The Utilisation of the WET-Health and WET-EcoServices Tools in the Application of Wetland Decision Making

Case Study of the uMdloti Catchment

The Utilisation of the WET-Health and WET-EcoServices Tools in the Application of Wetland Decision Making

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DECLARATION

I declare that the attached is my own work and does not involve plagiarism or collusion.

Signed: ____________________________ Date: ________________________

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Abstract

Wetlands serve many purposes in the landscape and are under increasing threat as a consequence of urbanisation despite their importance directly and indirectly to humans. Through an evaluation of the suitability of the WET-Health and WET-EcoServices tools in determining wetland functionality and the provision of goods and services of the wetlands, it was decided that these tools were particularly appropriate for fulfilling the purpose of this research. WET-Health, used in combination with WET-EcoServices, is effective in determining the overall health of wetlands and provides possible reasons for degradation which reduces the ability of wetlands to supply the benefits associated with the particular hydrogeomorphic type. A feedback and questionnaire survey was conducted with eThekwini municipality to determine if the WET-Health and WET-EcoServices tools satisfied their needs and to ascertain whether these tools would be suitable for management of their wetlands. This research, in collaboration with eThekwini municipality's Planning Department, seeks to contribute to the management and maintenance of wetlands within the uMdloti Catchment so that more informed wetland management decisions regarding wetland sustainability can be made.

A level 1 and 2 WET-Health and WET-EcoServices assessments were applied to three sites namely; the Robert Armstrong, Le Mercy and Lake Victoria Barn swallow roosting wetlands. A WET-Health Level 1 assessment can be considered more feasible than a Level 2 which provides similar results yet is more time consuming, however, expert knowledge and experience with the tool may be necessary. A Level 2 WET-EcoServices assessment is recommended as it not only highlights what benefits are being provided but the extent of each benefit thereof also determining whether a wetland has a greater chance to provide a particular benefit but may not being effective in doing so. This in turn allows for efforts and resources to be directed towards improving wetland management and land-use planning and decision making for which the tools are particularly suitable. The tools were considered appropriate and necessary for wetland management and can be adapted into eThekwini municipality's work situation. The tools provide a holistic approach for wetland assessment as catchment activities are considered.

List of Abbreviations

EIA: Environmental Impact Assessment

ERF: Eradication Reporting Framework

GIS: Geographic Information Systems

HGM: Hydrogeomorphic

IAS: Invasive Alien Species

IHI: Index for Habitat Integrity

PES: Present Ecological State

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Chapter One

Introduction

Wetland ecosystems supply numerous goods and services which effectively assist our daily activities and sustain livelihoods by providing access to resources (Rijsberman, 2006). Although water is a renewable resource it is finite and irreplaceable, it is therefore necessary to understand the purpose of wetlands and how they function so that we, as consumers and custodians of the environment, can maintain a sustainable future by managing our water resources wisely (Ehrenfeld, 2000). On a global scale, water scarcity in the next few decades will affect up to two-thirds of the global population (Postel, 2000). Thus, it is important to realise that for a sustainable future, environmental concerns and wetlands need to be taken into account whilst considering land use planning activities which may influence the functionality and health of wetlands and ultimately impact on the resources they yield (Kotze, Marneweck, Batchelor, Lindley and Collins, 2008).

Wetlands are considered to be the most productive and diverse ecosystems in the worlds despite their small global coverage of six percent accounting for 25% of global productivity. Freshwater wetlands cover only one percent of the earth's surface yet contain 40% of the world's species. Wetlands are of great value to humans as their permanent and semi-permanent flooding nature among their physical, biological and chemical functions make them biologically active (Wray and Bayley, 2006).

Wetlands, through their ability to generate ecosystem goods and services such as carbon storage, are beneficial to people and the surrounding community: wetland ecosystems can act as a filter which draws out pollutants and purifies the air (Gopal and Ghosh, 2008; Whigham, 1999). Babatunde, Zhao, O'Neill and Sullivan*,* (2008) and Hammer (1992) suggest that with increased carbon sink activity, clean air may reduce health risks and enhance quality of life. With South Africa being a water scarce country, wetlands are particularly important as they purify water and reduce costs of building dams for water storage (Turpie, 2008). Kivaisi (2001) suggests that in developing countries there is considerable potential to re-use water as water that has been passed through a wetland has been purified due to vegetation which 'draws out' harmful minerals and traps pollutants. Thus wetlands can contribute to a greater level of accessibility of water to surrounding communities of people.

However, despite the benefits wetlands provide in terms of ecosystems goods and services, they are often ruthlessly exploited for resources and become badly degraded (Whigham, 1999). Exploitation of resources degrades ecosystems and shifts the equilibrium such that wetlands are unable to sustain themselves and, in turn, creates non-sustainable livelihoods for those who are dependent on these systems. Past experiences of human interaction with wetlands show that wetland systems function at optimum levels when humans do not disturb the equilibrium that is established. However, if the balance is shifted, the ecosystem displays negative feedback which will bring the ecosystem back to its original set point and place of stability (Kentula, 2000).

Impacts causing disturbances to wetland ecosystems can originate from multiple surrounding catchment activities. In some instances, apart from the need for infrastructure and development especially in developing countries, the needs of people infringe on wetland ecosystems: housing may develop on the boundary of the wetland which will reduce vegetation cover, create infilling, and alter the natural movement of water as the hardened surfaces stimulate increased runoff (Eppink, Van den Bergh and Rietveld, 2004). Wetlands serve as a habitat for a diversity of animals and plants, if wetlands are destroyed, biodiversity maintenance may not be upheld.

Once a wetland ecosystem is degraded it has the potential to be rehabilitated or restored. This is, however, dependent on the resilience of the environment (Grayson, Chapman and Underwood, 1999). Begg (1990) looked at the health of priority wetlands in KwaZulu-Natal and since his assessments, further studies have been undertaken by various consultants and organisations namely Ezemvelo KZN Wildlife, EcoPulse, Groundtruth and WESSA-Mondi Wetlands Programme, to evaluate and monitor the health of these wetlands. The monitoring of these wetlands functionality is captured in the KwaZulu-Natal State of the Wetland Reports allowing for the sound management of wetlands and identifying problems which could be rectified through rehabilitation (Macfarlane, Walters and Cowden, 2011). Having mentioned the importance of wetland features in our landscape and the value they contribute to society, it is clear that the study of wetlands is appropriate with respect to urban development.

To establish the current state of health of wetlands the WET-Health tool can be utilised. The WET-Health tool is comprised of three main components that require field verification: hydrology, geomorphology and vegetation analysis (Macfarlane et al., 2008). The first component, hydrology, is undertaken to determine the amount of water flowing through the wetland system, how much of that is captured and stored as groundwater and how much is lost by surface run-off. The evaluation of water volume input provides information regarding the distribution of water passing through the wetland. The geomorphology is important in understanding the underlying structure of the wetland and the nature thereof which can influence the water flow patterns and the ecology of the area. A vegetation assessment is necessary as it analyses the state of the environment with respect to land use change or disturbances for example, natural vegetation when compared to alien species serves as an indicator of the extent of alteration of the particular site. Surrounding land use activities can play a role in altering the water flow patterns, for example, residential areas with hardened surfaces may divert water movement into side drains away from a wetland. Certain features in the landscape such as infrastructure may cause disturbances in the water regime thus ensuring that water may change or alter its natural course of progression for example, commercial agriculture whereby drains may transport water out of the wetland for the irrigation of crops (Macfarlane et al., 2008).

The WET-EcoServices (Kotze et al., 2008) tool is used to assess the goods and services that individual wetlands provide. Understanding a wetland's ability to deliver ecosystem goods and services can assist in informing planning and decision making from a local to a global scale. Wetlands can be prioritised depending on the context in which they are found. For example, a wetland with water purification abilities situated upstream of a community that is reliant on the wetland for water can be considered important. This wetland can be managed so that pending developments are withheld or measures of impacts mitigated. Ecosystem goods and services include flood attenuation, streamflow regulation, sediment trapping, phosphate, nitrate and toxicant assimilation, erosion control, carbon storage, biodiversity maintenance, provision of water for human use, provision of harvestable resources, provision of cultivated foods, cultural heritage, tourism and recreation and education and research (Kotze et al., 2008).

1.1 Aim and Objectives:

To utilise the WET-Health and WET-EcoServices tools to determine wetland functionality and the provision of goods and services using the uMdloti catchment as a case study.

Objectives:

- To delineate the wetlands within the uMdloti catchment through GIS desktop mapping and ground truthing (spatial extent and hydrogeomorphic type).
- To determine the health of wetlands within the uMdloti catchment using the WET-Health tool.
- To determine the ecosystem goods and services the wetlands provide within the uMdloti catchment using the WET-EcoServices tool.
- To present findings and feedback from eThekwini municipality to determine if the WET-Health and WET-EcoServices tools satisfied their needs.

This research was undertaken collaboratively with eThekwini municipality's Biodiversity Planning Department and seeks to combine their needs with the importance of managing and maintaining wetlands within the uMdloti Catchment. eThekwini municipality has requested that the wetlands found within Durban unicity's boundary be identified and mapped, each hydrogeomorphic unit within the landscape identified, and the health of the wetlands as well as the goods and services they provide determined. This information is necessary as it informs wetland management priorities, allows for the assessment of present and future impacts of urban development on wetlands and for use in the municipality's systematic conservation planning. This research evaluates the appropriateness of the WET-Health and WET-EcoServices tools for determining wetland functionality and the provision of goods and services of the wetlands in the uMdloti Catchment that fall within eThekwini municipality's area of jurisdiction.

Chapter Two
Theoretical Background

2.1 Introduction

Wetlands enhance water quality by performing a combination of a variety of ecosystem services. They act as natural filters by slowing down the flow of water and allowing for the trapping of sediment and the removal of chemicals from sediment and control erosion (Fisher and Acreman, 2004; Mitsch and Gosselink, 1993). Suspended particles act as a sink for chemicals and toxins due to chemical processes which occur due to soil and water interacting (Kotze, 1996; Kotze and Breen, 1994). Precipitation, ion exchange and adsorption are examples of the chemical processes which occur in wetlands and assist in the removal of toxins namely organic pollutants, metals and viruses (Kotze and Breen, 1994). The aerobic and anaerobic conditions present in wetlands assist chemical precipitation and denitrification processes which remove nitrogen whilst phosphorous is removed through adsorption (Kotze and Breen, 1994; Mitsch and Gosselink, 1993).

Wetland vegetation enhances the purification of water and as there is a high rate of mineral uptake (Verhoeven, Arheimer, Yin and Hefting, 2005) these processes often result in cleaner water leaving the wetland (Davies and Day, 1998; Mitsch and Gosselink, 1993). A variety of decomposers, sediment-water exchanges and peat accumulation encourage water quality enhancement (Kotze and Breen, 1994; Mitsch and Gosselink, 1993). A wetland's ability to enhance water quality is important for people who directly or indirectly rely on wetlands for either domestic water use or for saving costs in urban areas for water purification (Verhoeven, Arheimer, Yin and Hefting, 2005). Wetlands can also reduce municipalities' costs for constructing dams (Whigham, 1999).

A direct benefit which a wetland can supply is considered to be something that has importance to humans or individuals actively using a wetland example for recreation whilst an indirect benefit is considered to be something that has importance to humans but does not require the wetland to be used by individuals in order to realize the benefits the wetland provides example, it is the general public who benefits indirectly from the service of wetlands purifying water. Two of the indirect wetland benefits considered to be of importance for wetlands in a South African context are streamflow regulation and the attenuation of floods (Kotze et al., 2008). Davies and Day (1998) refer to wetlands as excellent flood-control agents, due to the existence of plants which slow down rapidly flowing water allowing for flood water to be stored in river channels. This is of particular importance in areas with predominantly hardened surfaces, which are likely to be found in urban areas (Oberndorfer et al., 2007). The presence of these surfaces decreases surface storage of storm-water which increases surface run-off (Ehrenfeld, 2000 and Oberndorfer et al., 2007). The sinuosity, wetland size, gentle slope and the presence of vegetation all contribute to surface roughness of wetlands which assist in the attenuating floods (Collins, 2005).

Another indirect benefit is the ability of wetlands to sequester carbon, due to the anaerobic conditions present in wetland soils which slow down the rate of decomposition of organic matter (Bernal and Mitsch, 2011). This process reduces the amount of carbon dioxide in the atmosphere, which may help stabilise global climate conditions (Wildlife Trusts Water Policy Team, 2001).

The direct ecosystem services provided by wetlands are benefits which are tangible. These benefits include the provision of cultivated foods, water for human use and harvestable resources such as grazing for livestock, plants for use in crafts and construction and medicines (Kotze et al., 2008). The Wildlife Trusts Water Policy Team (2001) states that direct ecosystem services include tourism and recreation, education and research. Wetlands often hold considerable cultural significance which is the basis for many local traditions. Harvestable resources can be considered as particularly important, especially for those where inland fisheries may be the primary source of food and protein for people (Millennium Ecosystem Assessment, 2005).

Wetlands have the ability to perform functions of all types as they are able to perform many vital functions within the landscape. This makes wetland ecosystem services invaluable, as Begg (1990: 6) emphasises: "a review of the major functions and values of wetlands is seen to be necessary to remind decision-makers that the strain on future resources of this country (such as freshwater) means that in the face of exponential population growth man's dependence upon wetlands is steadily increasing".

2.2 Defining wetlands and their functions

Cowardin, Carter, Golet and La Roe (1979: 3) define a wetland as: "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water… Wetlands must have at least one of the following three attributes: (i) at least periodically, the land supports predominantly hydrophytes, (ii) the substrate is predominantly hydric soil, and (iii) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season each year". Wetlands can be classified into various systems, subsystems and classes based on common characteristics which share hydrological, geomorphologic, chemical or biological components (Dini, Cowan and Goodman, 1998). Macfarlane et al (2008) substantiates Dini et al (1998) and the use of hydrogeomorphic units for the assessment of wetland functionality by the hydrology, geomorphology and vegetation modules which the WET-Health tool utilises. Gardiner (1999) suggests that to overcome the loss of information captured in various definitions specific indicators namely terrain morphological unit (position in the landscape), soil form and soil wetness factors (soil that is periodically saturated), should be a general guide that is followed when distinguishing and identifying a wetland.

Recommendations made by Dini et al., (1998) for determining the definition of wetlands and the hydrgeomorphic units thereof does not include all factors impacting wetlands, however, Macfarlane et al. (2008) regard obtaining and capturing this information as a necessary component in the process of undertaking WET-Health assessments. The supported definition of a wetland used by this research is adapted from Macfarlane et al. (2008) and is the premise of the WET-Management Series. It states that a wetland is "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 in normal circumstances supports or would support vegetation typically adapted to life in saturated soils" National Water Act 38 of (1998: 18)

2.2.1 Linking hydrogeomorphic type to wetland ecosystem benefits

Sheldon et al. (2005) state that wetlands perform many functions not all the same however, similar wetlands provide the same functions to the same level of performance. As such, the goods and ecosystem services provided by wetlands can be categorised according to the hydrogeomorphic type namely: floodplain, channelled and unchannelled valley bottom, hillslope seep and depression wetlands which would indicate particular hydrological benefits.

Floodplains are valleys with well defined channels often having ow-bow lakes, depressions and levees and are likely to enhance water quality by trapping sediment and removing nitrates, phosphates and toxins due to the majority of the water received by floodplains occurring during high flow events (Ellery, Grenfell, Grenfell, Jaganath, Malan and Kotze, 2010; Kotze et al., 2008). The presence of oxbow lakes and depressions aid the removal of nitrate and phosphorus. Unchannelled valley bottom wetlands have a distinct stream channel but lacks the prominent features of a floodplain namely the ox-bow lakes. Channelled valley bottom wetlands have no distinct stream channel and are similar to floodplains, although they are generally less effective than floodplain systems at enhancing water quality but there is a certain degree of sediment trapping and nutrient and toxin removal associated with this hydrogeomorphic unit (Kotze et al., 2008). Ellery et al. (2010) state that valley bottom wetlands are moderately effective at attenuating floods but are dependent on the surface roughness of wetlands which may impact the rate of movement of flood waters and ultimately the wetland's ability to attenuate floods. Nitrate and toxin removal is generally provided well by unchannelled valley bottom wetlands than by floodplains (Kotze et al., 2008).

Hillslope seepage wetlands are situated on hillsides or slopes and are associated with a clearly defined channel and can enhance water quality by removing nutrients and toxins, while assimilating nitrates due to the diffuse sub-surface flow which is characteristic of hillslope seepage wetlands (Kotze et al., 2008). Pans and other depressions are basin shaped areas of closed contours which are not effective at enhancing water quality. They receive surface and groundwater flows, and since water accumulates within them, they are generally not connected to the drainage network. The primary influences on the water quality in pans are pedology, geology, and local climate, which determine how these systems respond to the input of toxins and nutrients. In temporary pans, evaporation allows for precipitation of phosphates and denitrification and nitrogen removal is prevalent (Kotze et al., 2008).

2.2.2 Importance of wetland size in the provision of particular benefits

All ecosystem services are affected differently based on the hydrogeomorphic type of wetlands and the size of them thereof. Some ecosystem services may be little to unaffected by the size of the wetland whereas others may be affected: "For example, a wetland considered to have a high cultural value because it contains a sacred spring. Whether the wetland containing the spring is one ha or 500 ha it is unlikely to have any bearing on this cultural value" (Kotze et al., 2008: 31). However, other ecosystem services may be greatly affected. For example, a one hectare wetland which scores high for flood attenuation (as it occupies a high proportion of its catchment), has a high surface roughness and a gentle slope compared with another wetland having the same features except it is 500 ha in size. Although both wetlands are effective in attenuating floods, the larger wetland is 'servicing' a much larger catchment, and can be argued to be more important than the smaller wetland for attenuating floods. Despite this, it is assumed that collectively, several smaller wetlands could have an effect equivalent to or greater than a larger wetland (Kotze et al., 2008). The importance of wetland size in order of most to least, which should be considered in contribution to the following ecosystem services are: flood attenuation, sediment trapping, phosphate assimilation, nitrate assimilation, toxicant assimilation, erosion control, carbon storage, cultivated foods, streamflow regulation, biodiversity maintenance, water supply, harvestable resources, tourism and recreation, cultural significance and education and research (see Table 2.1).

Table 2.1 : The importance of wetland size in relation to the provision of particular ecosystem benefits (adapted from Kotze et al., 2008).

Ecosystem service	Importance of size
Flood attenuation	****
Streamflow regulation	**
Sediment trapping	****
Phosphate assimilation	****
Nitrate assimilation	***
Toxicant assimilation	***
Erosion control	***

Size is seldom important *
Size is usually moderately important **
Size is usually very important ***
Size is always very important ****

Ecosystem service	Importance of size
Carbon storage	***
Biodiversity maintenance	**
Water supply	**
Harvestable resources	**
Cultural significance	*
Cultivated foods	***
Tourism and recreation	**
Education and research	*

2.3 Implications associated with wetlands naturally being lost in the landscape

"The numerous effects of urbanisation on hydrology, geomorphology, and ecology make wetlands in urban regions function differently from wetlands in non-urban lands" (Ehrenfeld, 2000: 253). In urban areas, infrastructure may pose barriers in the landscape which can alter hydrological patterns in upper catchments and the movement of water through a wetland, thus reducing the wetland's ability to function as effectively as it would without the presence of barriers. It can be deduced that wetlands in urban areas are less effective with respect to their functional capacity than wetlands in non-urban areas (Ehrenfeld, 2000).

Wetlands in urban areas provide opportunities for green belts and recreation in urban landscapes. However, with the ever increasing need for development these green areas are becoming smaller in size and number. Urban expansion is slowly invading wetland areas bringing about land use change. With a change in land use there is generally an ecological disturbance which proceeds (Trabaud, 1987). Ecological disturbance modifies the natural flora found within the wetland allowing for the introduction of alien invasive species which can out-compete indigenous flora by utilising the available water resources (Li, Zhu, Sun and Wang, 2010; Rogers, 1997).

Biodiversity loss reduces an ecosystem's natural structure (Schulte-Hostedde, Walters, Powell and Schrubsole, 2007). "Evidence has shown that temporal lags in wetland restoration can temporarily reduce wetland function and impose high costs on society" (Bendor, 2009: 24). While a wetland is recovering from ecological disturbance it will not function to its optimum and as a result will not store water or purify the water passing through its system (Moreno, Pedrocchi, Comin, Garcia and Cabezas, 2007). This can result in high costs to local municipalities who may need to build dams and pay for expensive water purification processes (Hammer, 1992).

2.4 Factors which impact wetland functionality and ecosystem service provision

Factors which inhibit a wetland's capacity to function to its full potential are known as threats which may be caused by non-anthropogenic or anthropogenic factors (Bendor, 2009). Non-anthropogenic factors are those that occur naturally (Bendor, 2009) such as: climatic events through flooding near coastal areas, or increased rainfall events which may cause water logging (Turon, Comas and Poch, 2009). Hail storm events have been known to remove and damage vegetation which would increase soil instability and the potential for soil erosion (Arheimer, Tortensson and Wittgren, 2004). Soil erosion may result in accelerated eutrophication as nitrates and phosphates from soil enter the water (Arheimer et al., 2004). Anthropogenic factors are those that are human induced and include: removal of vegetation due to land use change, non-biodegradable forms of pollution such as plastics which may choke young species of flora, or even disturbance through the introduction of alien species for economic benefit (Burton and Tiner, 2009; Chenje and Mohamed-Katerere, 2003). Human induced influence on the landscape is rapidly increasing due to industrialisation and infrastructural developments.

As development efforts increase, sensitive ecosystems such as wetlands are increasingly susceptible to threats. Infrastructural developments generally utilise construction materials which are not conducive to maintaining the health of an ecosystem. Tar or concrete for example can perpetuate the loss of biodiversity either of plants and animals (Burton and Tiner, 2009) and can pollute nearby water sources and/or change the acidity: -alkalinity ratio of the soil content due to minerals from these materials being washed away in rainfall events (Li et al., 2010). Humans directly cause the destruction of wetlands and indirectly cause harm by over utilising resources which wetlands provide (Bendor, 2009).

2.5 Hydrological, Geomorphologic and Vegetation components of the WET-Health tool

The capacity of wetlands to purify water is dependent on hydraulic characteristics such as slope and the gaps in vegetation due to disturbance which allows vegetation to be colonised by competitors (Rogers, 1997). Hammer (1992) suggests that natural wetlands along streams or at strategic locations in large watersheds may provide low-cost, efficient control especially in limiting the removal of soil. Moreno et al., (2007) suggest that wetland functionality is more effective in upper rather than lower areas of a catchment and the higher the diversity level within a wetland , the greater the effectiveness of that wetland to remove pollution and prevent nutrient enrichment (eutrophication) in water systems.

Geomorphology is defined as the distribution and retention patterns of sediment within a wetland (Macfarlane et al., 2008). Geomorphic processes control and shape, size, structure and location of wetlands in the landscape thus affecting water circulation and vegetation within a particular climatic region (King 2004 and Macfarlane *et al*, 2008). Geological characteristics generally associated with wetland areas include "fine textured soils with low hydraulic conductivity and sufficient thickness to store water" (Brinson 1993). The WET-Health tool assesses geomorphic processes based on a variety of factors namely: the impacts of drains, deposition, erosional features such as gullies, areas of bare soil, number of dirt roads in the catchment, infilling, excavation, infrastructure, channel modifications and organic matter (peat) (Macfarlane et al., 2008). Wetland soils are largely dull grey in colour and are likely to contain mottles, as minerals in the soil dissolve into solution with soil water (Lyon, 1993). When the water table is lowered, iron minerals precipitate into solution and when the water table is high, anaerobic soil conditions occur causing the leaching of irons from the soil and resulting in an orange soil colour. This is referred to as mottling which indicates wetland soils have developed as a result of a fluctuating water table (Department of Water Affairs and Forestry, 2005). Wetland soils indicators are soil colour and mottling (Lyon 1993).

Vegetation is an important indicator of ecosystem health and is threatened, (United Nations Environment Programme, 2006) as it is particularly susceptible to the influx of Invasive Alien Species (IAS) (Milton, 2004). Given the critical role biodiversity plays in the maintenance of essential ecosystem functions, IAS may cause changes in environmental services, such as flood control and water supply, water assimilation, nutrient recycling, conservation and regeneration of soils (Chenje and Mohamed-Katerere, 2003).

Although only a small percentage of alien species are potentially invasive, their impacts are great and usually irreversible as they out-compete indigenous species (Chenje and Mohamed-Katerere, 2003 and Johnson and Miyanishi, 2007). Hydrophilic vegetation commonly associated with wetlands, varies according to surrounding environmental components endemic to a particular area such as climate, rainfall patterns and geological properties (Johnson and Miyanishi, 2007). These features inform what species enter and inhabit an area and denote the stages of ecological succession from pioneer to climax vegetation. Environmental hazards act as a disturbance to an ecosystem's equilibrium and induce alteration in vegetative species when indigenous plants are threatened by the introduction of exotic and alien species.

With external influences impacting directly on wetland vegetation composition and with environmental change reaching unprecedented levels, it is important to consider what impacts natural hazards such as veld fires, flooding, drought and deforestation are likely to have. This can bring about a change in the landscape which will change a wetland's ability to function and generate goods and services (Johnson and Miyanishi, 2007). The WET-Health tool assesses the extent to which disturbance units – comprising of croplands, plantations, annual pastures, forests, alien vegetation and exotic species – influence the wetland in terms of hydrology, geomorphology and vegetation, the intensity of impact of these features and the magnitude of impact as a result in both the catchment and wetland hydrogeomorphic unit (Macfarlane et al., 2008). For example, a cropland of sugarcane may reduce the amount of water in the wetland by draining the system for irrigation, thus affecting the hydrology. The change in water regime may impact on differences in the soil as levels of ground water may change from permanent inundation to seasonal or temporary associated conditions, hence the geomorphology is affected. The natural vegetation which may have historically occupied the wetland area would have been removed so that the crop could be established (Macfarlane et al., 2008).

2.6 Tools assessing wetland functionality

Hydrology is viewed as the driving force behind creating and maintaining wetlands because is it due to the introduction of water by means of direct rainfall, runoff from nearby areas, stream flow and ground water discharge, soils and the ground water table that enables the control of soil colours and textures, the quality of water, the abundance of vegetation and microbial features occurring in the wetland (Ellery et al., 2010; Williams, 1991). The process of water being inputted, stored and removed is referred to as the water budget Williams (1991) cited in (King 2004: 35). External factors that impact on the water budget are evaporation determined by air, humidity, temperature, vegetation cover, wind speed, soil moisture content, rainfall patterns and transpiration (Love *et al*, 2010). "Wetland construction is mostly focused on water quality improvement, although there is an increasing scientific interest in multipurpose approaches" (Moreno *et al,* 2007: 103). The capacity of wetlands to purify water which passes through it is dependant on hydraulic characteristics such as high shoot densities enabling a higher hydraulic slope and the gap in vegetation left behind by disturbance which allows vegetation to be colonised by competitors (Rogers 1997). (Hammer 1992: 49) also suggests that " natural wetlands along streams and at strategic locations in large watersheds may provide low-cost, efficient control" especially in limiting the removal of soil, however, wetland functionality is said to be more effective in upper areas of a catchment than in lower ones provided it has higher diversity values, thus translating into, soil erosion will most likely be less prevalent in the upper areas of a catchment (Moreno *et al*, 2007). From the case study provided in Moreno *et al*, (2007), regarding the creation of wetlands for the improvement of water quality and landscape restoration in semi-arid zones degraded by intensive agricultural use, it can be supposed that the higher the diversity level within a wetland the greater the effectiveness in removing pollution and preventing nutrient enrichment in water systems thus reducing eutrophication (Moreno *et al*, 2007). "The incorporation of the use of constructed wetlands into new or existing agricultural policies, will allow land planners to improve the water quality in irrigated agricultural catchments in the semi-arid regions" (Moreno-Mateos *et al,* 2010: 638).

Mitsch and Gosselink (2007) suggest that the land cover change metric tool was developed solely on the hydrological component of wetlands since this is the most important determinant of wetland structure and function. Macfarlane et al. (2008) give more weight to hydrology than geomorphology and vegetation but argue that these three components cannot be seen in isolation or apart from each other. The Wetland Index for Habitat Integrity (Wetland-IHI) is the most similar tool to WET-Health with respect to method as the tool requires hydrology, geomorphology and vegetation assessments to determine Present Ecological State categories. However, a water quality module has been included as the tool was developed for riverine ecosystems and is only applicable for the assessment of floodplain and channelled valley bottom wetlands which excludes unchannelled valley bottom, hillslope seep and depression wetlands (Department of Water Affairs and Forestry, 2007). It was therefore inappropriate for this research which investigated all wetland types except for floodplain and depression.

