present study.

However, and of great importance for the ongoing management of this catchment, the wetland layer does not indicate valley bottom wetlands upstream of the De Bos Dam in the main stem of the Onrus River; nor does it depict the extensive seepage and valley bottom wetlands in the mountainous catchments that feed into the Onrus River itself.

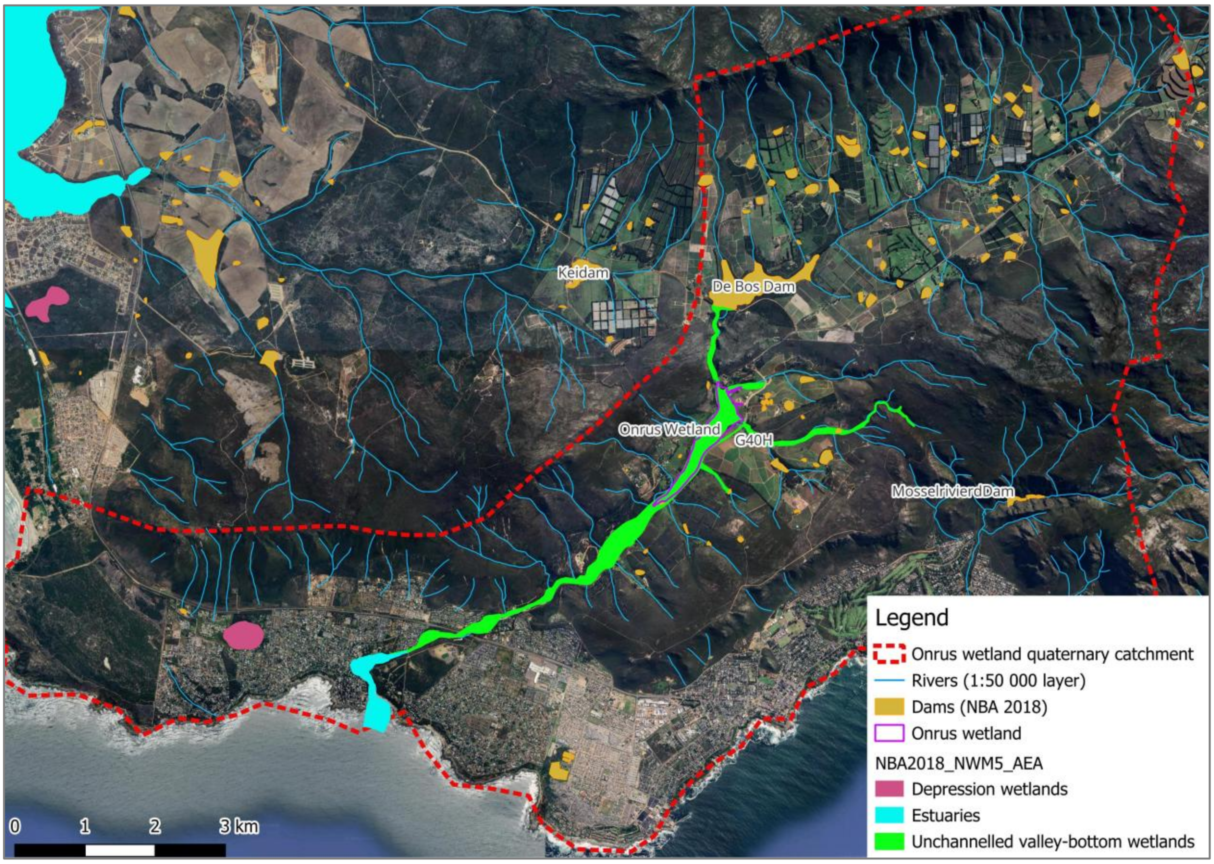

Figure 3.4
Inland and estuarine aquatic ecosystems in and in the vicinity of the Onrus Catchment.
Data from Van Deventer et al (2019).

The mapped unchanneled valley-bottom wetlands in the catchment are classified in Van Deventer et al (2019) as South West Fynbos Bioregion valley-bottom wetlands, with an Ecosystem Threat Status of Critically Endangered and an Ecosystem Protection Level of Poorly Protected. This

The Onrus Wetland itself has been identified as a peatland (Grundling et al 2021). Peatlands are wetlands of particular importance, being recognised for their role in climate regulation as carbon sinks (see Elshehawi et al 2019) (if conserved) or alternatively as carbon sources, if degraded.

3.8 Key factors affecting present watercourse condition in the catchment

While this section does not try to present a detailed assessment of the Onrus River catchment, the following key issues affecting both inland aquatic ecosystems (wetlands) and, indirectly, the Onrus Estuary downstream, were highlighted during catchment drive-arounds and spot visits to selected sites, both upstream and downstream of the De Bos Dam:

- Catchment-wide abstraction that from multiple dams that reduce surface flows into the Onrus River wetlands and affects groundwater recharge;
- Invasion of the catchment, and riparian areas in particular, by woody alien vegetation that reduces base streamflow (SRK 2024); impacts on watercourse condition and function; and can threaten bridges, culverts and other infrastructure in the vicinity of watercourses;
- Poorly designed infrastructure such as road culverts, bridges and stormwater pipes that have triggered downstream channel incision and /or upstream headcut erosion of valley bottom wetlands;

- Largescale erosion of the main stem of the Onrus River throughout the catchment, including upstream of De Bos Dam, that will potentially trigger headcut erosion in tributaries of the river, particularly those that comprise seep or valley bottom wetlands with high susceptibility to erosion;
- Lowering of the water table as a result of deep channel incision along parts of the Onrus River including in its reaches through the Onrus Wetland;
- Sediment transport and sedimentation of wetlands and river channels, stemming from upstream erosion, both induced by human activities such as poorly designed infrastructure as well as from major natural storm events, contributing to significant debris flows off the mountainside and into watercourses, where it results *inter alia* in smothering of wetland vegetation; diversion and realignment of natural braided flows; and the creation of disturbed conditions conducive to invasion by opportunistic alien vegetation such as *Acacia mearnsii*.

Table 3.1 illustrates some of the above issues photographically, drawing on photos taken during the present study. Issues relating specifically to the Onrus Wetland are unpacked in Section 4 of this report.

Table 3.1
Photographic illustrations of aspects of the Onrus River catchment.
Photos between June 2024 and July 2025

Photo 3A
Wetland seeps in the upper Onrus River catchment

Photo 3B
Sediment debris trails into the Onrus River following severe storms in 2023

Photo 3C
Sedimentation of the upper Onrus River as a result of erosion in the upstream mountain catchment

Photo 3D
Large, low-lying culverts in the Onrus River (upper reaches) create concentrated flows into the downstream system, triggering channel incision and resultant loss of valley bottom wetlands, including possible peatlands

Photo 3E
Upstream view of Onrus River, being entrained through narrow culvert

Photo 3F
Downstream view of Onrus River, with concentrated flows through narrow culverts that precipitate downstream erosion and channel incision

Photo 3G
Spillway at De Bos Dam

Photo 3H
Unstable, incised flows into the Onrus River from the un-named tributary, passing under the Hemel en Aarde Road

Photo 3I
Antjies River upstream of the Onrus River confluence, at the Hemel en Aarde Road crossing

Photos 3J
Degraded Onrus Wetland, showing channel incision and exposure of organic soils

Photo 3K
Establishment of (mainly) indigenous wetland vegetation in incised channel in remnant Onrus wetland

Photos 3L
Dessicated stands of Palmiet vegetation in the Onrus Wetlands, on remnant blocks of decomposing organic soils / peat, with the water table clearly well below the level accessible by these plants,

3.9 Recommended approach to effecting sustainable watercourse condition

The present study focuses on the middle to lower reaches of the Onrus River catchment, specifically on drivers of degradation, present ecological state and planned rehabilitation of the Onrus Wetland and the Onrus Estuary. This section has however highlighted the fact that the condition and trajectory of these important downstream systems is highly dependent on upstream activities and processes. This means that consideration of the upstream catchment should be an integral informant of strategic planning around the sustainable management of these systems.

In addition, it must also be stressed that the upstream catchment of the Onrus River, upstream of De Bos Dam, has also been subjected to high levels of wetland erosion, assumed to include extensive peatlands, albeit not of the scale of the Onrus Wetland itself. There is thus high urgency to address and curtail such erosion as far as possible, from the perspective of sustainable wetland and peatland management. The root cause of much of this degradation appears to lie in a history of poorly designed culverts at wetland road crossings, which have triggered channel incision and headcut erosion. Since water is a precious and limited resource in this catchment, measures to remediate loss of wetland function and extent in upstream areas will play a role in effecting improved water resource management and, in particular, resilience against catchment-scale impacts such as COL storms, likely to increase in intensity with climate change.

Of critical urgency is however the fact that extensive channel incision in the Onrus River valley bottom wetlands means that headcut erosion is very likely to spread into wetland-dominated tributaries of the main stem river, that enter the river from the steep slopes to the east and west. Such changes could significantly increase loss of wetlands, soils and flood and drought resilience in the catchment, while further degrading downstream ecosystems and reducing the efficacy of remediation and rehabilitation efforts proposed considered as part of the present study.

With this in mind, it is recommended that the present project should be followed by additional phases, as a matter of urgency, with the intention of:

1. Identifying tributaries of the Onrus River that are in good condition but are vulnerable to degradation as a result of channel incision / headcut erosion
2. Identifying and implementing measures to arrest further degradation of such systems before they spiral out of control
3. Designing and implementing measures to stabilise and ultimately improve the function of wetlands in the main stem of the Onrus River that have degraded as a result of channel incision and lateral erosion. Such measures should include attention to amending the design of problematic culverts that trigger erosion by concentrating downstream flows and/or triggering headcut erosion upstream.

4 THE ONRUS WETLAND

4.1 Wetland Reference Condition

4.1.1 Overview

The Onrus Wetland comprises a large (± 37.5 ha) wetland on the main stem of the Onrus River, in the Hemel en Aarde Valley of quaternary catchment G40H (see Section 3). Using the national classification system for aquatic ecosystems of Ollis et al (2013), the wetland is classified as a naturally **unchanneled valley bottom wetland** and, prior to the impacts that have progressively ravaged it in recent decades, comprised a wide (approximately 220 m wide at its widest point), ± 2 km long wetland, with a downstream slope in the order of 1% on average (slopes estimated off 5 m contours) and dense wetland vegetation that provided a nearly 100% cover of the wetland, with occasional areas of channelled surface flow visible in early aerial imagery (e.g. 2004 Google Earth imagery). The lateral cross-sectional; slope within the wetland (i.e. from side to side) would be less than a 5m drop, as shown in aerial imagery in Cape Farm Mapper that indicate that the entire wetland pre-2023 floods lay within a 5 m vertical band (see **Figure 4.1**).

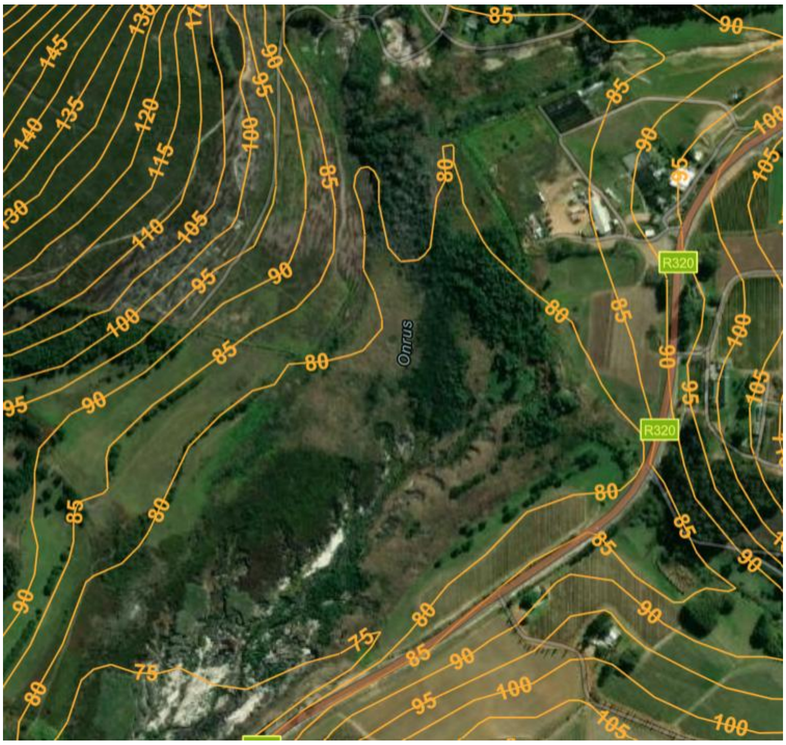

Figure 4.1
Upstream section of the Onrus wetland post 2023 floods (image 24/4/2025) but showing original (pre flood) contours. Map from Cape Farm Mapper (https://gis.elsenburg.com/apps/cfm/)

The Onrus Wetland itself is located in the wetland South West Fynbos Bioregion – a bioregion identified as Critically Endangered in van Deventer et al (2019) (see Section 3.6) and lying, in the present case, within a terrestrial area mapped as naturally comprising (now Critically Endangered) Elim Ferricrete Fynbos (see Section 3.5).

Although considered in this section as a separate unit, it is important to note that the wetland, under natural conditions, would have formed a near-continuum of (mostly channelled) valley bottom wetlands along the river reaches upstream of the wetland. These wetlands are evidenced today in deeply incised, actively eroding channels, along the banks of which remnants of deep organic soils can still be seen, as illustrated in photographs 3D in **Table 3.1** of the previous section.

The natural (or reference) condition of the Onrus wetland is assumed to be a wetland dominated by *Prionium serratum* (palmiet) reedbeds. This species is a South African endemic, occurring naturally in (mainly coastal) wetlands in the Western and Eastern Cape Provinces and southern KwaZulu-Natal (Cook 2004). In the Onrus wetland, it occurs in conjunction with other indigenous wetland plants, including *Pteridium aquilinum* (bracken fern) (often forming dense bands in disturbed areas), as well as *Psoralea pinnata*, and *Cliffortia strobilifera*, in patches along the dense wetland margins and *Phragmites australis* (common reed), along drier wetland margins in places on the eastern sides of the wetland.

The contours shown in **Figure 4.1** suggest two natural flow pathways into the wetland from the upstream Onrus River, one on the east and one on the west, which fed surface flows into the wetland from upstream. These flow pathways subsequently eroded into deeply incised dongas, as outlined in Sections 4.2 and 4.3 (Le Roux et al 2023).

4.1.2 Peatland status

The[2] Onrus Wetland is listed among South Africa's known peatlands in the current Global Peatland Map (https://maps.work/gpd/) and included in Grundling et al.'s (2021) listing of peatlands in the Cape Fold Mountains peat ecoregion that have been affected by fire. Nevertheless, no organic carbon for the wetland's soils could be sourced as part of the present assessment, although exposed soils in the wetland clearly show high levels of organic material that has accumulated to depths of several meters (Grundling et al 2021 cite peat thickness in the wetland to depths of 7m; on the basis of field visits carried out in the present project it is possible that it may have extended to greater depths in places).

> **Peat** is defined in the 2018 revised "Soil Classification: A Natural and Anthropogenic System for South Africa" as requiring more than 20% organic carbon.
>
> **Organic soils** are defined as having a minimum organic carbon threshold of 10% (Soil Classification Working Group (SCWG) 2018).

Soil carbon data collected from the wetland in the present project showed TOC of up to 38.8 % in sampled soils, well above the mean of 26 for peat in this ecoregion (Grundling et al 20221) but also ranging down to 3.3 % (see Appendix C: Table C.4 and Figure C.55). Of the 18 samples analysed for TOC from visibly organically enriched sites located along the length of the wetland, five fell below the threshold of 10% for organic soils, while seven fell well within the threshold for peat categorisation, as per SCWG (2018). These samples were all taken from the highly degraded wetland in 2025, and some (unquantified) degradation of soils is assumed as a result of prolonged desiccation and associated exposure to air.

