Accidental Wetlands - A southern African Case Study from the Kgaswane Mountain Reserve, Rustenburg

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ABSTRACT

Wetlands form part of a diverse range of habitats and play an important role in the ecology and hydrological cycle but are amongst the most threatened ecological systems. It is therefore critical to understand the hydrology of wetlands, and their contributing water sources in particular, to ensure appropriate management of these systems. Land use activities not only alter the runoff characteristics of catchments, but also often result in modified flow regimes in watercourses. Wetlands often develop accidentally in anthropogenic landscapes and are not uncommon. However, these wetlands are poorly documented and researched. An accidental wetland formed in the Kgaswane Mountain Reserve, Rustenburg, due to leaking water infrastructure. The aim of this project was to categorise the wetland and confirm its origin, focussing on the role of the leakage. Methods included hydrogeomorphic classification, water ion composition analysis, as well as infield temperature and electrical conductivity measurements. Historical satellite imagery was used to study the evolution of the wetland over time. The electrical conductivity and ionic composition results suggest an unnatural water source, providing support that a leaking pipe caused the wetland to form. Management of accidental wetlands is discussed and the potential for future, related research is contemplated.

Keywords: accidental wetland, ecological management, water source, mountain reserve, urban development.

Introduction

Wetlands cover more than 12 million km² of the Earth's surface, according to the Ramsar Convention (Ramsar Convention on Wetlands, 2018). From a biological perspective, they are the most productive ecosystems, but also the most threatened (Ramsar Convention on Wetlands, 2018). They provide valuable ecosystem services, such as flood attenuation, water storage and carbon sequestration (UNEP, 2019; Joosten and Clark, 2002). Wetlands support livelihoods and provide a multitude of services to communities globally (Mitsch & Gosselink, 2015) and in sub-Saharan Africa, for example, many countries rely on and value wetlands as a source for water, agriculture, protein and various other resources, as well as income from recent niche markets, such as ecotourism (Marambanyika & Beckedahl, 2016).

In landscapes with the same climatic regime and geology, wetlands with similar hydrogeomorphic features and processes develop (Kotze *et al.*, 2007). Springs and seeps are often related to preferential flow zones where outcrops occur in regions with strong structural controls, including faults, fissures, and contact planes, (Ellery *et al.,* 2008). Wetlands are particularly vulnerable due to their spatial distribution in transition zones between aquatic and terrestrial habitats (Maltby, 2009) where the biota and internal processes continuously adapt to fluctuating moisture regime. Seasonal and permanent wetlands will only develop and continue to persist, if water is available to form hydric soils and support hydrophytic vegetation (Collins, 2005; Wigham, 2009).

The South African National Water Act No 36 of 1998 defines a wetland as '*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*', (South Africa, 1998). Wetlands, therefore, must have at least one of the following properties present (DWAF, 2005): hydromorphic soils that exhibit characteristics due to prolonged saturation; the presence of hydrophytic vegetation, and a high-water table, creating anaerobic conditions in the upper 50 cm of the soil. South African inland wetlands are classified according to geomorphology, landscape setting, and hydrological processes (Kotze *et al.,* 2007, Ollis *et al.,* 2013) and other than depressions (pans) are mostly fluvial and linked to streams (Ellery *et al.,* 2008), whether perennial or ephemeral. Wetlands form when the surrounding geomorphology, such as dykes, alluvial fans or slope changes allow the water to slow down and disperse (Tooth *et al.,* 2009). Wetlands in southern Africa are, in this regard, fundamentally different to temperate wetlands in the northern hemisphere due to a water deficit resulting from a high potential evapotranspiration and a mean annual rainfall that is well below that of global mean averages for other continental areas (Ellery *et al.,* 2008).

Accidental urban wetlands, however, are unintentional ecosystems that develop as a result of urban development and human interferences in the natural landscape and remain largely undocumented and under-studied (Palta *et al*., 2017). It is, however, imperative to understand the geomorphological processes and water sources responsible for such wetland formation, as these can give important information on how to further manage these ecosystems.

Accidental Wetlands Globally and in South Africa

Accidental urban wetlands are common throughout the world arising largely from developmental and infrastructural inefficiencies in urban settings (Palta *et al*., 2017). These include the development of major settlements in close proximity to water sources (Mitsch & Gosselink, 2007; Grimm *et al.,* 2008), the modification of water courses by drainage or infilling, as well as the use of various water network infrastructures to manage storm-, waste- and potable water flow (Kentula *et al.* 2004; Steele & Heffernan 2014). Leaking reticulation and diversion of stormwater into vacant urban areas can lead to the accumulation of water in preferential flow paths, low-lying areas and impeded drainage, consequently creating suitable conditions for wetland formation (Palta *et al*., 2017). Despite high levels of development, urban areas fulfil two key requirements needed for wetland formation: preferential flow paths and potential sources of water.

Accidental wetlands in non-urban areas will likely be more dependent on a 'new' water source due to human activities, such as irrigation, which together with existing geomorphic and topographic conditions, influence the hydrology of the developing wetland. Accidental wetlands in a water scarce country such as South Africa are a concern, as they can potentially indicate water loss through poor maintenance. For example, old and failing municipal water infrastructure can cause leaks of wastewater and valuable potable water from reservoirs and pipelines. The observation of a newly formed wetland attracted the attention of the Kgaswane Mountain Reserve (KMR) management in 2015 and during a site assessment in August 2018 a major leakage was noted at a pump and reservoir facility of the Rustenburg Local Municipality and bulk water supply utility adjacent to the reserve's border. The objective of this study was therefore to confirm the new wetland's origin, to document its process of becoming an established accidental wetland and discuss its role in the landscape.