Wetland management and monitoring strategies are unlikely to be successful unless practical measures such as field assessments are undertaken to assess the state of wetlands (Janssen, Goosen, Verhoeven, Verhoeven, Omtzigt and Maltby*,* 2005) however, White and Fennessy (2005) argue that wetland processes such as soil formation occur over long periods of time which may not require regular intervals of monitoring as assessments would not indicate these changes in short periods of time. A number of ecosystem services may be accredited to wetlands. According to the Virginia Department of Environmental Quality (2005)

Geographic Information Systems (GIS) and Remote Sensing techniques have been utilised and are considered to be successful for the purpose of monitoring wetlands. Johnson (2005) substantiates the use of GIS based techniques for wetland monitoring as integration of existing datasets would derive new datasets specific for wetland related management. Lowry (2006) states that GIS databases may be beneficial to wetland monitoring, however, they do create a large quantity of data which, although easily accessible, is likely to be outdated since a GIS database is continually updated. A problem associated with a GIS database is that the quality of monitoring can only be as good as the wetland mapping; the United States Environmental Protection Agency (1999) states that wetland delineation is subjective and field verification is necessary.

2.7 Tools assessing wetland goods and services

The WET-EcoServices tool, unlike the economic valuation of wetlands tool has a higher acceptance amongst communities and hence a greater success rate (Lambert, 2003). The economic valuation tool associates the goods and services wetlands provide with a monetary value so that the importance of these benefits can be determined.

Lambert (2003) suggests that the economic valuation tool enables government decision makers to be aware of the role of wetlands in the landscape which would assist in the more effective management of wetlands. However, to what extent is monetary value important? A low monetary value may not necessarily mean that the wetland is providing goods and services that are of low intrinsic value since communities may depend on wetlands to sustain their livelihood (Kotze et al., 2008; Sullivan et al., 2008). This may result in management of these 'less significant' systems not being prioritised despite the role the wetlands play in the landscape and the importance of the goods and services they provide.

Emerton and Bos (2004) suggest that a cost benefit analysis which compares the benefits and costs to society against actions to protect or restore an ecosystem can provide an accurate account of how to manage wetlands. The WET-EcoServices tool assesses characteristics of the surrounding catchment and wetland type (Kotze et al., 2008) whereas the economic valuation and cost benefits analysis tools take only the wetlands into account, excluding the catchment in which they are found, although Kotze et al. (2008) state that catchment activities do influence the ability of these systems to deliver goods and services. WET-

EcoServices tools characterise wetlands into hydrogeomorphic (HGM) units, each with the identical characteristics similar to those units used in WET-Health, based on the fact that different wetland types provide different functional benefits (Kotze et al., 2008). This differs from the broad traditional form of wetland classification known as the Cowardin approach (Freshwater Consulting Group, 2009).

2.8 Conclusion

Wetlands are unique ecosystems which provide vital benefits to society, and may occur as either natural or artificial features in the landscape. These wetland systems are increasingly under threat from various anthropogenic and non-anthropogenic factors (Bendor, 2009) such as urban expansion or industrialisation which may impact on wetland areas negatively as changing land use types generally precede an ecological disturbance (Trabaud, 1987).

These impacts influence the hydrology, geomorphology and vegetation of wetlands and may alter their ability to perform necessary functions including their ability to generate relevant ecosystem goods and services according to the hydrogeopmorphic type. Although there is no direct relationship between wetland health and the wetland services, it is a common belief that a healthier wetland generates more goods and services (Macfarlane et al., 2008). Wetlands that are considered to be in a state of poor health can be restored or rehabilitated provided there is more effective allocation of resources through planning and monitoring initiatives (Janssen et al., 2005; Grayson et al., 1999). Although Geographical Information Systems (GIS) techniques are considered to be an effective monitoring tool they may not be entirely appropriate for assessing wetland health as wetland processes occur over long periods of time which may not be captured. Also this may be a subjective approach which can only be as informative as the quality of the mapping.

Chapter Three

Methods

3.1 Site Description

The uMdloti catchment (see Figure 3.1) is surrounded by the urban areas of Le Mercy, Tongaat, Canelands, Umhlanga and Verulam. The uMdloti catchment and surrounding areas are predominantly under commercial agriculture. Hazelmere dam is the only major source of water in the uMdloti catchment: it provides water for irrigation for farmlands, human consumption, recreation and industrial use (Nemai Consulting, 2008).

This research used a Level 1 and two WET-Health and WET-EcoServices tools to complete a desktop evaluation and field verifications to determine the state of health of the wetlands and the goods and services they provide. Ascertaining the hydrogeomorphic type of wetlands and mapping their spatial extent would serve to inform and enhance wetland management decisions.

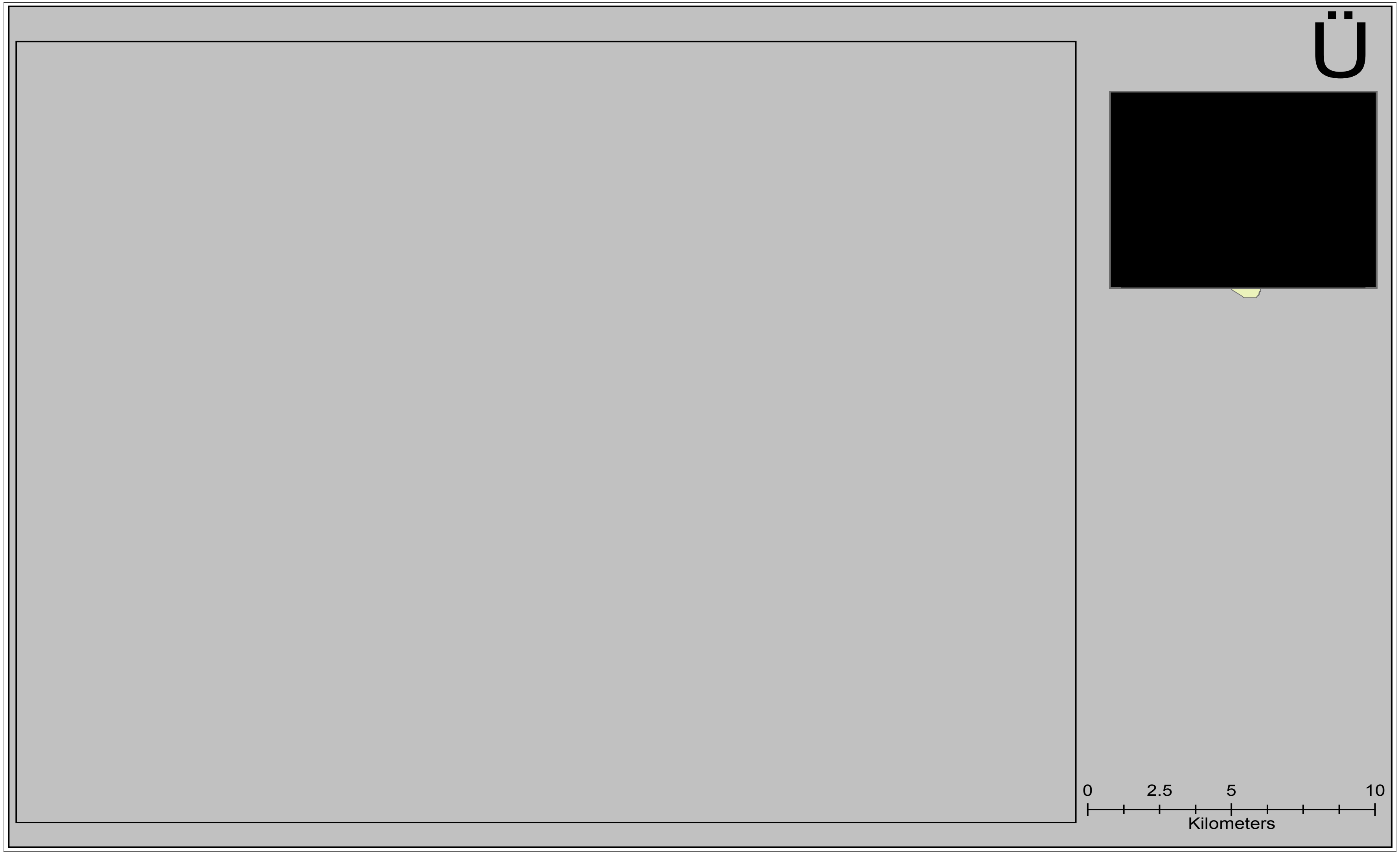


Figure 3.1: Location of the uMdloti study site

In discussion with eThekwini municipality, three wetlands were selected that would complement their estuarine management plan for the uMdloti catchment. Fieldwork Level 1 and 2 WET-Health and WET-EcoServices assessments were conducted on all three wetlands. The assessments served as guidelines to determine the health status of the wetlands and goods and services they provide and thus served to inform wetland management decisions. All three wetlands, consisting of eight hydrogeomorphic (HGM) units, were assessed using Level 1 and 2 WET-Health and WET-EcoServices.

The wetlands were distributed across a moderately high gradient of three percent in a highly urbanised catchment. There are various catchment activities which impact on the wetlands such as commercial agriculture which comprises approximately half of the study area, roads, dams, sewage treatment plants, sand winning and industries.

A desktop evaluation prior to the commencement of fieldwork provided the following information: catchment boundary and catchment areas units (in hectares), wetland boundary and HGM unit boundaries and the area of each HGM unit (in hectares), the quaternary catchment and the Mean Annual Precipitation (MAP) which was recorded as 1 086 mm per annum (Alcock, 1999), Potential Evapotranspiration (PET) at 1 400 mm per annum (Kwezi V3 engineers, 2008), thus the MAP/PET ratio is 0.78 and the Median Annual Simulated Runoff 271 mm per annum (Alcock, 1999), land uses in the catchment and the wetland and their approximate extent (in hectares) and the presence of any drains, dams, erosion features in the wetlands catchment and their extent (in hectares) (Macfarlane et al., 2008).

Three wetlands were selected to obtain a diversity of catchment activities and wetland features (see Figure 3.2). The three wetlands were separated into their hydrogeomorphic (HGM) units (Table 3.2) and each HGM unit was assessed using Level 1 and 2 WET-Health and WET-EcoServices tools (see Table 3.1). The Robert Armstrong wetland comprised of one unit – channelled valley bottom (Figure 3.3), the Le Mercy wetland 2 units – hillslope seep linked to channel and unchannelled valley bottom (Figure 3.4) and the Lake Victoria Barn Swallow roosting site five units – channeled and unchannelled valley bottom, hillslope seep linked to channel, and two isolated hillslope seeps (Figure 3.5).

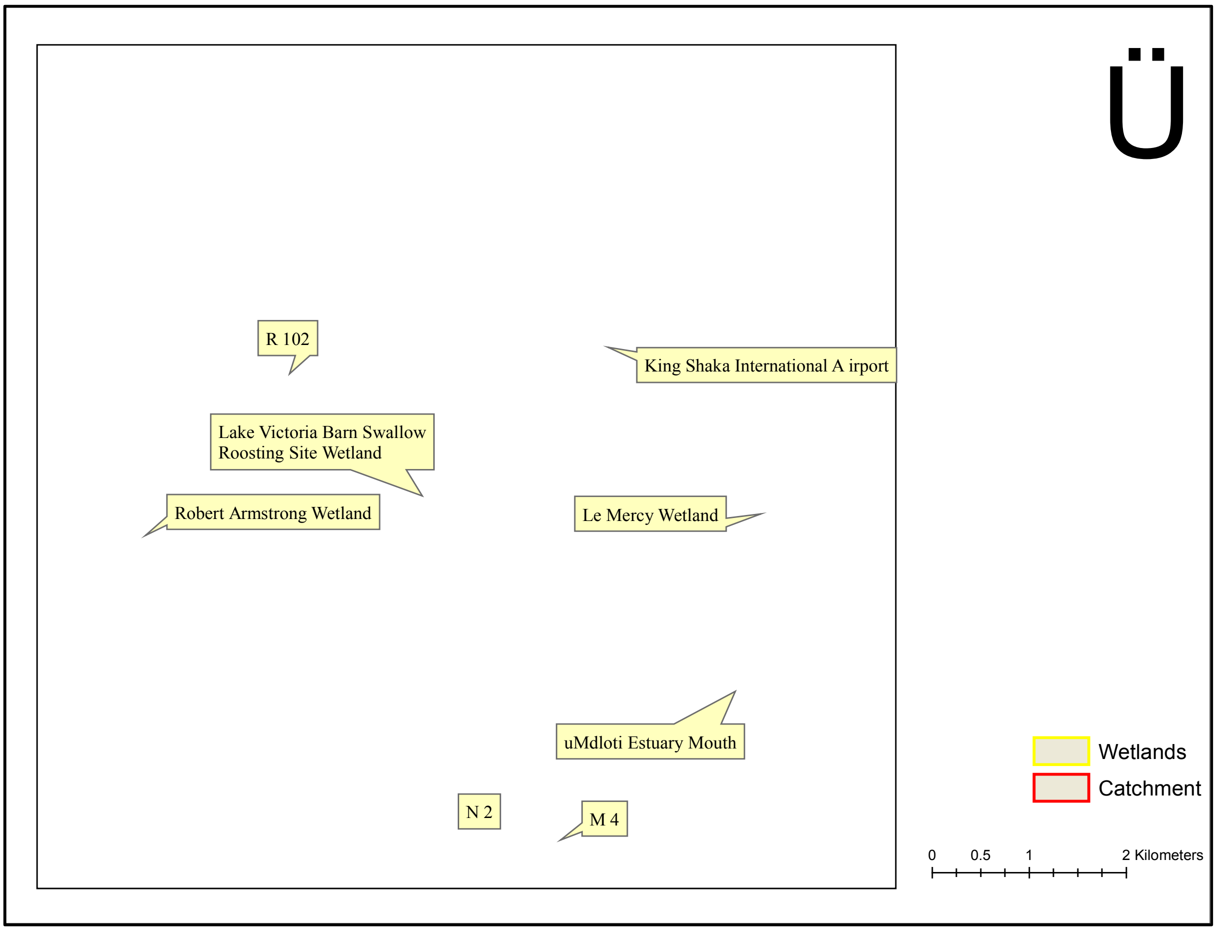


Figure 3.2: Distribution of wetlands across the uMdloti region

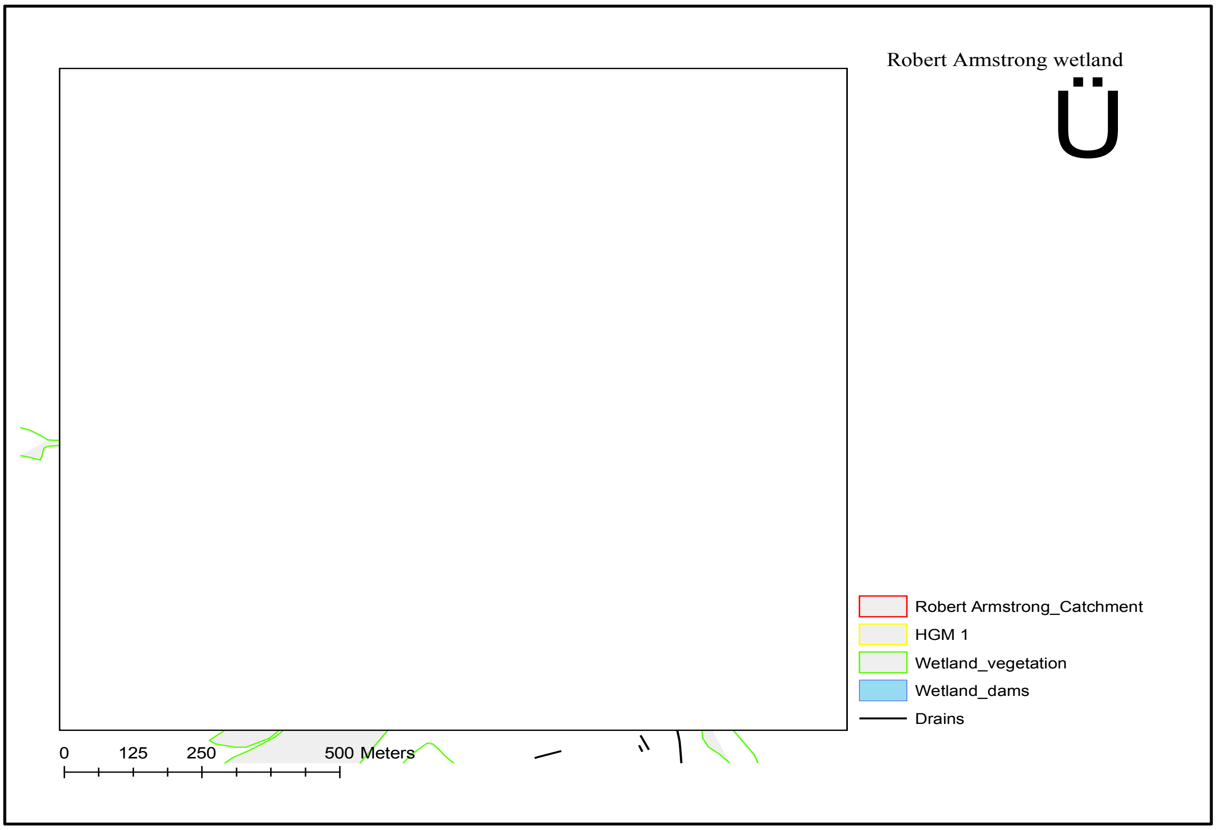


Figure 3.3: Robert Armstrong wetland with one HGM unit

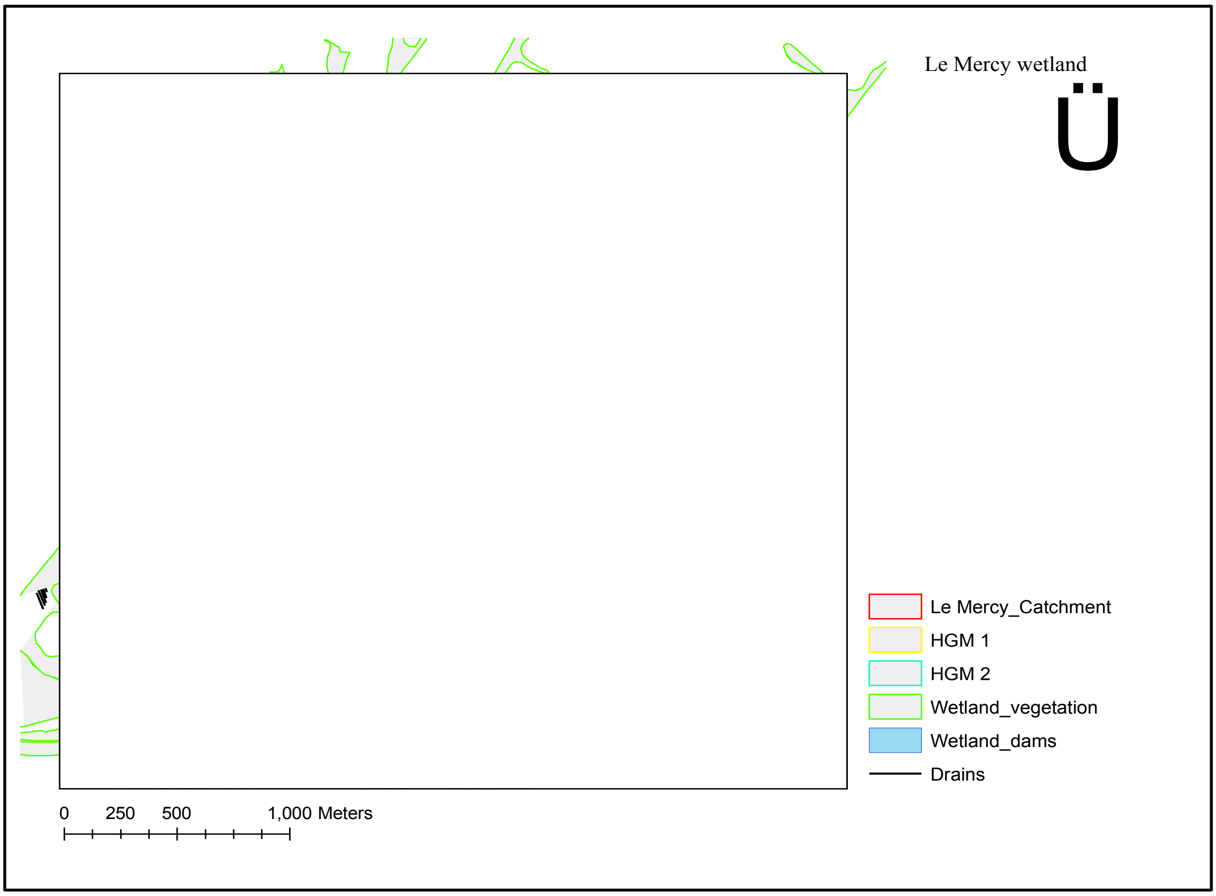


Figure 3.4: Le Mercy wetland with two HGM units

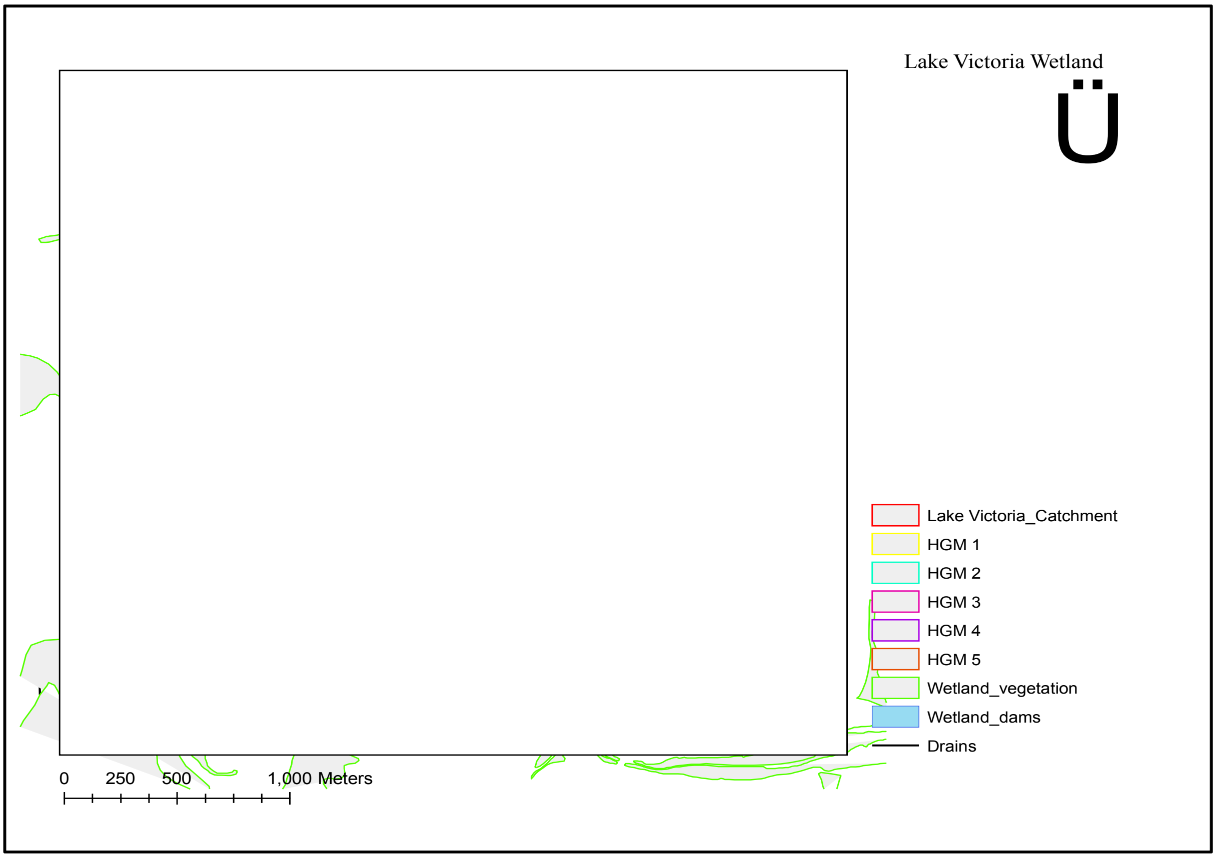


Figure 3.5: Lake Victoria Barn Swallow roosting site wetland with five HGM units

Table 3.1: The three wetlands and their HGM units

Robert Armstrong wetland			Le Mercy wetland			Lake Victoria Barn Swallow roosting site wetland	
HGM 1: Channelled valley bottom	HGM 1: Hillslope seep linked to channel	HGM 2: Unchannelled valley bottom	HGM 1: Channelled valley bottom	HGM 2: Unchannelled valley bottom	HGM 3: Hillslope seep linked to channel	HGM 4: Isolated hillslope seep	HGM 5: Isoloated hillslope seep

3.2 Study site

Sites were selected in consultation with members of the Planning Department of eThekwini municipality as they are interested stakeholders in the area and require information that will enable them to allocate resources into effective management. The uMdloti catchment was chosen as the intention of the Department was to develop an estuarine management plan and any information which was provided to them on the state of the wetlands in this specific catchment would be of value. The study site became the portion of the uMdloti catchment that falls within eThekwini's jurisdiction since the upper portion of the uMdloti catchment fell out of the eThekwini municipality's area of jurisdiction.

The study area is 12 510 hectares in extent with 1 228 hectares of wetlands comprised of unchannelled and channelled valley bottoms and hillslope and isolated seepage areas. Land uses include: industrial, residential, recreational, utility, commercial agriculture (sugarcane, covers more than half of the catchment), sand winning and commercial plantations. Comparing the catchment situation with that of the wetland activities may offer insight into causes of wetland degradation (Macfarlane et al., 2008).

The surrounding urban areas are Le Mercy, Tongaat, Canelands, Umhlanga and Verulam. This area experiences a sub-tropical climate and is associated with warm wet summers and mild moist to dry winters, receiving 1 100 mm of rainfall per annum. A prominent feature in the uMdloti catchment is Hazelmere Dam and the area relies on it for domestic, industrial, irrigation and recreational purposes (SACCTN Marketing, 2006).

3.3 WET-Management series tools

An important constituent of this research, with respect to proposing the WET-Health and WET-EcoServices tools, was to determine wetland ecosystems' functionality and the goods and services they provide. For this, quantitative studies were carried out. The WET-Health tool was used to determine the functionality of the wetlands within the landscape whereas the WET-EcoServices tool was used to determine the goods and services that the wetlands provide. These WET-Management series tools were considered an appropriate method as the desktop information required for use of these tools fulfilled the objectives of this research and provided Durban eThekwini with the information that they require, for example, by delineating the wetlands within the catchment one can determine the spatial extent of the wetlands and their HGM types.

This method was preferred, as opposed to the Wetland-IHI method, as it would indicate the differences between the level of detail of Level 1 and two so that eThekwini municipality could determine the health of their wetlands and the goods and services they provide and have a better informed understanding of these systems (Kotze, Ellery, Macfarlane and Jewitt, 2011). (WET) The WET is a comprehensive approach for evaluating individual wetlands that was developed in 1983 and considers wetland functions to be the physical, chemical, and biological characteristics of a wetland. It assigns wetland values to the characteristics that are valuable to society. The WET evaluates functions and values in terms of effectiveness, opportunity, social significance, and habitat suitability (Novitzki, Smith and Fretwell, 1997).

Effectiveness assesses the capability of a wetland to perform a particular function. For example, a wetland that has no outlet is assigned a high value for sediment retention, whereas a wetland just downstream from a dam is assigned a low value. Opportunity assesses the potential for a wetland to perform a specific function; for example, a wetland in a forested area that has no potential sediment sources would be assigned a low opportunity value for sediment retention. Social significance assesses the value of a wetland in terms of special designations (does it have endangered species?), potential economic value, and strategic location (is it in a State where very few wetlands of its type remain?). The WET uses predictors that relate to the physical, chemical, and biological characteristics of the function being evaluated. As an example, the presence or absence of a constricted outlet from a wetland could be used to predict whether the wetland might be effective in storing floodwaters. Criticised by the developers of the tool itself for possibly being too reliant on predictors of scenarios make it difficult to rely on and translate to a municipality who requires factual scientific proof of the condition of their wetlands in order to manage them appropriately.