The Onrus Wetland under natural conditions was therefore clearly a peatland, with deep organic /peaty soils. With regard to its age and time of formation, no formal dating of the wetland appears to have taken place, using radiocarbon analyses, although there are anecdotal suggestions that its peats date back to around 11 000 years ago (e.g. REF). Elshehawi et al (2019) provide ^{14}C dating data for 40 peatlands in South Africa. These do not include the Onrus Wetland, and the nearest wetland for which ^{14}C data are listed is Cape Hangklip, located some 35 km west of Onrus, but within the same ecoregion. The initiation of this wetland has been dated to 11 140 years Before Present (BP) (Meadows 1988 in Elshehawi et al 2019), with peat forming during the glacial-interglacial transition period (21 000-11000 years ago). These conditions were not considered optimal for peat formation (warming, compared with the previous glacial period) but with dry conditions) and rates of peat accumulation would have been slow (Elshehawi et al 2019). Between

[2] In fact, the map shows a peatland immediately north of the actual Onrus wetland – it is assumed that this is an issue of scale and that the data relate to this wetland

11000 and 6000 years BP, peatland initiation in South Africa was mainly along the coast, and often related to sea level rise that raised local water table levels in coastal areas. The above study cites peat accumulation rates from nine ^{14}C dated wetlands in South Africa, that range between 0.07 and 2.19 mm per year. None of these wetlands are however located within the Cape Fold Mountains ecoregion.

4.1.3 Wetland drivers

The main drivers of peatland formation and persistence are conditions that favour permanently saturated, anaerobic and acidic conditions (which reduce plant decomposition rates) and where temperature and nutrient availability are sufficient to promote the growth of plants suitable to contribute organic matter for peat formation. Geology and geomorphology are important factors that provide the structural environment for permanent wetland development (e.g. basins with or without impermeable linings). Thus climate, hydrology, geology, geomorphology and vegetation type are all important considerations in understanding peatland development.

> A model of the interactions of wetland surface and groundwater flows, based on long-term monitoring data, would have been a useful informant of this study.

Many of South Africa's peatlands are groundwater-dependent (Grundling et al 2017). This is because peat requires permanent saturation for its development and persistence, and the negative balance between rainfall and evaporation in many parts of the country, including in the Onrus River catchment, means that rainfall alone would not usually be sufficient to sustain the required conditions. It is thus assumed that the wetland has a history of permanent exposure to groundwater flows that enter the wetland from both within the wetland and upstream, supplemented by surface flows, that perched on peat formations, maintaining saturation levels in the wetland. Grundling et al (2019) note however that the Onrus peatland contains a peat layer of more than 7.25 m thick, dominated by a lower 4 m-thick sedge layer, but with a basal sand and not bedrock layer, which makes it unlike other palmiet systems elsewhere in South Africa. This suggests that the sand layer, perched on the Peninsula formation in this area (see Section 3.4) may act as a primary aquifer, storing water that, under natural conditions, created an elevated water table that maintained the saturated conditions needed to sustain the overlying peat.

Uncertainty exists at the time of this report as to the exact surface-groundwater linkages and dependencies of the wetland under natural conditions. It is however clear that both surface and groundwater flows were vital for the maintenance of the peatland under natural conditions and changes in these, either at source or as a result of changes in wetland geomorphology that promote rapid conveyance, would have profound impacts on wetland integrity. This issue is considered in the following sections.

4.2 History of changes affecting wetland condition and function

This project was initiated from the need to address the impacts of severe, episodic erosion of the Onrus Wetland caused by cut-off-low systems that resulted in floods in 2023 and 2024, described by Umvoto (2024) as including ±154 mm on the 24th September and similarly high rainfall between the 7th and 8th April 2024 (±168 mm reported by the Hermanus Rainfall Station. These events resulted in catastrophic wetland loss and degradation, and caused severe damage downstream of the wetland, including the sedimentation of the estuary, described in Anchor (2025). The extent of damage, summarised in the following sections, is likely to have been exacerbated by a loss of wetland resilience as a result of sustained and increasing impacts to the wetland, affecting its hydrology, hydraulics, surface and groundwater links, sediment transport and capacity to support wetland vegetation and maintain the carbon stores in its wetland soils.

This section, illustrated in **Figures 4.2 to 4.12** provides a brief sequence of events that contributed to the present condition of the wetland, as follows:

- Construction of the De Bos Dam in 1976, upstream of the wetland, resulting in:
  - **Reduced (but unquantified) inflows** into the Onrus Wetland, particularly during the dry season when upstream wetlands would have released water slowly during the dry season, helping to sustain downstream aquatic ecosystems and their processes – this, along with extensive abstraction throughout the catchment from multiple small on- and off-channel dams as well as shallow groundwater abstraction (Umvoto 2024) is likely to have contributed to a reduction in the saturated conditions required to maintain peat, contributing to wetland desiccation and increasing its vulnerability to erosion and fire;
  - Potential **increases in flow intensity** when the dam overflows, as a result of concentrated flows over its spillway, versus more naturally attenuated flows over the assumed rougher surfaces of the wide valley bottom wetlands assumed to have been in place prior to the dam's construction.
- Invasion of the catchment by **alien vegetation**, including invasion of the Onrus Wetland margins (gums) extending into the wetland itself in places, particularly in the upper and lower wetland (mainly poplars, gums and black wattle – see Section 3.5). SRK (2024) modelled a dramatic increase in alien vegetation over the 6-year period between 2018 and 2024, from 0.82 km^2 in 2018 to 8.6 km^2 in 2024 (some 15.7% of the total Onrus catchment area). In addition to the assumed but currently relatively low impacts (reduction) to base flows as a result of uptake of water by these plants, in the Onrus Wetland itself, they would have contributed to:
  - **Wetland shading** in the immediate vicinity of invasive alien trees, linked to die-back of palmiet and other wetland vegetation and increased sensitivity to erosion;
  - **Wetland droughting** as a result of high water uptake from wetland soils, making soils increasingly prone to fire and with reduced water absorption capacity as a result of peat desiccation (see data in Appendix C, Figure C55);
  - **Changes in flow rates** through the wetland, such as an increased concentration of flows past highly invaded areas, triggering channel incision and precipitating early headcut erosion, as seen in **Figures 4.2 to 4.7**.
- Development of **gulley erosion** in the wetland, probably largely in response to the above issues – channel incision along the eastern edge of the lower wetland is evident in aerial imagery from 2004 and had advanced upstream by 2016 (**Figures 4.2, 4.3 and 4.7**).
- Gulley erosion resulted in **draw-down of the water table** in the wetland and desiccation of wetland soils, making them prone to fire and exposing peat soils to oxygen, which would increase decomposition rates dramatically – Le Roux et al (2023) describes "sagging" of affected wetland areas, as

> Soil analyses carried out in the present study showed high soil water repellency in desiccated organic / peat soils from the wetland (see Appendix C). Andriesse (1998) indicates that there are thresholds of desiccation in some peat soils, below which rehydration becomes increasingly difficult to achieve.

Soil analyses carried out in the present study showed high soil water repellency in some desiccated organic / peat soils from the wetland (see Appendix C) and low water absorption capacity. Experimental re-wetting of desiccated peat soils showed an initially slow rate of water absorption, increasing over a 60-day period to around 180% of initial soil mass (Appendix C, Figure C.56). Andriesse (1988) suggests that acid, humified peats exhibit the greatest resistance to re-wetting because of their carboxyl and phenolic hydroxyl groups, and high lignin content.

they shrunk with lost moisture. Data for piezometers and wells obtained from 13 sites in this study, spread across three wetland transects, showed that at that time:

- Groundwater flowed in a south easterly direction beneath the wetland;
- The western side of the wetland received sustained groundwater inflows;
- The eastern side of the wetland appeared to depend on seasonal water flows from the upstream channel – this was attributed in part to the poor water-retaining capacity of ash in the wetland, following the 2019 fires;
- Wetland water levels were lowest around the eroded channels, indicating water table draw-down, and these drawn-down areas burned deeper during the 2019 fires, as evidenced by the presence of ash at greater depths than in areas with higher water tables;
- Piezometer and wellpoint data from this study showed that rather than being sustained by permanent saturation from an elevated water table, groundwater recharge in fact was taking place in the wetland, with a net export of water from the wetland into the underlying water table while the wetland was fed predominantly by surface flows from the river, rather than by groundwater.

- **Fires** in the wetland in 2019 resulted in large-scale damage to the peatland, with an estimated 9 ha of wetland surface burning, resulting in some 90 000 m^3 peatland being burned and some 330 000 m^3 being desiccated, amounting to an estimated total carbon loss of 4 680 t and emissions of 17 176 t of carbon dioxide (data from Grundling et al 2021). The fires were exacerbated by wetland desiccation, linked to gulley formation, alien invasion and reduced upstream inflows into the system. The extent of wetland burned triggered reduced water holding capacity in ash-laden sediments and created compromised zones along long sections of the wetland (**Figure 2.6**).
- The September 2023 **floods** ripped through a wetland that was already compromised by the combined and additive effects of reduced surface water inflows; a lowered local water table as a result of channel incision; gulley erosion, resulting from alien invasion; changes in within-wetland flow velocities and retention time; fire and (associated) soil desiccation. Thes impacts meant that the wetland had little resilience to withstand the volume of flows passed through it within a short period of time, and the eroded and/or burned longitudinal channels through the wetland were particularly vulnerable to channelling concentrated flows, with little resistance, thus promoting deeper incision and severe widening of erosion channels.
- Above the incised channels, the vegetated wetland, comprising mainly extensive stands of palmiet, was cut off from both upstream surface and subsurface water, and thus lost saturation, with wetland soils draining into the channel, and the wetland vegetation itself subsiding as its underlying soils drained, and in places slumped down towards the eroded gullies formed during the flood.
- The second major flood in April 2024 reinforced the above impacts, eroding and transporting large blocks of (mainly palmiet) vegetation through the wetland. Palmiet that

was deposited within the newly created low flow channels generally remained alive, even while the peat dried out, while Palmiet in higher-lying areas dried out and, by mid-2025, vast areas of the wetland showed as brown and clearly in a state of drought.

- Le Roux et al (2023) noted that the Onrus Wetland upslope of the eroded eastern gulley in 2023 was "in pristine condition". **By the time of the 2024 and 2025 assessments informing the present study, no parts of the wetland could be considered pristine**; no intact peat could be found for analysis or mapping; all palmiet vegetation was in a state of desiccation, other than where it had been transported in blocks of peat by floods, and deposited in the incised, wetted channel. **Figures 4.9-4.12** illustrate some of these issues.

Figure 4.2
2004 image of the Onrus Wetland, with (assumed) erosion channel arrowed and extensive alien vegetation established downstream

Figure 4.3
2016 image showing deepening of the headcut along the eastern edge of the wetland (arrowed) and extensive alien invasion within the wetland

Figure 4.4
2018 image showing extensive alien invasion within the wetland

Figure 4.5
2020 image, showing post-fire wetland damage (note discoloured desiccated wetland vegetation, arrowed) and apparent upstream end of incised channel (asterisked).

Figure 4.6
The burned Onrus Wetland peat fire of 2019, showing extensive burned pathways along the length of the lower wetland (Photo from Le Roux et al 2023, credited to Onrus Municipality)

Figure 4.7
2023 image of the headcut incision in the Onrus River wetland (photo after King 2025)

Figure 4.8
2025 image of the Onrus Wetland (image from Cape Farm Mapper) showing largescale erosion post the 2023 and 2024 floods.

Figure 4.9
Extensive droughting of palmiet wetland as a result of gully erosion, leading to water table draw-down.

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Figure 4.10
Largescale erosion in lower Onrus wetland, showing deposition of inorganic sediments, carried into the wetland from eroded areas upstream, including sediment from debris flows off mountain slopes under flood conditions

Figure 4.11
Largescale gully erosion, with the photo showing peat blocks transported from upstream and now establishing in some cases in the wetted channel, albeit under desiccating conditions.

Figure 4.12
Post-flood area where peat layers have slid off underlying clay – Le Roux et al (2023) suggest clay layers here are a relic of past road construction activities, as they are underlain by more peat

4.3 WET-Health assessment outcomes

4.3.1 Background

A WET-Health assessment was carried out on the Onrus Wetland, using the methodology described in Section 2.4. This allowed wetland condition to be determined, relative to its assumed natural or reference condition (see Section 4.1).

The mapped wetland was coarsely divided into two units of analysis, namely Unit 1, including the upper reaches of the wetland from Volmoed downstream, and Unit 2, which comprised the majority of the wetland area, and was defined by wetland visibly affected by headcut erosion / channel incision as shown in the 2025 drone imagery accessed for this study. Droughting of palmiet beds and visible channel incision were used as primary indicators, informed by ground-truthing and on-site observations. **Figure 4.13** shows the relative extent of the two assessment units, noting that their delineation is coarse and, moreover, additional incision and wetland droughting may well have occurred since the images were created.

Landuse informants of the WET-Health assessment included:

- Mapping of major landuse areas off GOOOGLE Earth imagery
- Mapping of alien invasion and other landuse types within the Onrus Wetland onto 2025 LIDAR imagery, showing the Onrus Wetland post the 2023 floods
- Inclusion of the findings of SRK (2024) that 15,7% of the catchment comprised invasive alien vegetation (2024 assessment).

Figure 4.13
Wetland assessment units used in the WET Health assessment. Wetland mapping onto LIDAR image.

4.3.2 Informants of module assessments

The WET-Health module includes four modules – hydrology, geomorphology, water quality and vegetation. The previous sections have presented much of the data and its interpretation that informed the WET-Health assessment. This section presents summary comments and brief additional information regarding changes in wetland condition as assessed in 2024/2025, which were used in completing the assessment questionnaires and informing tweaking of the analysed results.

- Wetland hydrology:
    - Wetland hydrology has undergone significant and arguably catastrophic change, as a result of water-table draw-down from channel incision / gully erosion and sustained upstream abstraction;
- Wetland geomorphology:
    - Wetland geomorphology has also been fundamentally altered post the September 2023 floods, with extensive areas of the naturally unchanneled valley bottom wetland now comprising wide, incised and unstable gulleys or dongas that channel both flood and sediment flows through them, sustaining unstable conditions throughout the wetland and exacerbating wetland drainage and water-table draw-down;
- Water quality:
    - Once-off water quality analyses of three sites, upstream and immediately downstream of the Onrus Wetland and just upstream of the Onrus Estuary, presented in Appendix B, showed that:
        - pH was neutral to mildly acidic (acid waters are expected in this fynbos system);
        - Nitrate, nitrite and total ammoniacal nitrogen concentrations decreased markedly with passage through the wetland, indicating effective nitrification and nitrate plant uptake in these reaches, without significant additional sources of nitrogen in inflowing waters;
        - Orthosphosphate concentrations were in the range for hypertrophic wetland systems, and thus likely to promote plant growth. Most plants in the wetland were however out of reach of surface flows through the incised wetland. Nevertheless, orthophosphate and total phosphorus concentrations decreased with passage through the wetland;
        - Total suspended sediments were relatively low, nut nevertheless increased with passage through the wetland, suggesting mobilisation of mainly inorganic, sandy sediments at this time, as a result of increased sediment availability following deposition during the 2023 and 2024 storms, as well as increased concentration of flows through the wetland as a result of channel incision;
- Wetland vegetation:
    - Natural vegetation in the Onrus Wetland was dominated by dense stands of palmiet;
    - Post the 2023/2024 floods, this palmiet has almost wholly been compromised, either by erosion and downstream transport of vegetated blocks of peat or by desiccation as a result of water-table draw-down. Much of the palmiet in the upper reaches of the wetland has slumped down towards the incised channel (s). Connection to the water table has been catastrophically altered by channel incision, and almost all of the palmiet throughout the wetland was clearly in a state of drought at the time of the 2024/2025 assessments.

- Along the incised low-flow channel (s), wetland vegetation establishing, and comprises manly indigenous sedges such as *Juncus capensis, Isolepis cf prolifer* and multiple other wetland species;
- Invasive alien plants are establishing at high rates in disturbed areas of the wetland, and include extensive *Acacia mearnsii* (black wattle).

4.3.3 *Assessment Results*

The results of the WET-Health assessments (Version 2 Level 2 assessment protocols of Macfarlane et al 2020) are presented in summary form in **Table 4.1**. Raw data that populated the WET-Health spreadsheets are available in spreadsheet form from the project team.

The WET-Health results clearly (and unsurprisingly) show that ecosystem health and function in the Onrus Wetland have been critically modified, particularly with regard to hydrology and geomorphology, both of which have had serious impacts on wetland vegetation. Water quality is moderately affected by catchment-scale activities but is still moderated with passage through the (highly degraded) wetland system. It is likely that, prior to the 2023 / 2024 flood effects, water quality amelioration function was far higher.