Location and Physical Characteristics of the Kgaswane Mountain Reserve

Kgaswane Mountain Reserve is situated in the North-West Province of South Africa, south-west of Rustenburg (25°43′ S, 27°11′ E) on a plateau of the Magalies Mountains (Figure 1). The reserve has an area of 4500ha with an elevation of between 1250m and 1600m above sea level (Parrini and Owen-Smith, 2010) and has a prominent summit plateau and drainage line, the Waterkloof Spruit. The plateau is between 2 and 3.5km in width and 8km in length (Coetzee, 1975) at 1470m above sea level with a near pristine wetland system located in the low-lying centre of the plateau. The accidental wetland (25°43'08.6"S, 27°14'01.6"E) is located on a slope within the headwaters of an ephemeral drainage line at an elevation of 1350m above sea level below and east of the plateau (Figure 1).

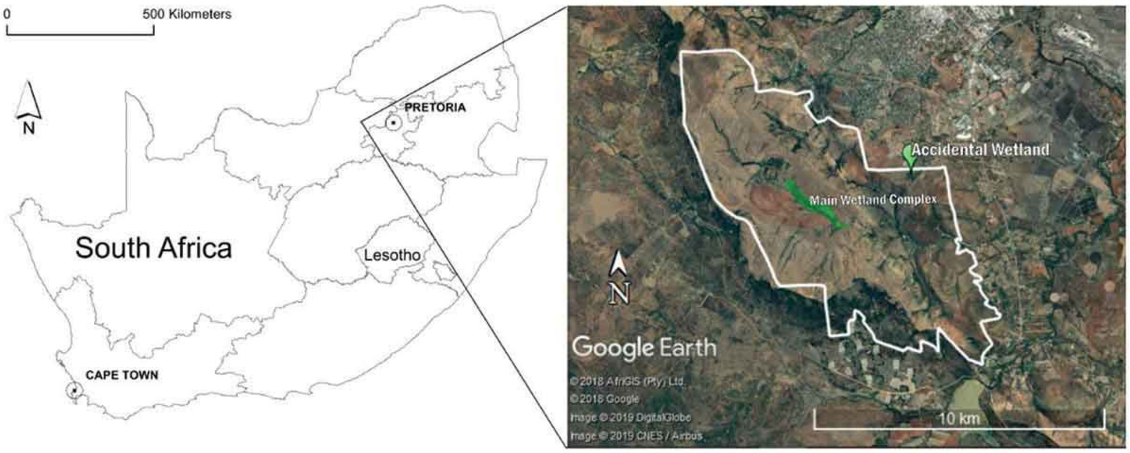

FIGURE 1. The location of Kgaswane Mountain Reserve (white polygon), within South Africa and the location of the accidental wetland and main wetland complex within the reserve boundary (Map data: Google Earth Pro 7.3.2.5776 and AfriGIS (Pty) Ltd, 2018, 2016)

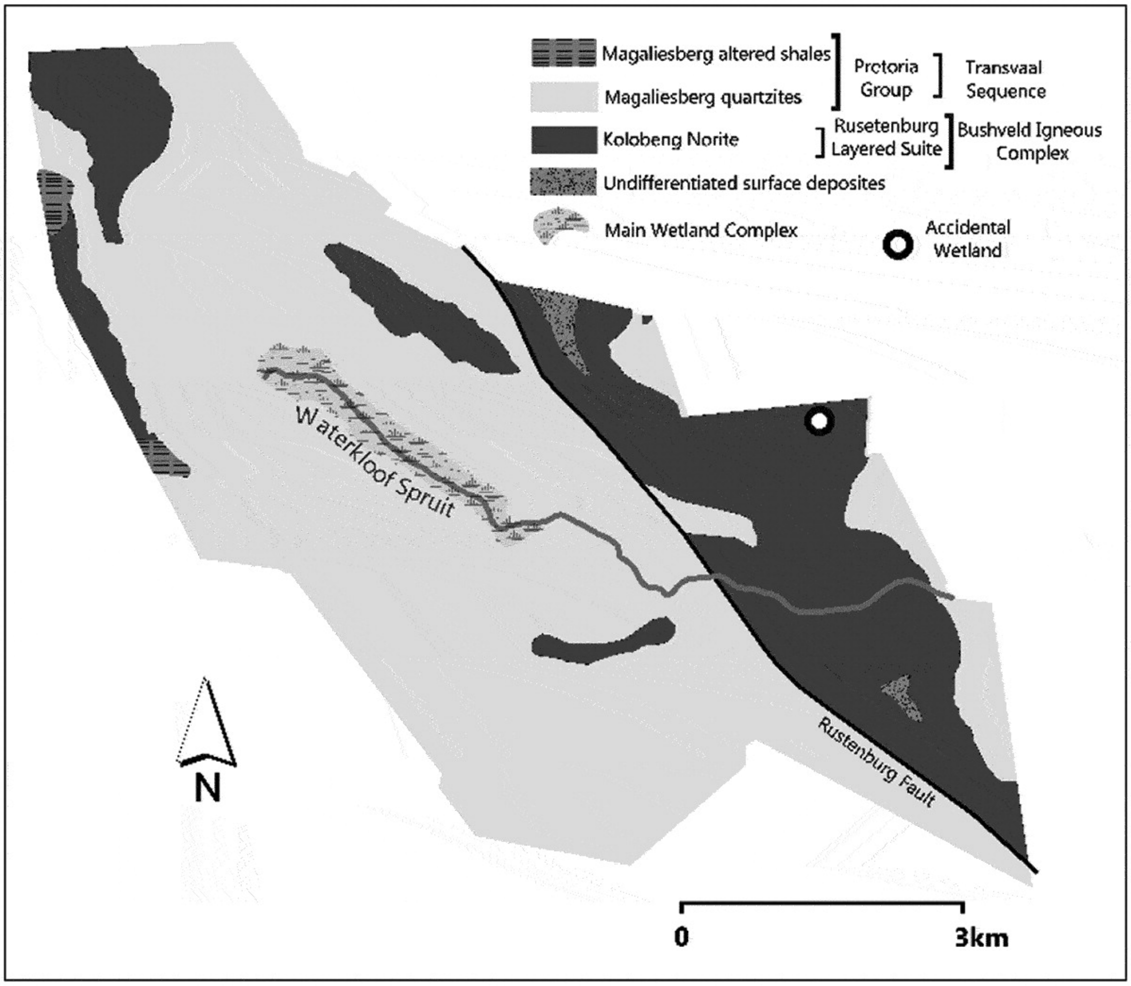

FIGURE 2: Geological map of Kgaswane Mountain Reserve adapted from Nel (2000), indicating the accidental wetland and main wetland complex. The position ofthe accidental wetland is indicated by a white and black symbol, not to scale.