The different levels of assessment, when compared to each other, can yield meaningful information which may not have been available had only one level of assessment been used, for example, a Level 2 WET-Health assessment takes slope and vulnerability into account with respect to wetland health as opposed to the Level 1 which does not. The Level 1 assessment allocates extents and intensity values to the same features that a Level 2 would review but does not require as much fieldwork as the Level 2. The Level 2 could yield accurate results to relatively inexperienced users of the tool due to the level of depth of fieldwork.

For the Level 1 assessment it is important to note whether a feature is present or not and the likelihood of magnitude of impact on the wetland, however, a Level 2 assessment requires more detail. For example, a Level 1 would show sugarcane and the extent it covers whereas a Level 2 assessment would determine sugarcane present, the extent it covers, distinguish between plant types such as shrubs or trees or a combination of the two and determine the distribution of alien woody plants in riparian areas, non-riparian or a combination of both, as well as whether the sugarcane uses more or less water than wattle, pine or eucalyptus trees. Instead of assessing all alien vegetation as one feature, the Level 2 assessment requires that every alien plant be listed as certain species may consume more water than others (Macfarlane et al., 2008).

3.4 Qualitative measures

3.4.1 Questionnaire and feedback session

Two closed ended questionnaires, consisting of 15 questions were designed to capture feedback from eThekwini municipality (Appendix 1). All attendees of the feedback session which consisted of a one-hour presentation based on the WET-Health and WET-EcoServices tools, assessments and results with time being allocated for questions, were provided questionnaires both before and after the presentation. The purpose of the questionnaire before the presentation was to determine the eThekwini municipality's needs regarding wetlands and to determine their prior knowledge of the WET-Health and WET-EcoServices tools. The post-presentation questionnaire determined if the methods fulfilled their needs, if and how these tools are taken into consideration with respect to land use planning and decision making and if these methods could be used for assessing the wetlands.

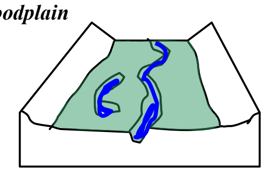
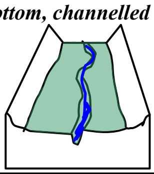
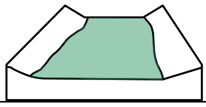
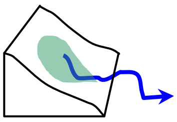
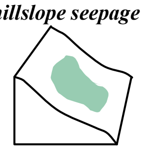
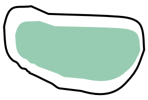
3.5 Quantitative measures

3.5.1 WET-Health tool

The WET-Health framework involves three primary components namely: hydrology, geomorphology and vegetation. For this research a Level 1 and two WET-Health assessment was conducted. Three Level 1 and two assessments were carried out on unchannelled and channelled valley bottoms and seepage hydrogeomorphic (HGM) types.

WET-Health can be seen as a "deviation from the natural reference condition" (Macfarlane et al., 2008: 10). The tool was used to determine the deviation of the condition of the wetland compared to the wetland in its natural state. The WET-Health tool was used to provide best management practices with an understanding of wetland functions and inform decision makers such that the decisions made could ensure more effective functioning of the wetland ecosystem. The scoring system used for WET-Health is a scale from zero to ten with zero being the natural condition while ten indicates the most deviance away from the natural state (Macfarlane et al., 2008). Within each individual hydro-geomorphic unit in the wetlands, the hydrological, geomorphological and vegetation health were assessed and scored to determine the overall current state of health of the wetland (Appendix 2).

Table 3.2: Wetland hydrogeomorphic types (Table adapted from the WET-Health guidebook by Macfarlane et al., 2008: 27).

Hydrogeomorphic types	Description	Source of water maintaining the wetland	
		Surface	Sub-surface
Floodplain 	Valley-bottom areas with a well-defined stream channel gently sloped and characterised by floodplain features such as ox-bow depressions and natural levees and the alluvial transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*
Valley-bottom, channelled 	Valley-bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterised by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/ ***
Valley-bottom, unchannelled 	Valley-bottom areas with no clearly defined stream channel, usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs are mainly from the channel entering the wetland and also from adjacent slopes.	***	*/ ***
Hillslope seepage linked to a stream 	Slopes on hillsides, which are characterised by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and out flow is usually via a well-defined stream channel connecting the area directly to a stream channel.	*	***
Isolated hillslope seepage 	Slopes on hillsides, which are characterised by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel	*	***
Depression (includes Pans) 	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent, and therefore this type is usually isolated from the stream channel network.	*/ ***	*/ ***

Water source: * Contribution usually small
*** Contribution usually large
Wetland */ *** Contribution may be small or important depending on the local circumstances

3.5.1.1 Hydrological health

The hydrology assessment considers variation in amount of water that flows through the wetland system and the proportion captured and stored as groundwater or carried away as surface run-off. The evaluation of water volume input provides the distribution of water through the wetland. The surrounding land use activities play a role in altering water flow patterns. Land use types may cause disturbances in the water regime thus ensuring that the natural course of progression of water is altered resulting in water following another path. The barrier may not permit water to filter through thus the ground water table becomes saturated leading to water logging.

Components within a wetland's catchment such as infiltration rates, the presence of water bodies and areas of little ground vegetation cover, influence the amount of water that passes through the wetland and flood peaks. The relationship between infiltration rates is: the presence of water bodies, the lack of groundcover and flood peaks, a lack of water bodies and groundcover vegetation the higher the flood peaks (Macfarlane et al., 2008 and Love, Uhlenbrook, Corzo-Perez, Twomlow and van der Zaag, 2010). Having identified the HGM units, the alterations of water inputs and flow patterns can be determined (Macfarlane et al., 2008).

Each activity affecting water movement is assigned a relevant percentage score in terms of the degree to which it affects the wetland. An intensity score is approximated from zero to ten with zero being pristine and ten being critically altered. A magnitude score is calculated by multiplying the percentage by the intensity score, for example, if an activity affects ten percent of a HGM unit and the intensity of impact in the affected area is six, then the magnitude of impact is calculated as 10/100 x 6 = 0.6. This indicates the extent of alteration is minimal and the Present Ecological State (PES) category is an A, with the wetland being unmodified, natural (see Table 3.3). If an activity affects 90 percent of a HGM unit and the intensity of impact in the affected area is nine, then the magnitude of impact is calculated as: 90/100 x 9 = 8.1. This indicates a F PES as modification is critical with flow patterns severely altered. When the scores for different activities are added together, a combined impact magnitude score for the entire HGM unit is derived (Macfarlane et al., 2008). A trajectory of change score is indicated to determine the conditions likely to occur within the wetland ecosystem over a five-year period: for example, if wetland conditions deteriorate slightly then a symbol of one downward facing arrow is indicated in the WET-Health assessment sheets (Table 3.4).

Table 3.3: Present Ecological State categories (Table adapted from the WET-Health guidebook by Macfarlane et al., 2008: 30)

Description	Combined impact score	PES Category
Unmodified, natural.	0-0.9	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable.	6-7.9	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

Table 3.4: Trajectory of Change Scores (Table adapted from the WET-Health guidebook by Macfarlane et al., 2008: 148)

Change Class	Description			
Improve	condition is likely to improve over the over the next 5 years	1	0.3 to 1.0	(↑)
Remain stable	condition is likely to remain stable over the next 5 years	0	-0.2 to +0.2	(→)
Slowly deteriorate	condition is likely to deteriorate slightly over the next 5 years	-1	-0.3 to -1.0	(↓)
Rapidly deteriorate	substantial deterioration of condition is expected over the next 5 years	-2	-1.1 to -2.0	(↓↓)

3.5.1.2 Geomorphological health

Geomorphic health is important to consider as a consequence of rates of erosion and deposition (Macfarlane et al., 2008). Geomorphic processes control and shape the structure of a wetland affecting water distribution (Macfarlane et al., 2008). However it is essential to understand that geomorphology is linked to both the hydrology and ecology of the wetland and the interpretation of the results should show integration of hydrology, geomorphology and vegetation. Thus, the evaluation of geomorphological health of a wetland, present geomorphic state and trajectory of change must be assessed (Macfarlane et al., 2008).

3.5.1.3 Vegetation health

The study site is categorised as Sub-Escarpment Savanna with the majority of the area falling into the Indian Ocean Coastal Belt bioregion category (Mucina and Rutherford, 2006). The uMdloti area can be categorised under the KwaZulu-Natal Coastal Belt vegetation unit which is characterised by timber plantations, extensive sugarcane fields, and coastal holiday resorts with secondary *Aristida* grasslands, thickets and patches of coastal thornveld. The natural vegetation types in the uMdloti area have been transformed due to sugarcane cultivation and timber plantations (Kwezi V3 Engineers, 2008).

Wetland vegetation is important as it serves to sustain local fauna and act as a break to water flowing through the wetland. By reducing the velocity of water, there is a greater opportunity for infiltration to occur thus allowing the groundwater table to store water as a reserve and reduce the amount of topsoil which could be removed by surface flow. Therefore it is important and appropriate to assess the health of wetland vegetation. To assess vegetation health, the assessor must have prior knowledge of the subject matter so that wetland vegetation can be identified and its composition under natural conditions in its native habitat be understood. This is important as there must be a template to compare the identified vegetation against vegetation under disturbed conditions.

In order to illustrate the process of a WET-Health level 1 assessment, an example will be outlined from the Qokololo wetland site situated in Edendale, Pietermaritzburg. This study aimed to investigate what impacts urbanisation had on the Qokololo wetland ecosystem's functionality. The Qokololo wetland is comprised of three HGM units, of which two were hillslope seeps linked to a channel and a depression (Figure 3, 6) being situated in Edendale where there has been, in recent years, rapid urban expansion made it an ideal site to undertake as a project as the wetland is encroached upon by various forms of urbanisation and human activity namely; burning, cattle grazing, solid waste disposal and the soccer stadium which occupies the same site.

According to table 3.5 and 3.6 the various activities within the Qokololo wetland are summarised along with their impacts on its hydrological health which was identified during the field assessment. From table 3.5 it is apparent that activities in the catchment do not have a great impact on the water inputs as they can be considered negligible (0 to 0.9). There has been a moderate increase (4 to 6) in the flood peaks. This increase in flood peaks is a result of the increased amount of hardened surfaces such as plinthite and areas of bare soil within the wetland's catchment, which reduces the rate of infiltration and increases the amount of surface run-off, hence the increase in flood peaks (Macfarlane *et al*, 2008).

Table 3.5: A summary of the affect of both volume of water inputs and the pattern of flood peaks on each HGM unit

Description	**HGM Unit 1**	**HGM Unit 2**	**HGM Unit 3**
Catchment activities that cause a reduction in water inputs	Negligible (0 to -0.9)	Negligible (0 to -0.9)	Negligible (0 to -0.9)
Level to which the natural pattern of floods have been altered and delivered to the HGM unit	Moderate Increase (4 to 6)	Moderate increase (4 to 6)	Moderate Increase (4 to 6)
Magnitude of impact on the HGM unit	1.5	1.5	1.5

Figure 3.6: Map showing the Hydrogeomorphic Units within the Qokololo wetland

Plate 3.1 shows the inlet in HGM unit 3 which formed due to the water flow being cut off by a linear disturbance. The linear disturbance altering water flow which restricts infiltration but increases surface runoff is the railway line.

Plate 3.1: Inlet found in HGM unit 3 caused by the railway line impeding surface flow of water

Table 3.6: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of the extent and intensity of different on-site impacts

	Type of Modification	Extent %	Intensity	Magnitude
HGM Unit 1:	Gullies and artificial drainage channels	10	0.5	0.05
	Modifications to existing channels	70	1.5	1.05
	Impeding features – upstream effects	100	3	3
	Deposition/ infilling or excavation	1	0.5	0.005
	Reduced Roughness	60	1.5	0.9
Combined Impact Score				**5.005**
HGM Unit 2:	Gullies and artificial drainage channels	40	5	2
	Deposition/ infilling or excavation	50	7	3.5
	Reduced Roughness	100	0.5	0.5
Combined Impact Score				**6**
HGM Unit 3:	Gullies and artificial drainage channels	5	3	0.15
	Deposition/ infilling or excavation	40	7	2.8
	Reduced Roughness	80	5	4
Combined Impact Score				**6.95**

Calculation of overall magnitude of impact for the wetland:
HGM Unit 1 comprises approximately 25%, HGM Unit 2 comprises 60% and HGM Unit 3 comprises 15%.

From table 3.7 the impact scores were as follows; HGM Unit 1= 5.005, HGM Unit 2= 6 and HGM Unit 3= 6.95

Table 3.7: Summary of hydrological impact scores obtained from the catchment and within the wetland

HGM Units	**Impact Scores**
HGM Unit 1	5.005
HGM Unit 2	6
HGM Unit 3	6.95

Thus: (5.005×25/100) + (6×60/100) + (6.95×15/100) = **5.9**

Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	D

This impact score suggests that hydrological patterns are largely altered with a large change in ecosystem processes occurring such that there is loss of natural habitat and biota. These water flow patterns show signs of major alterations due to the surrounding features which impact on the wetland of which have been previously discussed.

In terms of the geomorphology of the wetland the degree to which sediment deposition can associate with the occurrence, distribution, size, activity and extent of gullies and trenches erosion or even decreased ground vegetation cover in the catchment or wetland, generates sediment during rainfall events. The impacts of these depositional features are assessed in terms of the extent to which they replace and remove already existing wetland features which is indicated by plate 3.2 and 3.3 which is calculated in table 3.8. The position of the depositional features occurring in the wetland plays a role in determining potential impacts because as Macfarlane *et al* (2008) suggests; if they occur lower down in the wetland as shown in plate 4.4 this may hinder the development of the wetland.

Plate 3.2: A trench occurring in HGM unit 2

Plate 3.3: An anthropogenic induced gully along the fenced roadside in HGM unit 3

Table 3.8: Guideline for assessing the magnitude of impact on the HGM units based on the consideration of erosional and depositional features

	Impact Type	**Extent %**	**Intensity**	**Magnitude**
HGM Unit 1:	Erosional features	7	0.5	0.035
Combined Impact Score				**0.035**
HGM Unit 2:	Erosional features	45	1.5	0.675
Combined Impact Score				**0.675**
HGM Unit 3:	Erosional features	10	0.5	0.05
	Despoitional features	5	1.5	0.075
Combined Impact Score				**0.125**

Calculation of overall magnitude of impact for the wetland:
HGM Unit 1 comprises approximately 25%, HGM Unit 2 comprises 60% and HGM Unit 3 comprises 15%.

From table 3.9 the impact scores were as follows; HGM Unit 1= 0.035, Unit 2= 0.675 and HGM Unit 3= 0.125

Table 3.9: Summary of Geomorphological impact scores from within the wetland

HGM Units	**Impact Scores**
HGM Unit 1	0.035
HGM Unit 2	0.675
HGM Unit 3	0.125

Thus: (0.035×25/100) + (0.675×60/100) + (0.125×15/100) = **0.43**

0-0.9	**Unmodified, natural**	**A**

This impact score of 0.43 (category A) for the geomorphology analysis indicates that the state of health is good and the nature of this component is unmodified and natural however, there is some modification to the geomorphology which is present in the form of the erosion ditch which may expand into a deep gully found in HGM Unit 1.

The vegetation in the wetland based on the calculations in table 3.10 remain consistent with the field evaluation as the species identified as mainly dryland instead of obligate species. Amongst the number of species that were identified, there are alien invasive plants prominent throughout HGM units 1, 2 and 3. However in HGM unit 2 a dense thicket of alien invasive species can be seen in Plate 4.5 which contributes mostly to the high impact ecological score of 9.04 (F category) which indicates the vegetation is totally or almost totally altered and if any indigenous species remain they are of a low extent.

Plate 3.4: Dense alien vegetation occurring in HGM unit 2

Table 3.10: A summary of the magnitude of impact on ecological health for each HGM unit based on the extent and the intensity of impact scores

	Disturbance	Extent %	Intensity	Magnitude
HGM Unit 1:	Deposition/ infilling or excavation	5	2	0.1
	Dense Alien vegetation	20	3	0.6
	Infrastructure (Railway line)	30	5	1.5
Combined Impact Score				**2.2**
HGM Unit 2:	Deposition/ infilling or excavation	60	6	3.6
	Sports Field	40	5	2
	Dense Alien vegetation	90	9	8.1
Combined Impact Score				**13.7**
HGM Unit 3:	Dense Alien vegetation	10	3	0.3
	Infrastructure (Road)	30	5	1.5
Combined Impact Score				**1.8**

Calculation of overall magnitude of impact for the wetland:
HGM Unit 1 comprises approximately 25%, HGM Unit 2 comprises 60% and HGM Unit 3 comprises 15%.

From table 3.11 the impact scores were as follows; HGM Unit 1= 2.2, Unit 2= 13.7 and HGM Unit 3= 1.8

Table 3.11: A summary of the impact scores for each HGM unit based on the disturbance classes

HGM Unit	Impact Scores
HGM Unit 1	2.2
HGM Unit 2	13.7
HGM Unit 3	1.8

Thus: (2.2×25/100) + (13.7×60/100) + (1.8×15/100) = **9.04**

.Vegetation composition has been totally or almost totally altered, and if any characteristic species still remain, their extent is very low.	8-10	F

The overall health assessment of the Qokololo wetland incorporates all three modules namely; hydrology, geomorphology and ecology. The scores that have been calculated for each module are represented in table 3.12 and illustrate the current state of health of the wetland. The hydrology of the wetland scored moderately at 5.9 compared to the geomorphology and ecology modules. Even though the hydrology is largely altered it is not in a critical state. The geomorphology of the wetland is in the best state of health, scoring the lowest of all three modules at 0.43. The ecology module scored the highest, at 9.04 indicating that the wetland vegetation health is in a critical state whereby vegetation is totally or almost totally transformed and if any indigenous vegetation characteristic remains it is of a low extent. These modules combined indicate that the wetland is in poor health as two of the three modules show high impact scores. Therefore it can be said that the wetland's functionality is low due to the impacts of urbanisation and disturbance that it causes within this ecosystem.

Table 3.12: A summary of the overall impact scores for each HGM Unit with respect to each module

Modules	**HGM Unit 1**	**HGM Unit 2**	**HGM Unit 3**	**Overall Impact Score**
Hydrology	5.005	6	6.95	**5.9**
Geomorphology	0.035	0.675	0.125	**0.43**
Ecology	2.2	13.7	1.8	**9.04**

3.5.2 WET-EcoServices tool

WET-EcoServices is a tool used to assess the goods and services that wetlands provide and is developed for a particular class of wetlands known as palustrine wetlands of which the following are considered: marshes, floodplains, vleis or seeps (Kotze et al., 2008). The first step in the process is to categorise the wetlands according to their hydro-geomorphic type. The Level 1 assessment, conducted at desktop level is based on existing knowledge (Table 3.13) and assesses indirect benefits namely: flood attenuation, streamflow regulation, erosion control, sediment trapping, phosphate, nitrate and toxicant assimilation and carbon storage. Direct benefits such as: biodiversity maintenance, provision of water for human use, provision of harvestable resources, provision of cultivated foods, cultural heritage, tourism and recreation and education and research are verified by limited fieldwork. The Level 2 assessment ensures that direct and indirect benefits (Table 3.14) are determined by in-depth field verification with aspects of a wetland's catchment, HGM unit, landscape, threats and opportunities scored ranging from one to four, based on the existence and extent to which the wetland provided the goods and services. Confidence scores are allocated to each of the aspects outlined in the Level 2 assessment (Appendix 3). These confidence scores range from one to four and serve as an indication of the level of accuracy associated with the assessments to researchers and users of the information. The assessor derives this score based on the amount of confidence the assessor has in allocating a particular score to a feature. For example, if peat is present in a wetland then it would be providing carbon storage benefits. If it is providing carbon storage at a high level, then the effectiveness score would be a four and the confidence would be based on how certain the assessor is of the wetland providing this benefit or of it being present. If the assessor is very certain then a four may be scored for confidence.

Table 3.13: Ecosystems services included in and assessed using WET-EcoServices (Table adapted from Kotze et al., 2008)

Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits	Flood attenuation		The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream
			Streamflow regulation		Sustaining streamflow during low flow periods
			Water quality enhancement benefits	Sediment trapping	The trapping and retention in the wetland of sediment carried by runoff waters
				Phosphate assimilation	Removal by the wetland of phosphates carried by runoff waters
				Nitrate assimilation	Removal by the wetland of nitrates carried by runoff waters
				Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters
				Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation.
			Carbon storage		The trapping of carbon by the wetland, principally as soil organic matter
	Direct benefits	**Biodiversity maintenance[2]**			Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity
		Provisioning benefits	Provision of water for human use		The provision of water extracted directly from the wetland for domestic, agriculture or other purposes
			Provision of harvestable resources		The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
			Provision of cultivated foods		The provision of areas in the wetland favourable for the cultivation of foods
		Cultural benefits	Cultural heritage		Places of special cultural significance in the wetland, e.g. for baptisms or gathering of culturally significant plants
			Tourism and recreation		Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife
			Education and research		Sites of value in the wetland for education or research

Table 3.14: Rating of hydrological benefits provided by a wetland based on HGM type (Table adapted from Kotze et al., 2008)

WETLAND HYDRO-GEO-MORPHIC TYPE	REGULATORY BENEFITS POTENTIALLY PROVIDED BY WETLAND							
	Flood attenuation		Stream flow regulation	Enhancement of water quality				
	Early wet season	Late wet season		Erosion control	Sediment trapping	Phos-phates	Nitrates	Toxicants[2]
1. Floodplain	++	+	0	++	++	++	+	+
2. Valley-bottom - channelled	+	0	0	++	+	+	+	+
3. Valley-bottom - unchannelled	+	+	+?	++	++	+	+	++
4. Hillslope seepage connected to a stream channel	+	0	+	++	0	0	++	++
5. Isolated hillslope seepage	+	0	0	++	0	0	++	+
6. Pan/ Depression	+	+	0	0	0	0	+	+

Notes: [1] The rationale for the rating of benefits is given in Section 3.6
[2] Toxicants are taken to include heavy metals and biocides.

Rating: 0 Benefit unlikely to be provided to any significant extent
\+ Benefit likely to be present at least to some degree
++ Benefit very likely to be present (and often supplied to a high level)

3.6 Limitations experienced by the researcher when undertaking this study

WET-Health requires a pre-existing knowledge for utilisation and implementation of the tool to assess the health of wetlands. Having worked on the KwaZulu-Natal State of the Wetland Report in 2011 with a number of environmental consultants, the necessary skills and experience for conducting the assessments had been obtained. However, the WET-EcoServices tool had not been used by the researcher prior to this research. This made the confident use of this tool difficult as first-time users may easily be confused with technical requirements. To make the learning process of this tool easier, assistance and support from my mentors were available. Another challenge, however, to using these tools would be that currently eThekwini municipality does not use quaternary catchments (subdivided tertiary catchments) which is the scale required for a WET-Health assessment. Due to this challenge it may be difficult to adapt this approach to the other catchments which eThekwini manages. This facilitated the work with eThekwini municipality and also assisted the training workshop on wetland assessment tools to Msunduzi municipality. Pilot studies such as hosting a workshop with Msunduzi municipality were undertaken so the researcher could gain experience and confidence with the tools.

Chapter Four
Results and Discussion: WET-Health Assessments

4.1 Introduction

The three wetlands, consisting of a combined total of eight HGM units were scored using Level 1 and two WET-Health assessments. In the process of obtaining the health scores, the WET-Health Level 1 and two data spreadsheets, provided by the authors of the WET-Health tool (Macfarlane et al., 2008) were completed (Appendix 2). The WET-Health assessments were utilised in conjunction with WET-EcoServices which were evaluated and recorded in a separate results and discussion chapter providing scores of the goods and services of wetlands at a Level 1 and two basis. The separation of the results and discussion into two chapters were for analysis and integration of the levels of the tools and for comparisons between the two levels to be made clearer. The same applies to the WET-EcoServices Level 1 and two assessments. A summary of results for the three wetlands at a Level 1 WET-Health (Table 4.1) and Level 2 basis (Table 4.2) indicate the different aspects of a Level 1 and two assessment. These tables assist in determining what information is required for each assessment and at what level of detail the information obtained is necessary.

Table 4.1: Summary of results for Level 1 WET-Health for all three wetlands where; P = Permanent; S = Seasonal; T = Temporary; m/d per ha = metres of drain per hectare; N/ A = not assessed

	WET-Health Level 1							
	Robert Armstrong	**Le Mercy**		**Lake Victoria Barn Swallow roosting site**				
	Unit 1	**Unit 1**	**Unit 2**	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**
Trees or shrubs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Distribution of alien woody plants	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hardened surfaces	Yes	No	Yes		No	No	No	No
Seasonality	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Texture of mineral soil	Clay Loam	Clay Loam	Clay Loam	Loam	Clay Loam	Loam	Loam	Clay Loam
Natural level of wetness	P & S	S	S & P	P & S < 30 %	P & S> 60 %	P & S < 30 %	T	S
Change in surface roughness	Increase	Increase	Increase	Increase	No change	Increase	Increase	Increase
Dams	One	No	No	No	No	No	No	No
Flooding by dams	N/A	Yes	No	No	No	No	No	No
Irrigation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water conservation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deposition	No	No	No	Yes	No	No	No	No
Infilling	Yes	No	Yes	No	No	No	No	No
Excavation	No	No	No	No	No	No	No	No
Infrastructure	Yes	No	Yes	No	No	No	No	No
Erosion	No	No	No	Yes	No	No	No	No
Drain	Yes	No	No	Yes	No	No	No	No
Drain depth	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Drain density	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Drain location	Poor	No	No	Effective	No	No	No	No
Drain obstruction	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Organic matter	No	No	No	No	No	No	No	No
Channel straightening	Yes	No	No	No	No	No	No	No
Tillage	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Disturbance units	Sugarcane, Alien	Annual pastures, Alien	Natural, Alien	Alien abandoned cropland,Untransformed	Alien	Alien, cropland, Untransformed	Alien	Alien

Table 4.2: Summary of results for Level 2 WET-Health for all three wetlands where; P = Permanent; S = Seasonal; T = Temporary; m/d per ha = metres of drain per hectare; N/ A = not assessed

	WET-Health Level 2							
	Robert Armstrong	**Le Mercy**		**Lake Victoria Barn Swallow roosting site**				
	Unit 1	**Unit 1**	**Unit 2**	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**
Trees or shrubs	Trees and Shrubs	Trees and Shrubs	Trees and Shrubs	Trees	Trees	Trees	Trees	Trees
Distribution of alien woody plants	Riparian & Non Riparian	Riparian & Non Riparian	Non Riparian	Riparian & Non Riparian	Riparian & Non Riparian	Riparian & Non Riparian	Riparian & Non Riparian	Riparian & Non Riparian
Hardened surfaces	5-20 %	< 5 %	5-20 %	5-20 %	5-20 %	5-20 %	5-20 %	5-20 %
Seasonality	No change	No change	No change	No change	No change	No change	No change	No change
Texture of mineral soil	Clay Loam	Clay Loam	Clay Loam	Loam	Clay Loam	Loam	Loam	Clay Loam
Natural level of wetness	P & S < 30 %	S	S & P 30-60 %	P & S < 30 %	P & S> 60 %	P & S < 30 %	T	S
Change in surface roughness	Increase	Increase	Increase	Increase	No change	Increase	Increase	Increase
Dams	One	No	No	No	No	No	No	No
Flooding by dams	5 % downstream	No	No	No	No	No	No	No
Irrigation	No	Ad-hoc	No	Seasonal	No	Seasonal	No	No
Water conservation	No	Low	No	Intermediate	No	Intermediate	No	No
Deposition	No	Yes 0.2-1.9 %	No	No	Yes 0.2-1.9 %	No	No	No
Infilling	10 %	No	20%	No	No	No	No	No
Excavation	No	No	No	No	No	No	No	No
Infrastructure	1 %	No	1 %	No	No	No	No	No
Erosion	No	No	No	No	No	No	No	No
Drain	Yes (One)	No	No	Yes (One)	No	No	No	No
Drain depth	0.2-0.5m	N/A	N/A	0.2-0.5m	N/A	N/A	N/A	N/A
Drain density	< 25 % m/d per ha	N/A	N/A	< 25 % m/d per ha	N/A	N/A	N/A	N/A
Drain location	Poor	N/A	N/A	Moderate	N/A	N/A	N/A	N/A
Drain obstruction	None	N/A	N/A	No	N/A	N/A	N/A	N/A
Organic matter	No	No	No	No	No	No	No	No
Channel straightening	Yes, 10 %	No	No	No	No	No	No	No

Tillage	1-2 Years	No	No	No	No	No	No	No
Disturbance units	Sugarcane, Alien	Annual pastures, Aliens	Alien	Alien, Abandoned cropland, Untransformed	Alien, Untransformed	Alien, Cropland, Untransformed	Alien, Cropland (sugarcane)	Alien

4.2 WET-Health assessments

4.2.1 WET-Health Level 1

4.2.1.1 Robert Armstrong wetland

4.2.1.1.1 HGM 1

Wetland one (Figure 3.3) comprises of a single HGM unit namely: channeled valley bottom. The wetland has a single dam and is affected by channel straightening, croplands (sugarcane), dense patches of alien vegetation, a drain, infilling and excavation and minimal infrastructure which may be contributing to the overall poor WET-Health scores (Table 4.3 – Table 4.17). The wetland is not affected by gully erosion and the surrounding catchment has little variation in land-use activities and is dominated by sugarcane.