Table 4.1
Results of the application of the Version 2, Level 2 WET-Health assessment protocols of Macfarlane, et al., (2020) to the Onrus Wetland

Final (adjusted) Scores				
PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	9.7	9.4	3.5	7.9
PES Score (%)	3%	6%	65%	21%
Ecological Category	F	F	C	E
Trajectory of change	↓↓	↓↓	→	↓↓
Confidence (revised results)	Medium	High	High	Medium
Combined Impact Score	8.3			
Combined PES Score (%)	17%			
Combined Ecological Category	F			

4.3.4 *Motivation for the need for wetland rehabilitation/ remediation*

Reporting on present wetland ecosystem condition has highlighted the critical level of wetland degradation that has accrued in the Onrus Wetland. Up until September 2023, this was a recognised peatland wetland of very high conservation importance, supporting critically endangered wetland ecosystems and importantly, in the current context, also performing wetland ecosystem services including flood attenuation and sediment trapping, the loss of which has been felt in the downstream catchment, where the Onrus Estuary has been infilled with eroded sediment from the wetland and where road and sewage infrastructure has been damaged by unattenuated flood passing through the degraded wetland.

In this context, it is strongly recommended that rehabilitation of the Onrus Wetland is implemented with a high degree of urgency. Rehabilitation design and planning should take note of the recommendations outlined in Section 5.

5 WETLAND REHABILITATION PLANNING

This section outlines broad principles and guidelines that should be used to inform wetland rehabilitation design.

5.1 Need for wetland rehabilitation

Section 4 has clearly highlighted the urgent need for rehabilitation of the Onrus Wetland, if only to address issues such as the currently unconstrained passage of sediment out of the wetland and into the downstream estuarine reaches as well as reduced shallow subsurface water level in shallow boreholes or wellpoints accessed by some local landowners (see Umvotu 2024).

In addition, however the ecosystem services once performed by the Onrus Wetland have been almost wholly lost with the destruction of the wetland. Lost services include flood attenuation, retardation of flow velocities, water storage, sediment capture, erosion control, carbon storage, provision of water for agricultural and other use, biodiversity value and the provision of an aesthetically pleasing landscape that was previously valued as a scenic route by the tourism industry and others.

5.2 Rehabilitation objectives

While loss of the above ecosystem services is largely irretrievable, at least to previous levels, recovery of at least some level of some of these services is important for the recovery / rehabilitation of the downstream system including the estuary, as well as for the maintenance of infrastructure such as roads, sewers and other pipelines located downstream of the wetland and which are threatened by unmanaged flows from the upstream catchment. Although restoration of the wetland to its previous level of function is not a practical rehabilitation objective (given that formation of the now largely destroyed wetland took place over a period of some 11 500 years (see Section 4.1), amelioration of wetland function could and should allow for improvement in ecosystem services such as flood attenuation, retardation of flow velocities, water storage, sediment capture, erosion control, provision of water for agricultural and other use by restoring water tables to previous levels, improvement in biodiversity value and the provision of a more aesthetically pleasing landscape than that currently provided by the erosion-devastated wetland.

5.3 Likely rehabilitation outcomes

It is important to note upfront that while rehabilitation of the Onrus Wetland is urgently required, with a view to ameliorating wetland ecosystem devices that are currently critically impacted, and to improving wetland resilience in the face of an increasing likelihood of climate-change induced storms with a high intensity in the area, **restoration of the wetland to its previous condition is not a feasible outcome of any planned rehabilitation process for this system**. Nevertheless, rehabilitation of the wetland to a more sustainable level of ecological function is achievable with effort and should be pursued as a matter of urgency, noting that the wetland remains gravely vulnerable to fire in its present degraded and desiccated condition, while the downstream estuary will remain the recipient of ongoing sediment loads, in the absence of wetland stabilising measures.

5.4 Important issues to consider in rehabilitation design

At the time of completion of this report, rehabilitation design was still underway, but informed by the following principles, developed in collaboration with the project team as a whole:

1. Rehabilitation interventions will not aim to, or be able to, rehabilitate / restore the wetland to its previous function as a peatland wetland, although small pockets of peat may retain or recover functionality over time.

2. The main objectives of rehabilitation interventions must be to stabilise sediments within the wetland to reduce substantially their downstream transport into the estuary.
3. Mechanisms to stabilise sediment will include requirements for major engineered structures (i.e. gabion weirs) as well as intensive efforts to re-establish appropriate indigenous plants in the wetland, to enhance sediment stabilisation and improve habitat quality and ecosystem services.
4. Raising of the local water table in the wetland must also be an important part of rehabilitation design, and will both improve wetland habitat quality and, as soils increase in moisture content and saturation, reduce the threat of fires.
5. The remnant palmiet reedbeds in the wetland are almost wholly compromised by extended droughting as a result of wetland drainage. In most cases, retention of these areas will not be helpful and will increase fire risk. Instead, it is recommended that functional plant material with propagation potential should be retained as far as is practical and used in the rehabilitation works. The remaining desiccated peatland should be mechanically graded and used to create flatter side-slopes that will lend themselves to revegetation, and to infill the incised main channels through the wetland.
6. Urgent attention should be paid to the sourcing, propagation and growing up of locally indigenous appropriate plant material, ideally sourced from the wetland or its catchment, in order for sufficient plants to be available for use in the rehabilitation works.
7. Given the extensive additional disturbance that will be a necessary part of undertaking the construction phase of the necessary rehabilitation works, it will be important that the project team communicates adequately with local communities, authorities and other Interested and Affected Parties (I&APs) regarding the nature, timing and intended outcomes of the rehabilitation process.

5.5 Legal authorisation for proposed interventions

The planned rehabilitation / remediation interventions for the Onrus Wetland will definitely trigger requirements for authorisation in terms of the National Environmental Management ACT (NEMA) (Act 107 of 1998) and the National Water Act (NWA) (Act 36 of 1998). Engagement with BOCMA and DEADP officials (see Section 1.4) resulted in agreement that authorisation for project implementation would be applied for through the submission of an Environmental Management Programme (EMPr) as gazetted in Government Notice (GN) 276 of 2021 for consideration for authorisation by the Department of Forestry, Fisheries and the Environment (DFFE) and in terms of the Emergency Protocols included in Appendix D of the General Authorisation for Section 21c and 21i water uses allowed for in GN4167 of 2023, in terms of the NWA. The necessary documentation for these authorisations will be prepared in subsequent phases of this project, once detailed rehabilitation plans have been prepared.

6 CONCLUSIONS AND WAY FORWARDS

This report has presented relevant information relating to the history and current condition of the Onrus Wetland. It has highlighted the catastrophic degradation that has affected the wetland, in particular since September 2023, but stemming from perhaps decades of accumulating impact and lowered resilience. While restoration of the wetland to its natural function as an important peatland wetland is not a realistic planning objective, rehabilitation of the wetland toa more sustainable condition that allows for a substantial improvement in the capacity of the wetland to retain sediments and attenuate flood flows is critically important and should be initiated with high urgency. Failure to do so will see the ongoing deterioration of the Onrus Estuary as a result of the continued or episodic passage of large volumes of unstable sediment from the system. Risks of fire through the degraded peat beds are also particularly high in its present condition.

Preparation of detailed plans for rehabilitation intervention works is the next step in this process, and ecological input will be an important informant of the design process, which will be provided as a Rehabilitation Report in the next phase of this project. The Rehabilitation Report will form the basis for the planned EMPr, to be submitted to LandCare for authorisation through the DFFE.

While the rehabilitation plan currently being developed will focus only on direct measures for the Onrus Wetland itself, it is important that later project phases consider and address the significant river and wetland degradation and threats to intact wetlands upstream of the Onrus Wetland, as well as in its reaches downstream, as far as the estuary. Such measures are necessary not only to prevent further upstream degradation, but also for the sustainability of the Onrus Wetland itself, which is increasingly dependent on water flows from the upstream catchment (Le Roux et al 2023) and impacted by upstream activities or processes such as erosion and sedimentation.

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APPENDICES

APPENDIX A

SPECIALIST CV

LIZ DAY'S CURRICULUM VITAE

SUMMARY DOCUMENT (2025)

Name	Dr Elizabeth (Liz) Day (née Reynolds)
Address	6 Flamingo Crescent, Zeekoevlei, 7941, Cape Town, South Africa
Cell number	083 454 2309
Email	liz@lizdayconsulting.co.za
Date of birth	3 May 1968
Place of birth	Zimbabwe
Nationality	South African
Current Position	Director: Liz Day Consulting (Pty) Ltd

Liz Day is a **Freshwater Ecologist** who provides specialist input into river and wetland ecosystems management and rehabilitation, water quality, baseline assessments, impact assessments, wetland offset determinations, strategic planning and review and other aspects of aquatic ecosystem consulting. She has particular experience in working in rehabilitation and management of urban and agricultural areas, across a wide range of socio economic conditions.

KEY WORK EXPERIENCE

2019 -	Specialist consultant on freshwater ecosystems (rivers and wetlands) – Liz Day Consulting (Pty) Ltd
1999- 2019	Specialist consultant on freshwater ecosystems; co-founder of Freshwater Consulting (FCG)
1997 - 1999	Senior Consultant for Southern Waters Ecological Research and Consulting cc
1994 - 1996	Scientific Officer on Water Research Commission Project, Freshwater Research Unit, UCT.

SUMMARY OF RELEVANT EXPERIENCE

> 30 years' experience in aspects of aquatic ecology, specialising in:

- Water quality - river, vlei and wetland water quality monitoring, data analysis and interpretation as well as urban stormwater quality, pollution tracking and pollution abatement assessments;
- Lake, wetland and river rehabilitation, (ecological) design and management;
- Urban river and wetland management and rehabilitation;
- Stormwater design with respect to freshwater ecosystems and water quality amelioration;
- Specialist input into environmental impact assessments; baseline and situation assessments;
- DWS Risk Assessments;
- Wetland Offset calculations and agreements;
- Catchment and River Management Plans;
- River corridor plans;
- River and wetland Maintenance and Management Plans;
- River and wetland mapping and biodiversity planning;
- Wetland and riparian area delineation;
- SASS5 bioassessments.

Liz has compiled over 1000 specialist riverine ecology technical reports, 12 scientific papers (6 in international literature); 20 popular biological articles published in local environmental magazines, scripts for several environmental documentaries; *ad hoc* lecturer in freshwater ecology at UCT; co-author on 5 Water Research Commission reports; lead author on chapter in UNESCO Sustainable Management of Urban Aquatic Ecosystems handbook; lead author on chapter in Fynbos Ecosystem Management book; project leader and author of WRC Technical Manual for River Rehabilitation in South Africa (2016) and on the (in prep) "Let's Fix your Rivers" WRC handbook series. She has also sat on the Reference Groups / Steering Committees of numerous Water Research projects, including those relating to wetland ecological infrastructure, wetland rehabilitation monitoring protocols, Sustainable Urban Drainage Systems (SUDS) and Water Sensitive Urban Design (WSUD) in the City of Cape Town and eThekwini Municipalities.

KEY QUALIFICATIONS

- Bachelor of Arts (English), University of Cape Town, 1989
- Bachelor of Science (Zoology and Environmental and Geographical Science); University of Cape Town; 1992
- Bachelor of Science (honours- Zoology, first class); University of Cape Town, 1993
- PhD (Zoology / Marine Biology); University of Cape Town, 1998

PROFESSIONAL AFFILIATIONS AND MEMBERSHIPS

- Registered Professional Natural Scientist by SACNASP (Reg No 004806)
- Member of SAWS, WISA, IAIA-SA and Society for Ecological Restoration (SER) (African Chapter)
- Member of False Bay Nature Reserve Protected Area Advisory Committee
- Member – Section 80 Mayoral Advisory Committee on Water Quality in Wetlands and Waterways
- Chair: Zeekoe Catchment Management Forum

APPENDIX B

WATER QUALITY ANALYSIS CERTIFICATES AND *IN SITU* DATA

Table B1

Certificate of analyses for water quality measurements: Onrus wetland. Sites as in Figure 2.1

aquatico
Cape Laboratories (Pty) Ltd

ilac-MRA sanas Testing Laboratory T1067

Test Report **Page 1 of 1**

Client: Liz Day Consulting
Address: 6 Flamingo Crescent, Zeekoevlei, Cape Town, 7941
Report no: 207663
Project: Onrus

Date of report: 23 January 2025
Date accepted: 13 January 2025
Date completed: 23 January 2025
Date received: 13 January 2025

Lab no:					187478	187479	187480
Date sampled:					13-Jan-25	13-Jan-25	13-Jan-25
Aquatico sampled:					No	No	No
Sample type:					Water	Water	Water
Locality description:					OR WQ1	OR WQ2	OR WQ3
		Analyses	Unit	Method			
A	AQCL	pH @ 25°C	pH	ALM 20	7.29	6.87	6.81
A	AQCL	Nitrate (NO_3) as N	mg/l	ALM 06	2.60	0.377	0.229
A	AQCL	Total oxidised nitrogen as N	mg/l	ALM 06	2.61	0.385	0.237
A	AQCL	Nitrite (NO_2) as N	mg/l	ALM 07	<0.065	<0.065	<0.065
A	AQCL	Ammonium (NH_4) as N	mg/l	ALM 05	0.104	0.070	0.044
N	AQCL	Un-ionized Ammonia as N	mg/l	ALM 26	<0.005	<0.005	<0.005
A	AQL	Total phosphorus	mg/l	ALM 12	0.201	0.206	0.157
A	AQCL	Orthophosphate (PO_4) as P	mg/l	ALM 12	0.190	0.180	0.150
A	AQCL	Total suspended solids (TSS)	mg/l	ALM 25	<4.5	5.0	7.0
A	AQCL	Temperature	°C	ALM 20	23.0	23.1	23.0
A	AQL	TP-Microwave digestion	mg/l	ALM 90	Yes	Yes	Yes

A = Accredited N = Non accredited Sub = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine ATR = Alternative test report ; Results relate only to the items received and tested ; Results reported against the limit of detection; Results marked 'Non SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory; Uncertainty of measurement available on request for all methods included in the SANAS Schedule of Accreditation; The report shall not be reproduced except in full without approval of the laboratory

Iain Belford
Technical Signatory

AQL = Aquatico Laboratories ; AQCL = Aquatico Cape Laboratories

AQL	89 Regency Drive, R21 Corporate Park, Centurion, South Africa	Tel: +27 12 450 3800	www.aquatico.co.za
AQCL	Olive Grove Business Estate, Block H, Ou Paardevlei Rd,Somerset West, 7130	Tel: +27 12 450 4500	www.aquatico.co.za

Table 1.3
Results of *in situ* water quality data (13 January 2025)

Analyses	WQ1	WQ2	WQ3
pH @ 25ºC	7.29	6.87	6.81
Nitrate (NO_3) as N	2.6	0.377	0.229
Total oxidised nitrogen as N	2.61	0.385	0.237
Nitrite (NO_2) as N	<0.065	<0.065	<0.065
Ammonium (NH_4) as N	0.104	0.07	0.044
Un-ionized Ammonia as N	<0.005	<0.005	<0.005
Total phosphorus	0.201	0.206	0.157
Orthophosphate (PO_4) as P	0.19	0.18	0.15
Total suspended solids (TSS)	<4.5	5	7
Temperature(ºC)	23	23.1	23
TP-Microwave digestion	Yes	Yes	Yes

APPENDIX C

Wetland soils assessment results and brief discussion

C1 DATA

Raw data, analysed hydraulic infiltration data and brief descriptions of data implications are included in this appendix, and referenced in the main report. Sample methodologies are as outlined in Section 2.

Table C1
Soil samples Infiltration data with hydraulic conductivity(K), Van Ganutchen parameter(A), the value of the curve of cumulative infiltration vs square root of time and the repellency index. Data calculated from the MODEL Excel system included with the Mini Disk Infiltrometer Manual.