The reserve's underlying geology (Figure 2) is mostly meta-sediments – recrystallized quartzite and imbedded hornfels – in addition to Magaliesberg altered shales of the Magaliesberg Formation Pretoria Group, Transvaal Supergroup (Coetzee, 1975). Kolobeng Norite and Diabase intrusions from the Rustenburg Layered Suite, Bushveld Igneous Complex occurs in the eastern parts of the reserve (Nel, 2000). The accidental wetland's underlying geology consists of Kolobeng Norite. Due to these various underlying geologies and topographical changes, various soil forms can be found in the Kgaswane Mountain Reserve including lithosols, shallow litholitic soils, and numerous orthic A- and B-horizons of clay-loam, sandy-loam and sandy clay-loam textures (Coetzee, 1975). In addition, peat can also be found in the main wetland complex of the reserve (Grundling et al., 2018). The reserve is situated within the Gold Reef Mountain Bushveld vegetation zone, inside the Central Bushveld Bioregion; one of six bioregions in the Savanna Biome (Rutherford et al., 2006). There are four main vegetation types in the reserve: open shrubland, grassland, open to closed woodland and wetland grassland (Parrini and Owen-Smith, 2010). The accidental wetland occurs within the vegetation structure unit of tall open woodland with short grass (Nel, 2000).

Kgaswane Mountain Reserve is located in a summer rainfall region with 95.9% of annual rainfall occurring between September and April (Nel, 2000). The average annual rainfall is 670mm (Smakhtin and Batchelor, 2005), primarily from unstable atmospheric conditions such as convective thunderstorms. The reserve has a temperate climate with cool winters (minimum: -1°C and maximum: 25°C); and warm summers (minimum: 12°C and maximum: 35°C) (Coetzee, 1975). These temperatures differ with the elevation of the park, due to differences in the incoming radiation experienced by slope aspect - resulting in higher temperatures on the north-facing (Nel, 2000).

Wetland Indicators

The characteristics of the accidental wetland were assessed using the guidelines of the Department of Water and Sanitation (DWAF, 2005). This classification scheme is widely used in South Africa and assesses the wetland using four field indicators. The terrain unit indicator describes the landscape setting, the soil form indicator rates the presence of distinctive hydromorphic soils, the soil wetness indicator categorises the presence of surface water or water near the surface, and the vegetation indicator gives an indication of the extent to which the vegetation is tolerant and/or adapted to saturated soil (DWAF, 2005). The terrain unit was determined by comparing the elevation and slope of the reported wetland with the catena of the area. Baseline studies by Nel (2000) were used to acquire soil formation data and soil sampling was used to determine the soil wetness. Soil samples were taken in August 2018 before the rainy season, with follow up samples taken in March 2019. A Munsell colour chart was used to identify the soil colour and chroma. Lastly, a qualitative species richness analysis was undertaken in terms of presence or absence (Van Oudshoorn et al., 1991; De Villiers et al., 2011) of wetland plant species, was used to determine the vegetation composition. The accidental wetland was then classified and described using the Wetland Hydrogeomorphic (HGM) types defined by Kotze *et al*. (2007).

The accidental wetland is a seep situated in the headwaters of the northern slope of a small defined drainage line therefore meeting the criteria of a midslope terrain unit 3 (DWAF, 2005). The slope is made up of colluvium material with a slight rise in the catena's elevation next to the riparian boundary. The area of the reserve where the accidental wetland is found is mainly associated with shallow to medium depth soil horizons found on the eastern slopes of Kgaswane Mountain Reserve. These stony soils consist of Orthic A and lithocutanic B horizons, therefore classified as the Glenrosa soil form by Nel in 2000. The soil form can further be classified as a Trevanian (Gs 17) soil family due to a higher clay-content (25.1% - 29.5%) and lower sand content of the A-horizon in relation to the rest of the reserve. This is due to the underlying Kolobeng Norite geology (Figure 2), (Nel, 2000).

Surface water exists at the study site and drains towards the drainage line. As a result, soil samples (Table 1) were saturated. The first sample had a dark brown colour (7.5YR4/4) within the first 10cm horizon, and dark reddish brown (5YR4/4) for the next 10cm horizon with faint brown colour variations but lacking visible evidence of gleyed mottling colour variations. Faint darkening was noted on the surface horizon due to organic matter. The field estimate of clay content is 30-35% and 35-45% for the first 10cm and second 10cm respectively, with slight plasticity and sticky wet consistency. When wet, the sample had a massive apedal structure but a very weak subangular block structure when dry, together with a medium sand grade. The second sample from the seep, sampled seven months after the first from the same location, contained organic matter in the form of roots throughout the horizon. The following 10cm showed signs of manganese undergoing reduction, in the form of a black incipient manganese accumulation mottle, although the matrix is still predominantly red in colour. The sample at 25-35cm depth showed less organic material and clear manganese reduction and a transition from 7.5YR in colour, to 2.5YR3/4 – 5 YR indicating that the soil is becoming yellower in the red matrix. The colour further changed to 10YR4/2 in depth indicating gleying. The third sample, from a second location, was taken close to the riparian edge of the perennial stream and showed a well-defined G-horizon with low chroma colours at 20cm.