4.2.1.1.1.1 Hydrology

The hydrology module for this wetland scored a D indicating a large modification in terms of its present ecological state (PES) category. A significant contributor to the modification to the natural movement of water through the wetland system is the channel straightening which has altered the natural flow pattern. This is an anthropogenic modification which allowed for infilling into the wetland. Dense alien vegetation concentrated within the channel increased the WET-Health hydrology score as it contributes to a greater level of on-site water use being abstracted from the wetland. The sugarcane did not score very highly as it is not as great a water consumer as pine and eucalyptus trees. The poor location of the drain, determined by fieldwork, indicates it is not effective as it does not allow for maximum interception of flow. The trajectory of change for the overall hydrology is predicted to remain stable apart from a possible threat of re-spread of alien vegetation consuming water from the wetland.

4.2.1.1.1.2 Geomorphology

The geomorphology assessment indicates that this wetland is in a B PES category. This is due to no on-site erosional and depositional features, loss of organic matter such as peat, any upstream dams or increased runoff. Although this HGM unit is a 'channeled valley bottom' there is no stream diversion/shortening occurring. However, there is channel straightening and infilling occurring (20%) which is determined by estimating the portion of the unit being impacted on by these features expressed as a percentage when compared to the entire unit. The lack of impeding features possibly accounts for the good WET-Health score. The trajectory of change score value remains stable and there are no foreseeable threats to the geomorphology.

4.2.1.1.1.3 Vegetation

The vegetation module of the WET-Health assessment indicates the PES to be an E category with the trajectory of change indicating a slight deterioration in vegetation health. The largest contributors to poor vegetation health, in progression from most to least, are: sugarcane (covering 65%), the dense alien vegetation (20%) and infilling which caused a disturbance which would allow for a greater invasion of alien vegetation into the wetland.

Table 4.3: WET-Health Level 1: Robert Armstrong wetland scores

	Robert Armstrong wetland
	HGM 1
Hydrology	D
Hydrology change score	
Geomorphology	B
Geomorphology change score	
Vegetation	E
Vegetation change score	

4.2.1.2 Le Mercy wetland

The Le Mercy wetland (Figure 3.4) is situated within a residential area and comprises of two HGM units namely: unit one – hillslope seep linked to channel and unit two – unchannelled valley bottom. The surrounding catchment demonstrates little variation in land-use activities and is dominated by residential housing establishments. The wetland is situated behind private property and is inaccessible, which would make managing the wetland difficult if co-operation is not obtained from home owners.

4.2.1.2.1 HGM 1

4.2.1.2.1.1 Hydrology

A possible reason for the poor health scores from unit one in the hydrology (E PES category) module can be attributed to pastures covering 20% of the wetland area and 75% of alien vegetation within the remaining wetland area contributing to this unit's on-site water use increase. The trajectory of change score for the hydrology remains stable. The only possible threat to this unit is a further spread of alien vegetation.

4.2.1.2.1.2 Geomorphology

Unit one experiences no impacts from drains, gullies, channel straightening, erosional and deposition features, infilling, excavation and infrastructure. The lack of these features ensures that the geomorphology assessment scores very well in terms of health as reflected by an A PES category. The trajectory of change score (based on foreseeable change which could occur in the area within the next five years for the geomorphology module) remains stable, since this area is remote and there are no specific pending developments for this area.

4.2.1.2.1.3 Vegetation

The vegetation is in an E PES category due to 95% of the wetland being occupied and transformed by pastures covering 20% of the wetland area and alien vegetation 75%. The trajectory of change is predicted to slightly deteriorate over the next five years.

4.2.1.2.2 HGM 2

4.2.1.2.2.1 Hydrology

This unchannelled valley bottom is in a B PES category. The lack of on site water use features such as drains has allowed for the water to remain within the wetland. Although there are alien vegetation present, there are some indigenous plants occupying the unit.

4.2.1.2.2.2 Geomorphology

Unit two is affected by infilling (20%) and infrastructure (sewer pump station located within the wetland covering one percent). The geomorphology assessment module is represented by an A PES category as there are no drains, gullies, channel straightening, erosional and deposition features, excavation, loss of organic matter or dams creating an opportunity for change, therefore indicating a stable trajectory of change.

4.2.1.2.2.3 Vegetation

The alien vegetation on site amounts to 20% and is reflected in the WET-Health scores, even though there is indigenous wetland vegetation present. Vegetation health (C PES category) with the trajectory of change deteriorating slightly is due to the likelihood of further encroachment of alien vegetation into the area. Possible threats to unit two are the spread of alien vegetation as a result of disturbance, sewage and infilling which would cause loss of the wetland.

The overall hydrology, geomorphology and vegetation modules health scores as a result of the average taken between the two HGM units' individual health and trajectory of change scores were hydrology in a C PES category deteriorating slightly, geomorphology in an A PES category remaining stable and vegetation in a D PES category deteriorating slightly (Table 4.4).

Table 4.4: WET-Health Level 1: Le Mercy wetland scores

	Le Mercy wetland	
	HGM 1	**HGM 2**
Hydrology	**E**	**B**
Hydrology change score		
Overall	**C**	
Geomorphology	**A**	**A**
Geomorphology change score		
Overall	**A**	
Vegetation	**E**	**C**
Vegetation change score		
Overall	**D**	

4.2.1.3 Lake Victoria Barn Swallow roosting site wetland

The Lake Victoria Barn Swallow roosting site wetland (Figure 3.5) is situated in the residential area of Verulum, comprising of agricultural cropland (sugarcane). King Shaka International Airport is situated near the Mount Moreland and Lake Victoria Barn Swallow roosting sites which is situated near the study area. The wetland is comprised of five HGM units namely: unit one 'channeled valley bottom', unit two – 'unchannelled valley bottom', unit three – 'hillslope seep linked to channel', unit four – 'isolated hillslope seep' (one of two) and unit five – being the second of the two 'isolated hillslope seeps'. The surrounding catchment demonstrates variation in land use activities such as residential establishments, an airport, cropland, sewage treatment works and untransformed areas.

4.2.1.3.1 HGM 1

4.2.1.3.1.1 Hydrology

The 'channeled valley bottom' has none of the following noticeable features: gullies, channel straightening, infilling, excavation, infrastructure and dams; however, alien vegetation has increased on-site water use and there are artificial drainage channels (16%) that have been recently abandoned and are effective in intercepting, capturing and transporting water out of the wetland. This supports the result for the hydrology score of an E PES category. The predicated trajectory of change score shows that the hydrological condition of the wetland will remain stable due to indigenous vegetation re-establishing in the drains (Table 4.5).

4.2.1.3.1.2 Geomorphology

In terms of geomorphological health, there are erosional and deposition features which together account for 50% of the unit. Although the extent of these combined erosional and depositional features amounts to half the unit, the intensity is not high thus ensuring the magnitude of impact is low which is represented by the A PES category score – unmodified, natural thus its trajectory of change score is stable.

4.2.1.3.1.3 Vegetation

The vegetation module suggests that the main disturbance units contributing towards a D PES category are dense alien vegetation and recently abandoned cropland, thus the vegetation is largely modified.

4.2.1.3.2 HGM 2

4.2.1.3.2.1 Hydrology

This unit is an 'unchannelled valley bottom'. The Lake Victoria Barn Swallow roosting site is predominantly natural and intact with no features altering hydrological flow patterns. However, alien vegetation covering 30% of the unit does increase on-site water use and although not currently an issue, there is a drain that poses a threat to the entire system if it becomes functional in the future. Hydrology is an A PES category attributing to the change in flood peaks which are affected by increased flows (water inputs) rather than a reduction in flows.

4.2.1.3.2.2 Geomorphology

Geomorphological health is in an A PES category as there are no features or characteristics which impact on this unit thus contributing to the stable trajectory of change score.

4.2.1.3.2.3 Vegetation

Vegetation health is a C PES category although the natural habitat remains predominantly intact as 30% is affected by alien vegetation with 70% being untransformed.

4.2.1.3.3 HGM 3

4.2.1.3.3.1 Hydrology

The hillslope seep linked to channel (HGM 3) is situated on the upper reaches of the wetland joining the 'channeled valley bottom' system (HGM 1). There is reduced roughness associated with this unit and a change in flood peaks (increased water inputs) and increased on-site water use from alien vegetation (10%). These factors have contributed to the E PES category reflected in the WET-Health scores which indicates that the change on ecosystems processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable. The trajectory of change remains stable as there is little that can alter the hydrology.

4.2.1.3.3.2 Geomorphology

The geomorphology module is in an A PES category as no modifications or changes have been made to the geomorphology of this unit. The trajectory of change is stable as there are no foreseeable threats to this unit.

4.2.1.3.3.3 Vegetation

The vegetation is in an A PES category even though it is covered by alien vegetation (30%) which is the same as HGM 2 having a C PES category. This is due to unit three having a lower intensity score than unit two which reduces the magnitude of impact. Thus, 70% of HGM 3 is natural with some indigenous vegetation occupying the area.

4.2.1.3.4 HGM 4

4.2.1.3.4.1 Hydrology

HGM 4 is one of the two isolated hillslope seeps found within this wetland. A change in flood peaks (increased water inputs) contributes to the higher WET-Health hydrology score.

A large proportion of this unit is affected by increased on-site water use as 80% of this unit is under alien vegetation. Thus the hydrology in a F PES category (modifications have reached a critical level and the ecosystem processes have been modified completely with and almost complete loss of natural habitat and biota). The trajectory of change is stable as hydrology cannot be further modified than what it is at present.

4.2.1.3.4.2 Geomorphology

The geomorphology module is represented by an A PES category as there are no identifiable sources of change, therefore the geomorphology module remains stable.

4.2.1.3.4.3 Vegetation

Vegetation is represented by an E PES category to which change can be attributed to the alien vegetation presence in the unit and the recent abandoned lands which together leave very little to no natural or untransformed areas. The trajectory of change is stable and the only threat to hydrology, geomorphology and vegetation in this unit is possibly increasing alien plant abundance and density.

4.2.1.3.5 HGM 5

4.2.1.3.5.1 Hydrology

The last unit of this wetland, unit five, is the second of the two isolated hillslope seeps. This unit's hydrology is affected by an increasing on-site water use as the entire unit is covered by alien vegetation. The hydrology is characteristic of being in a F PES category. The trajectory of change is stable as there is little room for further transformation.

4.2.1.3.5.2 Geomorphology

There are no geomorphological features contributing to change within this unit indicative of an A PES category.

4.2.1.3.5.3 Vegetation

The vegetation score is affected by alien vegetation. Since this was the only disturbance unit and it covered to a large extent (100%) also having scored high for intensity, the magnitude of impact was high. This resulted in the F PES category. The trajectory of change is a stable condition.

This unit, similar to HGM 4, the first isolated hillslope seep, has no other threats other than the possible increase in alien plant abundance and density. The overall scores for the hydrology, geomorphology and vegetation respectively are in a D, A and C PES category with the trajectory of change respectively being stable, stable and deteriorating slightly.

Table 4.5 : WET-Health Level 1 : Lake Victoria Barn Swallow roosting site wetland scores

	Lake Victoria Barn Swallow roosting site wetland				
	HGM 1	HGM 2	HGM 3	HGM 4	HGM 5
Hydrology	E	A	E	F	F
Hydrology change score					
Overall	C				
Geomorphology	A	A	A	A	A
Geomorphology change score					
Overall	A				
Vegetation	D	C	A	E	F
Vegetation change score					
Overall	C				

4.2.2 WET-Health Level 2

4.2.2.1 Robert Armstrong wetland

4.2.2.1.1 HGM 1

This wetland, being comprised of a single HGM unit (channeled valley bottom) is 5.4 hectares in size and has a slope of 2.4% (Table 4.7), and is impacted upon by sugarcane, dense alien vegetation, a dam, a drain, channel straightening and infilling.

4.2.2.1.1.1 Hydrology

Factors potentially contributing to a decrease of flood peaks are the collective volume of dams in the wetland's catchment in relation to mean annual runoff and the level of abstraction from the dam. The dam, situated in the upper reaches of the wetland, makes allowances for releasing low flows. The magnitude of impact from the dam relative to the affected area's catchment allows for an interception of 21 – 40% of water in the catchment and an extent of five percent (0.5 hectares) of the HGM unit is affected by flooding downstream of the impeding structure (Appendix 2).

When assessing the level of modifications made to the stream channel, canalisation and channel straightening should be considered (Macfarlane et al., 2008). The size of the area affected by canalisation is 0.12 hectares (2%) and channel straightening (0.54 hectares, ten percent). The characteristics of the stream channel incorporates reduction in length of stream per unit valley length, percentage increase in cross sectional area of the stream and change in surface roughness in relation to the surface roughness of the channel in its natural state. The length of the stream channel has been reduced by 25 – 50% whilst the percentage of cross sectional area of the stream is low and has increased by less than five percent. Altered surface roughness affects the majority (75%) of the unit. The current state of surface roughness is moderately high, dense vegetation (e.g. dense stand of reeds) which offers a high resistance to water flow as opposed to the historical state – moderate with vegetation offering slight resistance to water flow (Appendix 2). The change in surface roughness of the wetland from its natural state to its current state has increased.

In terms of deposition, infilling and excavation, there are no depositional features influencing the unit, or any signs of excavation. Infilling, which accounts for ten percent (0.54 hectares) of the modifications occurring within the unit, can be attributed to the channel modifications including channel straightening which has altered the natural path of stream flow. There is a covered path where the historic channel used to flow. The effect of infilling on vertical drainage properties allows for effective drainage and the effect on the horizontal movement of water is moderately modified. The impact of the modifications is detrimental to the hydrological integrity which places it in a D PES category: approximately 50 % of the hydrological integrity has been lost. The trajectory of change states the hydrological condition will deteriorate slightly in the next five years as a particular threat to the hydrology is the presence of alien vegetation which may become increasingly established in the stream channel.

4.2.2.1.1.2 Geomorphology

There are no impacts of erosion and/or deposition and no features on site contributing to erosion and/or depositional features in this wetland/HGM unit. The impact of loss of organic sediment is associated with the depth of peat fires or extraction of peat relative to the depth of the peat deposit – of which this HGM unit has none – and determining if tillage is practised and if so, then the duration of tillage. Tillage is practised every one to two years in this unit. The geomorphology assessment indicates that this wetland system is in a B PES category and the trajectory of change indicates the geomorphological condition should remain stable for the next five years (Table 4.8).

4.2.2.1.1.3 Vegetation

There are three disturbance classes namely: dense alien vegetation, cropland (sugarcane) and untransformed areas. The disturbance classes cover 1.2 hectares (22%), four hectares (74%) and 0.2 hectares (4%) respectively. The vegetation module does not differ greatly between Level 1 and 2 assessments except the Level 2 requires that alien plant species found in each HGM unit be identified (table 4.6).

Table 4.6: Alien vegetation found in the Robert Armstrong wetland

Ageratum conyzoides	*Melia azedarach*
Arundo donax	*Ricinus communis*
Bambuseae vulgaris	*Schinus terebinthifolius*
Canna indica	*Solanum mauritianum*
Lantana camara	*Tagese minuta*
Mangifera indica	

The vegetation module is in a F PES category. A possible reason for this low WET-Health score is that since most vegetation in this HGM unit is transformed (alien species and cropland) covering a combined total of 5.2 of 5.4 hectares. The trajectory of change is stable over the next five years as it could not possible deteriorate much further. There is little natural vegetation, therefore the threat of invasion given the current management practices is considered to be low. The Level 1 assessment indicates the vegetation to be in an E PES category (7.8) whilst the Level 2 assessment shows a F PES category (8.4). This difference can be attributed to limited field verification which is associated with a desktop Level 1 assessment.

Table 4.7: Characteristics of the Robert Armstrong wetland

	HGM 1
HGM type	Channelled valley bottom
Wetland area (ha)	5.4
MAP (mm)	1086
PET (mm)	1400
MAP:PET ratio	0.8
MAR (mm)	271
Approximate slope (percent)	2.4
Vulnerability	0.9

Table 4.8: WET-Health Level 2: Robert Armstrong wetland scores

	Robert Armstrong wetland
	HGM 1
Hydrology	**D**
Hydrology change score	
Overall	**D**
Geomorphology	**B**
Geomorphology change score	
Overall	**B**
Vegetation	**F**
Vegetation change score	
Overall	**F**

4.2.2.2 Le Mercy wetland

This wetland comprises two HGM units – 'hillslope seep linked to channel' and 'unchannelled valley bottom' (6.7 and 6.0 hectares respectively) – and has a slope of 1.7 and 1.2% respectively (Table 4.10). This wetland system is impacted by sugarcane and dense alien vegetation.

4.2.2.2.1 HGM 1

4.2.2.2.1.1 Hydrology

In terms of impacts of dams, drains, deposition, infilling and excavation there are no features influencing this unit, nor are there any signs of such occurring on site. The impact of the modifications is detrimental to the hydrological integrity which places it in an E PES category. Fifty-one percent to 79% of the hydrological integrity has been lost. The trajectory of change states that the hydrological condition will deteriorate slightly in the next five years, with particular threats being an increase in extent of annual pastures with crops requiring more water being planted and alien vegetation.

4.2.2.2.1.2 Geomorphology

There are no impacts of erosion occurring in this wetland/HGM unit as there are no features on site contributing to erosion, however, there are depositional features (0.2 – 1.9%). There are few dirt roads in the catchment and this may contribute to the small sediment load being deposited into the unit which contributes to the A PES category.

4.2.2.2.1.3 Vegetation

There are three disturbance classes namely: dense alien vegetation, annual pastures and untransformed areas. The disturbance classes cover 4.33 hectares (65%), 1.33 hectares (20%) and one hectare (15%) respectively. The vegetation module is in an E PES category because of the many dense areas of alien vegetation found in the unit (table 4.9). A possible reason for this poor WET-Health score is presence of alien species and annual pastures, with only one hectare of the unit untransformed. Factors contributing to the increased abundance of alien plants are: the lack of fire, bad management and disturbance caused by annual pastures. The trajectory of change indicates that the vegetation condition will deteriorate slightly over the next five years as there could be a further encroachment of alien species. Both the Level 1 and two assessments indicate the vegetation to be in an E PES category.

Table 4.9: Alien vegetation in the Le Mercy wetland unit 1

Ageratum conzoides	*Melia azedarach*
Arundo donax	*Ricinus communis*
Bidens pilosa	*Schinus terebinthifolius*
Canna indica	*Senna didymobotrya*
Cardiospermum grandiflorum	*Solanum mauritianum*
Chromolaena odorata	*Tagese minuta*
Ipomoea indica	*Tecoma stans*
Lantana camara	

4.2.2.2.2 HGM 2

4.2.2.2.2.1 Hydrology

The second HGM unit – 'unchannelled valley bottom' – is 6.0 hectares and has a slope of 1.2% (Table 4. 11). This unit is impacted by dense alien vegetation and there are no croplands of sugarcane present. The sum of the magnitude of impact has contributed towards decreasing the flow of water inputs to the HGM unit whilst the magnitude of impact associated with the increase in water input is small.

Comparing the surface roughness of this HGM unit (1.79 hectares – 30%) in its current state, with the historical state being moderately high, indicates the change in surface roughness in relation to the surface roughness of the wetland in its natural state, has increased.

There are no impacts of dams and drains, erosion and/or deposition, however there is infilling, associated with a sewer pump station and the surrounding area of land has been infilled with concrete and rubble which may alter the natural path of flow and thus the hydrology. Infilling accounts for 20% (1.2 hectares) of the modifications occurring within the unit making the reduction in active wetland width at the point of infilling 26 – 50%. The impact of modification on hydrological integrity is identifiable, but limited, as represented by a C PES category. The trajectory of change states the hydrological condition will deteriorate slightly in the next five years (Table 4.12) due to an increase in extent of infilling and alien vegetation.

The Level 1 assessment suggests the unit is in a B PES category which varies from a C PES category as reflected in the Level 2 assessment. This may be due to the underscoring of the infilling component in the Level 1 assessment which could have lowered the magnitude of the impact score. The overall hydrology, geomorphology and vegetation are in the D, A and C PES categories respectively. The trajectory of change score indicates a slight deterioration in the condition of the wetland system.

4.2.2.2.2.2 Geomorphology

The Level 2 geomorphology assessment indicates that this HGM unit is in an A PES category although the trajectory of change indicates that the geomorphological condition of the wetland will deteriorate slightly over the next five years as more infilling, as noted from fieldwork, seems to be the main potential threat.

4.2.2.2.2.3 Vegetation

There are two disturbance classes namely: dense alien vegetation according to Table 4.10 of the extent 20% and untransformed areas (80%). The vegetation module is in an A PES category and the good WET-Health score can be associated with 4.80 of 6.0 hectares being untransformed. The Level 1 assessment indicates the vegetation to be in a C PES category as opposed to the Level 2 assessment which indicates the vegetation is in an A PES category. The inconsistency could be due to the abundance of the alien vegetation being over-scored, thus increasing the magnitude of impact score. Alien plants that were found are .

Table 4.10: Alien Vegetation in the Le Mercy wetland unit 2

Arundo donax	*Schinus terebinthifolius*
Bidens pilosa	*Solanum mauritianum*

Table 4.11: Characteristics of the Le Mercy wetland and each HGM unit

	HGM 1	**HGM 2**
HGM type	Hillslope seep linked to channel	Unchannelled valley bottom
Wetland area (ha)	6.7	6.0
MAP (mm)	1086	1086
PET (mm)	1400	1400
MAP:PET ratio	0.78	0.8
MAR (mm)	271	271
Approximate slope (percent)	1.7	1.2
Vulnerability	0.9	0.9

Table 4.12: WET-Health Level 2: Le Mercy wetland scores

	Le Mercy wetland	
	HGM 1	HGM 2
Hydrology	E	C
Hydrology change score		
Overall	D	
Geomorphology	A	A
Geomorphology change score		
Overall	A	
Vegetation	E	A
Vegetation change score		
Overall	C	

4.2.2.3 Lake Victoria Barn Swallow roosting site wetland

This wetland is comprised of five HGM units namely: 'channeled valley bottom', 'unchannelled valley bottom', 'hillslope seep linked to channel', and two 'isolated hillslope seeps' which are 11, 6.4, 0.3, 0.6 and 0.6 hectares in size respectively and which have a slope of 3.12, 0.34, 8.69, 4.74 and 4.40 percent respectively (Table 4.15).

4.2.2.3.1 HGM 1

4.2.2.3.1.1 Hydrology

HGM 1 is impacted by sugarcane, alien vegetation and a drain. The drain has a depth of between 0.2 – 0.5 metres. The drain flows into and through the wetland and is located such that flows are moderately well intercepted and the drain poses no obstruction to the flow of water. The extent to which roads interrupt low flows to downstream areas is slight (e.g. a moderate number of culverts through a road embankment).

There are no depositional features, infilling, excavation or channel straightening occurring in this unit. The impact of the modifications is detrimental to the hydrological integrity which places it in a C PES category (Table 4.16). The Level 1 assessment indicates the hydrology to be in an E PES category and this could be due to the over-scoring of the impact of the drain and the impact of the recently abandoned lands on the unit, as opposed to the Level 2 assessment which assesses a greater level of detail pertaining to these features and their impacts. A particular threat to the hydrology is alien vegetation.

4.2.2.3.1.2 Geomorpology

There are no impacts of erosion occurring in this HGM unit, however, depositional features (the presence, size and distribution of gullies or active erosion of drains) within the catchment or wetland were assessed and determined to be of moderate size and distribution.

The geomorphology assessment indicates that this HGM unit is in a B PES category. The Level 1 assessment indicates that the geomorphological condition is in an A PES category which varies from the Level 2 B PES category. A possible reason for the variation in scores is the lower intensity allocated to features in a Level 1 assessment which may place the magnitude of impact score lower. A further reason is that the Level 2 assessment investigated depositional features and their impact at a greater level of detail compared to a Level 1.

4.2.2.3.1.3 Vegetation

The disturbance classes in this unit are: dense alien vegetation, recently abandoned croplands and untransformed areas. The disturbance classes cover an extent of 4.16 hectares (65%), 1.92 hectares (30%) and 0.32 hectares (5%) respectively. The vegetation module is in an E PES category. The poor WET-Health score can be associated with only a small area of the unit not being affected by vegetation change. The Level 1 assessment indicated the vegetation to be in a D PES category opposed to the Level 2 E PES category. The inconsistency could be due to the intensity or extent of the alien vegetation being scored higher than it should, thus increasing the magnitude of impact score. Contributing to increased abundance of alien vegetation is poor management following the disturbance of land use change (table 4.13).

Table 4.13: Alien vegetation in HGM 1 of the Lake Victoria Barn Swallow roosting site wetland

Lantana camara
Psidium cattleianum
Schinus terebinthifolius

4.2.2.3.2 HGM 2

4.2.2.3.2.1 Hydrology

HGM 2 'unchannelled valley bottom' is 6.4 hectares in size and has a slope of 0.34 % (Table 4.16). This HGM unit is not impacted upon by sugarcane, drains, gullies, dams, channel modification, erosion, infilling and excavation or loss of organic matter, however, it is impacted on by some deposition (0.2 - 1.9%) and dense alien vegetation. This particular site consists of exotic and alien trees which would increase on-site water usage. The distribution of alien woody plants occurs across riparian and non-riparian areas which indicate wetland areas are diminishing.

Modification on hydrological integrity is small as reflected by a B PES category. The Level 1 assessment indicates the hydrology to be in an A PES category and this could be due to the under-scoring of the intensity of alien vegetation in the unit, as opposed to the Level 2 assessment which assesses a greater level of detail pertaining to these features (such as plant type and species).

4.2.2.3.2.2 Geomorphology

The Level 2 geomorphology assessment indicates that this HGM unit is in a B PES category. The Level 1 assessment indicates that the geomorphological condition is in an A PES category which varies from the Level 2 B PES category. A possible reason for the variation in scores across the different assessment levels could be the lower intensity allocated to features in a Level 1 assessment which may keep the magnitude of impact score lower than what it should be.

4.2.2.3.2.1 Vegetation

The disturbance classes in this unit are dense alien vegetation and untransformed areas. The disturbance classes cover an extent of 1.65 hectares (15%) and 9.37 hectares (85%) respectively. The vegetation module is in an A PES category. The high WET-Health score can be attributed to little alien vegetation and a floating reed marsh of *Phragmites australis* (85%). The Level 1 assessment indicates the vegetation to be in a C PES category which varies from the Level 2 assessment of an A PES. The inconsistency could be due to the type of alien vegetation species found in the unit which could be over-scored in terms of water usage in the Level 1 assessment. Disturbance caused by a drain situated at the lower portion of the HGM unit contributes to increased abundance of alien vegetation. Even though this drain exists outside of the HGM unit, it may threaten the entire wetland system if it were deepened as this would cause underground water or base flow to be removed from the wetland. Currently the drain is inactive, ineffective and is re-vegetated.