Site	Soil	K(Hydraulic conductivity)(cm/s)	A	C1(cm/s)	Repellency
S1 (water)	sand	0.097	1.73	0.17	0.22
S1 (ethanol)	sand	0.011	1.73	0.019	
S2 (water)	sand	0.076	1.73	0.13	0.15
S2 (ethanol)	sand	0.0056	1.73	0.0098	
S3 (water)	sand	0.1	1.73	0.18	0.14
S3 (ethanol)	sand	0.0076	1.73	0.013	
UP3 (water)	sandy loam	0.0007	3.91	0.003	0.65
UP3 (ethanol)	sandy loam	0.0003	3.91	0.001	
EXP2 (water)	sandy loam	0.0002	3.91	0.0008	14.63
EXP2 (ethanol)	sandy loam	0.002	3.91	0.006	
EXP3 (Water)	sandy loam	0.001	3.91	0.004	2.93
EXP3 (ethanol)	sandy loam	0.002	3.91	0.006	
EXP1 (water)	sandy loam	0.0001	3.91	0.0004	29.25
EXP1 (ethanol)	sandy loam	0.002	3.91	0.006	
EXP2 (water)	sandy loam	0.0002	3.91	0.0007	1.39
EXP2 (ethanol)	sandy loam	0.0001	3.91	0.0005	
UNP1 (water)	loamy sand	0.00021	3.91	0.0008	4.88
UNP1 (ethanol)	loamy sand	0.0004	3.91	0.002	
UNP2 (water)	sandy loam	0.00001	3.91	0.00005	7.80
UNP2 (ethanol)	sandy loam	0.00006	3.91	0.0002	
UNP3 (water)	loamy sand	0.0002	3.91	0.0008	17.06
UNP3 (ethanol)	loamy sand	0.002	3.91	0.007	
UNP4 (water)	sandy Loam	0.0005	3.91	0.002	1.95
UNP4 (ethanol)	sandy loam	0.0004	3.91	0.002	
UNP5 (ethanol)	sandy loam	0.0003	3.91	0.001	1.37
UNP5 (ethanol)	sandy loam	0.0002	3.91	0.0007	
UNP6 (water)	sandy loam	0.0006	3.91	0.002	0.98
UNP6 (ethanol)	sandy loam	0.0003	3.91	0.001	
UNP7 (water)	sandy clay loam	0.0002	3.91	0.0009	1.30
UNP7 (ethanol)	sandy clay loam	0.0002	3.91	0.0006	
UNP8 (water)	sandy loam	0.0004	3.91	0.001	1.37
UNP8 (ethanol)	sandy loam	0.0002	3.91	0.0007	
UNP9 (farm)	sandy loam	0.0002	3.91	0.001	3.90
UNP9 (ethanol)	sandy loam	0.0005	3.91	0.002	
UNP10 (water)	sandy loam	0.0005	3.91	0.002	0.39
UNP10 (ethanol)	sandy loam	0.0001	3.91	0.0004	
EXP3 (water)	sandy loam	0.0003	3.91	0.001	1.95
EXP3 (ethanol)	sandy loam	0.0002	3.91	0.001	
EXP4(water)	sandy loam	0.0004	3.91	0.002	0.98
EXP4 (ethanol)	sandy loam	0.0002	3.91	0.001	
UNP11 (water)	sandy loam	0.0005	3.91	0.002	2.93
UNP11 (ethanol)	sandy loam	0.0007	3.91	0.003	
UNP12 (water)	sandy loam	0.0003	3.91	0.001	1.17
UNP12 (ethanol)	sandy loam	0.0002	3.91	0.0006	
UNP13 (water)	sandy clay loam	0.0005	3.91	0.002	0.20
UNP13 (ethanol)	sandy clay loam	0.0005	3.91	0.0002	
UNP14 (water)	sandy clay loam	0.0002	3.91	0.0007	5.57
UNP14 (ethanol)	sandy clay loam	0.0006	3.91	0.002	
UNP15 (water)	sandy loam	0.0003	3.91	0.0001	19.50
UNP15 (ethanol)	sandy loam	0.0004	3.91	0.001	
EXP5 (water)	sandy loam	0.0005	3.91	0.002	0.98
EXP5 (ethanol)	sandy loam	0.0003	3.91	0.001	
UNP16 (water)	sandy loam	0.0001	3.91	0.004	2.44
UNP16 (ethanol)	sandy loam	0.001	3.91	0.005	
UNP17 (water)	sandy loam	0.0004	3.91	0.001	0.59
UNP17 (ethanol)	sandy loam	0.00008	3.91	0.0003	

Table C2
Soil sample codes as shown on maps and in main report body (Figure 2.3) and corresponding laboratory codes

Map codes	lab Codes
SS1	S1-2
SS2	S3
SS3	UP3
SS4	EXP1-3
SS5	UNP1
SS6	UNP2
SS7	UNP3
SS8	UNP4
SS9	UNP5
SS10	EXP1
SS11	UNP6
SS12	EXP2
SS13	UNP7
SS14	UNP8
SS15	UNP9
SS16	UNP10
SS17	EXP3
SS18	EXP4
SS19	UNP11
SS20	UNP12
SS21	UNP13
SS22	UNP14
SS23	UNP15
SS24	EXP5
SS25	UNP16
SS26	UNP17
SS27	UNP19
SS28	EXP6
SS29	UNP18

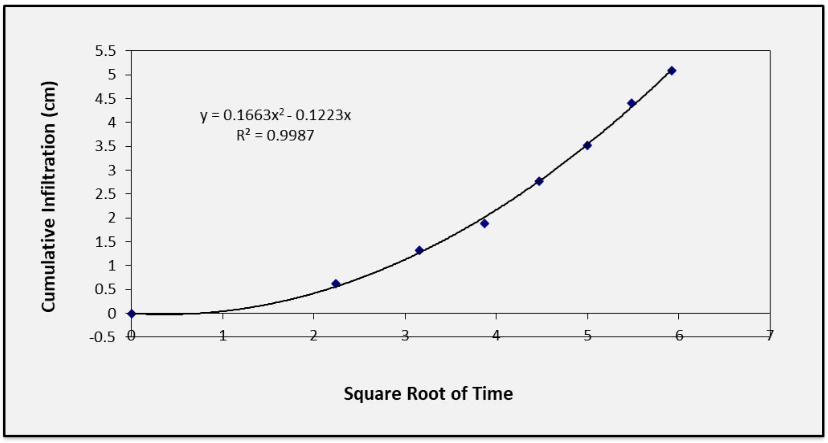

Figure C.1: Infiltration graph of sample S1 (water)

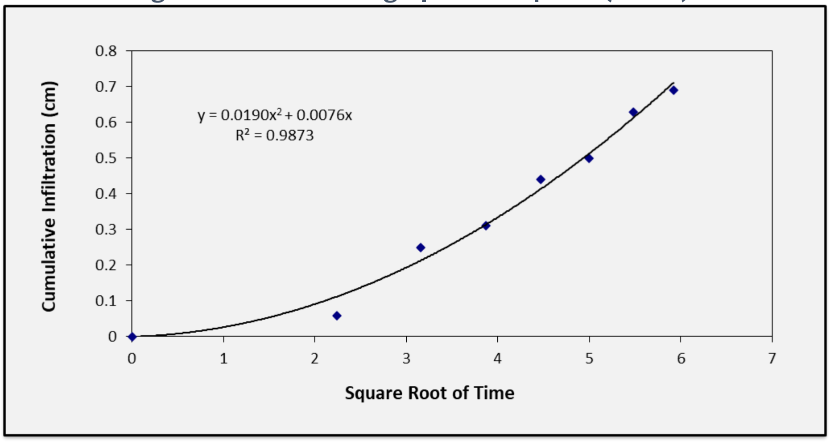

Figure C.2: Infiltration graph of sample S1 (ethanol)

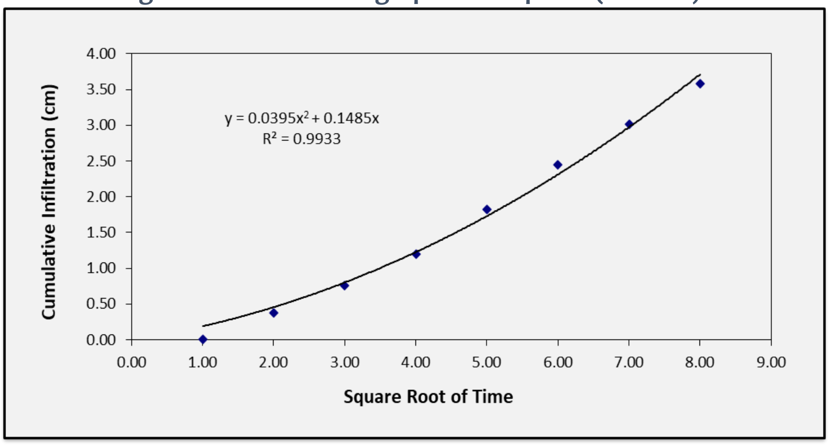

Figure C.3: Infiltration graph of sample S2 (water)

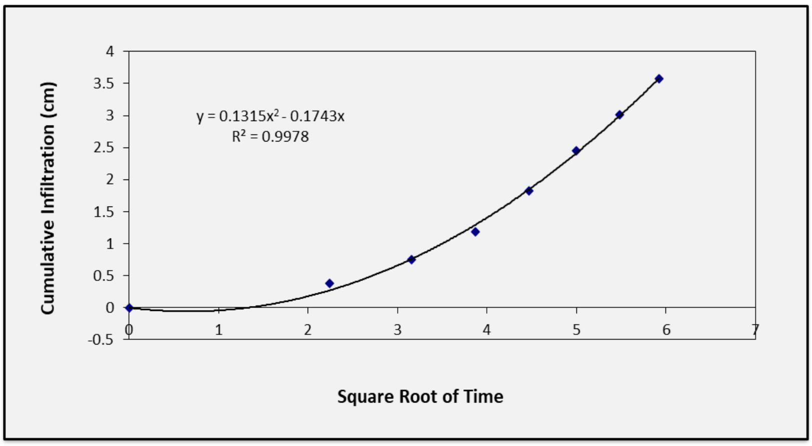

Figure C.4: Infiltration graph of sample S2 (ethanol)

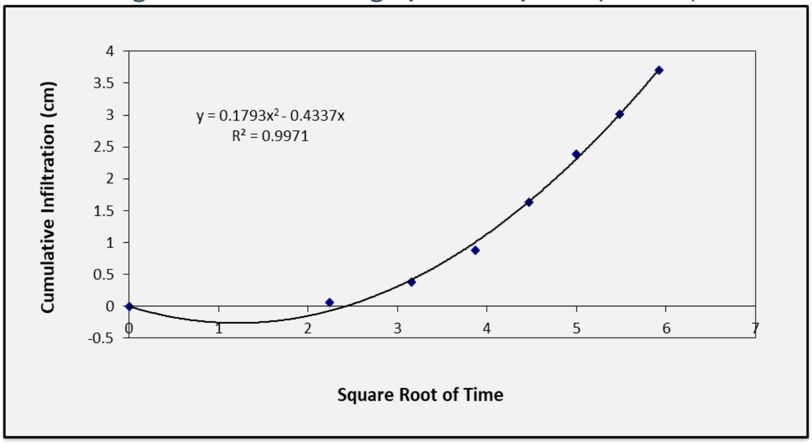

Figure C.5: Infiltration graph of sample S3 (water)

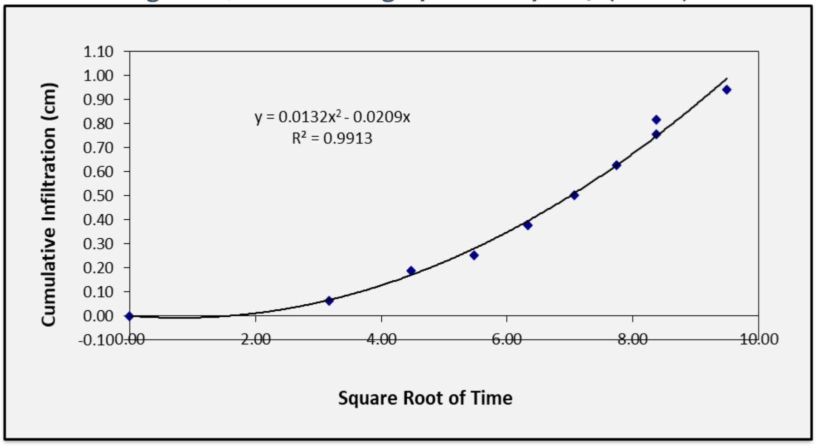

Figure C.5: Infiltration graph of sample S3 (ethanol)

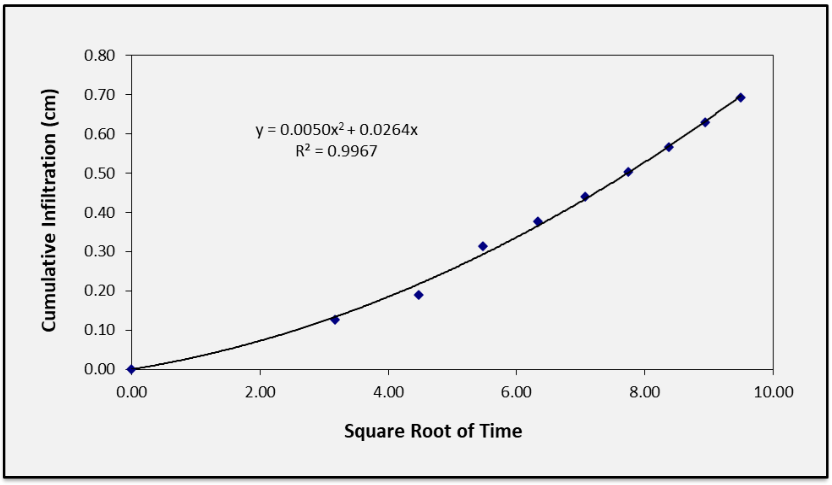

Figure C.7: Infiltration graph of sample UP2 (water)

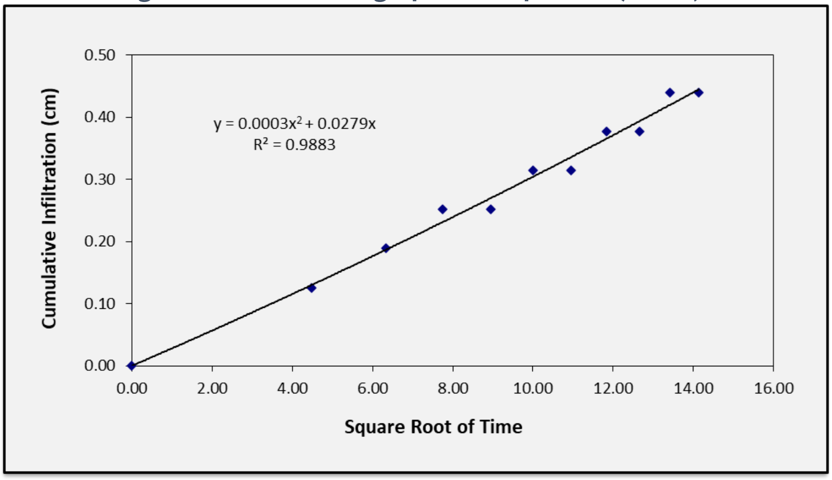

Figure C.8: Infiltration graph of sample UP2 (ethanol)

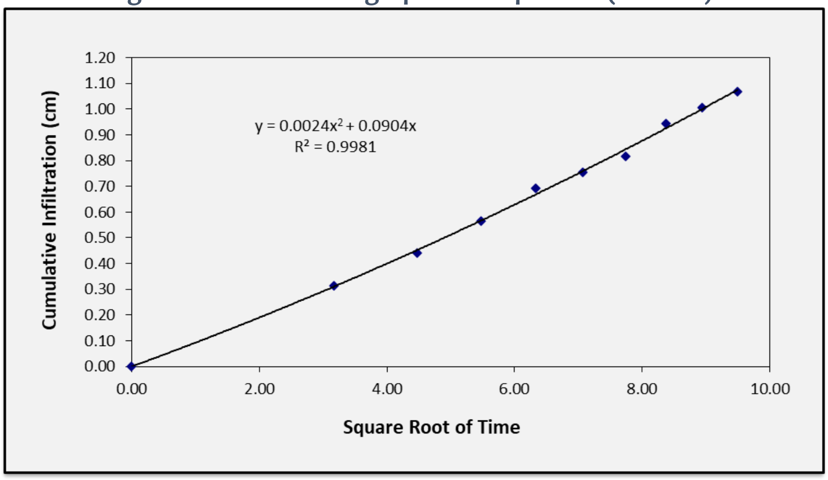

Figure C.9: Infiltration graph of sample UP3 (water

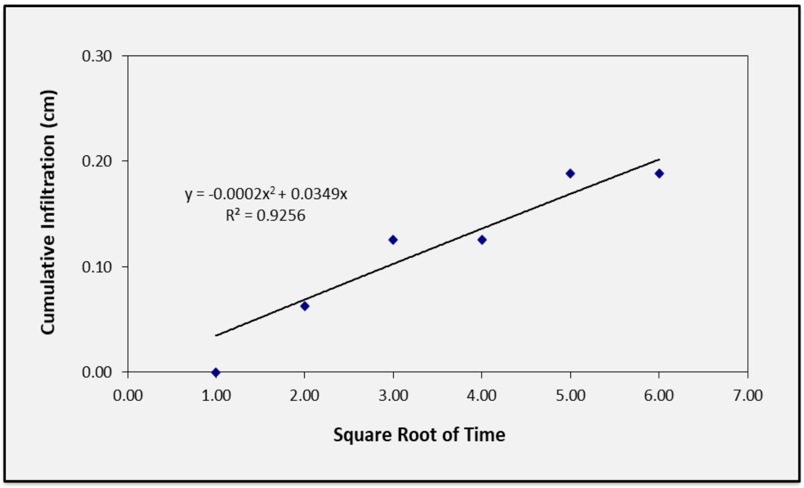

Figure C.10: Figure C.10: Infiltration graph of sample UP3 (ethanol)