A species richness assessment was conducted throughout the catena and identified 20 transitional and hydrophytic species including rush species such as *Juncus punctorius* and sedge species such as *Cyperus marginatus.* Furthermore, the site had various dead trees, mainly *Acacia* species.

TABLE 1: Soil characteristics of two samples from the accidental wetland taken seven months apart.

Sample Characteristics	Sample 1	Sample 2
Date Sampled	09-08-2018	21-03-2019
Level of Saturation	Completely saturated	Completely saturated
Organic matter	Evident on surface horizon	Roots in consecutive horizons
Colour	**0 - 10cm:** 7.5YR4/4	**0 - 25cm:** 7.5YR
	10 - 20cm: 5YR4/4	**25 - 35cm:** 2.5YR3/4 – 5 YR
		35cm<: 10YR4/2
Structure		
- **Dry**	Weak subangular block	Weak subangular block
- **Wet**	Massive apedal	Massive apedal
Consistency	Sticky wet and slightly plastic	Sticky wet and slightly plastic
Gleying	None present	Present
Signs of Wetness	None present	Manganese accretion mottle

Land use

Urban development to the northeast of the reserve can be seen on satellite imagery from 2004 (Figure 3a), with construction of municipal water facilities underway in 2009 (Figure 3b), adjacent to the Kgaswane Mountain Reserve border. Vegetation response can clearly be seen on both sides of the border on the 2013 image (Figure 3c). The observed leak (Figure 4) was traced by following the vegetation signature up the slope.

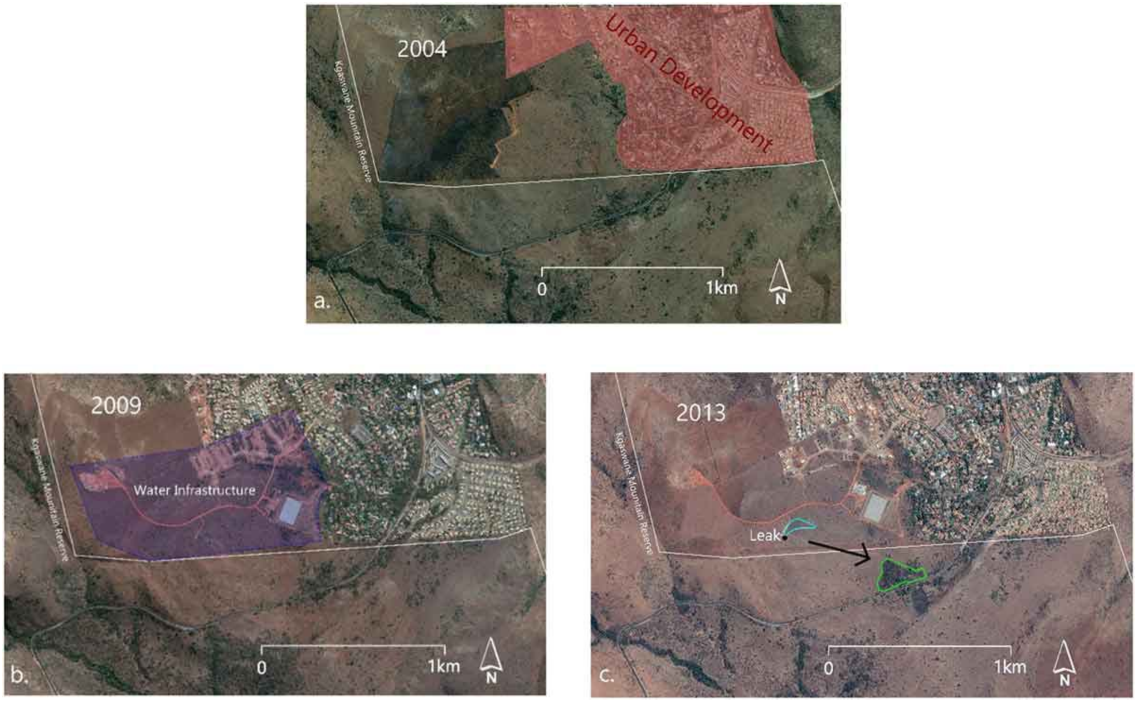

FIGURE 3. (a). Urbanization and development extend towards the reserve's boundary in 2004. The wetland in question is not evident on this image (Map data: Google, Maxar Technologies, 2020a)

b. Constructed municipal infrastructure, including access roads, the reservoir and pump station/tank are indicated on the 2009 image (Map data: Google, Maxar Technologies, 2020).

c. Wetland development, indicated with a green polygon, along the slope (general slope indicated with a black arrow) in 2013 (Map data: Google, CNES/Airbus, 2020). Dark green vegetation response adjacent to the leak (black dot) due to the water leak is indicated with a blue polygon.

FIGURE 4. The water pump and storage infrastructure leak adjacent to the Kgaswane Mountain Reserve, taken on 9 August 2018

Water Analysis

To confirm whether the accidental wetland's water source is the leaking pipe, historical satellite imagery from Google Earth Pro was used to document land use change of the wetland and the surrounding area over the past 16 years. Water analyses were also conducted, including comparisons of the electrical conductivity (EC) and ionic composition between samples of the accidental wetland (AW), main wetland complex (MWC) and municipal (Treated) from the reserve's main gate and the leaking municipal infrastructure (Figure 5). A quick-scan eco-hydrological analysis method (Grootjans *et al.,* 2006; Grootjans & Jansen, 2012; Van Wirdum, 1991) was used at various sampling points. This analysis method consists of measuring quantitative aspects, such as water temperature, and electrical conductivity, as well as water levels. An Adwa AD33 EC meter was used to measure the electrical conductivity of the water (μS/cm) and temperature (°C). EC was measured in field and corrected for water temperature using equation 1 (Hayashi, 2004). Where EC_{25} is electrical conductivity calibrated at 25°C, EC_t is the pre-calibrated in-field electrical conductivity at the sample's measured temperature *t* (°C) and *a* is a constant temperature compensation factor, 0.019, used for natural waters in environmental monitoring for temperatures ranging between 0°C and 30°C (Hayashi, 2004).

$$EC_{25} = EC_t / [1 + a\,(t - 25)] \qquad (1)$$

In addition, water samples were normalised to 25°C and tested for EC by the Agriculture Research Council- Soil, Climate and Water (ARC-SCW). A full water analysis for ionic composition was performed using the ICP-MS method (Bos & Fredeen, 1989) by the ARC-SCW laboratory.