Table 4.14: Alien vegetation in HGM 2

Canna indica	*Lantana camara*
Cardiospermum gradiflorum	*Schinus terebinthifolius*
Chromolaena odorata	*Solanum mauritianum*

4.2.2.3.3 HGM 3

4.2.2.3.3.1 Hydrology

This HGM 3 is impacted on by sugarcane and dense alien vegetation, which both have an adverse effect on hydrological integrity (table 4. 14). Hydrological integrity has been lost which places it in an E PES category. The Level 1 assessment score concurs with that of the Level 2 E PES category.

4.2.2.3.3.2 Geomorphology

The geomorphology assessment did not require the following components to be assessed: impacts of dams upstream of and/or on floodplains, impacts of channel straightening and artificial wetland infilling. There are no impacts of erosion and/or deposition features or loss of organic sediment occurring in this HGM unit and there are no on-site features contributing to these features. However, changes in runoff characteristics were assessed. This unit has the steepest slope in the wetland (8.69%) and although it may be the most vulnerable to erosion, there is no evidence of such occurring.

Changes in runoff characteristics are assessed by determining the extent of altered water inputs (altered movement of water into a wetland) which is calculated based on length of wetland affected by increased flow as a proportion (percent) of the entire wetland length. Based on the hydrology assessment, changes to flood peaks influence the runoff potential indicating the impact of this modification is small although identifiable.

The geomorphology assessment indicates that this HGM unit is in a B PES whilst the Level 1 assessment indicates that the geomorphological condition is in an A PES. A possible reason for the variation in scores could be due to the under-estimation of the high slope (8.69%) which contributed to the changes in runoff and flood peak characteristics.

4.2.2.3.3.3 Vegetation

The disturbance classes in this unit are: dense alien vegetation (35%), cropland (25%) and untransformed areas (40%). The vegetation module is in a C PES category although the Level 1 assessment indicates the vegetation to be in an A PES category. The inconsistency could be due to the intensity or extent of the alien vegetation being scored higher than it should have in the Level 2 assessment, as the Level 2 suggested that there were more trees than shrubs which may increase on-site water use. There are no suspected factors contributing to increased abundance of alien vegetation as the only alien plant found in this unit is *Schinus terebinthifolius*.

4.2.2.3.4 HGM 4

4.2.2.3.4.1 Hydrology

HGM 4 is impacted on by sugarcane and dense alien vegetation. Approximately 50% of the hydrological integrity has been lost which places it in a D PES category. The Level 1 assessment indicates the hydrology to be in a F PES category. The Level 1 desktop assessment over-scored the intensity of impact of sugarcane occurring in this HGM unit as sugarcane is confined to non-riparian areas, however it is growing poorly due to the lack of irrigation.

4.2.2.3.4.2 Geomorphology

This particular unit is affected by none of the features evaluated in the geomorphology assessment. As a result the unit is in an A unmodified, natural PES category.

4.2.2.3.4.3 Vegetation

The disturbance classes in this unit are: dense alien vegetation 0.46 hectares (80%) and recently abandoned cropland 0.12 hectares (20%). The vegetation module is in a F PES category as the recently abandoned cropland caused a disturbance in land-use change which encouraged the establishment of alien vegetation (table 4.17).

Table 4.15: Alien vegetation in HGM 4

Schinus terebinthifolius
Psidium cattleianum
Schinus terebinthifolius

4.2.2.3.5 HGM 5

4.2.2.3.5.1 Hydrology

HGM 5 is not impacted on by sugarcane, drains, gullies, dams, channel modification, deposition, infilling and excavation, however there is dense alien vegetation occurring in the unit. Hydrological integrity is reflected by an E PES category as opposed to the Level 1 assessment which reflects a F PES category. This could be due to the over-scoring of the intensity of alien vegetation in the Level 1 as opposed to the Level 2 assessment which assesses the alien vegetation at a greater level of detail (such as plant type and species) and which may provide a more accurate account of their scores.

4.2.2.3.5.2 Geomorphology

Although the geomorphology module covers many conditions for assessment of this particular unit, it is affected by none of these factors. As a result the unit is in an A PES category which indicates the unit to be in an unmodified, natural state. The Level 1 and two assessments reflect this.

4.2.2.3.5.3 Vegetation

The only disturbance class in this unit is dense alien vegetation which covers an extent of 0.56 hectares (100%). The vegetation composition has been totally or almost totally altered, and if any characteristic species still remain, their extent is very low which is characteristic of a F PES category. There are no suspected factors contributing to increased abundance of alien vegetation within the unit as the only alien plant found in this unit is *Schinus terebinthifolius*.

Table 4.16: Characteristics of the Lake Victoria Barn Swallow roosting site wetland and each HGM unit

	HGM 1	HGM 2	HGM 3	HGM 4	HGM 5
HGM type	Channelled valley bottom	Unchannelled valley bottom	Hillslope seepage	Isolated hillslope seepage	Isolated hillslope seepage
Wetland area (ha)	6.4	11	0.3	0.6	0.6
MAP (mm)	1086	1086	1086	1086	1086
PET (mm)	1400	1400	1400	1400	1400
MAP:PET ratio	0.78	0.78	0.78	0.78	0.78
MAR (mm)	271	271	271	271	271
Approximate slope (percent)	3.12	0.34	8.69	4.74	4.40
Vulnerability	0.9	0.9	0.9	0.9	0.9

Table 4.17: WET-Health Level 2 : Lake Victoria Barn Swallow roosting site wetland scores

	Lake Victoria Barn Swallow roosting site wetland				
	HGM 1	**HGM 2**	**HGM 3**	**HGM 4**	**HGM 5**
Hydrology	C	B	E	D	E
Hydrology change score					
Overall	C				
Geomorphology	B	A	B	A	A
Geomorphology change score					
Overall	A				
Vegetation	E	A	C	F	F
Vegetation change score					
Overall	C				

The variation in overall WET-Health Level 1 and two scores (Table 4. 18) indicate the differences and similarities between levels of assessment and between wetland modules assessed. The Robert Armstrong (D, B, F) and Lake Victoria Barn Swallow roosting site wetlands (C, A, C) demonstrate similar hydrology, geomorphology and vegetation scores across the two levels of assessment whereas the Le Mercy wetland has only a similar geomorphology score (A). The Le Mercy wetland Level 1 (C, D) and two assessment scores (D, C) for hydrology and vegetation scores respectively differ as the Level 2 assessments were more detailed which may have eliminated over-scoring of extents and intensity scores, but may have in certain cases caused redundancy in scoring of impacts.

The wetland health scores for HGM units two and three of the Lake Victoria Barn Swallow roosting site wetland indicate that although the hydrology is represented by a B and E Present Ecological State (PES) category respectively, both units are functional.

According to Kotze et al., (2008) irrespective of differing wetland size, slope and the presence of vegetation contributing to surface roughness of wetlands, the health of the wetland system may be functional. The unchannelled valley bottom wetland – HGM 2 of the Lake Victoria wetland – is 11 hectares in size, has a gentle slope of 0.34% and majority of the unit (85%) is untransformed with the hydrology, geomorphology and vegetation being a B, A and A PES category respectively. HGM 3 – hillslope seep linked to channel – of the Lake Victoria Barn Swallow roosting site is 0.3 hectares in size, has the highest slope in the wetland with 8.69 % and, although may be the most vulnerable to erosion, there is no evidence of this occurring from the field verification. The Level 2 assessments with the hydrology, geomorphology and vegetation modules are in an E, A and A PES category respectively. These two HGM units regardless of health scores, size and slope are able to provide their necessary functions in the landscape by controlling erosion.

Table 4.18: Overall WET-Health Level 1 and 2 scores

	WET-Health					
	Robert Armstrong wetland		**Le Mercy wetland**		**Lake Victoria Barn Swallow roosting site wetland**	
	Level1	Level2	Level 1	Level 2	Level1	Level2
Hydrology	D	D	C	D	C	C
Geomorphology	B	B	A	A	A	A
Vegetation	F	F	D	C	C	C

Although the WET-Health Level 1 and two assessments indicate the Robert Armstrong, Le Mercy and Lake Victoria barn swallow roosting site wetlands to be functional, they range in degree of health. Their health can be attributed to a variety of catchment activities and direct factors of change associated with the wetlands. Whilst other assessment tools such as the Wetland Index of Habitat Integrity (Wetland-IHI) yields similar information to that required in WET-Health it applies to floodplain and channeled valley bottom type wetlands not hillslope seepage wetlands and depressions (DWAF, 2007). Although the Present Ecological State scoring system and modules considered for assessment are the same, the IHI does include a water quality assessment since it is developed to be river health orientated, is to be used by non-wetland specialists and cannot be implemented by new users unless EcoStatus training is acquired. This contrasts with the WET-Health tool as the Level 2 assessment compensates for new users of the tool and allows for the assessment of all wetland types even those that may be river health based such as the floodplains and channeled valley bottoms (Macfarlane et al., 2008).

Both these tools are useful for monitoring wetland and riverine ecosystems as they involve a desktop evaluation to be completed which includes delineation and mapping of impacts affecting the systems which allows for the comparison of changes to the system over time. According to Johnson (2005) Geographic Information System (GIS) is an effective tool which generates data which can be monitored and improved over time and this data is required by the two above mentioned tools. This implies that both tools would be appropriate for monitoring wetlands; however, WET-Health assesses all wetland types as opposed to Wetland-IHI, which makes WET-Health more suitable for decision makers.

Chapter 5
Results and Discussion: WET-EcoServices Assessments

5.1 Introduction

The three wetlands, consisting of a combined total of eight HGM units were scored using Level 1 and two WET-EcoServices assessments (Table 5.4). In the process of obtaining the scores, the WET-EcoServices data spreadsheets, provided by the authors of the WET-EcoServices tool (Kotze et al., 2008) were completed (Appendix 3). For a Level 2 assessment the goods and services provided by a wetland can be determined (Table 3.5) and verified from fieldwork. The effectiveness and opportunity scores are assigned to the WET-EcoServices data spreadsheets which indicate the ability of a wetland to provide goods and services and the opportunity it has to do so. The WET-EcoServices assessments were utilised in conjunction with WET-Health which were evaluated and recorded in a separate results and discussion chapter providing scores of the goods and services wetlands provide, as this allows for analysis and integration of the levels of the tools and for comparisons between the two levels.

5.2 WET-EcoServices assessments
5.2.1 WET-EcoServices Level 1

5.2.1.1 Robert Armstrong Wetland
A WET-EcoServices Level 1 assessment is considered to be a desktop study only (Kotze et al., 2008). The goods and services are taken directly from Table 3.6 in the method chapter of this research which lists the HGM types with one or more of the indirect benefits that can be provided by a wetland. The fieldwork, which is limited for a Level 1 assessment, however, is necessary to determine direct benefits, and was conducted during the late wet season. This particular HGM unit – channelled valley bottom (Table 5.1) suggests that the wetland is providing flood attenuation, sediment trapping, phosphate, nitrate and toxicant assimilation to a certain degree whereas erosion control is very likely to be present and is provided at a high level. The direct benefits determined from on-site verification showed that biodiversity maintenance, provision of water for human use, provision of harvestable resources, provision

of cultivated foods, cultural heritage, tourism and recreation and education and research are not supplied by the wetland.

Table 5.1: WET-EcoServices Level 1: Robert Armstrong wetland benefits

	Robert Armstrong wetland
	HGM 1
Indirect benefits	
Flood attenuation	
Streamflow regulation	None
Erosion control	
Sediment trapping	
Phosphate assimilation	
Nitrate assimilation	
Toxicant assimilation	
Carbon storage	None
Direct benefits	
Biodiversity maintenance	None
Provision of water for human use	None
Provision of harvestable resources	None
Provision of cultivated foods	None
Cultural heritage	None
Tourism and recreation	None
Education and research	None

Legend

= Provided to a certain degree

= Provided at a high level

5.2.1.2 Le Mercy wetland

HGM 1 (hillslope seep linked to a channel) provides the following indirect benefits: flood attenuation and streamflow regulation whilst erosion control, nitrate and toxicant assimilation are likely to be present and are being provided at a high level (Table 5.2). The direct benefits which were assessed on-site indicated that the unit provides: provision of cultivated foods (annual pastures) and cultural heritage as there were *Tagetes erecta* flowers (commonly known as marigolds) frequently used for traditional ceremonial use and customary practices.

Unit two, being the unchannelled valley bottom, provides flood attenuation, phosphate and nitrate assimilation to some extent, and this unit provides erosion control, sediment trapping and toxicant assimilation. This unit provides no known direct benefits as determined by fieldwork.

Table 5.2: WET-EcoServices Level 1: Le Mercy wetland benefits

	Le Mercy wetland	
	HGM 1	**HGM 2**
Indirect benefits		
Flood attenuation		
Streamflow regulation		None
Erosion control		
Sediment trapping	None	
Phosphate assimilation	None	
Nitrate assimilation		
Toxicant assimilation		
Carbon storage		
Direct benefits		
Biodiversity maintenance	None	None
Provision of water for human use	None	None
Provision of harvestable resources	None	None
Provision of cultivated foods		None
Cultural heritage		None
Tourism and recreation	None	None
Education and research	None	None

Legend

= Provided to a certain degree

= Provided at a high level

5.2.1.3 Lake Victoria Barn Swallow roosting site wetland

According to Kotze et al. (2008) HGM 1 provides the following indirect benefits: flood attenuation, sediment trapping, phosphate, nitrate and toxicant assimilation to a certain degree, and erosion control which is likely to be present and is being provided to a high level (Table 5.3). There are no direct benefits being provided by unit one. Unit two, an 'unchannelled valley bottom', provides flood attenuation, phosphate and nitrate assimilation to some extent and erosion control, sediment trapping and toxicant assimilation to a high degree. Unit two provides certain direct benefits: biodiversity maintenance and tourism and recreation. This is due to the unit being a Barn Swallow (*Hirundo rustica*) roosting site which is the alternative site to the Mount Moreland Barn Swallow roosting site. This site serves as a tourist attraction during barn swallow migration. Unit three, the hillslope seep linked to channel, provides: flood attenuation and streamflow regulation to a certain degree and erosion control, nitrate and toxicant assimilation to a high degree with no direct benefits being supplied. Unit four is one of the two isolated hillslope seeps and provides flood attenuation and toxicant assimilation to a certain degree and erosion control and nitrate assimilation to a likely high level. No direct benefits are known to be supplied by this unit. Unit five, the second of the two isolated hillslope seeps, provides the same benefits as unit four since they are of the same HGM type. There were no direct benefits being provided by unit five based on field verification.

Table 5.3: WET-EcoServices Level 1: Lake Victoria Barn Swallow roosting site wetland benefits

	Lake Victoria Barn Swallow roosting site wetland				
	HGM 1	**HGM 2**	**HGM 3**	**HGM 4**	**HGM 5**
Indirect benefits					
Flood attenuation					
Streamflow regulation	None	None		None	None
Erosion control					
Sediment trapping			None	None	None
Phosphate assimilation			None	None	None
Nitrate assimilation					
Toxicant assimilation					
Carbon storage	None	None	None	None	None
Direct benefits					
Biodiversity maintenance	None		None	None	None
Provision of water for human use	None	None	None	None	None
Provision of harvestable resources	None	None	None	None	None
Provision of cultivated foods	None	None	None	None	None
Cultural heritage	None	None	None	None	None
Tourism and recreation	None		None	None	None
Education and research	None	None	None	None	None

Legend

= Provided to a certain degree

= Provided at a high level

WET-EcoServices level 1 has been outlined for the wetlands in this study, however, the level 2 assessments can be explained using Table 5.4 and follows on from the previous results. Instead of simply identifying whether a particular wetland HGM unit has certain goods, services and benefits, this allows for effectiveness and opportunity scores to be determined. The effectiveness scores are those which indicate how effective or sufficient a wetland is in supplying a particular benefit. For example, with respect to a wetland providing flood attenuation benefits, if the slope is gentle the wetland will be more effective in providing flood attenuation benefits. Thus the effectiveness score will be higher being either a three or four out of a total of four. The opportunity scores are derived based on the ability of the wetland to perform a function whilst also being in a particular area whereby it can sufficiently contribute to the provision of benefits previously mentioned.

5.2.2 WET-EcoServices Level 2

Table 5.4: Overall summary of WET-EcoServices Level 2 effectiveness and opportunity scores

	Robert Armstrong wetland		Le Mercy wetland				Lake Victoria Barn Swallow roosting site wetland									
	Unit 1		Unit 1		Unit 2		Unit 1		Unit 2		Unit 3		Unit 4		Unit 5	
	E	O	E	O	E	O	E	O	E	O	E	O	E	O	E	O
Flood attenuation	2	1.5	1.5	1	1.5	1.5	1	1.5	1	1	1.5	2	2	1.5	2	1
Streamflow regulation	0	0	4	4	0	0	0	0	0	0	4	4	0	0	0	0
Erosion control	3.5	0.5	4	1	4	0.5	3.5	1.5	4	0.5	4	2.5	4	1	4	1
Sediment trapping	1	2	0	0	0.5	2.5	0.5	1.5	0.5	1.5	0	0	0	0	0	0
Phosphate assimilation	2	2	0	0	3	1.5	2	1.5	3	1.5	0	0	0	0	0	0
Nitrate assimilation	1.5	2.5	2	2.5	3	2	2	2	4	2	3	2.5	2	2	2	2
Toxicant assimilation	2	1.5	2	1.5	3	1.5	2	1.5	3.5	1.5	2.5	1.5	2	1.5	2	1.5
Carbon storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legend

E = Effectiveness score **O = opportunity Score**

All information presented in this table is provided in more detail in Appendix 3.

5.2.2.1 Robert Armstrong wetland

5.2.2.1.1 HGM 1

A Level 2 WET-EcoServices assessment requires opportunity and effectiveness to be scored from zero to four based on the benefits the HGM unit provides. The scores as indicated by Kotze et al. (2008) are ranked accordingly: very high confidence = four, high confidence = three, moderate confidence = two, marginal/low confidence = one and not being provided = zero. From the Level 1 assessment the 'channeled valley bottom' (HGM 1) provides flood attenuation, sediment trapping, phosphate, nitrate and toxicant assimilation to a certain degree, with erosion control very likely to be present and supplied at a high level. The direct benefits determined from on-site verification are biodiversity maintenance, provision of water for human use, provision of harvestable resources, provision of cultivated foods, cultural heritage, tourism and recreation; opportunities for education and research are not supplied by the wetland.

Flood attenuation is provided more effectively than the opportunity for this unit to do so (Figure 5.1). There is no opportunity for streamflow regulation and carbon storage as the Level 1 suggests and this unit is not effective in providing these services. Kotze et al. (2008) suggests that channelled valley bottom wetlands are generally characterised by less active deposition of sediment. The WET-Health assessments indicate that there is no deposition of sediment in this wetland which is substantiated by the WET-EcoServices assessment which indicates this unit contributes less to sediment trapping since there is a greater opportunity than effectiveness score for this wetland in providing this service. Phosphate assimilation is provided effectively (to its full potential) as indicated by both the opportunity and effectiveness scores being two (Table 5.4). There is a greater opportunity for nitrate assimilation to occur, however this wetland is not providing this service as effectively as it has the potential to do so (Appendix 3). Toxicant assimilation is provided more effectively than it has the opportunity to do so, which is contrary to the Level 1 assessment which mentions that this service is only provided to a certain degree rather than at a high level. Erosion control as the Level 1 assessment shows is provided at a high level, which is supported by the scores from the Level 2 assessment. This wetland is more than twice as effective in providing erosion control compared to the opportunity it has to provide this service.

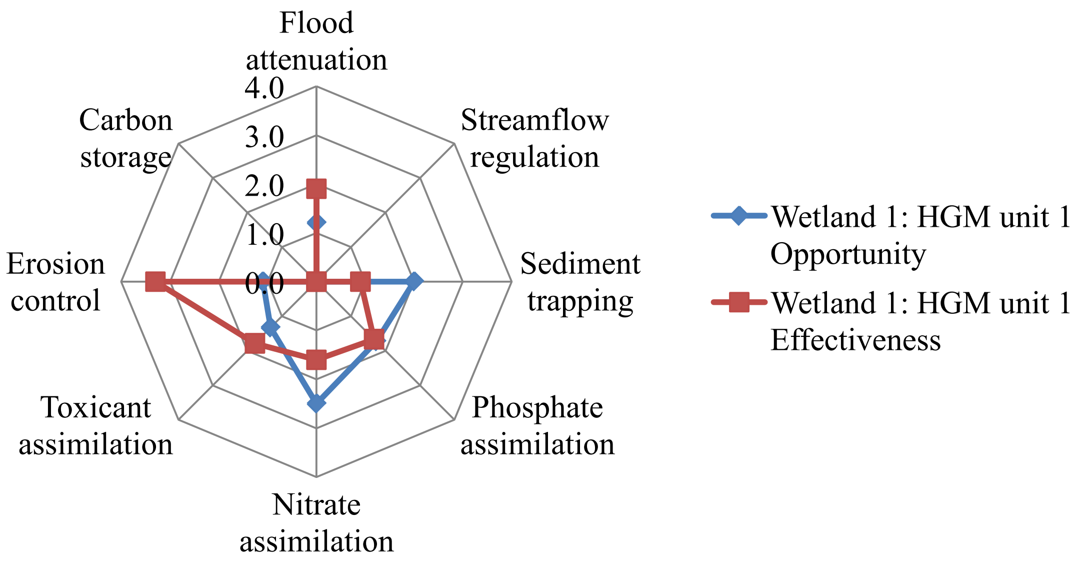


Figure 5.1: WET-EcoServices Level 2: Robert Armstrong wetland, HGM 1 opportunity and effectiveness scores

5.2.2.2 Le Mercy wetland

5.2.2.2.1 HGM 1

From the Level 1 assessment, HGM 1 (hillslope seep linked to channel) is providing flood attenuation and streamflow regulation, to a certain degree but erosion control, nitrate and toxicant assimilation is very likely to be present and supplied at a high level. The direct benefits determined from on-site verification showed that provision of cultivated foods and cultural heritage are supplied by the wetland.

Flood attenuation is provided effectively with less opportunity for this unit to do so (Figure 5.2). Streamflow regulation is effective to its full potential which is contrary to the Level 1 assessment which states that this service is only provided to a certain degree rather than at a high level as indicated by both the opportunity and effectiveness scores being four. There is no opportunity for sediment trapping, phosphate assimilation and carbon storage as the Level 1 suggests and this unit is not effective in providing these services. Kotze et al. (2008) states that hillslope seep wetlands are generally characterised as being effective in removing nitrates yet this is not the case here. The WET-EcoServices assessment suggests this unit contributes less to nitrate assimilation as there is a greater opportunity for nitrate assimilation to occur, however this wetland is not providing this service as effectively as it has the potential to do so.

The Level 2 assessment indicates that toxicant assimilation is provided more effectively than it would appear to have the opportunity to do so which is in keeping with the Level 1 assessment which mentions that this service is provided at a high level. Since hillslope seepage wetlands have generally steep slopes there is a greater risk of erosion associated with these systems, and hillslope seepage is not particularly effective is controlling erosion (Kotze et al., 2008). The WET-Health assessment indicates that the slope of this unit is 1.7% which is regarded as moderate which may contribute to a greater potential of erosive processes occurring, however, there was no evidence from fieldwork. Erosion control as the Level 1 WET-EcoServices assessment indicates, is provided at a high level which is supported by the scores from the Level 2 WET-EcoServices assessment: this particular wetland is four times more effective in providing this service compared to the opportunity it has to be providing this service.

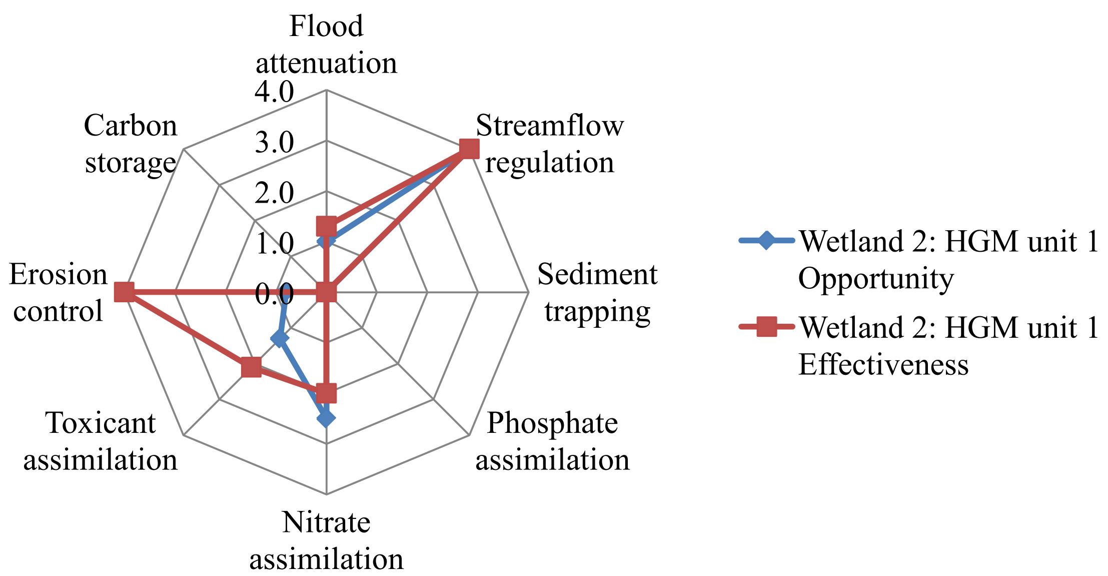


Figure 5.2: WET-EcoServices Level 2: Le Mercy wetland, HGM 1 opportunity and effectiveness scores

5.2.2.2.2 HGM 2

From the Level 1 assessment the 'unchannelled valley bottom' wetland of HGM 2 is providing flood attenuation, phosphate and nitrate assimilation to a certain degree, whilst erosion control, sediment trapping and toxicant assimilation is very likely to be present and supplied at a high level. No streamflow regulation and carbon storage services are supplied by this unit. The direct benefits determined from on-site verification showed that biodiversity maintenance, provision of water for human use, provision of harvestable resources, provision of cultivated foods, cultural heritage, tourism and recreation and education and research are not supplied by the wetland.

Flood attenuation is provided to a certain degree and is being effective to its full potential as indicated by both the opportunity and effectiveness scores of 1.5 (Figure 5.3). There is no opportunity for streamflow regulation and carbon storage, as the Level 1 assessment suggests, and this unit is not effective in providing these services. Unchannelled valley bottom wetlands are generally characterised by having gentle gradients with fairly high levels of sediment deposition (Kotze et al., 2008). The WET-Health assessment substantiates these findings as it indicates that there are depositional features of sediment occupying this unit with infilling accounting for 20 % (1.2 hectares) of modifications occurring in this unit. Although WET-EcoServices suggests this unit should contribute substantially to sediment trapping, there is a higher opportunity than effectiveness score, meaning this wetland provides this services to a lower degree than it could. Phosphate, nitrate and toxicant assimilation is effectively being provided as the scores are higher than that of the opportunity of providing this service and this is substantiated by Kotze et al. (2008) who suggests that nitrate and toxicant removal is higher in these HGM types than in floodplain systems. Erosion control as the Level 1 assessment shows is provided at a high level which is supported by the scores from the Level 2 assessment. This wetland is eight times more effective in providing erosion control compared to the opportunity it has to provide this service.