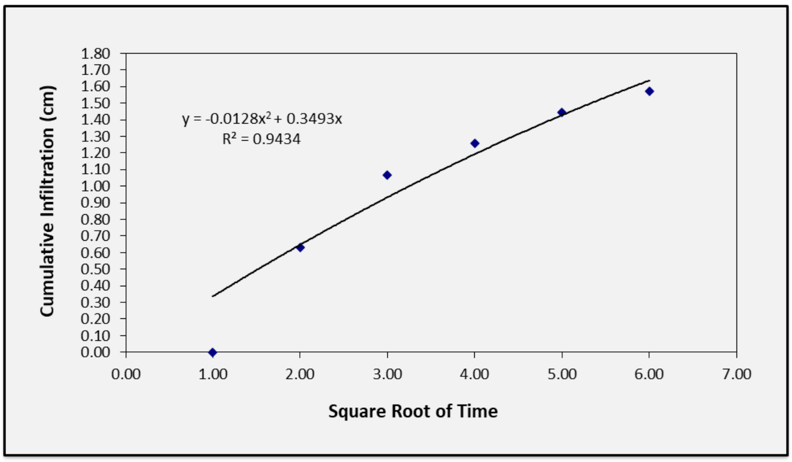

Figure C.11: Infiltration graph of sample EXP2 (water)

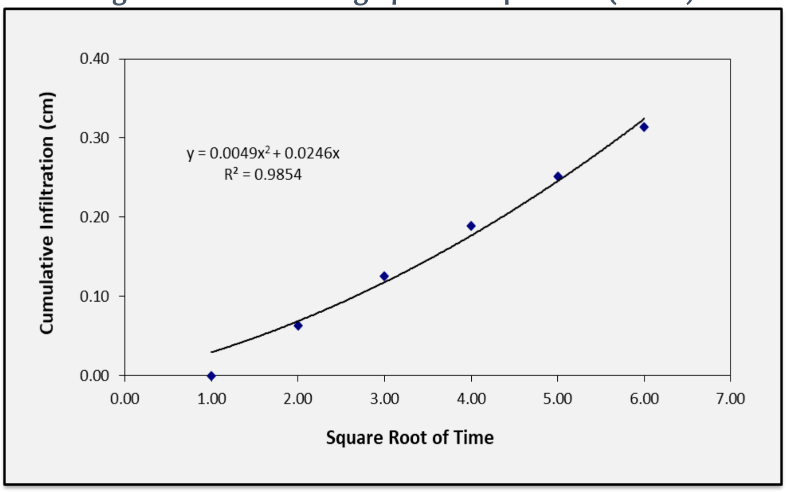

Figure C.12: Infiltration graph of sample EXP2 (ethanol)

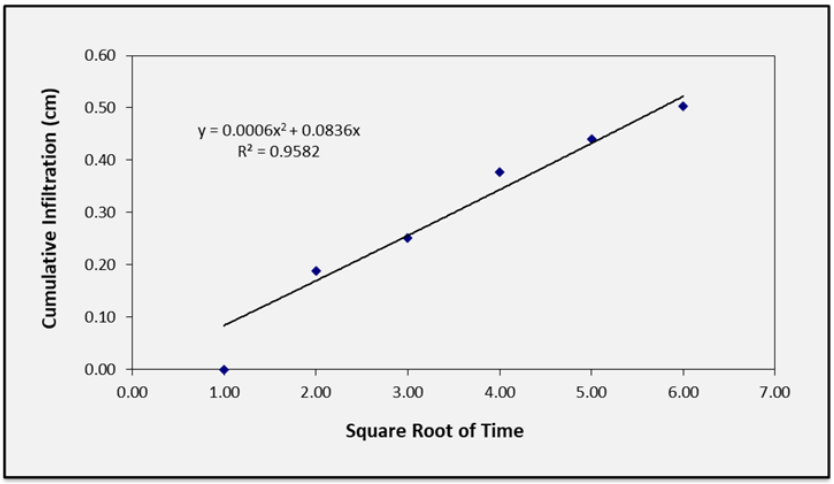

Figure C.13: Infiltration graph of sample EXP3(water)

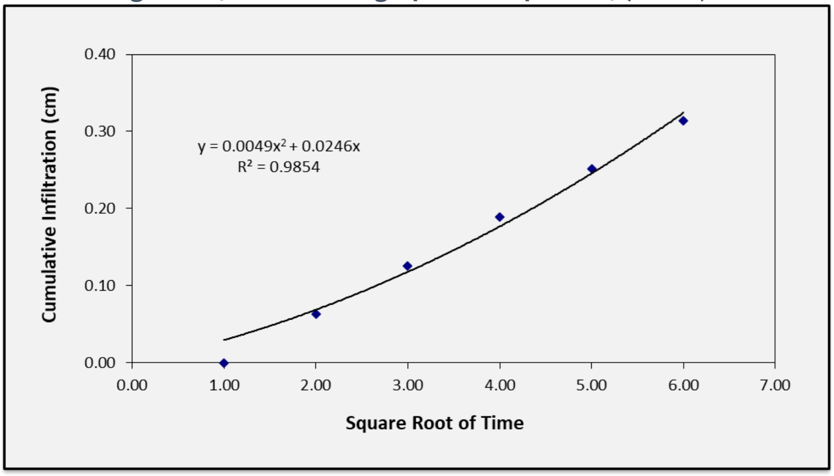

Figure C.14: Infiltration graph of sample EXP3(ethanol)

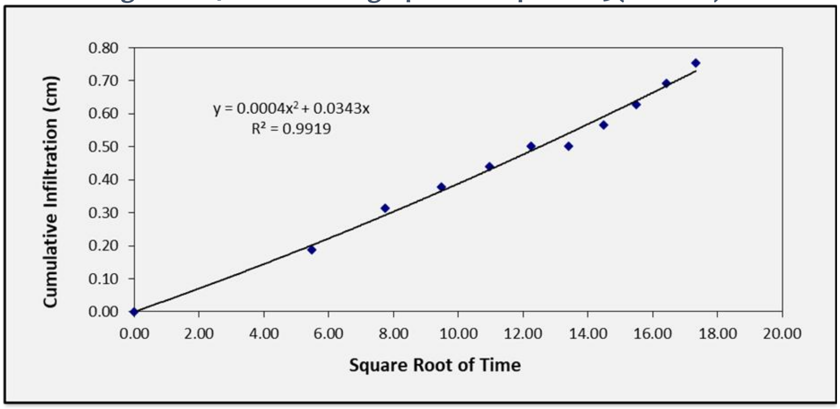

Figure C.15: Infiltration graph of sample EXP1(water)

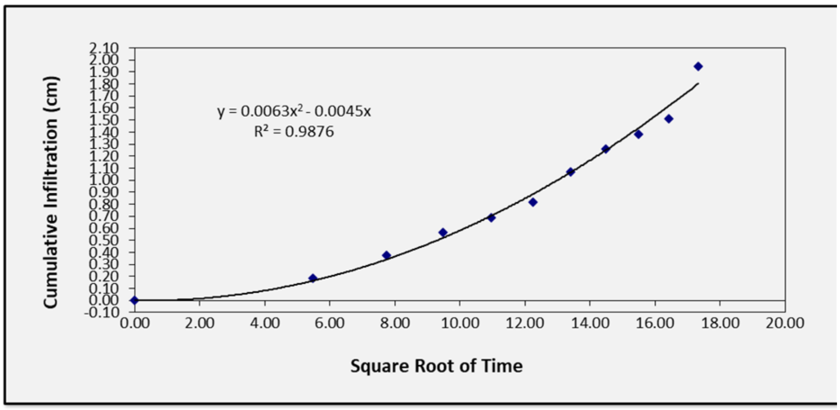

Figure C.16: Infiltration graph of sample EXP1(ethanol)

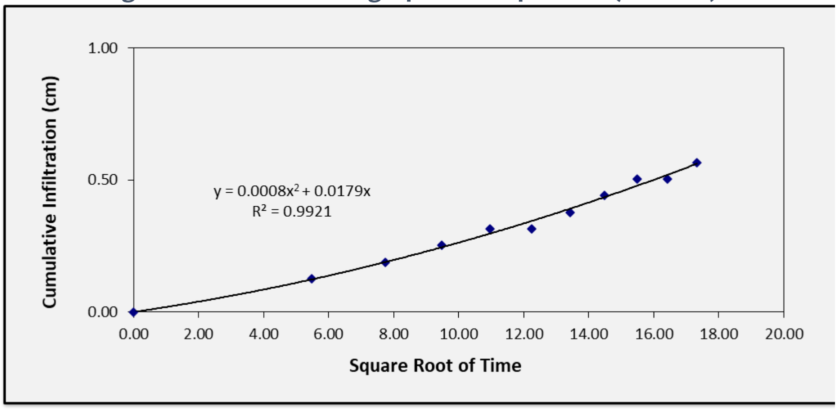

Figure C.17: Infiltration graph of sample UNP1 (water)

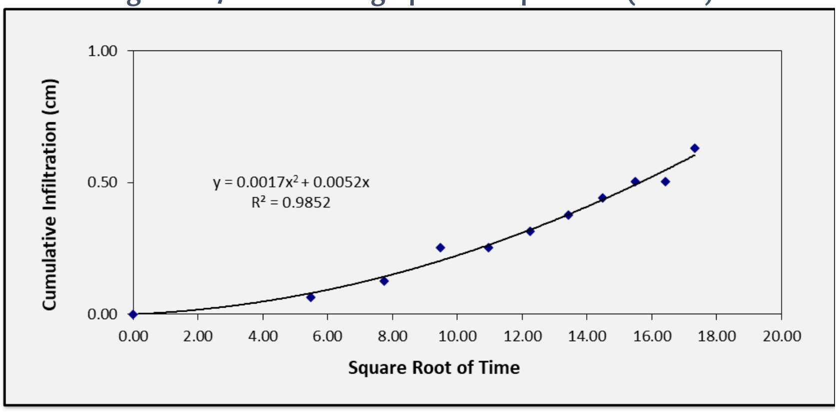

Figure C.18: Infiltration graph of sample UNP1 (ethanol)

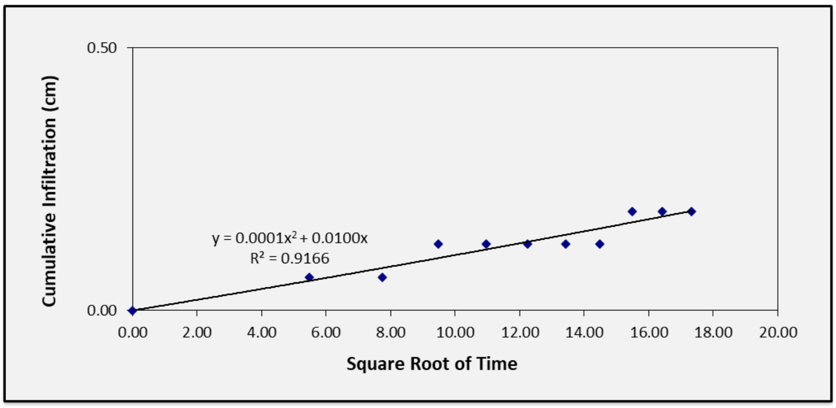

Figure C.19: Infiltration graph of sample UNP2(water)

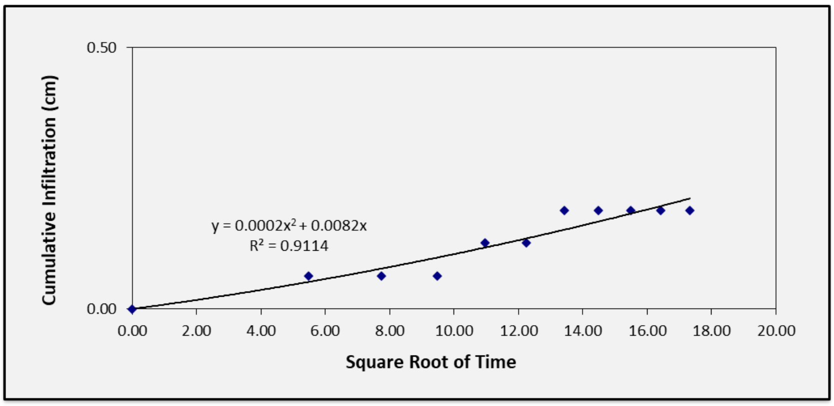

Figure C.20: Infiltration graph of sample UNP2 (ethanol)

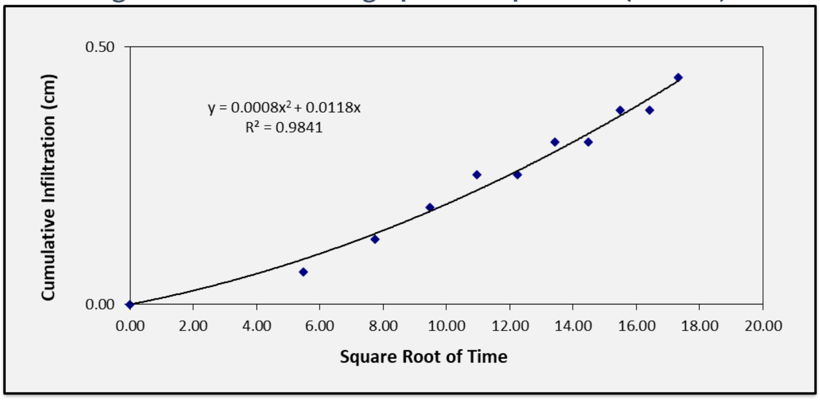

Figure C.21: Infiltration graph of sample UNP3 (water)

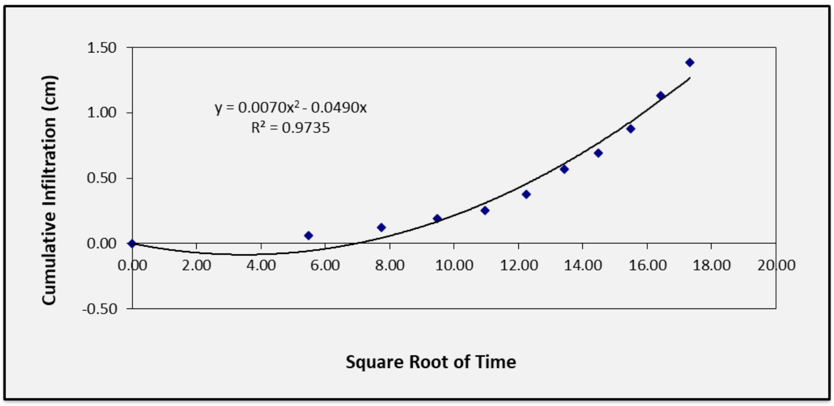

Figure C.22: Infiltration graph of sample UNP3 (ethanol)

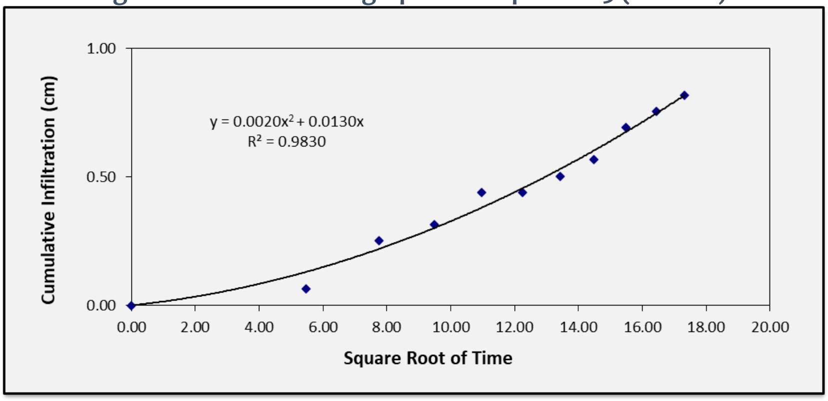

Figure C.23: Infiltration graph of sample UNP4 (water)