The EC_{25} values of the natural water from the main wetland complex are significantly lower than those of the treated water ($F=1020.1$, $p<<<0.01$), as expected, and that of the accidental wetland ($F=51.17101$, $p<<<0.01$). However, there was no significant difference in EC_{25} values between the accidental wetland and the treated water samples ($F=0.495153$, $p=0.48593$), (Figure 6).

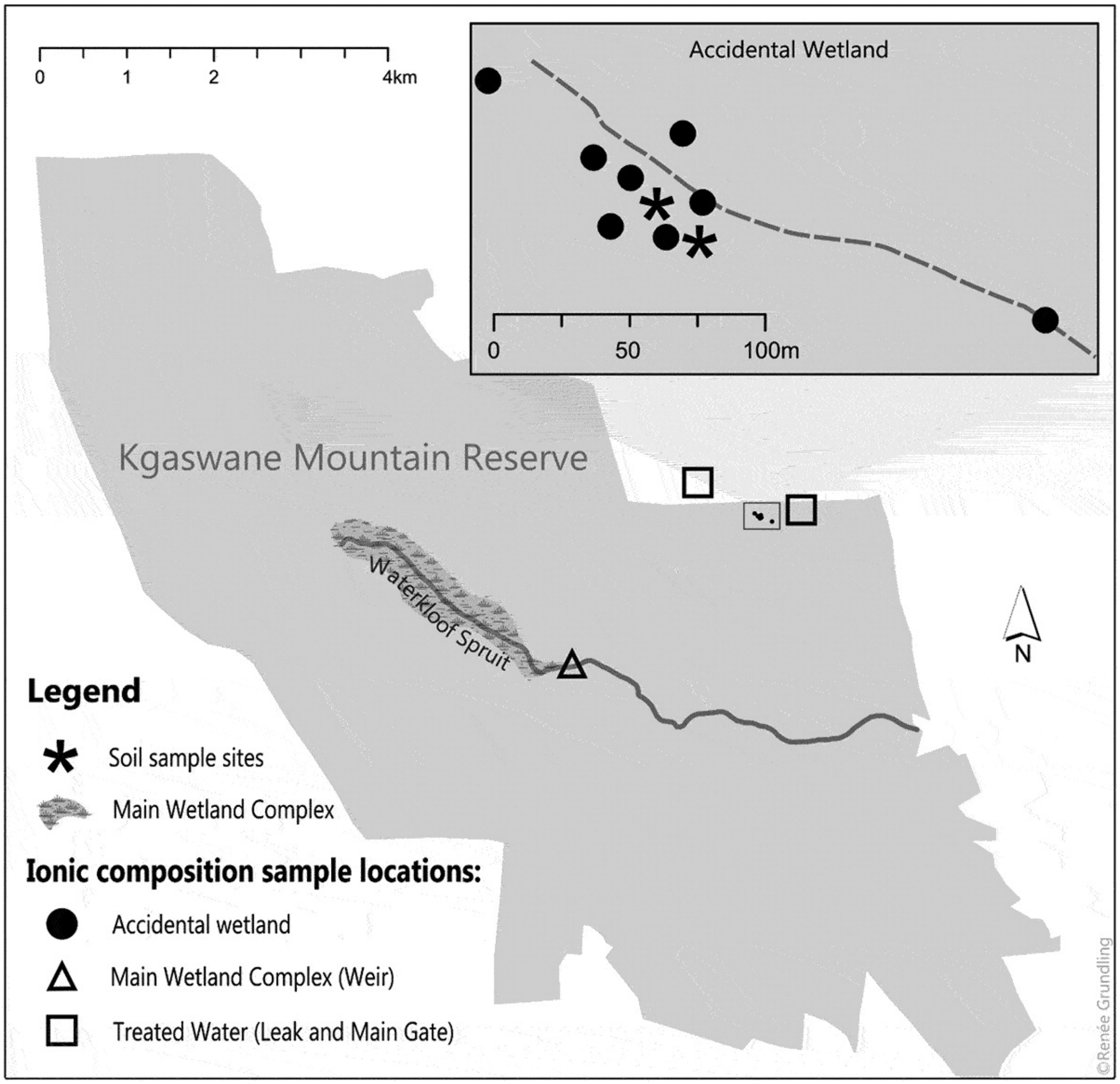

FIGURE 5. Sampling sites (11) for ionic composition of the water throughout the study area. A total of 16 samples were taken (including repetitions taken at different dates): treated water from the main gate (n = 1) and leak (n = 2), water from the main wetland complex's weir, (n = 2) and water from the accidental wetland (n = 11)

The distribution of ionic composition values shows two distinct ranges (Figure 7) with the low values of the natural stream in contrast against the relatively higher values from samples taken from the treated municipal water sites – the reserve's main gate and the leaking pipe at the municipal pump station – and the accidental wetland. For example, the natural stream values for chloride range between 0.61mg/l to 0.63mg/l, an order of magnitude less than that of the treated water (8.6mg/l to 10.33mg/l). However, values of the treated water compare well with the values of the accidental wetland. The same correlation can be seen for the other ions as well (Table 2, Appendix 1), specifically calcium, magnesium, potassium, bicarbonate and sulphate (Figure 7).