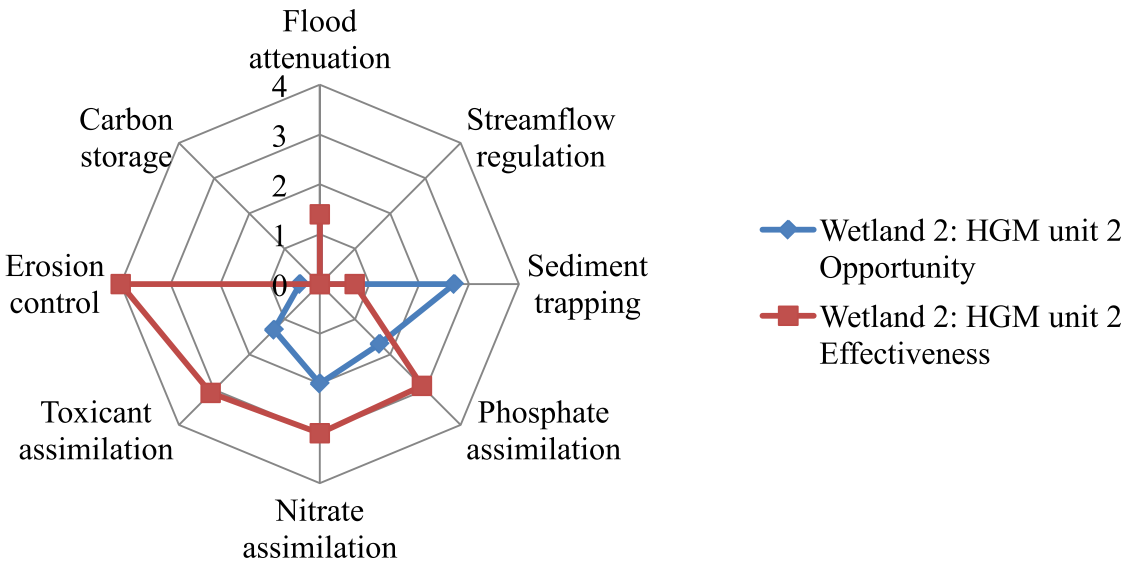


Figure 5.3: WET-EcoServices Level 2 – Le Mercy wetland, HGM 2 opportunity and effectiveness scores

5.2.2.3 Lake Victoria Barn Swallow roosting site wetland

5.2.2.3.1 HGM 1

Flood attenuation is not being provided more effectively than the opportunity indicated for HGM unit (Figure 5.4). There is no opportunity for streamflow regulation and carbon storage as the Level 1 assessment suggests and this unit is not effective in providing these services. This unit contributes less to sediment trapping as indicated by the higher opportunity (1.5) than effectiveness (0.5) score, indicating that this wetland provides this service to a lower degree than it could, which is in keeping with the WET-Health findings of no deposition of sediment features. Phosphate assimilation is being provided more effectively than opportunity would indicate. Nitrate assimilation is being effectively provided to its full potential as indicated by both the opportunity and effectiveness scores being two. Toxicant assimilation is provided more effectively than the opportunity indicated. Erosion control as the Level 1 assessment shows is provided at a high level which is supported by the scores from the Level 2 assessment. This wetland is four times more effective in providing erosion control compared with the opportunity it appears to have for providing this service.

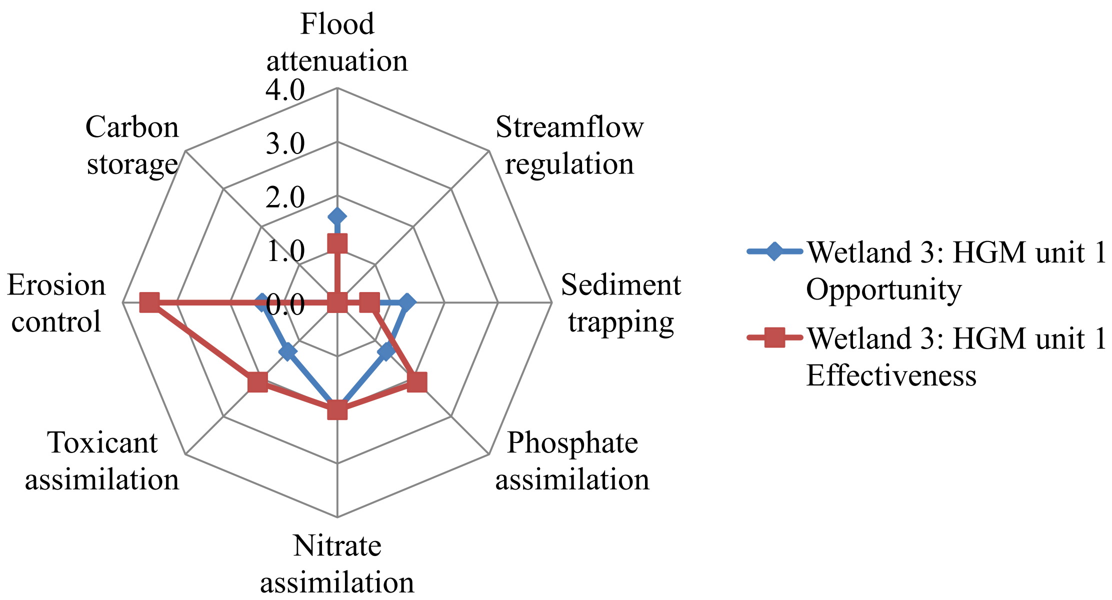


Figure 5.4: WET-EcoServices Level 2: Lake Victoria Barn Swallow roosting site wetland, HGM 1 opportunity and effectiveness scores

5.2.2.3.2 HGM 2

HGM 2, an unchannelled valley bottom wetland, generally characterised by having gentle gradients (this unit has a slope of 0.34%), should be associated with fairly high levels of sediment deposition (Kotze et al., 2008). The WET-Health assessment substantiates these findings as it indicates depositional features of sediment occupying an extent of 0.2 – 1.9% of this unit. Although the Level 2 WET-EcoServices assessment suggests this unit should contribute substantially to sediment trapping there is a higher opportunity than effectiveness score meaning this wetland provides this service to a lower degree than it could. This may be due to the level of modification made to the health of this unit thus the ability of the unit to provide this service is lowered. The health scores reflect a C, A, C for hydrology, geomorphology and vegetation respectively.

Flood attenuation is provided to a certain degree and is effective to its full potential as indicated by both the opportunity and effectiveness scores being one (Figure 5.5). There is no opportunity for streamflow regulation and carbon storage as the Level 1 assessment suggests and this unit is not effective in providing these services. Nitrate and toxicant removal are thus expected to be higher than in floodplain systems (Kotze et al., 2008). This concurs with the results of the Level 2 assessment suggesting that phosphate, nitrate and toxicant assimilation is effectively provided as the scores are higher than those for opportunity. Nitrate assimilation and erosion control services are both provided to their full potential as the effectiveness score is four.

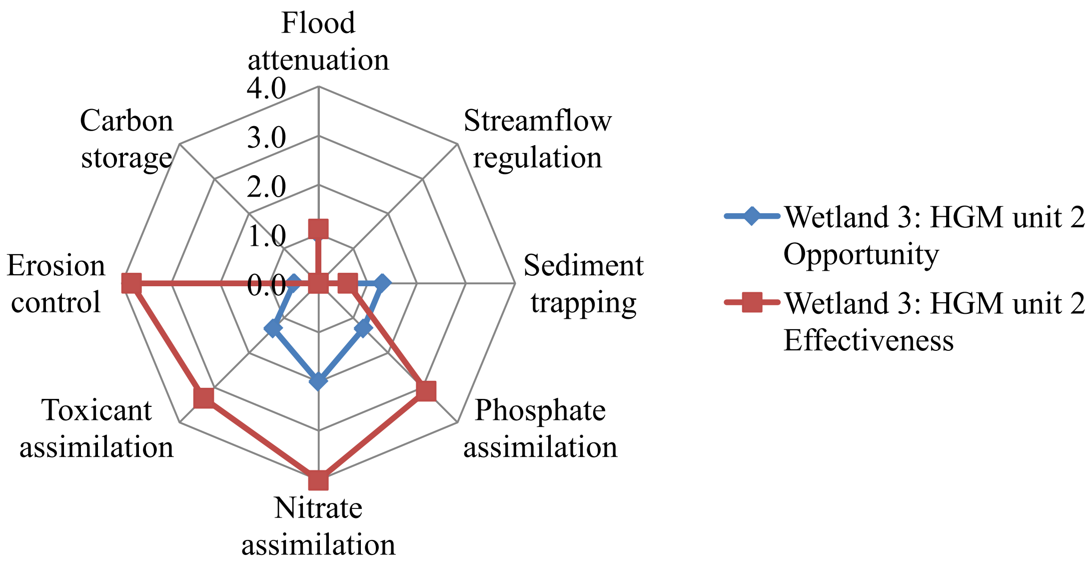


Figure 5.5: WET-EcoServices Level 2: Lake Victoria Barn Swallow roosting site wetland, HGM 2 opportunity and effectiveness scores

5.2.2.3.3 HGM 3

Flood attenuation is being provided less effectively than opportunity indicates for HGM 3 (Figure 5.6). Streamflow regulation is being effective to its full potential which is contrary to the Level 1 assessment which mentions that this service is only provided to a certain degree rather than at a high level as indicated by both the opportunity and effectiveness scores being four. There is no opportunity for sediment trapping, phosphate assimilation and carbon storage as the Level 1 assessment suggests and this unit is not effective in providing these services.

Kotze et al. (2008) states that hillslope seepage wetlands are supposed to be most effective in removing nitrates and this is the case with this unit providing this service more effectively than the opportunity to do so. The WET-Health score is poor with regard to this unit performing its function effectively. This indicates that WET-Health and WET-EcoServices complement each other, though it is worth noting what Macfarlane et al. (2008: 23) have to say: "there is, of course, a general relationship between the two, with healthy wetlands generally believed to provide a greater level of ecosystem services. This relationship is very poor however and will depend very strongly on the specific ecosystem service examined. This is certainly an area requiring further study".

Toxicant assimilation is provided more effectively than the opportunity to do so which is in keeping with the Level 1 assessment which notes the high level of this service at a. Hillslope seeps generally have steep slopes which increase the risk of erosion, however they are not particularly effective is controlling erosion (Kotze et al., 2008). The WET-Health assessment indicates that the slope of this unit is 8.69% which is regarded as high, may contribute to a greater potential of erosive processes occurring, however, there was no evidence of this from the fieldwork and the Level 1 and two WET-EcoServices assessments show that erosion control is provided at a high level.

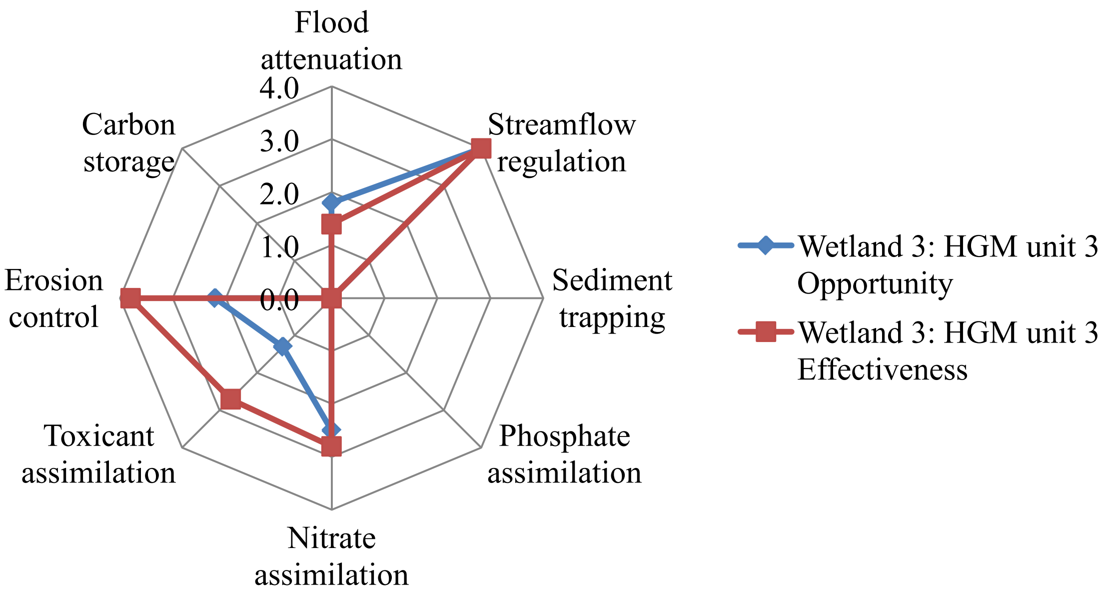


Figure 5.6: WET-EcoServices Level 2: Lake Victoria Barn Swallow roosting site wetland, HGM 3 opportunity and effectiveness scores

5.2.2.3.4 HGM 4

Isolated hillslope seep wetlands (HGM 4) are similar to hillslope seep linked to channel wetlands in terms of functioning and water sources. Therefore these HGM types are generally characterised by being associated with groundwater discharge which can be supplemented by surface flows and for being effective in removing nitrates. A major difference is that isolated hillslope seeps are not as wet as hillslope seeps as there is no direct link to a stream channel; this results in these HGM types contributing very little to streamflow regulation (Kotze et al., 2008) and this is supported by the findings that streamflow regulation is not being provided by the unit as both effectiveness and opportunity scores are zero.

Flood attenuation is being provided more effectively than the opportunity for this unit to do so (Figure 5.7). Nitrate assimilation is being effective to its full potential which is in keeping with WET-Health– (as previously mentioned, hillslope seeps are effective in removing nitrates) and the WET-EcoServices Level 1 assessment which mentions that this service is provided at a high level as indicated by both the opportunity and effectiveness scores being two. There is no opportunity for sediment trapping, phosphate assimilation and carbon storage as the Level 1 assessment suggests and this unit is not effective in providing these services.

Toxicant assimilation is provided more effectively than the opportunity to do so which is contrary to the Level 1 assessment which indicates that this service is provided to a certain degree. The WET-Health assessment indicates that the slope of this unit is 4.74% which is regarded as high, may contribute to a greater potential of erosive processes occurring; however, the texture of mineral soil is loam, therefore the ability to erode is less likely than if it were comprised of sandy soils. Erosion control, as the Level 1 assessment shows, is provided at a high level which is supported by the scores from the Level 2 assessment. This service is provided four times more effectively than it has the opportunity to do so.

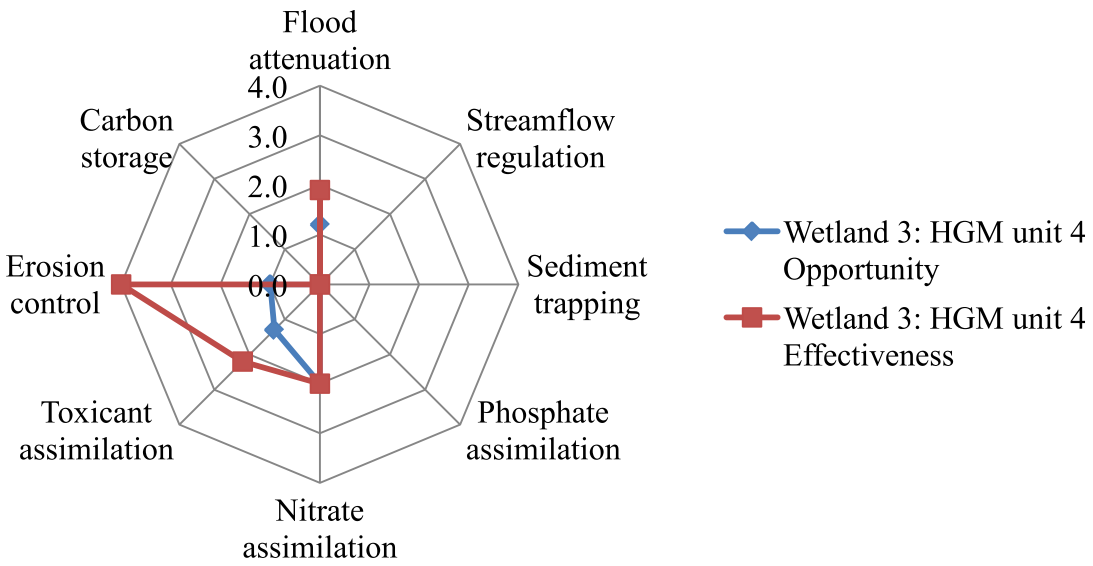


Figure 5.7: WET-EcoServices Level 2: Lake Victoria Barn Swallow roosting site wetland, HGM 4 opportunity and effectiveness scores

5.2.2.3.5 HGM 5

In HGM 5 flood attenuation is provided more effectively than there is the opportunity for this unit to do so (Figure 5.8). Nitrate assimilation is effective to its full potential, which is in keeping with the WET-EcoServices Level 1 assessment, which suggests this service is provided at a high level as indicated by both the opportunity and effectiveness scores being two. There is no opportunity for streamflow regulation, sediment trapping, phosphate assimilation and carbon storage as the Level 1 assessment suggests and this unit is not effective in providing these services. Toxicant assimilation is provided more effectively than it has the opportunity to do so, which is contrary to the Level 1 assessment which indicates this service is provided to a certain degree, when it is actually provided at a higher level. Erosion control, as the Level 1 assessment shows, is provided at a high level which is supported by the scores from the Level 2 assessment. This wetland is twice as effective in providing these services than it has the opportunity to do so.

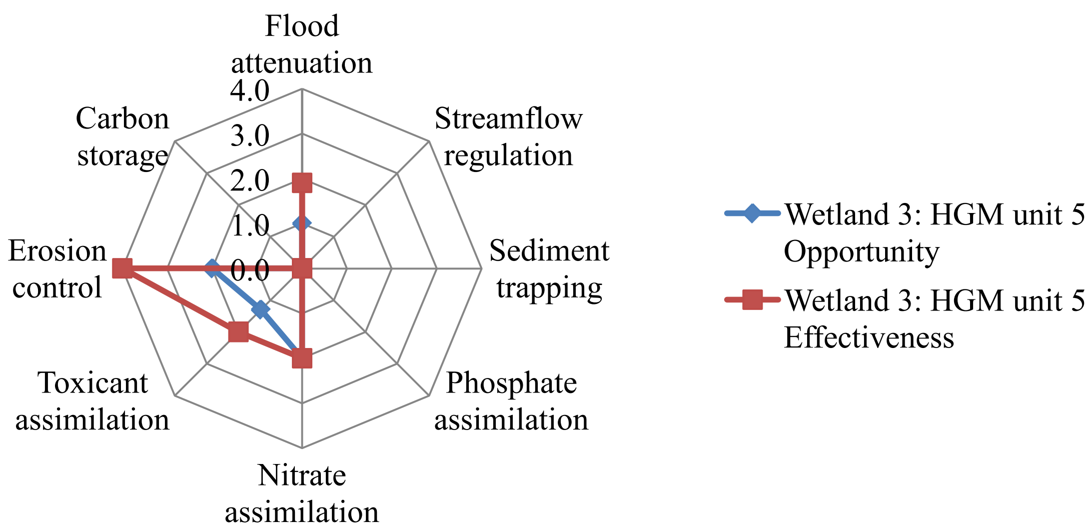


Figure 5.8: WET-EcoServices Level 2: Lake Victoria Barn Swallow roosting site wetland, HGM 5 opportunity and effectiveness scores

5.4 Questionnaire and feedback session

The pre-presentation questionnaire (Appendix 1) indicated that the two participants were knowledgeable about wetlands and could define them. It was recorded that wetlands were naturally occurring systems which are characterised by anaerobic soil conditions favouring hydrophytes. The second question asked whether they understood how wetlands are classified into different HGM types and if they did, to provide an example of a HGM classification. The participants could provide examples of seepage and channelled valley bottom wetland systems. Following on from the previous question, they were asked to describe what role the HGM type they mentioned previously, plays in the landscape. One participant who answered channelled valley bottom said that the role this system plays in the landscape is for flood attenuation, water purification and streamflow regulation purposes. According to Kotze et al. (2008) channelled valley bottom wetlands do provide flood attenuation in the early wet season to a certain degree therefore making this answer true, however these HGM types do not provide streamflow regulation. All wetland types will enhance water quality to some extent. Another participant who identified hillslope seeps as an HGM type did not answer the next question of what role that same HGM type plays in the landscape. It was difficult to determine if the participant did not know the role the HGM type played in the landscape or had merely forgotten to go back and answer it. These questions show that the participants are, to some degree, knowledgeable of wetlands – what they are, and some types of them, however this is not conclusive.

Questions one to three asked if the participants had any knowledge of wetlands whereas questions four to six dealt with the tools used to assess wetland health and ecosystem goods and services. Question four asked participants if they had been exposed to the WET-Health and WET-EcoServices tools before and if yes, through what medium. One participant had some idea of the methods required in using the tools but had not practically conducted assessments using the tools. Another had been exposed to the tools at university and whilst working as a wetland consultant.

Questions five and six are similar and follow on from question four as they seek to probe whether or not the participants understand these tools, if they have any experience using them and if they have used these tools, their levels of competence. One participant did not have any prior experience using these tools and therefore competence in using the tools was low, whereas others had prior experience using the tools with fairly high competence but had not used these tools in a while. Macfarlane et al. (2008) suggests that an experienced user conduct a WET-Health Level 1 assessment: participants may be more likely to successfully undertake Level 2 rather than a Level 1 assessment as the level of knowledge they have regarding the tool and method may be irrelevant.

Questions seven to nine address the participants' expectations of the tools and considers the application of the tools. Participants thought that the WET-Health tool should provide information about the state/condition and determine the functionality of the wetlands within the catchment, whilst WET-EcoServices should provide a level of indication as to the goods and services which are provided by the wetlands. When asked how well wetlands were considered with respect to land use planning and decision making, the participants mentioned that, in the past, wetlands were not taken into consideration but recently they have become more popular. One participant said that even though they are not becoming more important in terms of land use planning, the problem is that only larger wetland systems are taken into account not the smaller less obvious ones. Another stated that NEMA (National Environment Management Act) and the Water Act guide land use planning thus protecting wetlands by prohibiting developments in wetlands. When asked if land use planning takes the WET-Health and WET-EcoServices tools into account when managing wetlands one response was "I'm not aware that it does at all". It was mentioned that generally these tools are only used when Environmental Impact Assessments (EIA) are conducted when there might be a negative impact on wetlands; on a strategic level, however, they are not considered at all. It is believed that although not much consideration is given to wetlands in land use planning there should be a greater drive to include them in such efforts. These tools could be useful in more strategic planning for the city's resources as it will aid in identifying no-go options and can develop site-specific wetland management plans. This substantiates the potential benefit of these tools for improved wetland management which can be influential at all stages of the development process.

The second questionnaire, which was administered after the presentation of results from the assessments, consisted of six questions and sought to determine if the methods proposed in this research fulfilled their needs, if and how these tools could be taken into consideration with respect to land use planning and decision making, and to determine if these methods could be useful for assessing all of the wetlands within the jurisdiction of eThekwini municipality.

Question one asked if the WET-Health tool provides the following information: number of wetlands, identification of HGM types and indication of the spatial extent of these units. Respondents answered affirmatively: the tool does provide such information as it takes the user through a process which requires these factors to be investigated. Furthermore, by conducting a Level 1 desktop assessment the HGM types can be identified and the other information acquired. This indicates that the WET-Health tool does meets Durban eThekwini's needs of determining the condition their wetlands are in. Although this research only looked at one catchment (the uMdloti) as part of a pilot process to determine if this method can also be up-scaled to the rest of eThekwini municipality's catchments further research would have to be done on the entire catchment to determine a valid outcome.

When asked if WET-EcoServices provided meaningful insight into the goods and services the wetlands provided (yes or no, give a reason to support your answer), the participants responded "yes", indicating an awareness of the usefulness of the WET-EcoServices tool. It was the general consensus that WET-EcoServices does allow for the provision of meaningful insight into the goods and services obtained from the wetland. One participant stated that WET-EcoServices clearly outlines (Figure 3.9) which HGM types provide particular regulatory benefits. The tool assesses various characteristics of a wetland which influence the provision of ecosystem services, for example, surface roughness for flood attenuation. Scores are attached to different aspects of the wetland characteristics, thus clearly representing how well the wetland is providing the goods and services. Once again the outcome from these responses implies that the WET-EcoServices tool was useful in fulfilling their fourth and last need to determine what goods and services the wetlands within the catchments under their jurisdiction provide.

This approach, of utilising these particular tools to meet the above mentioned needs of eThekwini municipality, is a pilot study to determine if this research can be up-scaled to the remainder of the catchments under their jurisdiction. It is therefore important to determine what level of each assessment would be manageable, appropriate and feasible. One participant believes that Level 2 assessments for both the tools are more accurate and more appropriate especially when detailed information is required for a particular system; however, a Level 1 assessment would be more appropriate for more strategic demands. From the comments received after the presentation it was mentioned that time constraints would favour the Level 1 assessment more than the Level 2. Mention was made that the two levels would be preferred and they gave a breakdown of what they believed would be the features consistent with each level of assessment such as: at a Level 1 basis the HGM unit will be identified and drains would be briefly looked at to determine the magnitude of impact on the wetland system, but when doing a Level 2 assessment, the appropriate level of detail should encompass the following features: overall health of the wetland, surrounding land use impacts, features causing disturbances and the level of modification associated with the wetland.

Question four was designed to obtain eThekwini municipality's feedback after the presentation of results and it asked if the study provided the necessary information that would meet their needs in terms of managing wetlands more effectively and efficiently and if yes, how so. Participants answered affirmatively to this question. Level 1 assessments of both tools are seen as useful as they are fairly accurate if the right expertise is available. Level 1 assessments can also be used to make informed comments when regarding a wetland holistically. The results from this study will also be useful for justifying why these particular systems should be managed or rehabilitated.

When asked how well the tools took wetlands into consideration with respect to land use planning and decision making, the respondents expressed that wetlands were taken into account very well. The tools were said to clearly define wetlands, taking the catchment activities which surround the wetland and impact on the health and ability of the wetland to provide goods and services into account. Since catchment activities were considered, the tools were useful in assessing the different land use types and their impact on the wetland system. This information would enable more effective and efficient management when prioritising land-uses so that wetlands which were in good health and provide important goods and services could be conserved.

The last question, question six, is subjective in that it required the participants to say whether or not they believe the methods of this study, and in other words the tools used, can be applied to other catchments within eThekwini municipality's jurisdiction. If the respondents said "yes" they needed to give a reason to support their choice. Participants agreed that this study can be applied to the other catchments which they manage which suggests that this pilot study does meet their needs and the tools used in this study fulfils the requirements to determine firstly, how many wetlands there are in the catchments under their jurisdiction (spatial extent), secondly what HGM type the wetlands are comprised of, thirdly their state of health, and lastly what goods and services the wetlands within the catchments provide. The

The WET-Health and WET-EcoServices assessment tools provide a vast amount of information which is relevant to eThekwini municipality. Having worked through the process of WET-Health, the wetlands were mapped providing their spatial extent, their area in hectares, their HGM types were identified, the roles these HGM types play in the landscape were identified and through the WET-EcoServices assessment, the goods and services they provide were also determined. From the feedback session it was understood that this research utilising these tools ultimately provided for eThekwini municipality's needs and although the health score is not directly associated with the goods and services the wetland can supply, there was some verification of present ecological state when both the levels of assessment are conducted.

Durban eThekwini prefer using the Level 1 WET-Health assessment as this is not as time consuming, is more convenient and if expertise knowledge is acquired, it can yield accurate results which do not differ greatly from the Level 2 assessments. There were only two instances whereby overscoring and underscoring of extents and intensity scores, which increased or decreased the magnitude of impact score, provided different scores to the Level 1 assessment. These tools are said to be widely accepted amongst consultants and other user groups and although they are generally used when Environmental Impact Assessments are conducted when there is a danger of negative impacts on wetlands, not much consideration is given to wetlands with respect to land use planning. It is believed that there should be a greater drive to include these tools in such efforts as they could be useful in more strategic planning for the city's resources: they can aid in identifying no-go options and can contribute to the development of site-specific wetland management plans.

Chapter Six
Recommendations and Conclusion

eThekwini municipality requested that the wetlands found within Durban unicity's boundary be identified, mapped and the purpose of each hydrogeomorphic unit within the landscape be defined, the health of the wetlands and the goods and services they provide be determined, so that this information could inform wetland management priorities, allow for the assessment of present and future impacts of urban development on wetlands and be used in the Metro's systematic conservation planning. This research sought to meet these needs by determining if the WET-Health and WET-EcoServices tools were suitable for determining this information. A feedback session involving two questionnaires with eThekwini municipality sought to obtain their feedback on the process of this research and whether or not their needs were met. WET-Health was utilised in conjunction with WET-EcoServices assessments to evaluate three wetland systems.

These wetlands, with a combined total of eight HGM units, were assessed at Level 1 and 2. Being situated in a water stressed catchment, surrounded by various forms of land-uses including industry, residential, recreational, King Shaka International airport, and commercial agriculture (sugarcane) in more than half of the catchment, the wetlands are functional and provide many goods and services (Kotze et al., 2008). It is suggested that when a wetland is disturbed and converted to cropland most of the indirect benefits which that wetland could have provided will be lost and drained wetlands may be less effective at regulating streamflow and purifying water whilst also increasing the likelihood of probability since water flow is concentrated through a channel (Kotze, 1996). The wetland may not be providing goods and services to its full potential because of the expansive amount of conversion from wetland to cropland.