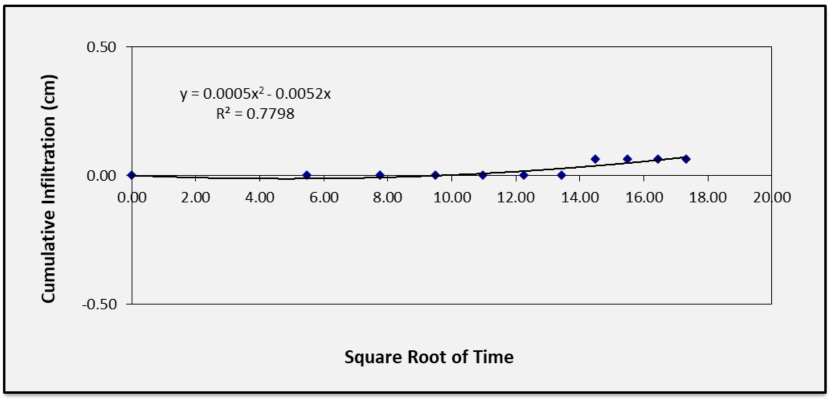

Figure C.24: Infiltration graph of sample UNP4 (ethanol)

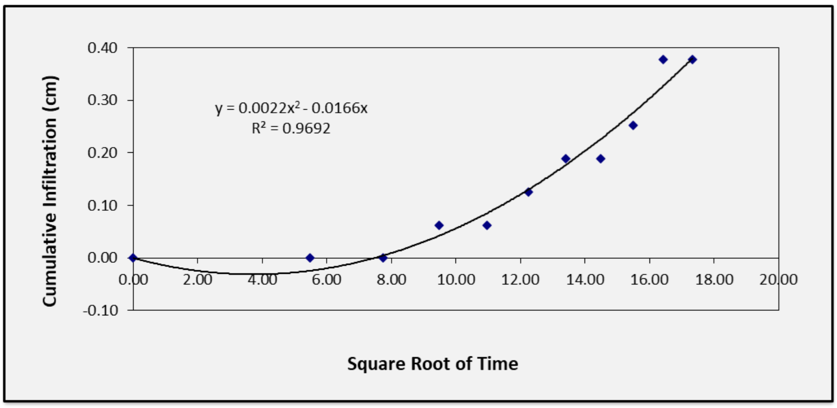

Figure C.25: Infiltration graph of sample UNP6 (water)

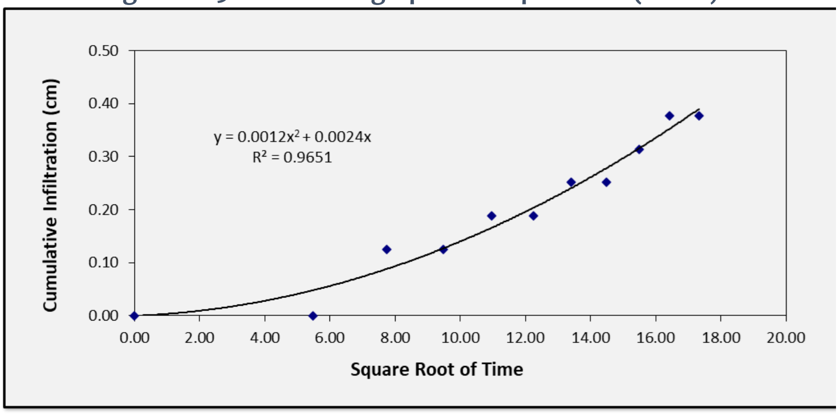

Figure C.26: Infiltration graph of sample UNP6 (ethanol)

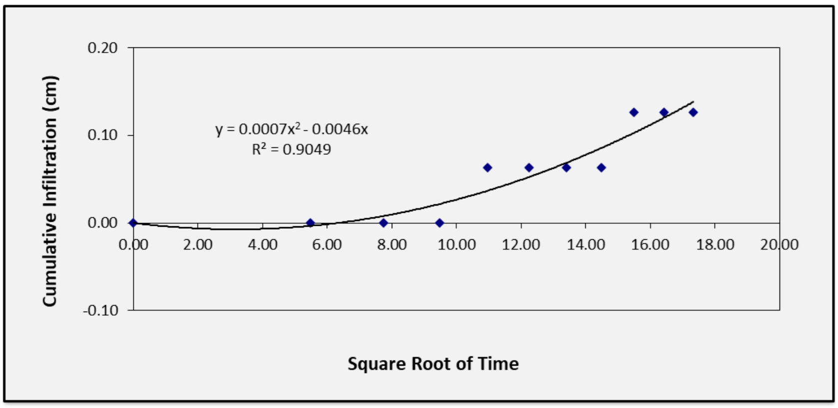

Figure C.27: Infiltration graph of sample EXP2 (water)

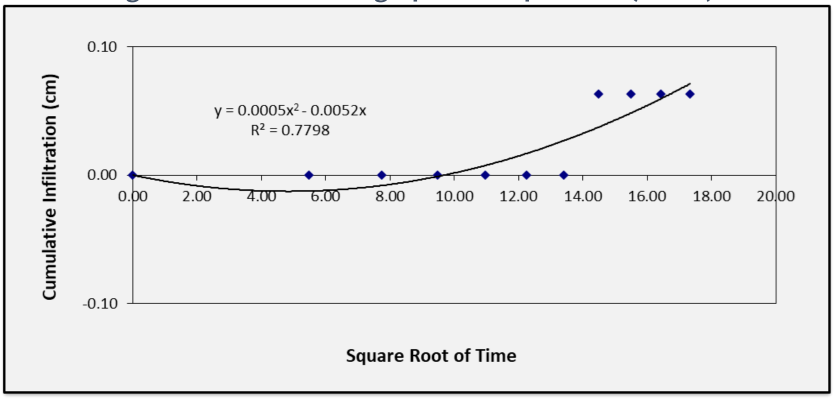

Figure C.28: Infiltration graph of sample EXP2 (ethanol)

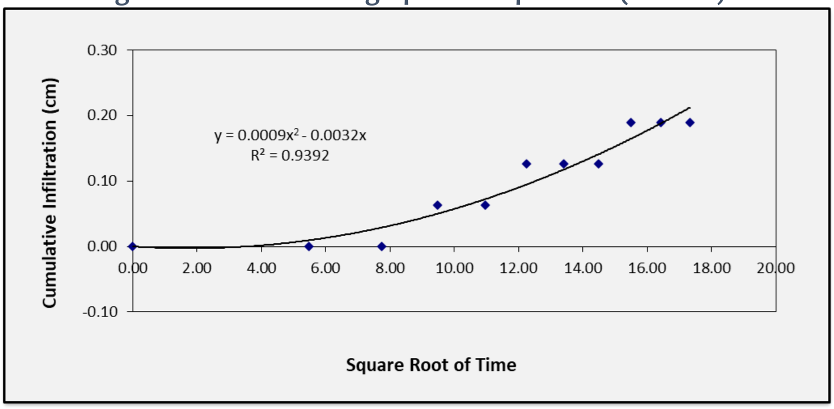

Figure C.29: Infiltration graph of sample UNP7 (Water)

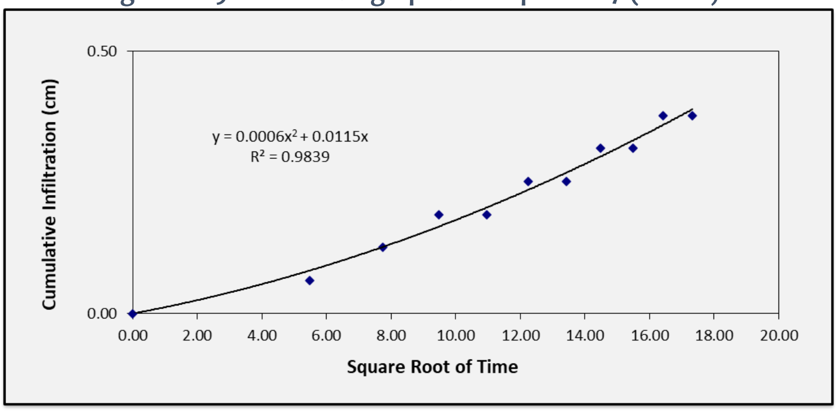

Figure C.30: Infiltration graph of sample UNP7 (ethanol)

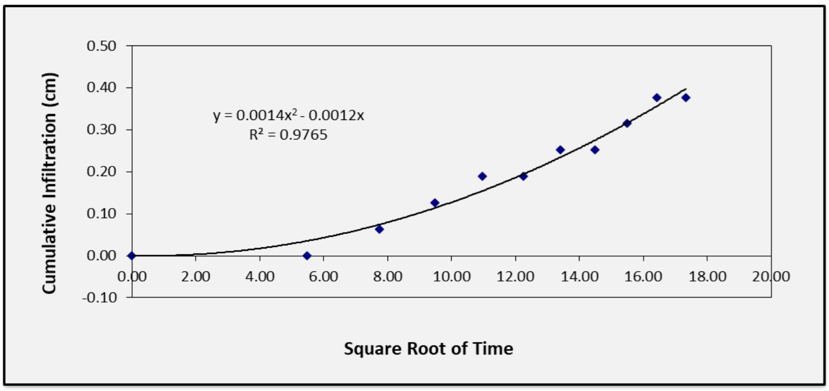

Figure C.31: Infiltration graph of sample UNP8 (water)

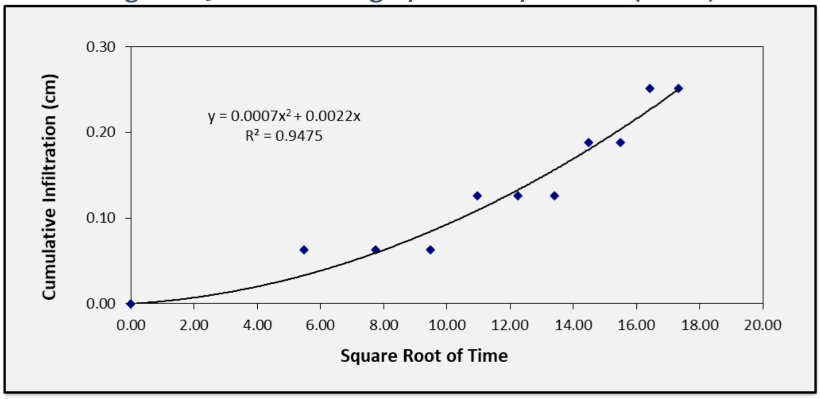

Figure C.32: Infiltration graph of sample UNP8 (ethanol)

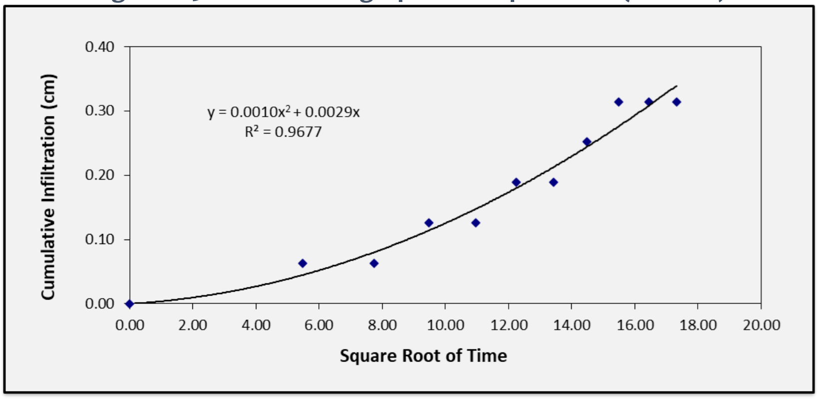

Figure C.33: Infiltration graph of sample UNP9 (water)

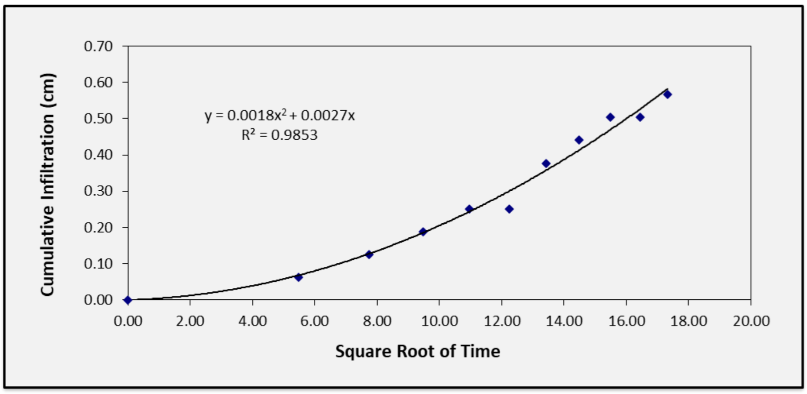

Figure C.34: Infiltration graph of sample UNP9 (ethanol

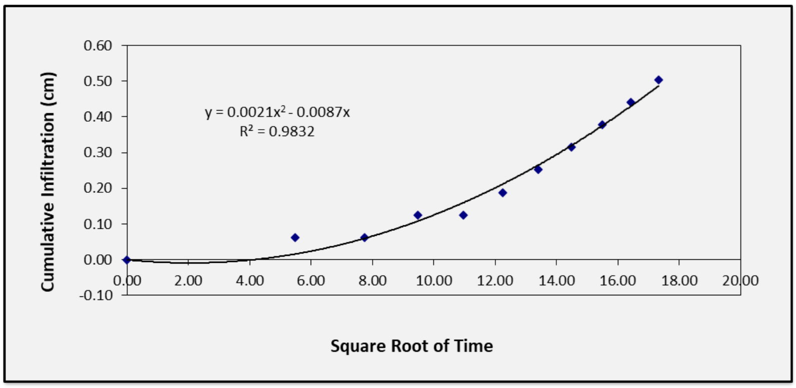

Figure C.35: Infiltration graph of sample UNP10 (water)

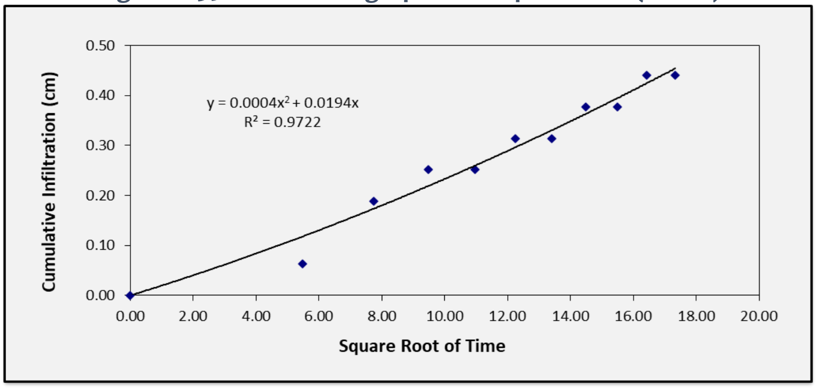

Figure C.36: Infiltration graph of sample UNP10 (ethanol)

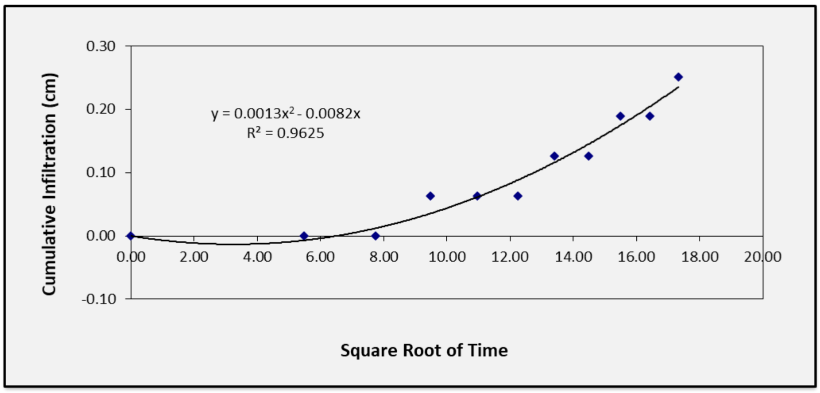

Figure C.37: Infiltration graph of sample EXP3 (water)