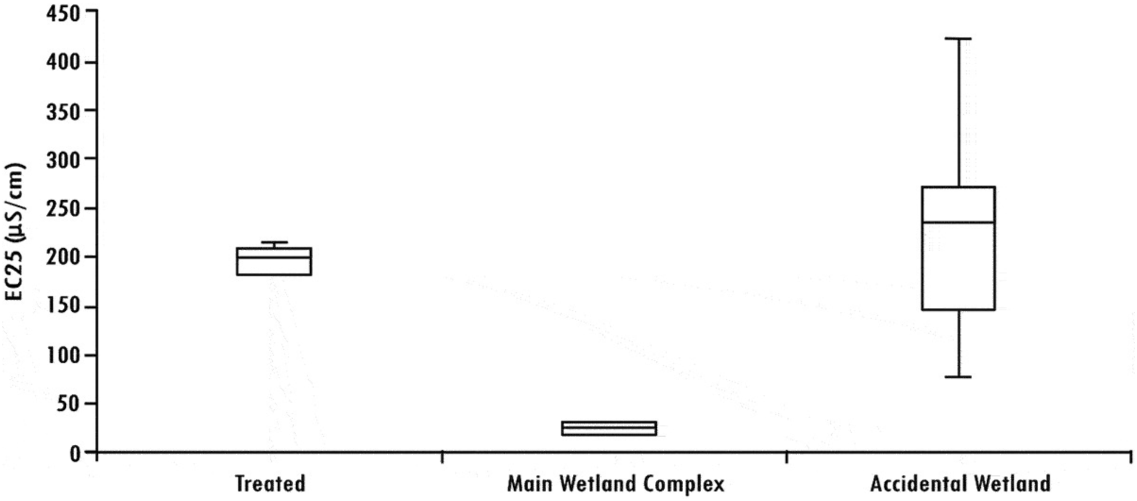

FIGURE 6. Distribution of EC_{25} for the three main sampling sites.

TABLE 2: Laboratory analysis (in cooperation with the ARC-ISCW) depicting ionic composition (mg/l) results in water sample taken from the main wetland complex, accidental wetland and treated water.

	Fluoride	Nitrite	Nitrate	Chloride	Sulphate	Phosphate	Bicarbonate	Sodium	Potassium	Calcium	Magnesium	Boron
Treated	0.19	1.11	2.36	11.46	13.95	0.48	78.08	9.72	3.34	18.1	6.58	0.01
	<0.43	<1.38	<1.93	10.5	13.57	<2.07	76.25	9.02	2.81	18.14	6.5	<0.01
	<0.43	<1.38	<1.93	10.56	12.97	<2.07	76.86	2.74	2.82	18.4	6.61	<0.01
Main Wetland Complex	<0.43	0	1.11	0.61	1.57	0.33	16.47	0.82	0.72	0	0.68	0
	0.05	<1.38	<1.93	0.63	<1.74	<2.07	24.4	1.81	0.99	0.82	1.6	<0.01
Accidental Wetland	0.1	0	1.03	8.97	7.49	0.74	121.39	2.34	1.28	16.7	19.32	0
	0.13	0	0.81	10.42	9	0.28	127.49	2.5	2.58	18.5	19.7	0
	0	0	0.72	17.48	8.17	0.23	184.22	9.56	2.14	19.4	22.4	0.1
	0.32	0	0.72	12.31	26.59	0	149.39	6.64	1.01	18.3	21.3	0.12
	0	<1.38	<1.93	10.33	12.97	<2.07	107	2.74	2.37	15.5	18.3	<0.01
	0.47	<1.38	<1.93	12.66	6.8	<2.07	125	2.47	1.95	15.3	20.6	<0.01
	<0.43	<1.38	<1.93	14.97	4.76	<2.07	119	1.78	2.11	17.7	21	<0.01
	<0.43	<1.38	<1.93	11.21	14.02	<2.07	70.15	1.9	1.63	11.07	13.2	<0.01
	<0.43	<1.38	<1.93	13.63	4.96	<2.07	131	2.03	1.81	21.7	21.1	<0.01
	<0.43	<1.38	<1.93	13.69	6.48	<2.07	97.6	1.85	2.52	15.1	19	<0.01
	<0.43	<1.38	<1.93	8.6	9.37	<2.07	36.6	4.87	1.76	5.35	6.67	<0.01