WET-Health can be seen as a tool which may bring to light impacts caused by humans who may negatively impact the condition of wetlands or reduce their capacity to perform their necessary function in the landscape. For example, if a farmer drains a wetland and uses the water for irrigation of his crops the wetland may not be in as good a condition as it could have been had it not been drained or touched by man. The WET-Health tool was used to suggest best management practices and inform decision makers of wetland functions so that decisions could ensure more effective functioning of the wetland ecosystem. Grayson et al., (1999) suggest that if better management, planning and monitoring initiatives are adhered to, the allocation of resources for wetland rehabilitation and restoration can enhance wetland functioning and the goods and services they provide. People can only effectively manage and conserve these systems if they are aware of what they are, what they look like, what they do in the landscape and what they provide for us. The National Environment Act 107 of 1998 places an emphasis on government and local municipalities to provide co-operative governance with respect to natural resources (Cousins, du Toit and Pollard, 2004). Therefore it is important for the people in a position to manage these resources are aware of what they have and are all the different options they have regarding them. This tool can in this manner be seen assisting co-operative governance by giving relevant information regarding wetland condition and the goods and services provided to those thus directly and indirectly dependent on the system for a variety of functions which wetlands supply such as flood or erosion control.

The WET-Health assessments encompassed a range of features which were used to evaluate the wetlands namely: the extent of hardened surfaces in the wetland's catchment, the texture of the mineral soil, surface roughness of the HGM unit comparing its current state with its natural state, the disturbance classes, changes to floodpeaks, impacts of dams upstream of and/or on floodplains, impacts of channel straightening, artificial wetland infilling and changes in runoff characteristics, impacts of erosion and/or deposition and impacts of the loss of organic sediment. These characteristics allowed for an overall health score to be determined for the hydrology, geomorphology and vegetation module which the WET-Health tool addresses, so that the 'health' of the wetland can be determined.

The hydrological, geomorphological and vegetation condition or health of the Robert Armstrong wetland falls within in D, B and F PES categories respectively. The Le Mercy wetland scored C, A and D PES categories for the Level 1 assessment which varied from the Level 2 D, A and C PES category scores, due to the underscoring and overscoring of extents and intensity scores, which decreased or increased the magnitude of impact score accordingly. The Lake Victoria Barn Swallow roosting site wetland indicated the health to fall within C, A, and C PES categories. Although health scores vary from an A to a F PES category, wetlands may still be providing vital ecosystems services. This reiterates that wetland health can be seen in complete isolation from the goods and services wetlands provide.

eThekwini municipality would prefer using a Level 1 WET-Health assessment as this is not as time consuming, more convenient, would fit into their work situation easier and if expertise knowledge is acquired, can yield accurate results which do not differ greatly from the Level 2 assessments. There were only two instances whereby overscoring and underscoring of extents and intensity scores which increased or decreased the magnitude of impact score accordingly, provided different scores to the Level 1 assessment in the hydrology and vegetation modules for the Le Mercy wetland. Both Level 1 and two assessments would be acceptable to use, however, if a Level 1 is more suitable for eThekwini municipality to use and integrate into their work plan to manage and conserve the wetlands within their jurisdiction, a greater knowledge and expertise of the tools would be required, as opposed to a Level 2 assessment which may be more accurate but is very tedious, time-consuming and is associated with more in-depth fieldwork. As the researcher, I found the level 1 assessment to be much easier than a level 2. This was because, firstly the gathering of information required from field work is not as intense, secondly, the computing of information was simpler and quicker and thirdly, since there was less information to consider it made understanding the wetland system dynamics and its problems easier.

The WET-EcoServices tool provided guidelines for scoring the importance of the three wetlands in terms of delivering different ecosystem goods and services thereby contributing to informed planning and decision making. Depending on the level of assessment undertaken, the results varied as a Level 1 stated that each wetland of the same hydrogeomorphic type would provide the same benefits, as opposed to the Level 2 WET-EcoServices assessment which provided more in-depth information about the service being provided, allowing for the uniqueness of each HGM unit, for example, two hillslope seep linked to channel wetlands can provide differing degrees of flood attenuation. Therefore the Level 2 assessment is more comprehensive and reliable than a Level 1 assessment.

The assessments evaluated the three wetlands in terms of their health and the goods and services they provide which include flood attenuation to a certain degree, and streamflow regulation, which as previously mentioned, is important in a South African context. In the Level 2 WET-EcoServices assessment the degree to which a service is provided, can be articulated. For example, with flood attenuation, a wetland can provide flood attenuation less effectively than it has the opportunity to do so, while in some instances the wetland supplies flood attenuation to its full potential and in other instances, the wetland provides this service more effectively than it has the opportunity to do so. This varies from the Level 1 WET-EcoServices which states that each wetland of the same hydrogeomorphic type will provide the same benefits such as flood attenuation.

The Level 2 WET-EcoServices assessment is more in-depth and reliable than a Level 1 assessment as it provides more detailed information about the service being provided and allows each HGM unit (which although categorised as the same HGM type may be unique) to be seen differently, for example, two hillslope seep linked to channel wetlands can provide differing degrees of flood attenuation. HGM 1 of the Le Mercy wetland indicates that flood attenuation is being provided more effectively that the opportunity for the wetland to do so while HGM 3 (also a hillslope seep linked to channel wetland) of the Lake Victoria Barn Swallow roosting site is providing flood attenuation less effectively than the opportunity provided to do so. A recommendation would be to use the Level 2 WET-EcoServices assessment rather than a Level 1: although the Level 1 is a desktop study and is less timing consuming, there is no variation in level of services provided in terms of HGM types and the situation surrounding the wetland.

The response from the questionnaires suggest that the WET-Health and WET-EcoServices tools be included in efforts to engage in more strategic planning for the city's resources as they will aid in identifying no-go options and can develop site specific wetland management plans. This would ensure that wetlands are given a higher priority in the landscape with respect to land use planning which may promote greater conservation of these very important ecosystems.

This research, having addressed the importance of wetlands in the landscape and their ability to provide many direct and indirect benefits to people in society, has showed the suitability of the WET-Health and WET-EcoServices tools in determining wetland functionality and the goods and services they provide respectively, and described how these tools can be used in land use planning, management and decision making. eThekwini municipality believe that these tools provided the information they needed and were willing to implement the usage of them as this was convenient, practical, appropriate and suitable given their availability of resources and time constraints. It is important to recognise the significant information these tools have provided which could allow for effective monitoring of these wetlands and assist land use planning and decision making efforts.

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Appendix 1: Questionnaires

Pre-Presentation Questionnaires

Appendix A contains two questionnaires. Of which was completed before and after the presentation of assessment results to the eThekwini stakeholders. The pre-questionnaire was important to do before the stakeholders were aware of the results because this would not taint their responses and give me the researcher a clear insight into whether or not they knew what wetlands are and how they function. The post questionnaire was simply to engage with the stakeholder and determine whether the results they were presented with, met their expectations and helped to understand the WET-Health and WET-EcoServices tools better. The relevance of these questionnaires was to see if eThekwini municipality gathered the information they needed through the use of the WET-Health and WET-EcoServices tools.

Job Description: Environmentalist : Biodiversity Impact Assessm

Department: Environmental Planning & Climate Protection

1. a. Do you understand what wetland systems are?

Yes ☒ No ☐

1. b. How would you define a wetland?

naturally occuring system that is characterised by soil conditions (seasonally/permanently watterlogged) with a presence of mottles and hydrophytes

2. Do you understand how wetlands are classified into different hydrogeomorphic (HGM) types? If yes, provide an example of a HGM classification that you are aware of.

Yes ☒ No ☐

A seepage slope wetland

3. Do you know what role – or the importance – each hydrogeomorphic type plays in the landscape? If yes, describe the role the HGM classification you previously mentioned in question 2 plays in the landscape.

Yes ☒ No ☐

4. Have you ever used or have been exposed to the WET-Health and WET-EcoServices tools before? If yes how/ through what medium?

No. I am aware of the Wet-Health method but I do not have practical experience of both methods (Wet-Health & Wet-EcoServices)

5. Do you have any prior experience in using the WET-Health tool? If yes, what would you consider your level of competence of using the tool to be?

Yes ☐ No ☒

6. Do you have any prior experience in using the WET-EcoServices tool? If yes, what would you consider your level of competence of using the tool to be?

Yes ☐ No ☒

7. What would you expect the WET-Health and WET-EcoServices tools to provide?

My expectation of the tool is to map all the Ecoservices within a particular catchment. After identifying the ecoservices provided by the catchment, then the WetHealth method can be used to ~~the~~ determine the health/functionality of wetlands within a catchment.

8. How well do you think wetlands are taken into consideration with respect to land use planning decision making? Explain your response.

Over the last few years (±10) wetlands have gained recognition in land-use planning. NEMA & the Water Act also guides land-use planning & in the same token protects wetlands by prohibiting developments in wetlands.

9. How well do you think land use planning decision making takes the WET-Health and WET-EcoServices tools into account when managing wetlands?

I don't think that land-use planning decision making takes Wet-Health/Ecoservices into account as much as it should. It's a tool that is used for bigger development and not on an Erf-level. There is room to use the tool/method more in strategic planning for the city's resources, ~~This wi~~ as it will aid in identifying no-go areas and developing site-specific wetland management plans.

Consent to use this information in my Research Thesis and Academic Articles

Yes ☒ No ☐

Thank you for taking time to participate in this questionnaire and for taking part in this study / project. Your feedback is appreciated.

Job Description: Environmentalist: Biodiversity impact assessment

Department: EPCPD

1. a. Do you understand what wetland systems are?

Yes ☑ No ☐

1. b. How would you define a wetland?

Transisional between aquatic and terrestrial environments, where anaerobic conditions occur (in soil) within the root zone of plants (50cm)

2. Do you understand how wetlands are classified into different hydrogeomorphic (HGM) types? If yes, provide an example of a HGM classification that you are aware of.

Yes ☑ No ☐

~~1. Hillslope seepage~~ 2. unchannelled valley bottom ~~etc.~~

3. Do you know what role – or the importance – each hydrogeomorphic type plays in the landscape? If yes, describe the role the HGM classification you previously mentioned in question 2 plays in the landscape.

Yes ☑ No ☐

Flood attenuation, water purification, and stream flow augmentation / regulation

4. Have you ever used or have been exposed to the WET-Health and WET-EcoServices tools before? If yes how/ through what medium?

Yes. At university during wetland studies, and working as a wetland consultant.

5. Do you have any prior experience in using the WET-Health tool? If yes, what would you consider your level of competence of using the tool to be?

Yes ☑ No ☐

Fairley High (haven't use it for a while)

6. Do you have any prior experience in using the WET-EcoServices tool? If yes, what would you consider your level of competence of using the tool to be?

Yes ☑ No ☐

Fairley High (same as above)

7. What would you expect the WET-Health and WET-EcoServices tools to provide?

They should provide and indication of the state or condition of the wetland (WET-Health) and the level of goods and services provided by wetlands (WET-Ecoservices)

8. How well do you think wetlands are taken into consideration with respect to land use planning decision making? Explain your response.

Up until recently they were not taken into consideration. But it seems like that is changing. The problem seems to be taking into account smaller less obvious systems.

9. How well do you think land use planning decision making takes the WET-Health and WET-EcoServices tools into account when managing wetlands?

I'm am not aware that it does at all. These tools only seem to be used during EIA's, when wetlands might be destroyed. But at a strategic level, not at all.

Consent to use this information in my Research Thesis and Academic Articles

Yes ☑ No ☐

Thank you for taking time to participate in this questionnaire and for taking part in this study / project. Your feedback is appreciated.

Post-Presentation Questionnaires

Job Description:

Department:

1. Do you think WET-Health provides relevant information about how many wetlands can be found occupying a specific area of interest it clearly identifies what hydrogeomorphic type the wetlands are and indicates the spatial extent of them thereof? If yes, how does it achieve doing this?

Yes ☒ No ☐

By doing level 1 assessment, the user can determine the HGM unit of a wetland.

2. How did WET-EcoServices give meaningful insight into the goods and services the wetlands provide? Give a reason to support your answer.

Yes ☒ No ☐

The table ~~with the services that wetlands~~ ~~pr~~ clearly outlines the services that wetlands provides & the extent to which the services can be provided depending on the HGM type.

3. What would you consider the appropriate level of assessment to be from the detail of results indicated by the varying WET-Health and WET-EcoServices level 1s and 2s?

WetHealth 1 - HGM unit; drains;
2 - overall health of a wetland taking into account the surrounding land-use; disturbance; level of modificatio

4. Did this study provide necessary information that would meet Durban Metropolitan's needs in terms of managing wetlands more effectively and efficiently? If yes, how so?

Yes ☒ No ☐

Level 1 assessments of both WetHealth & WetEcoservices can be used to make informed comments by looking at wetlands holistically (ie. HGM units; level of disturbance) then offer better protection.

5. How well did the tools take wetlands into consideration with respect to land use planning decision making? Explain your response.

Yes both tools did. The tools clearly 'defines' the wetlands and takes into account the surrounding land-use when coming-up with an overall score.

6. Do you think the methods of this study / project can be applied to other catchments within Durban Metropolitan's jurisdiction? If yes, why is this so?

Yes ☒ No ☐

The tool can be adapted to other catchments, however the difficulty is that currently eThekwini does not use quanary catchments. ~~and use~~

Consent to use this information in my Research Thesis and Academic Articles

Yes ☒ No ☐

Thank you for taking time to participate in this questionnaire and for taking part in this study / project. Your feedback is appreciated.

Job Description: Environmentalist : Biodiversity assessment

Department: EPCPD

1. Do you think WET-Health provides relevant information about how many wetlands can be found occupying a specific area of interest it clearly identifies what hydrogeomorphic type the wetlands are and indicates the spatial extent of them thereof? If yes, how does it achieve doing this?

Yes ☑ No ☐

It takes the user through a detailed process that requires these things to be investigated. It also provides some base info on what HGM types there are and how to assign them.

2. How did WET-EcoServices give meaningful insight into the goods and services the wetlands provide? Give a reason to support your answer.

Yes ☐ No ☐

It assesses various characteristics of the wetland that allow it to provide ecoservices (e.g. surface roughness for flood attenuation)

The tool provides scores the represent how well the wetland is providing each service.

3. What would you consider the appropriate level of assessment to be from the detail of results indicated by the varying WET-Health and WET-EcoServices level 1s and 2s?

Level 2s in both cases are more accurate and are perhaps more appropriate when detailed info is required for a single system. However level 1 would be more appropriate for more strategic assessments

4. Did this study provide necessary information that would meet Durban Metropolitan's needs in terms of managing wetlands more effectively and efficiently? If yes, how so?

Yes ☑ No ☐

seems like it

It will show that level 1 assessments are very useful, and can be fairly accurate if the correct expertise are available. The results of the study are also useful in backing up reasons why these system should be managed or rehabed.

5. How well did the tools take wetlands into consideration with respect to land use planning decision making? Explain your response.

Very well. The tools both require that the condition of the catchment be taken into account.

6. Do you think the methods of this study / project can be applied to other catchments within Durban Metropolitan's jurisdiction? If yes, why is this so?

Yes ☑ No ☐

Both tools are in a fairley advanced stage and have a high level of acceptance amongst the academic and consulting sectors.

Consent to use this information in my Research Thesis and Academic Articles

Yes ☑ No ☐

Thank you for taking time to participate in this questionnaire and for taking part in this study / project. Your feedback is appreciated.

Appendix 2: WET-Health Assessments

Please note that All Tables are adapted from the WET-Health guidebook except for the results which was completed for the particular study sites in this research (Macfarlane, Kotze, Ellery, Walters, Koopman, Goodman, and Goge: 2008)

Appendix 2 consists of all the WET-Health level 1 and 2 data sheets used during the assessment of the three wetlands in this study. There are three sections which WET-Health highlights which must be assessed namely; hydrology, geomorphology and vegetation. Within each of these three sections are various indicators that when addressed during field work would yield information about the condition of the wetland or what state it is in, for example, if it is natural or highly modified due to external factors such as land use change or mining in the wetland's surrounding catchment. This is important to understand as wetlands are important features in the ecosystem since they for example, purify water and promote and sustain biodiversity. This tool was relevant to the study because it can assess wetlands and ensure that munuicpalities are aware of wetlands that are in poor condition. These could then assist the management decisions which may proceed so as to the caring for a degraded wetland to restore it, or to not allocate resources and funds into that particular wetland as it has been completely transformed.

WET-Health | **Robert Armstrong Wetland** | Level 1

PAGE 1: SUMMARY PAGE

STEP 1: IDENTIFY THE HGM TYPES IN THE WETLAND AND DIVIDE THE WETLAND INTO HGM UNITS

HGM Unit	HGM Type	Ha	Extent (%)*
1	Valley-bottom with a channel	5.4	100
Total		**5.4**	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated. If this is the case, "1" must be included in the Ha column to ensure that calculations in the summary table still work.

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INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 5: REPRESENT THE HEALTH SCORES FOR THE OVERALL WETLAND

Table 5.28. Summary of the overall health of the wetland based on impact score and change score.

HGM Unit	Ha	Extent (%)	Hydrology		Geomorphology		Vegetation	
			Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
1	5	100	4.0	0	1.1	0	7.8	-1
Area weighted impact scores*			**4.0**	**0.0**	**1.1**	**0.0**	**7.8**	**-1.0**
PES Category (See Table 5.29)			**D**	→	**B**	→	**E**	↓

* The total impact score for the wetland as a whole is calculated by summing the area-weighted HGM scores for each HGM unit.

HGM Unit	Threat descriptions		
	Hydrology	Geomorphology	Vegetation
1	Alien vegetation in wetland	None	More aliens coming in

Table 5.29: Present Ecological State categories used to define health of wetlands.

Description	Combined impact score	PES Category
Unmodified, natural.	0-0.9	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2-3.9	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4-5.9	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 - 10	F

PAGE 2: HGM UNIT 1

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 2A: EVALUATE CHANGES TO WATER INPUT CHARACTERISTICS FROM THE CATCHMENT

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes
Reduction in flows (water inputs)	Table 5.1	-3	Sugarcane
Increase in flows (water inputs)	Table 5.1	0	
Combined impact Score		**-3**	
Change in flood patterns (peaks)	Table 5.2	-3	
Magnitude of impact Score	Table 5.3	**2.5**	Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.

STEP 2B: EVALUATE CHANGES TO WATER DISTRIBUTION & RETENTION PATTERNS WITHIN THE WETLAND

	Intensity rating guidelines	Extent (%)[1]	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Gullies and artificial drainage channels	Table 5.5	1	1.5	0.015	
Modifications to existing channels	Table 5.6	10	3	0.3	
Reduced roughness	Table 5.7	97	1.5	1.455	
Impeding features (e.g. dams) – upstream effects	Table 5.8	0	0	0	
Impeding features – downstream effects	Table 5.9	13.2	3	0.396	
Increased on-site water use	Table 5.10	75	1.5	1.125	
Deposition/infilling or excavation	Table 5.11	10	3	0.3	
Combined impact Score [3]				**3.6**	

1 Extent refers to the extent of the HGM unit affected by the modification expressed as a percentage of the total area of the HGM unit

2 Magnitude = Extent /100 x Intensity

3 Calculated as the sum of magnitude scores across all modifications

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 3A: DETERMINE THE PRESENT GEOMORPHIC STATE OF INDIVIDUAL HGM UNITS

Impact type	Applicability to HGM type	Extent rating guidelines	Extent (%) [1]	Intensity rating guidelines	Intensity (0 - 10)	Magnitude [2]	Land-use factors contributing to impacts, and any additional notes
Daignostic component							
(1) Upstream dams	Floodplain	See below [3]	0	Table 5.14	0	0.0	
(2) Stream diversion/shortening	Floodplain, Channeled VB	See below [4]	10	Table 5.15	4	0.4	
(3) Infilling	Floodplain, Channeled VB	See below [5]	10	See below [5]	7	0.7	
(4) Increased runoff	Non-floodplain HGMs	Table 5.16	0	Table 5.16	0	0.0	
Indicator-based component							
(5) Erosional features	All non-floodplain HGMs	Table 5.17	0	Table 5.18	0	0.0	
(6) Depositional features	All non-floodplain HGMs	Table 5.19	0	Table 5.20	0	0.0	
(6) Loss of organic matter	All non-floodplain HGMs with peat	see below[6]	0	Table 5.21	0	0.0	
Combined Impact Score based on a sum of all magnitude scores[7]						1.1	

1 Extent refers to the extent of the HGM unit affected by the modification, expressed as a percentage of the total area of the HGM unit

2 Magnitude = Extent (%)/100 x Intensity

3 Extent is determined based upon the area of the HGM unit that is flooded (in the case of a dam in the HGM unit) and the area of the HGM unit area downstream of the dam (for a dam upstream of the HGM unit, this will be 100% of the HGM unit).

4 Extent of area affected by stream straightening is expressed by measuring the length of the wetland affected by stream straightening and expressing this as a percentage of the overall length of the HGM unit. Extent of the wetland affected by stream diversions is determined based upon a distance upstream of the point of diversion along the channel of 20 km if the sediment is sandy and 5 km if it is clayey (or to the upstream end of the HGM unit if this is less than the specified distance). The specified distances are given based on the fact that headward erosion in the stream channel advances much more readily through sand than through clay. Assume that in the example given below the sediment was clayey, then the length of wetland affected by diversion and straightening would be 5 + 6 km, which, expressed as a proportion of the total length of the wetland, would be 11/17 km= 65%.

5 Extent of area affected by infilling is based on the following guideline: for a small stream (i.e., 1st to 2nd order stream), filled area + 1 km upstream and downstream, and for a large

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 4A: FAMILIARIZATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 4B: IDENTIFY AND ESTIMATE THE EXTENT OF DISTURBANCE CLASSES

See Column 2 in Table below

STEP 4C: ASSESS THE CHANGES TO VEGETATION COMPOSITION IN EACH CLASS, AND INTEGRATE THESE FOR THE OVERALL WETLAND

Disturbance Class	Extent (%)	Table references	Intensity [1] (0 - 10)	Magnitude [2]	Additional Notes
Infrastructure	1	Table 5.22 (Descriptions) & Table 5.23 (Typical intensity Scores)	8	0.1	
Deep flooding by dams	0		0	0.0	
Shallow flooding by dams	0		6	0.0	
Crop lands	65		9	5.9	
Commercial plantations	0		9	0.0	
Annual pastures	0		9	0.0	
Perennial pastures	0		8	0.0	
Dense Alien vegetation patches.	20		7	1.4	
Sports fields	0		9	0.0	
Gardens	0		8	0.0	
Areas of sediment deposition/ infilling & excavation	10		4	0.4	
Eroded areas	0		7	0.0	
Old / abandoned lands (Recent)	0		7	0.0	
Old / abandoned lands (Old)	0		5	0.0	
Seepage below dams	2		3	0.1	
Untransformed areas	2		0	0.0	
			Overall weighted impact score [3]	7.8	

1 Default scores are provided which should be adjusted based on field investigations or local knowledge
2 Magnitude of impact score is calculated as extent / 100 x intensity of impact.
3 The overall magnitude of impact score for the HGM unit is the sum of magnitude cores for each disturbance class

STEP 4D: DETERMINE THE PRESENT OVERALL VEGETATION STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

PAGE 2: HGM UNIT 1

STEP 2: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE WETLAND

Vulnerability factor	0.9

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STEP 2A: IDENTIFY, MAP AND ASSESS IMPACT OF LAND-USE ACTIVITIES THAT REDUCE THE INFLOW QUANTITY TO THE HGM UNIT

Table 2.2: Different land-use types and activities potentially altering inflow quantities to the HGM unit from its upstream catchment, and the magnitude of their collective effect (1)

Reduced Flows

Land-use activity descriptors		Low High					Scores	Intensity of water loss (2)	Extent (%)	Magnitude (3)
		0	-2	-5	-8	-10				
Irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	Seasonal	Year-round	0	0.0	0	0.0
	(2) Prevalence of water conserving practices[R]		High	Intermediate	Low		0			
Other abstractions not used for irrigation in the catchment (4)										
Alien plants	(1) plant type[R]			Shrubs	Trees		-6	-5.0	30	-1.5
	(2) Distribution of alien woody plants in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-5			
Plantations	(1) Tree type[R]				Wattle & pine	Eucalyptus	0	0.0	0	0.0

	(2) Distribution of tree plantations in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Sugar (5)	(1) Crop type[R]		Sugar				-2	-1.8	70	-1.3
	(2) Distribution in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-2			
Dams: specific allowance for releasing low flows within the operating rules of the dam[R]				Allowance made	No allowance		-5	-4.5	4	-0.2
Overall magnitude of reduction in water inputs to the HGM unit as the sum of all the above impact magnitudes:										**-2.9**

Increased Flows

Description of the level of increase	**Magnitude score**
Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).	10
Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.	7
Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).	3
No increase, or flow is increased by a negligible amount.	0
Magnitude of impact associated with increases in water inputs	0

Combined score: Increased flows score + Decreased flows score The combined score will range from -10 to +10, depending on the magnitude of the factors causing an increase or decrease in flow respectively	**-2.9**

STEP 2B: ASSESS THE INTENSITY OF IMPACT OF FACTORS POTENTIALLY ALTERING FLOW PATTERNS TO THE HGM UNIT

Table 2.3: Factors potentially contributing to a decrease or increase of floodpeak magnitude and/or frequency received by the HGM unit

Level of reduction	Low		High	Score

	0	-2	-5	-8	-10	
(1) Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R*]	<20%	20-35%	36-60%	60-120%	>120%	0
(2) Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	High	0
(3) Specific allowance for natural floods within the operating rules of the dam[R] **	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	-5
Level of increase	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
(4) Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	2
(5) Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R***]	<10%	11-40%	41-80%	>80%		0
Combined Score: [Ave of (1), (2) and (3)] + (4) + (5)] adjusted**						**0.3**

Table 2.4: Level of alteration of the natural pattern of floods delivered to the HGM unit

Combined score	Alteration classes	Description
>6	Large increase	Floodpeaks have been substantially increased, resulting in the marked reduction of sub-surface water inputs.
4 to 6	Moderate increase	Floodpeaks have been moderately increased, often resulting in the noticeable reduction of sub-surface water inputs
1.6 to 3.9	Small increase	Discernable but small increase in floodpeaks that may not necessarily have resulted in the discernable reduction of sub-surface water inputs.
-1.5 to 1.5	No effect	No discernable effect on floodpeaks.
-1.6 to -3.9	Small decrease	Discernable but small reduction in floodpeaks.
-4 to -6	Moderate decrease	Floodpeaks have moderately decreased.

<-6	Large decrease	Floodpeaks greatly reduced, such that in the case of a floodplain, no further flooding out of the main channel across the wetland takes place unless during major floods (i.e. >1 in 20 year flood events).

STEP 2C: ASSESS THE COMBINED MAGNITUDE OF IMPACT OF ALTERED QUANTITY AND PATTERN OF INPUTS, ACCOUNTING FOR THE WETLAND UNIT'S VULNERABILITY

Reduction in quantity of water inputs (Table 2.2):	**-2.9**

Alteration to floodpeaks (Table 2.3):	**0.3**

Table 2.5: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs.

(a) Floodplains and channeled valley bottoms driven primarily by over-bank flooding

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Score from Table 2.3)**						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to	(-4 to -6)	(<-6)
> 9	7	6	5	4	5	6	7
4 - 9	5	4	3	3	4	6	7
1-3.9 (Increase)	3	2	1	1	2.5	4.5	7
-0.9- +0.9 (Negligible)	1	1	0	0	1	5	7.5
-1- -1.9 (Decrease)	2	1.5	1	1	2.5	5	7.5
-2- -3.9	3	2.5	2	2	4	6	8
-4- -5.9	4	3.5	3	3	5	7	8.5
-6- -7.9	-**	-**	-**	4	6	8	9
-8- -9	-**	-**	-**	-**	-**	9	9.5
< -9	-**	-**	-**	-**	-**	-**	10

(b) Other hydro-geomorphic settings, including floodplains and channeled valley bottoms driven primarily by lateral inputs (e.g. from tributaries)

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Table 2.3)**						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to -3.9)	(-4 to -6)	(<-6)
> 9	6	5	4	3	3	3.5	4

4 - 9	4.5	4	3	2	3	3	3
1-3.9 (Increase)	3	2	1	1	1	2	2.5
-0.9- +0.9 (Negligible)	2.5	1.5	0.5	0	0.5	1	1.5
-1- -1.9 (Decrease)	3.5	2.5	1.5	1	1.5	2	2.5
-1 - -3.9	4.5	3.5	2.5	2	2.5	3	3.5
-2 - -3.9	6	5	4	3.5	4	4.5	5
-4- -5.9	-**	-**	-**	5	5.5	6	6.5
-6- -7.9	-**	-**	-**	-**	-**	7.5	8
< -9	-**	-**	-**	-**	-**	-**	10

**These classes are unlikely, given that when there is a high level of reduction of quantity of inputs then there would be insufficient water to maintain unaltered or increased floodpeaks (i.e. a decrease in floodpeaks would be inevitable).