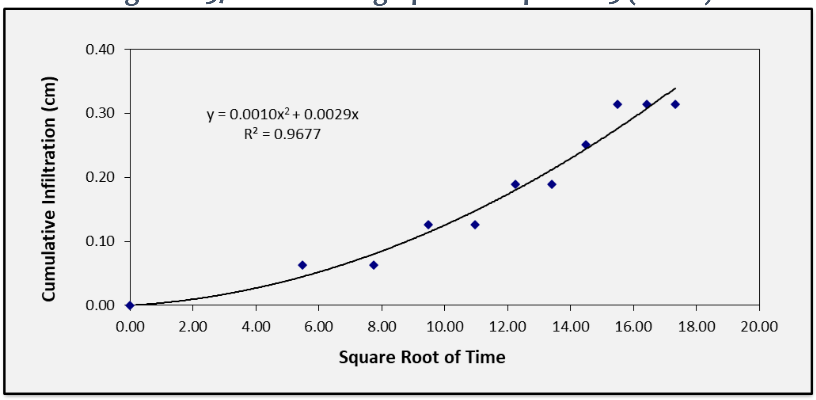

Figure C.38: Infiltration graph of sample EXP3 (ethanol)

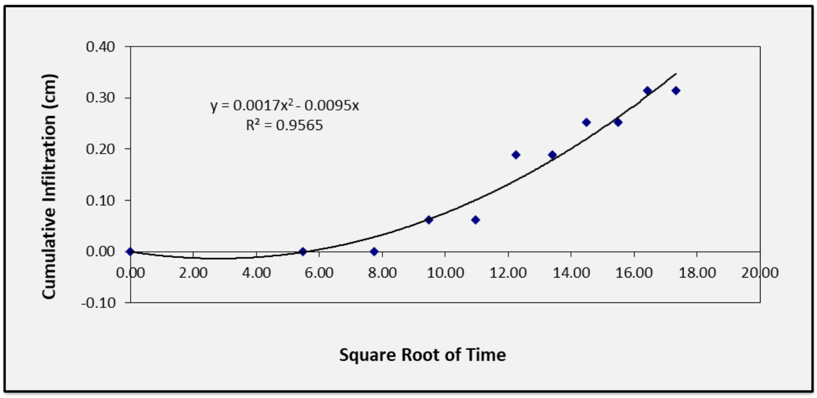

Figure C.39: Infiltration graph of sample EXP4 (water)

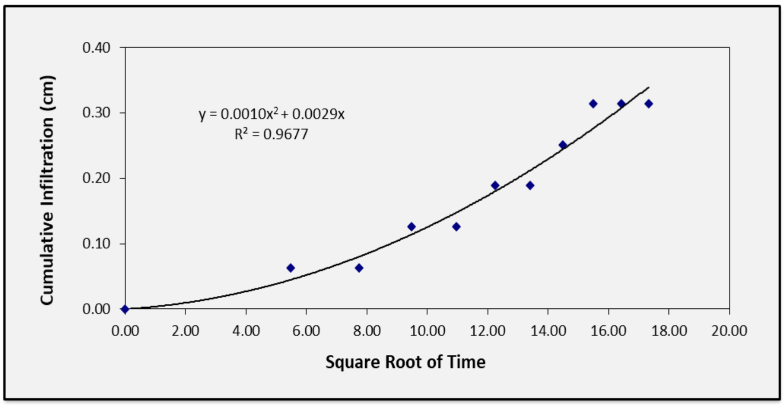

Figure C.40: Infiltration graph of sample EXP4 (ethanol)

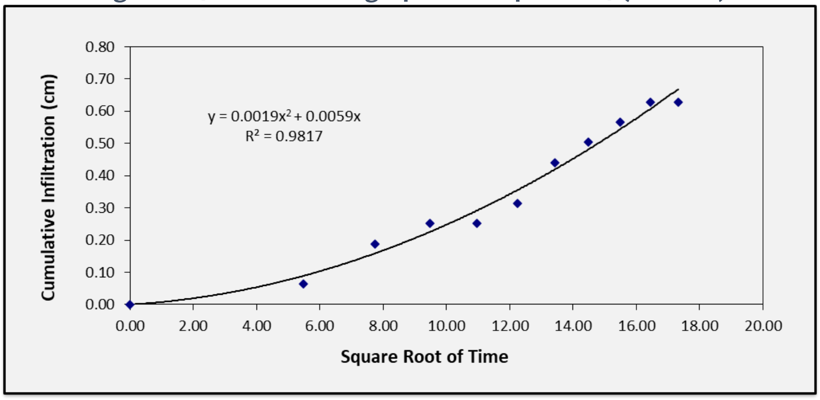

Figure C.41: Infiltration graph of sample UNP11 (water)

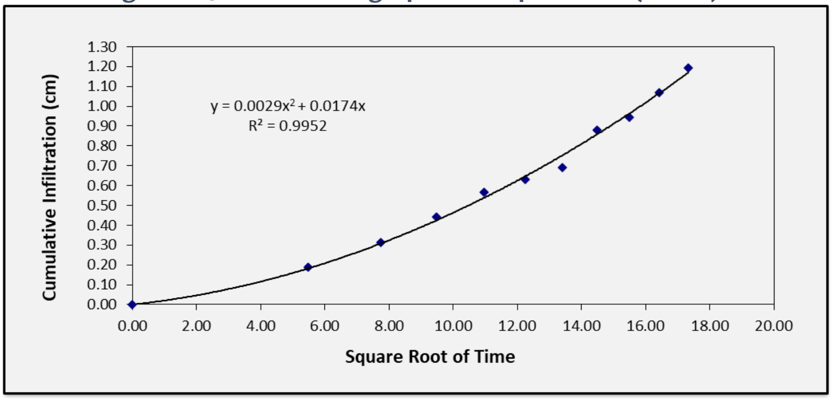

Figure C.42: Infiltration graph of sample UNP11 (ethanol)

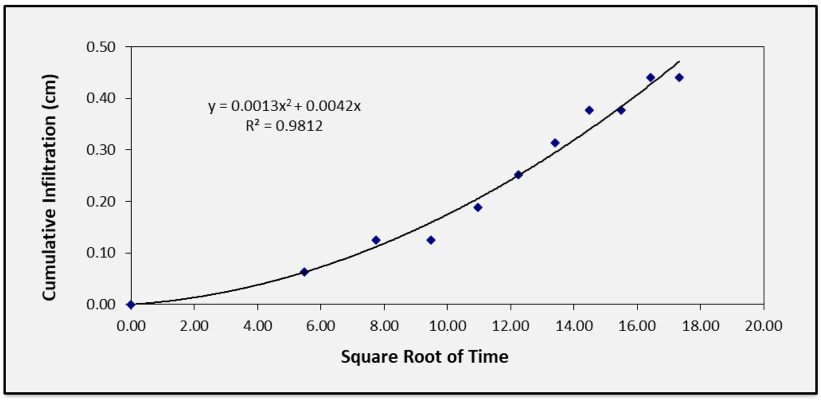

Figure C.43: Infiltration graph of sample UNP12 (water)

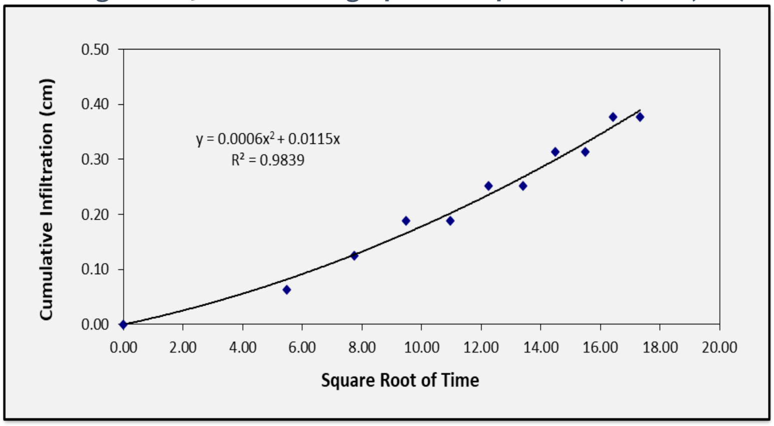

Figure C.44: Infiltration graph of sample UNP12 (ethanol)

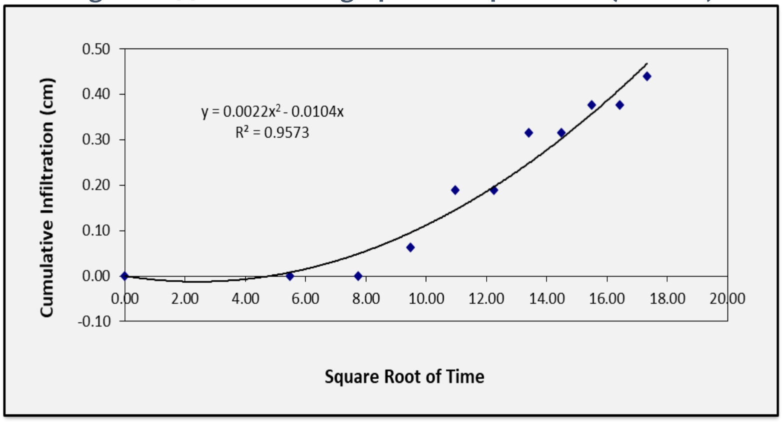

Figure C.44: Infiltration graph of sample UNP13 (water)

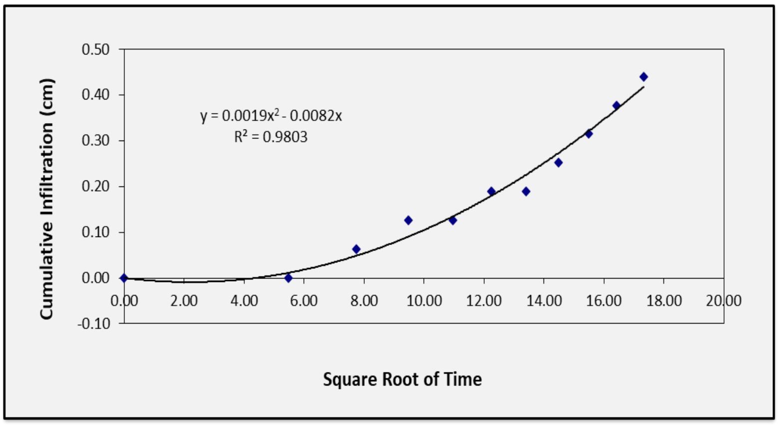

Figure C.45: Infiltration graph of sample UNP13 (ethanol)

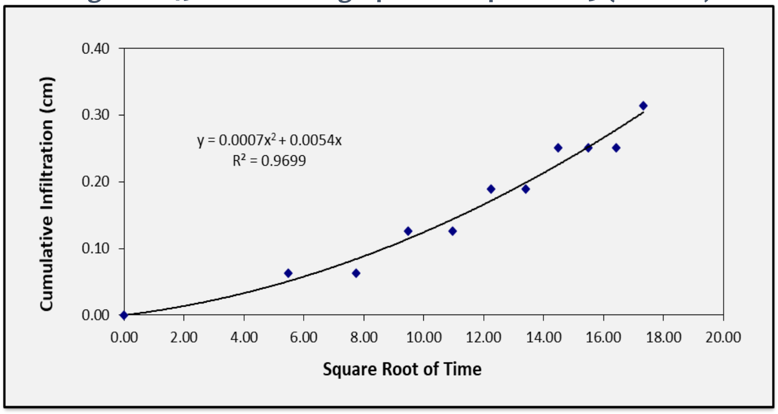

Figure C.46: Infiltration graph of sample UNP14 (water)

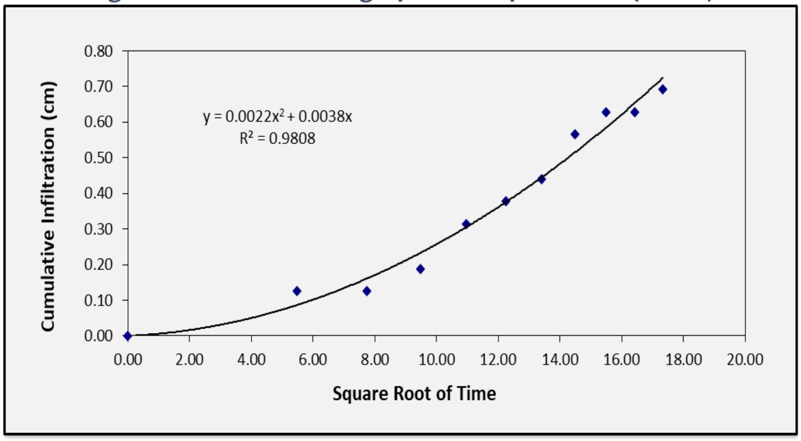

Figure C.47: Infiltration graph of sample UNP14 (ethanol)

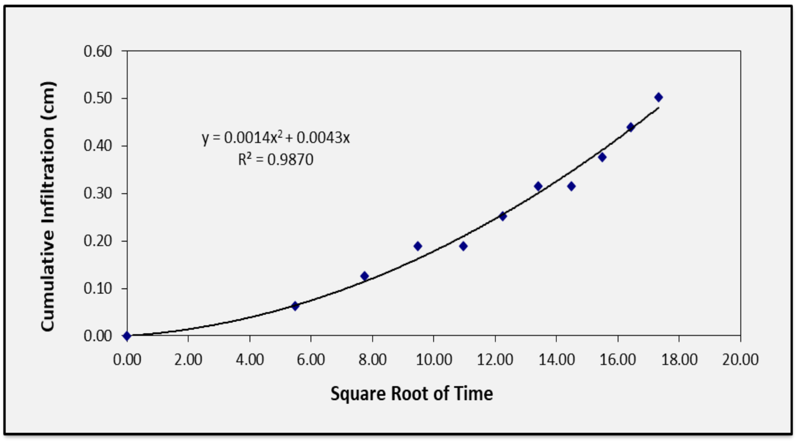

Figure C.48: Infiltration graph of sample UNP15 (water)

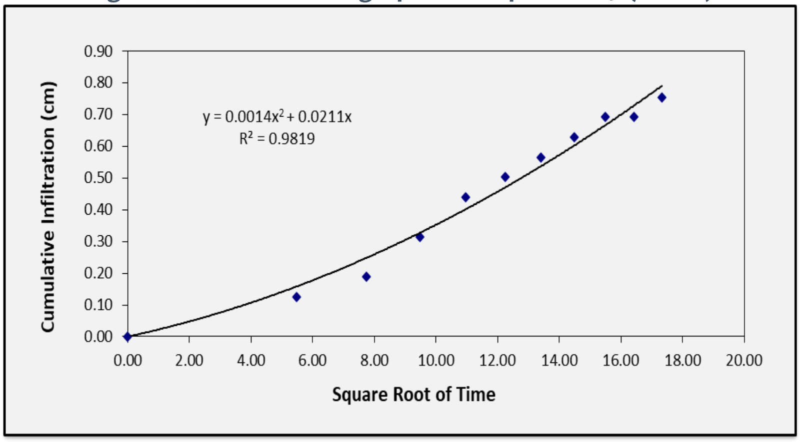

Figure C.49: Infiltration graph of sample UNP15 (ethanol)

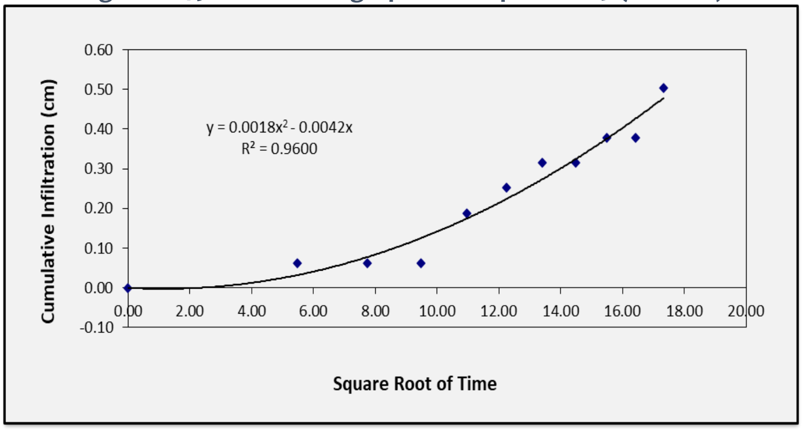

Figure C.50: Infiltration graph of sample EXP5 (water)