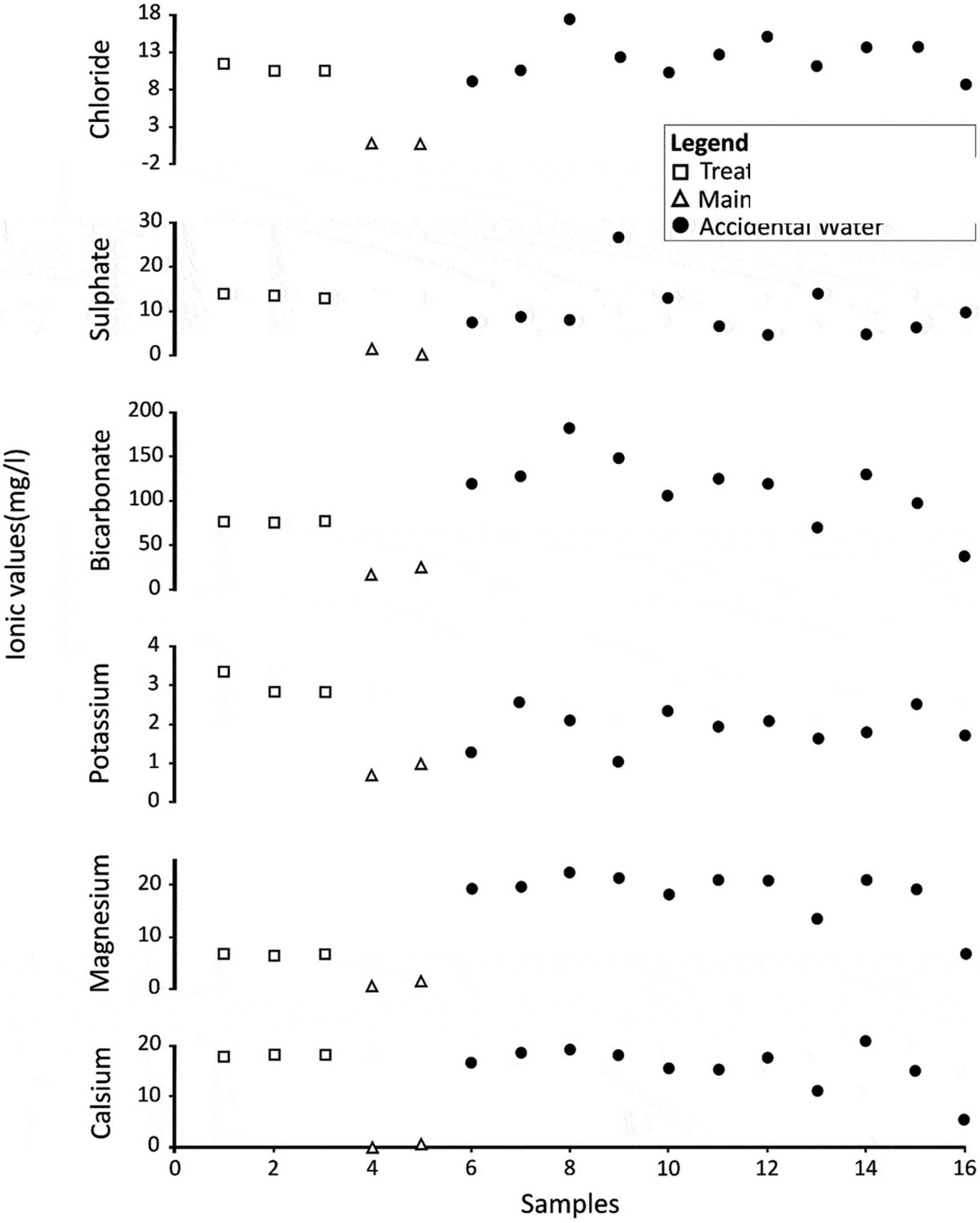

FIGURE 7. Ionic values (mg/l) of calcium, magnesium, potassium, bicarbonate, sulphate and chloride from the treated municipal water (square), the main wetland complex (triangle) and accidental wetland (circle)

Discussion

It is clear that the accidental wetland did not exist before the construction of the water utility facilities. By 2013 the wetland had already formed. Follow up site visits in March 2019 indicated that the leakage at the pump station had been fixed. However, the accidental wetland persisted, with greater than expected continued seepage flows at the end of two succeeding dry seasons. This indicates water also leaking from the reservoir, and not just the pump station further upslope. An independent reservoir maintenance contractor confirmed the likelihood of the leak (van Rensburg, 2019), indicating that it will likely not be fixed in the near future due to logistical problems that will arise if the reservoir is drained for this purpose. The permanent reparation of the leak seems improbable, given the size of the reservoir and the large service area of Rustenburg it supplies water to. The origin of the accidental wetland therefore correlates with the origin of urban accidental wetlands theory from Palta *et al.*, (2017).

According to the Kotze *et al.* (2007) HGM system, the accidental wetland can be classified as a hillslope seep linked to a stream channel. The hillslope seep is characterized by colluvial movement of material with water inputs from sub-surface flow expressed in the landscape with a well-defined stream channel linked directly to the midslope seep. The wetland has a water table at the surface and hydrophilic vegetation is thriving. It can therefore be classified as a 3(5) terrain unit, where 5 signifies a wetland on a midslope (Kotze *et al.*, 2007).

The mineral poor Magaliesberg quartzite underlying the main wetland complex results in water with low level EC values. The high EC values from the municipal water, on the other hand, correlates to treatment the water has undergone to comply with potable standards. The EC values from the accidental wetland is expected to be higher than the main wetland complex due to the underlying norite geology and is comparable to the treated water's values. The ionic composition water analyses showed that the water source of the accidental wetland is similar to the leaked municipal water, with the majority of the results showing the same correlations as the EC results. The variance in EC at the accidental wetland is most likely due to the subsurface hydrology, between the leak and the discharge points, that influences its chemistry.

The Glenrosa soil form of the area (Nel, 2000) may indicate presence of wetland but certainty is dependent on signs of soil wetness indicators (DWAF, 2005). The differences in colour of the first soil sample taken in August 2018 (Sample 1, Table 1), 7.5YR and 5YR, may indicate dissimilarities found in the goethite (brown) in contrast to the hematite (red) in the clay mineralogy. The apedal soil structure indicates kaolinite, a 1:1 mineral, as the probable dominant clay mineral with limited or no 2:1- or swelling minerals. These morphological features, together with the lack of gleyed mottles and pore structure, are typical features of freely drained red and yellow-brown apedal horizons. Red soils customarily occur to the edge of a saturated zone that indicates the absence of the reduction of iron minerals and/or the presence of freely drained soils. The fact that this sample was thoroughly saturated indicates that the soil at the time was not in equilibrium with the current soil water regime. This is further visible in the current perennial stream that used to be an ephemeral stream as the result of the leaking water infrastructure, an external water source. The second soil sample (Sample 2, Table 1) taken in March 2019 at the same location as the first, showed morphological differences that developed in the seven months after the first sample was taken and is comparable with rates reported for laboratory experiments in which unmottled soils were saturated (Vepraskas and Craft, 2016; Vepraskas, and Bouma, 1976). In the process of becoming a wetland soil, a black insipient mottle indicating manganese reduction is evident, as well as a colour change in the red soil to a yellow colour, 7.5YR to 2.5YR3/4 – 5 YR. Reduction has therefore begun but does not have an intense follow through. The third soil sample has low chroma values indicating wetness (Soil Classification Working Group and Macvicar, 1991). This is due to water moving into the colluvium of the hillslope and then laterally towards the water course where it encounters the basal impeding norite layer. This then forces it upwards to daylight on the slope where the wetland has formed. With little to no signs of wetness in the soil samples, the soil wetness indicator can be used to describe the wetland in question as newly developed. Should the current water regime continue, a fully developed wetland soil will likely form. This could typically be in the next decade while the system is reaching an equilibrium, as discussed by Alexandrovskiy, 2007, for downward development of soils.