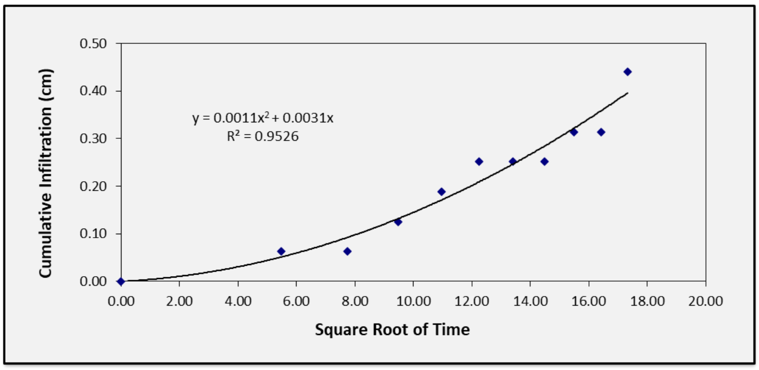

Figure C.50: Infiltration graph of sample EXP5 (ethanol)

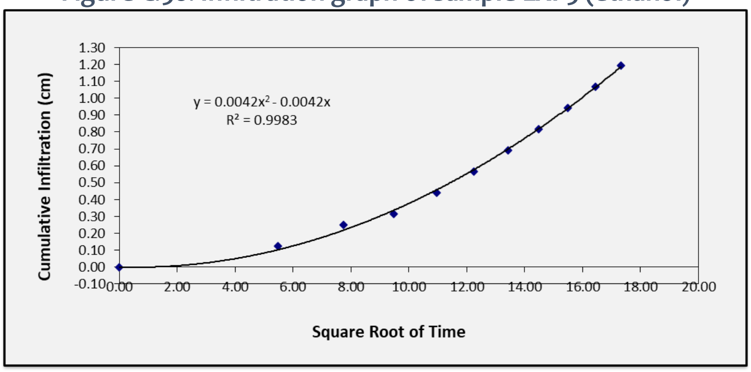

Figure C.51: Infiltration graph of sample UNP16 (water)

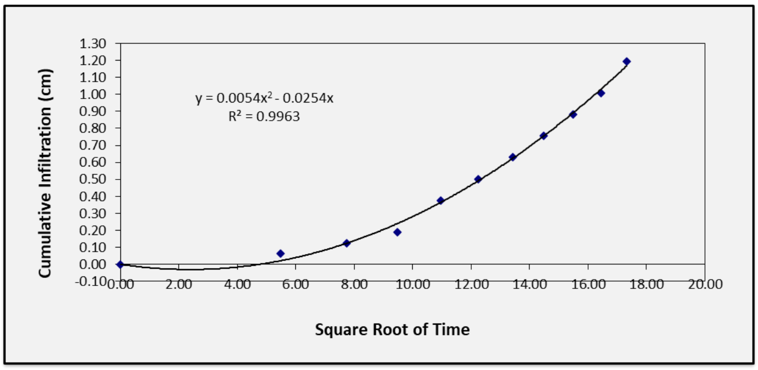

Figure C.52: Infiltration graph of sample UNP16 (ethanol)

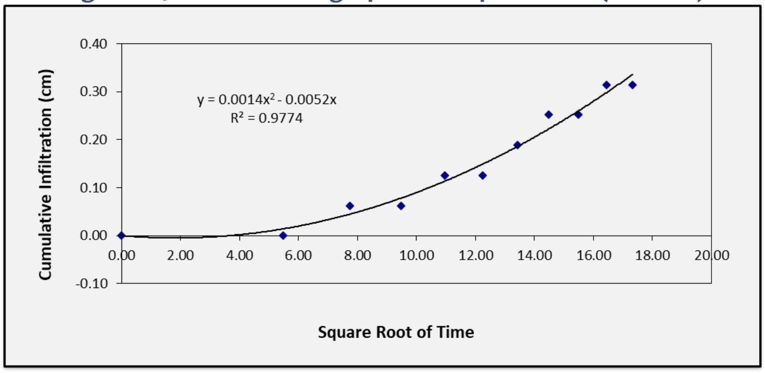

Figure C.53: Infiltration graph of sample UNP17 (water)

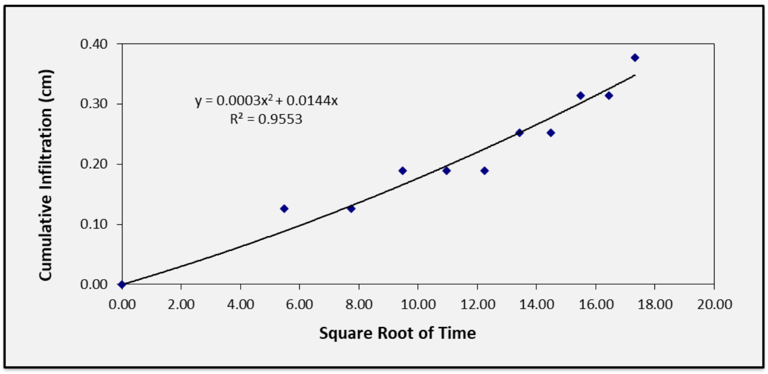

Figure C.54: Infiltration graph of sample UNP17 (ethanol)

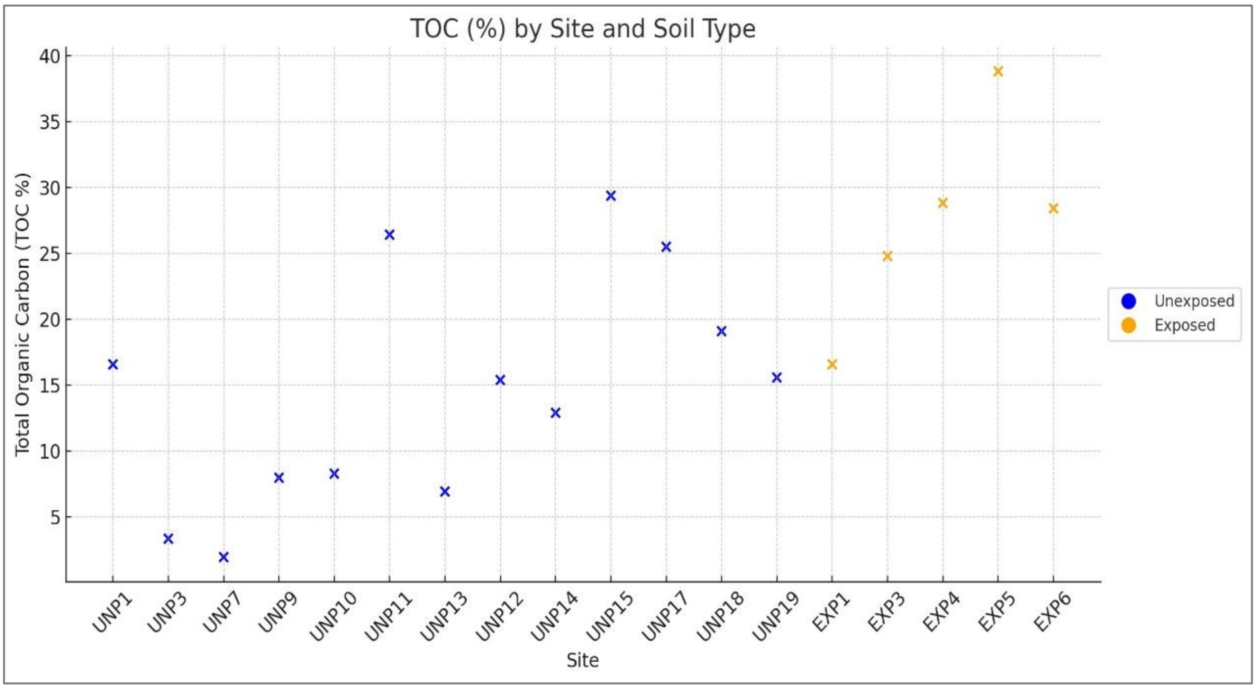

Figure C.55
Total organic carbon (%) of soil samples. Site codes as per Table C.2

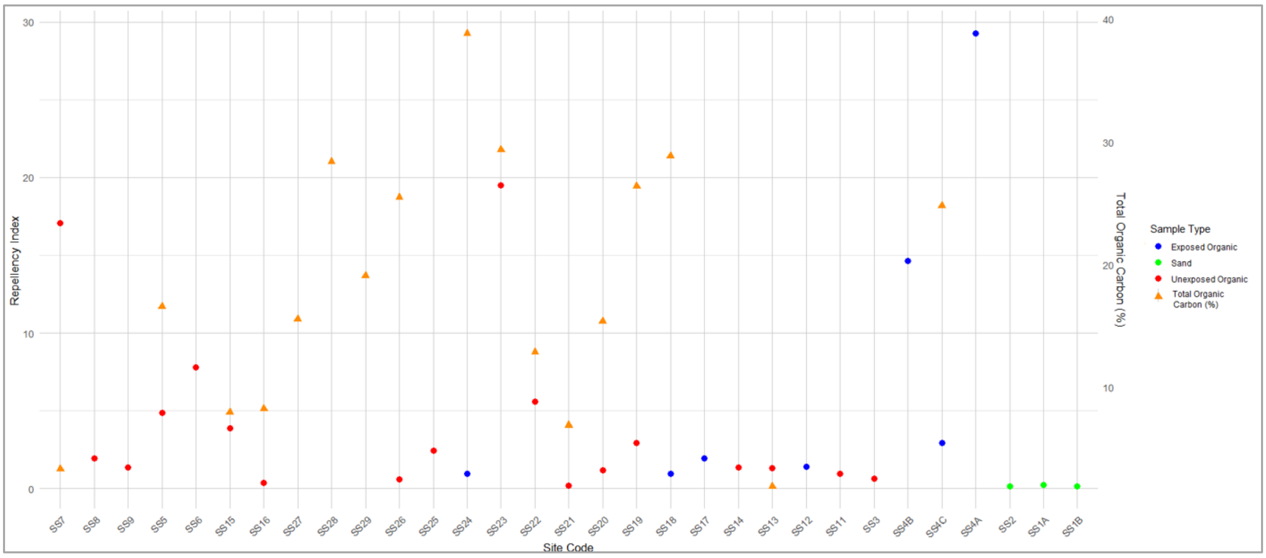

Figure C.56
Total organic carbon (%) of soil samples plotted with soil water repellancy Index data. Site codes as per Table C.2

Figure C.55
Total organic carbon (%) of soil samples. Site codes as per Table C.2

TABLE C.4:
Laboratory certificates showing results of soil analyses by BEMLAB.
Soil codes as shown in Table C.3 and Figure 2.3.

16 Van der Berg Crescent
Strand, 7140
Tel : 021 853 1490
VAT No : 4200161414
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CERTIFICATE OF ANALYSIS

Client: : Liz Day Consulting
Consultant : N/A
Address: : 6 Flamingo Crescent
Phone: : 0834542309
Contact: : Liz Day
Email : : liz@lizdayconsulting.co.za

Report NO : CP2025-00054
No. of Samples : 18
Department : Compost
Condition : Acceptable

Delivery Date : 25/03/2025
Delivery Time : N/A
Order No/Ref : N/A

Block No.	Lab No.	Depth cm	C (Leco) %
UNP 9 (Farm)	CP25-00097		7.96
UNP 12 (Main)	CP25-00098		15.38
UXP 1 (Main)	CP25-00099		16.57
UNP 3 (Farm)	CP25-00100		3.33
UNP 7 (Main)	CP25-00101		1.93
UNP 19 (Main)	CP25-00102		15.57
EXP 5 (Main)	CP25-00103		38.83
EXP 3 (Main)	CP25-00104		24.79
UNP 13 (Main)	CP25-00105		6.91
UNP 18 (Main)	CP25-00106		19.09
UNP 17 (Main)	CP25-00107		25.50
UNP 1 (Farm)	CP25-00108		3.53
UNP 10 (Farm)	CP25-00109		8.27
UNP 14 (Main)	CP25-00110		12.89
EXP 6 (Main)	CP25-00111		28.42
EXP 4 (Main)	CP25-00112		28.83
UNP 11 (Main)	CP25-00113		26.42
UNP 15 (Main)	CP25-00114		29.38

Date Analysed: 01/04/2025 Date Analysis Completed:04/04/2025 Date Reported: 04/04/2025 Page 1 of 5

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A PathCare Company

CERTIFICATE OF ANALYSIS

Client:	Liz Day Consulting	Report NO	CP2025-00054	Delivery Date	25/03/2025
Consultant	N/A	No. of Samples	18	Delivery Time	N/A
Address:	6 Flamingo Crescent	Department	Compost	Order No/Ref	N/A
Phone:	0834542309	Condition	Acceptable		
Contact:	Liz Day				
Email :	liz@lizdayconsulting.co.za				

Particle Size Analysis

Orchard	Lab No.	Depth cm	Stone	Clay	Silt	Sand	Fine Sand	Medium Sand	Coarse Sand	Klip	Classification	Waterholding		
			Vol %	%	%	%	%	%	%	% (v/v)		100kPa %	10kPa %	mm/m
UNP 9 (Farm)	CP25-00097		0.00	18.0	16.0	66.0	42.2	14.3	9.5	0.0	FINE SANDY LOAM	18.22	30.42	122.01
UNP 12 (Main)	CP25-00098		0.00	14.0	24.0	62.0	42.5	5.7	13.8	0.0	FINE SANDY LOAM	21.03	34.71	136.75
UXP 1 (Main)	CP25-00099		0.00	14.0	10.0	76.0	37.8	16.7	21.6	0.0	FINE SANDY LOAM	15.46	26.39	109.28
UNP 3 (Farm)	CP25-00100		0.00	6.0	10.0	84.0	42.0	13.8	28.2	0.0	LOAMY COARSE SAND	13.99	25.76	117.75
UNP 7 (Main)	CP25-00101		0.00	24.0	10.0	66.0	48.1	15.9	2.0	0.0	SANDY CLAY LOAM	17.33	29.66	123.26
UNP 19 (Main)	CP25-00102		0.00	14.0	24.0	62.0	57.0	3.2	1.8	0.0	FINE SANDY LOAM	20.79	36.59	158.06
EXP 5 (Main)	CP25-00103		0.00	10.0	10.0	80.0	27.0	15.6	37.5	0.0	COARSE SANDY LOAM	15.26	24.87	96.07
EXP 3 (Main)	CP25-00104		0.00	18.0	28.0	54.0	48.2	3.2	2.6	0.0	FINE SANDY LOAM	23.20	38.15	149.56
UNP 13 (Main)	CP25-00105		0.00	24.0	16.0	60.0	51.1	7.5	1.4	0.0	SANDY CLAY LOAM	20.29	34.23	139.39
UNP 18 (Main)	CP25-00106		0.00	16.0	22.0	62.0	46.7	7.9	7.4	0.0	FINE SANDY LOAM	20.35	34.21	138.66
UNP 17 (Main)	CP25-00107		0.00	14.0	16.0	70.0	40.0	10.5	19.5	0.0	FINE SANDY LOAM	18.09	30.35	122.60
UNP 1 (Farm)	CP25-00108		0.00	10.0	8.0	82.0	34.0	26.3	21.7	0.0	LOAMY SAND	12.56	22.02	94.57
UNP 10 (Farm)	CP25-00109		0.00	14.0	16.0	70.0	37.7	21.4	10.9	0.0	FINE SANDY LOAM	16.35	27.37	110.25
UNP 14 (Main)	CP25-00110		0.00	24.0	24.0	52.0	36.6	9.2	6.2	0.0	SANDY CLAY LOAM	22.92	35.48	125.54
EXP 6 (Main)	CP25-00111		0.00	10.0	16.0	74.0	43.7	14.6	15.7	0.0	FINE SANDY LOAM	16.35	28.76	124.18

Date Analysed: 01/04/2025 Date Analysis Completed:04/04/2025 Date Reported: 04/04/2025 Page 2 of 5

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Orchard	Lab No.	Depth cm	Stone	Clay	Silt	Sand	Fine Sand	Medium Sand	Coarse Sand	Klip	Classification	Waterholding		
			Vol %	%	%	%	%	%	%	% (v/v)		100kPa %	10kPa %	mm/m
EXP 4 (Main)	CP25-00112		0.00	8.0	16.0	76.0	23.4	14.7	37.9	0.0	COARSE SANDY LOAM	16.81	26.52	97.12
UNP 11 (Main)	CP25-00113		0.00	14.0	10.0	76.0	31.8	15.7	28.5	0.0	COARSE SANDY LOAM	15.90	26.12	102.17
UNP 15 (Main)	CP25-00114		0.00	8.0	16.0	76.0	21.8	14.2	40.0	0.0	COARSE SANDY LOAM	16.98	26.53	95.51

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