The dead trees indicate an increase in the wetness of the soil as *Acacia* tree species are a terrestrial species (Coates Palgrave *et al*., 1985). This increase is likewise confirmed by the existence of hydrophytic rush and sedge species, as mentioned above, in the area, indicating a permanent/semi-permanent soil wetness zone, as they are macrophytic vegetation in need of oxygen poor substrates (Ellery et al., 2008). The presence of hydrophytic vegetation and soils responding to saturation confirm the conclusion made by Palta *et al*., (2017) that accidental wetlands act as novel systems – not only being characteristic of the newly formed environment, but also in delivering related ecosystem services. The wetland vegetation, for example, forms a new grazing source for game, especially in the dry season, whilst the increased surface roughness results in erosion control on the relatively steep saturated slope.

How should a feature in the landscape with an anthropogenic origin be managed in a proclaimed conservation area such as the Kgaswane Mountain Reserve? In this case, based on the duration of the leak, and the fact that the leak was reported several times without being attended to, it is expected that the leak will not be dealt with in the foreseeable future, if at all. Due to the sustained nature of the leak and the HGM setting, a hillslope seep wetland has developed in the borders of the park. Wetland vegetation is colonising the area and animals are utilizing the area for grazing and as a source of drinking water. This can and already has led to trampling adjacent to the stream. The landscape is responding to the water input though the expression of seepage from the leaking water at the surface, causing biota to respond in the same way as if it were a natural system. However, overgrazing and trampling might result in erosion of the watercourse in which it is located, causing loss of the newly formed habitat, as well as water quality deterioration downstream.

Based on the definition of the South African National Water Act No 36 of 1998, this accidental wetland is characterised by saturated soils, due to water expressed at the surface and subsequent hydrophytic vegetation response. It is, therefore, recognized as a wetland in the South African legal system. Article 1 of the international Ramsar convention on wetlands (Ramsar, 2015) further acknowledges man-made wetlands. However, if the leak is fixed, this wetland might not have any legal standing. Furthermore, the Kgaswane Mountain Reserve as a whole was declared as a Ramsar site in September 2019, site no. 2385 (Ramsar, 2019), and consequently all the wetlands within its boundaries. Given its anthrophonic origin and the likelihood of a limited lifespan beyond the leak feeding it, the question remains: should it be afforded legal standing and international recognition? Nevertheless, the system remains at present a prominent feature in the landscape utilised by the fauna in the reserve and it is therefore recommended that the system be monitored by fixed point photography, vegetation and ecohydrology assessments (Wassen and Grootjans, 1996).

Conclusion

Once formed, accidental wetlands will only persist if the water source is maintained. In the case of the Kgaswane accidental wetland, the current level of saturation and volume of water moving through the wetland will decrease significantly if the leak at the reservoir is repaired. The wetland system will then most likely revert back to an ephemeral system, only responding in times of high precipitation. If, however, the soil regime changes to a fully developed wetland horizon with an impeding clay layer, one can expect a seasonal hillslope wetland forming due to the clay layer forming a perched aquifer and acting as a water source**.** This highlights the need for future research to determine at what stage an ‘accidental wet area’ becomes an ‘accidental wetland’ with wetland functionality in both a temporal, spatial and landscape context. Furthermore, the benefits of maintaining wetland functionality to provide ecological goods and services should be weighed up against the cost of losing the original habitat and municipal potable water.

South Africa is a water scarce country and water resource management is therefore of primary importance. Mountain catchment areas were identified by the Department of Water Affairs and Forestry (DWAF) as critical water source areas for South Africa (DWAF, 2004). The Kgaswane Mountain Reserve qualifies as a mountain catchment area and needs to, as one of its primary objectives, retain a sustainable flow of good quality water to ecosystems downstream (Nel, 2000). In order to reach this goal and conserve water, the reserve management needs to understand the wetland processes in the reserve, both natural and accidental.

Globally accidental wetlands are more likely to form if urbanisation continues unabated without water wise practices in planning frameworks whilst the demand for water will continue to rise with continued poor reticulation network maintenance. These systems need to be accommodated into anthropogenic landscapes providing services such as filtration and stormwater control. Furthermore, their role in contributing to biodiversity and a ‘sense of place’ in transformed landscapes supporting human wellbeing should not be underestimated.

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Appendix 1

List of plant species identified in and around the accidental wetland.

1. *Agrostis lachnantha*
2. *Andropogon eucomus*
3. *Bidens pilosa*
4. *Cyperus marginatus*
5. *Pycreus sp.*
6. *Cyperus sexangularis*
7. *Egrostis sp.*
8. *Eleocharis limosa*
9. *Isolepis costata*
10. *Juncus effusus*
11. *Juncus oxycarpus*
12. *Juncus punctorius*
13. *Juncus rigidus*
14. *Paspalum urvillei*
15. *Pennisetum sphacelatum*
16. *Schoenoplectus muriculatus*
17. *Schoenoplectus sp.*
18. *Sporobolus pyramidalis*
19. *Stripagrostis hochstetteriana*
20. *Verbena brasiliensis*