Magnitude of impact based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs:	0.5
Magnitude of impact adjusted to account for any change in seasonality:***	0.5

***If seasonality has been changed moderately then increase the magnitude of impact score by 1 and if it has been changed greatly then increase the magnitude of impact score by 2.

STEP 3: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE HGM UNIT HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES

STEP 3A: ASSESS MAGNITUDE OF IMPACT OF CANALIZATION AND STREAM MODIFICATION

Canalization

Note: Where more than one section of a HGM unit is affected by canalization, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.7: Characteristics affecting the impact of canalization on the distribution and retention of water in the HGM unit

Extent of HGM unit affected by canalization	ha	%
	0.12	2

Factors	Low High	Score

	0	2	5	8	10	
Characteristics of the wetland						
(1) Slope of the wetland	<0.5%	0.5-0.9%	1-1.9%	2-3%	>3%	8
(2a) Texture of mineral soil, if present*	Clay	Clay loam	Loam	Sandy loam	Sand/loamy sand	2
(2b) Degree of humification of organic soil, if present*	Completely amorphous (like humus)	Somewhat amorphous	Intermediate	Somewhat fibrous	Very fibrous	
(3) Natural level of wetness	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	5
Characteristics of the drains/gullies						
(4) Depth of the drains/gullies	<0.20 m	0.20-0.50 m	0.51-0.80 m	0.81-1.10	>1.10 m	2
(5) Density of drains (meters of drain per hectare of wetland)**	<25 m/ ha	26-100 m/ha	101-200 m/ha	201-400 m/ha	>400 m/ha	0
(6) Location of drains/gullies in relation to flows into and through the wetland[R]. Drains/gullies are located such that flows are:	Very poorly intercepted	Moderately poorly intercepted	Intermediately intercepted	Moderately well intercepted	Very well intercepted	0
(7) Obstructions in the drains/ gullies	Complete obstruction	High obstruction	Moderate obstruction	Low obstruction	No obstruction	10
Calculate the mean score for factors 1, 2a or 2b, 3, 4 and 5						3.4
Multiply the score for factor 5 by the flow alteration factor (Table 2.1)						0.0
Mean score for above two scores						1.7
Intensity of impact for canalization: Divide the score for factor 7 by 10 and multiply this by the mean score derived in previous row						1.7

Note: Leave either 2a OR 2b blank

Magnitude of impact of canalization: Extent of impact/100 × intensity of impact calculated in the row above	**0.0**

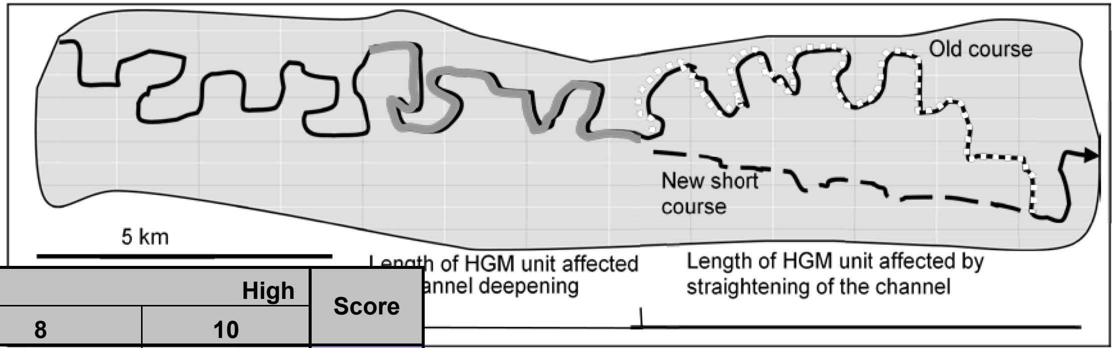
Stream channel modification

Note: Where more than one section of a HGM unit is affected by stream channel modification, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.8: Characteristics affecting the impact on the distribution and retention of water in the HGM unit through the modification of a stream channel

	%
Extent of HGM unit affected by stream channel modification*	10
HGM weighting factor	0.3

*should be expressed as a percentage of the length of the HGM unit (See diagram alongside)



Characteristics of stream channel	Low				High	Score
	0	2	5	8	10	
(1) Reduction in length of stream per unit valley length[D]	<5%	5 – 25%	25 – 50%	50 – 75%	75 – 100%	5
(2) % increase in cross sectional area of the stream[F]	<5%	5 – 25%	26 – 50%	51 – 75%	>75%	0
(3) Change in surface roughness in relation to the surface roughness of the channel in its natural state (see Table 2.9 for description of roughness classes)	Roughness is increased or is unchanged[1]	Decrease in roughnes s is moderate (i.e. by one class)	Decre ase in roughn ess is high (i.e. by two classe s)	Decrease in roughness is very high (i.e. by three or more classes)		8
Intensity of impact: use the maximum score of factors 1 to 3 x HGM weighting factor*						**2.4**
Magnitude score of impact of stream channel modification: extent of impact/100 × intensity of impact						**0.2**

Table 2.10: Calculation of the magnitude of impact of canalization and modification of a stream channel on the distribution and retention of water in a wetland HGM unit

Overall magnitude of impact score: canalization and stream channel modification	Score
Calculate the sum of scores from Tables 2.7 and 2.8.	0.3

STEP 3B: ASSESS MAGNITUDE OF IMPACT OF IMPEDING FEATURES

Note: Where more than one section of a HGM unit is affected by an impeding feature, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.11: Typical changes in water-distribution and -retention patterns within an HGM unit as a result of impeding structures

result of impeding structures

(a) Upstream impact of flooding

Extent Assessment	ha	%
(a) Extent of HGM unit affected by flooding **upstream** of the impeding structure	0.0	0

Descriptor	Low High					Score
	0	2	5	8	10	
Representation of different hydrological zones prior to flooding by the dam[R]	-	Seasonal and permanent zone both present and collectively >30%	Permanent and seasonal zones both present but collectively <30%	Seasonal zone present but permanent zone absent	Permanent and seasonal zones lacking (i.e. only the temporary zone present)	0
Intensity of impact: score for above factor X 0.8						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

(b) Downstream impact on quantity and timing of flows to downstream portion of the HGM unit

Extent Assessment	ha	%
(b) Extent of HGM unit affected by flooding **downstream** of the impeding structure	0.5	10

	Low 0	2	5	8	High 10	Score
Extent to which dams or roads interrupt low flows to downstream areas [R]	No interruption (e.g., many culverts through a road embankment)	Slight interruption (e.g., a moderate number of culverts through a road embankment)	Intermediate interruption (e.g. earth dam with very high seepage or road embankment with no/ very limited culverts)	Moderately high interruption (e.g. earth dam with some seepage/ flow releases)	High interruption (e.g. a concrete dam with no seepage and no low flow releases)	0
Level of abstraction from the dam/s [R]	Low	Moderately low	Intermediate	Moderately high	High	0
Location of dam/s relative to the affected area's catchment- proportion of catchment flows intercepted [D]	Dam intercepts <20% of the affected area's catchment	Dam intercepts 21-40% of the affected area's catchment	Dam intercepts 41-60% of the affected area's catchment	Dam intercepts 61-80% of the affected area's catchment	Dam intercepts >80 % of the affected area's catchment	2
Collective volume of dam/s in relation to MAR of the affected area[D]	<20%	20-35%	36-60%	60-120%	>120 %	0
Intensity of impact: mean score of the two highest scoring factors x 0.8						0.7
Magnitude-of-impact score: extent of impact /100 × intensity of impact						**0.1**

(c) Combined impact

Combined impact: Magnitude of impact for upstream + Magnitude of impact for downstream	0.1

STEP 3C: ASSESS MAGNITUDE OF IMPACT OF ALTERED SURFACE ROUGHNESS

Table 2.12: Comparison of surface roughness of an HGM unit in its current state compared with its natural state

Extent of HGM unit affected by change in surface roughness	ha	%
	4.05	75

Class	Descriptor	Current	Historic
Low	Smooth surface with little or no vegetation to offer resistance to water flow	Moderately high	Moderate
Moderately low	Vegetation is present but short (i.e. < 500mm) and not robust (e.g. rye grass)		
Moderate	Vegetation offering slight resistance to water flow, generally consisting of short plants (i.e. < 1 m tall)		
Moderately high	Robust vegetation (e.g. dense stand of reeds) or hummocks offering high resistance to water flow		
High	Vegetation very robust (e.g. dense swamp forest with a dense under storey) and offering high resistance to water flow.		

Note: Where roughness varies across the HGM unit, take the average condition, and where roughness varies over time (e.g. areas which are regularly cut short) take the average condition during the wet season.

Descriptor	Low 0	2	5	8	High 10	Score
Change in surface roughness in relation to the surface roughness of the wetland in its natural state[F]	Roughness increased or is unchanged[*]	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three		0

				or more classes)		
Intensity of impact: score for the above row X 0.6						0
Magnitude of impact score: extent of impact /100 × intensity of impact						0.0

*It is considered to be of greater consequence to water retention and distribution if the surface roughness of a wetland is decreased than if it is increased, therefore the focus of this assessment is primarily on a decrease in surface roughness.

STEP 3D: ASSESS THE IMPACT OF DIRECT WATER LOSSES

Table 2.13: Evaluating the effect of alien woody plants, commercial plantations and sugarcane growing in the HGM unit on water loss

Land-use activity descriptors	Low				High	Score	Intensity of water loss*	Extent (%)	Magnitude**
	0	2	5	8	10				
(1) Alien woody plant type[F]			Shrubs	Trees		6	5.4	22	1.3
(1) Plantation tree type[F]				Wattle & pine	Eucalyptus	0	0	0	0.0
(1) Sugarcane Growth[F]		Poor growth	Good growth			5	4.5	75	3.8
(4) Direct water abstractions		Low	Moderately low	Moderately high	High	0	0	0	0.0
Overall magnitude of increased water loss: (sum of (1), (2), (3) and (4)) x 0.8									4.1

*Intensity= Score x Vulnerability factor (from Table 2.1) **Magnitude=Intensity x Extent (%)/100

Note: When assessing extent, remember that the extent of the impact may extend beyond the direct area in which the alien woody plants or plantations occur in the HGM unit to also include a downstream portion subject to reduced flows. If this is the case, adjust the score accordingly with documented justification.

STEP 3E: ASSESS THE MAGNITUDE OF IMPACT OF RECENT DEPOSITION, INFILLING OR EXCAVATION

Table 2.14 Magnitude of impact of recent deposition, infilling or excavation

Extent Assessment	ha	%
Extent of HGM unit affected by deposition or excavation	0.5	10

Descriptor	Low				High	Score
	0	2	5	8	10	
Effect on vertical drainage properties of the uppermost soil layer	No effect	Rendered somewhat free-draining	Intermediate	Rendered free-draining	Rendered very well- drained*	10
Effect on the horizontal movement of water	No effect	Moderate modification	Large modification	Serious modification		2
Intensity of impact: use the highest score for the above two factors						10
Magnitude of impact score: extent of impact (%)/100 x intensity of impact x 1						1

*i.e. drainage is so free that the area no longer has any wetland characteristics

STEP 3F: DETERMINE COMBINED MAGNITUDE OF IMPACT OF ON-SITE ACTIVITIES

Table 2.15: Overall magnitude of impacts of on-site activities on water distribution and retention patterns n the HGM unit

Activity	Magnitude of impact	Justification for any modifications made
(1) Calculated magnitude of impact of canalization and stream channel modification from Table 2.10	0.3	
(2) Calculated magnitude of impact of impeding features from Table 2.11	0.1	
(3) Calculated magnitude of impact of altered surface roughness from Table 2.12	0.0	
(4) Calculated magnitude of impact of aliens, timber and/or sugarcane in the wetland from Table 2.13	4.1	
(5)) Calculated magnitude of impact of recent deposition/excavation from Table 2.14	1.0	
Total score of magnitude of on-site activities in the HGM unit (sum of the above scores)*	5.4	* If score is > 10, then magnitude of impact = 10

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF THE HGM UNIT THROUGH INTEGRATING THE ASSESSMENTS FROM STEPS 2 AND 3

Changes to water distribution & retention patterns (Table 2.15):	5.4

Changes to Water Inputs (Table 2.5):	0.5

Table 2.16: Derivation of overall magnitude-of-impact scores through combining the scores obtained from the catchment and within-wetland assessments. The colour codes correspond to the impact categories given in Table 2.17.

			Water Inputs (Step 2 - Table 2.5)					
			None	Small	Moderate	Large	Serious	Critical
			0-0.9	1-1.9	2-3.9	4-5.9	6-7.9	8 - 10
Water distribution & retention patterns (Step 3, Table2.18)	None	0-0.9	0	1	3	5	6.5	8.5
	Small	1-1.9	1	1.5	3.5	6	7	9
	Moderate	2-3.9	3	3.5	4	6.5	7.5	9
	Large	4-5.9	5	6	6.5	7	8	9.5
	Serious	6-7.9	6.5	7	7.5	8	9	10
	Critical	8 - 10	8.5	9	9	9.5	10	10

Combined magnitude score as a result of impacts on hydrological functioning	5

Wet-Health

Robert Armstrong Wetland Geomorphology Module Level 2

PAGE 1: SUMMARY PAGE

STEP 1: MAP EACH HGM UNIT AND IDENTIFY WHICH INDIVIDUAL ASSESSMENTS ARE REQUIRED

HGM Unit	HGM Type	Ha	Extent (%)*

Legend

1	Valley-bottom with a channel	5.4	100	Enter information
Total		**5.4**	**100**	

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

STEP 5: DETERMINE OVERALL PRESENT GEOMORPHIC STATE FOR THE WETLAND BY INTEGRATING SCORES OF INDIVIDUAL HGM UNITS

Table 3.19: Derivation of the overall Present Geomorphic State for the wetland being considered

HGM Unit number	Area (ha)	HGM unit extent (%)	HGM unit impact score (Table 3.17)	Area weighted impact score*	Present Geomorphic State Category
1	5	100	1.1	1.1	
Total		**0**	**Overall weighted impact score****	**1.1**	**B**

*Area weighted impact score = HGM extent /100 x impact score
**Overall area weighted impact score = sum of individual area weighted scores for each HGM unit

STEP 6: ASSESS VULNERABILITY AND TRAJECTORY OF CHANGE DUE TO EROSION

STEP 6A: ASSESS VULNERABILITY TO EROSION OF EACH HGM UNIT

HGM unit no.	Slope (%)	Area (ha)
1	2.4	5.4
6		5.4

Table 3.21: Tabulation of the geomorphic vulnerability of each HGM unit of the wetland

HGM unit no.	HGM unit type	Vulnerability score*	Extent of predicted headcut advancement (%)**	Comments (optional)
1	Valley-bottom with a channel	2	0	

HGM Unit	Description of relevant sources of change	HGM unit extent (%)	HGM Unit Change score*	Area-weighted change score**
1	Channel modification	100	0	0.0
			Overall weighted threat score:***	**0.0**

** Refer to Table 3.22 for a description of change classes

**Area weighted change score = HGM extent /100 x change score
***Overall area weighted change score = sum of individual area weighted scores for each HGM unit. Assign symbol based on Table 3.22.

STEP 7: DESCRIBE OVERALL GEOMORPHOLOGICAL HEALTH OF THE WETLAND BASED ON PRESENT GEOMORPHIC STATE AND TRAJECTORY OF CHANGE

Geomorphogical Health

Present Geomorphic State	B	see Table 3.18
Trajectory of Change	→	see Table 3.22

PAGE 2: HGM UNIT 1

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

Table 3.1: Guideline for assessing the impacts of activities according to HGM type

HGM type to assess	Activity/Indicator that should be assessed
Diagnostic component	
Floodplain	Dams upstream of or within floodplains (see Step 2A)
Floodplain, channeled valley bottom	Stream shortening or straightening (see Step 2B)
Floodplain, channeled valley bottom	Infilling that leads to narrowing of the wetland (see Step 2C)
All non-floodplain HGM's	Changes in runoff characteristics (see Step 2D)
Indicator-based component	
All non-floodplain HGM's	Erosional features (see Step 3A)
All non-floodplain HGM's*	Depositional features (see Step 3A)
All non-floodplain HGM's	Loss of organic sediment (see Step 3B)

* Consider floodplains if there are large alluvial fans impinging on the floodplain laterally to it (from the side).

HGM Type
Valley-bottom with a channel
If floodplain, are there large alluvial fans impinging laterally on the floodplain (from the side of the floodplain)?

Note: Steps that need to be completed are indicated with a "Yes" based on the HGM type selected in the summary page.

Step 2A: Impacts of dams upstream of and/or on floodplains	To assess?	No	See Table 3.1

Dams in the floodplain catchment

Table 3.2: Extent, intensity and magnitude of impacts of impoundments in the catchment

Extent of impact of dams situated above floodplains						Extent (%)
Extent: For dams upstream of floodplains extent is assumed to be 100%. If a dam is also situated on the floodplain, extent of impact for the dam above the floodplain is determined as the length of the floodplain above the dam / total floodplain length, expressed as a percentage						
Intensity of impact score – size of dams and nature of sediment transported						
Determine the size of dam/s on the stream and the nature of sediment load being transported						
	Small	Modest	Medium	Large	Very large	**Score**
	(<10 % MAR)	(10-20% MAR)	(20-40% MAR)	(40-80% MAR)	(>80% MAR)	

Suspended load dominated	0.5	1	1.5	2	2.5	
Mixed load	1	2	3	4	5	
Bedload dominated	2	3	4	5	5	
Intensity of impact score – location of dams in the catchment						
Score	**1**	**2**	**3**	**4**	**5**	**Score**
Location of dam/s	Dams on minor tributary stream or on trunk stream far upstream of floodplain	Intermediate between descriptions for scores 0 and 5	Dams on major tributary or on trunk stream a moderate distance upstream of floodplain	Intermediate between descriptions for scores 5 and 10	Dam on trunk stream immediately above floodplain	
Overall intensity of impact score for dams situated above floodplains: mean of above 2 scores						0.0
Magnitude of impact score for dams situated above floodplains: (extent of impact score/ 100) x overall intensity of impact score						0.0

Enter single score

Dams on the floodplain

Table 3.3: Extent, intensity and magnitude of impact of impoundments within the floodplain.

Extent of impact of dams situated within floodplains						**Extent (%)**
Extent: The percentage of the floodplain valley length flooded by the dam and below the dam wall						
Intensity of impact of dams situated within floodplains						
SCORE	**1**	**2**	**3**	**4**	**5**	**Score**
Size of dam	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	
Configuration of spillway/s			Baseflows to floodplain stream: peak flows to backswamp	Baseflows and peak flows to floodplain stream **OR** baseflows to backswamp and peak flows to floodplain stream	Baseflows and peak flows to backswamp	
Overall intensity of impact score for dams situated within floodplains: mean of above 2 scores						0
Magnitude of impact score for dams situated within floodplains: (extent of impact score / 100) x overall intensity of impact score						0.0

Combining impacts of dams in the catchment and on the floodplain

Table 3.4: Combining the magnitude of impact scores of impoundments upstream of and on the floodplain.

Magnitude of impact score for dams upstream of and on the floodplain	
Magnitude of impact score for dam/s located in the catchment (Table 3.2)	0.0
Magnitude of impact score for dam/s located within the floodplain (Table 3.3)	0.0
Overall magnitude of impact for floodplain wetlands with dams upstream of and on the floodplain = sum of above two rows	**0.0**

Impacts of channel straightening

To assess? **Yes** See Table 3.1

Table 3.5: Extent, intensity and magnitude of impacts of channel straightening

Extent of impact of channel straightening.						**Extent (%)**
Extent: the length of modification plus THE LESSER OF 10km for sandy stream beds OR 5km for silty/clayey stream beds OR the distance to the head of the floodplain OR to a dam wall (if present), expressed as a percentage of floodplain length[R]						10
Intensity of impact of channel straightening						
	0	**1**	**2**	**3**	**4**	Intensity
Reduction in stream length per unit valley length[R]	<5%	6-25%	26-50%	51-75%	>75%	2
Magnitude of impact of channel straightening: (extent of impact score/ 100) x intensity of impact score						**0.2**

Figure 3.2: Illustration of the calculation of extent of impact of channel straightening if the channel bed is silt or clay.

Step 2C: Impacts of artificial wetland infilling

To assess? **Yes** See Table 3.1

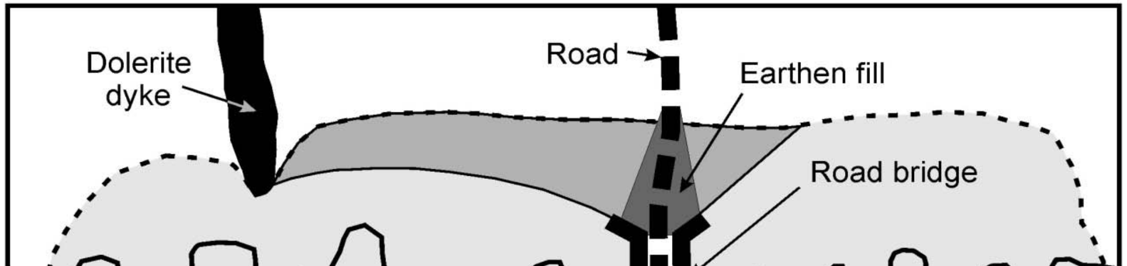


Table 3.6: Extent, intensity and magnitude of impact of infilling of floodplains and channeled valley bottom wetlands.

Extent of impact of infilling.						Extent (%)
Extent of impact of infilling as determined by establishing the area of wetland that will not be subjected to normal erosion and / or deposition, as a percentage of wetland area.						10
Intensity of impact of infilling						
	0	**1**	**2**	**3**	**4**	**Score**
Reduction in active wetland width at point of infillingR	<5%	6-25%	26-50%	51-75%	>75%	1
Magnitude of impact of infilling: (extent of impact score / 100) x intensity of impact score.						**0.1**

Step 2D: Impacts of changes in runoff characteristics

To assess? **Yes** See Table 3.1

Table 3.7: Effect of altered water inputs (increased flows and floodpeaks) on wetland geomorphological integrity

Extent of impact of altered water inputs						**Extent (%)**
Extent calculated based on length of wetland affected by increased flow as a proportion (%) of the entire wetland length.						0
Intensity of impact of altered water inputs						
		Increased floodpeaks (combined score in Table 2.3)				
		No effect (0-2)	Small increase (2.1-4)	Moderate increase (4.1-7)	Large increase (>7)	
Increased flows (increased flow score in Table 2.2)	No increase (0-2)	0	1	2	3.5*	
	Small increase (2.1-4)	1	1.5	3	4	
	Moderate increase (4.1-7)	2	3	4	4.5	
	Large increase (>7)	3.5*	4	4.5	5	
Change Score						2
Magnitude of impact score: (extent of impact score/100) x intensity of impact score (from above rows)						**0.0**

* Unlikely to occur

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

Step 3A: Impacts of erosion and/or deposition

Erosional features

To assess?	Yes

See Table 3.1

Table 3.8: Estimation of extent of impact of erosional features

		Length of wetland occupied by gully/ies as a percentage of the length of HGM[R]					
		0-20%	21-40%	41-60%	51-80%	>80%	
Average gully width (sum of gully widths if more than 1 gully present) in relation to wetland width[R]	< 5%	5%	10%	15%	20%	25%	
	5-10%	10%	15%	25%	35%	45%	
	11-20%	15%	25%	40%	55%	65%	
	21-50%	20%	30%	50%	70%	80%	**Extent (%)**
	>50%	25%	40%	60%	80%	100%	0

Table 3.9: Intensity and magnitude of impact of erosional features. The scores for rows 2 and 3 are unscaled for any natural recovery that may have taken place. Factors to use to scale the intensity of impact of erosional features for natural recovery are presented in rows 7 and 8.

Factor	**1**	**2**	**3**	**4**	**5**	**Unscaled score**
Mean depth of gullies[F]	<0.50m	0.50-1.00m	1.01-2.00m	2.00-3.00m	>3.00m	0
Mean width of gullies[F]	<2m	2-5m	5.1-8m	8.1-16m	>16m	0
Number of headcuts present[F]	1	2	3	4	>4	0
Unscaled intensity of impact score: mean score of above 3 rows						0.0
Scaling factor	**0.4**	**0.5**	**0.7**	**0.9**	**1**	**Factor**
Extent to which sediment from the gully is deposited within the HGM or wetland downstream of the HGM unit (as opposed to being exported)[F]	Entirely deposited	Mainly deposited	Intermediate	Mainly exported	Entirely exported	0
Extent to which the bed and sides of the gully have been colonized by vegetation and/or show signs of natural recovery[F]	Complete	High	Moderate	Low	None	0
Scaling factor score: mean of above 2 rows (value is between 0 and 1)						0.0
Scaled intensity of impact score = unscaled intensity of impact score x scaling factor score						0.0
Magnitude of impact score for erosional features: (extent of impact score (see Table 3.8)/100) × scaled intensity of impact score						**0.0**

Depositional features

To assess?	Yes

See Table 3.1

We are only interested here in recent depositional features. If the user feels confident in being able to map depositional features that can be attributed directly to recent human activity, then extent should be established directly using Table 3.10, but if they are not confident that they can do this, indirect indicators can be used as outlined in Table 3.11. Users may wish to use a combination of approaches by using the indirect indicators to assist in the location and mapping of depositional features in the wetland of interest, following which they may map depositional features directly, but ideally, one would only map these features directly.

Table 3.10: Estimation of the extent of impact of depositional features for known depositional features in the HGM unit.

Extent of depositional features in relation to area of HGM unit being considered	0.2-1.9%	2-10%	11-25%	26-50%	>50%	
Score for "extent" to be used in the estimation of magnitude of impacts	5	20	50	75	100	0

Table 3.11: Estimation of extent of depositional features based on indirect indicators of recent anthropogenic activity leading to excessive deposition.

Indicator	0	1	2	3	4	Score
Presence, size and distribution of gullies or active erosion of drains within the catchment or wetland	None or very small	Limited extent and size	Moderate size and distribution	Large size or widespread distribution	Very large size or widespread distribution	0
Presence / extent of dirt roads in the catchment	None / few	Moderate	Many / extensive			1
Breaching of upstream dams in the catchment or wetland	None	Very small earthen dams	Small earthen dams	Large earthen dams		0
Extent of decreased vegetation cover in the catchment	Slight	Moderate	High			0
Mean of two highest scores from the above						0.5
Extent of impact score of depositional features as a percentage is calculated as the score from the above multiplied by 10.						0

Table 3.12: Intensity and magnitude of impact of depositional features

Indicator	0	1	2	3	Score
The position of fan-like deposits within the wetland[R]		Toe	Middle	Upper	0
Impact of depositional features on existing wetland features[D]	Not evident	Minor destruction of features	Moderate destruction of features	Large impact on existing features	0
Intensity of impact score of depositional features: mean of two rows above					0
Magnitude of impact score of depositional features: (extent of impact score (Table 3.10 or 3.11) / 100) x intensity of impact score					**0.0**

Step 3B: Impacts of the loss of organic sediment	To assess?	Yes	See Table 3.1

Table 3.13: Extent of impact of the loss of organic sediment for direct indicators (A) and indirect indicators (B). Express results as a proportion of the total area of the HGM unit.

A. Extent of impact score based on direct indicators (if present)	75	%
B. Additional extent of impact score based on indirect indicators (if present)	0	%

To determine the intensity of impact in the affected area of the wetland, see Tables 3.14 and 3.15 for direct and indirect indicators respectively.

Direct indicators

Table 3.14: Macroscopic features (clearly visible direct indicators) determining the intensity of impact of the loss of organic sediments

Activity	1	2	3	4	5	Score
Depth of the peat fires or extraction of peat relative to the depth of the peat deposit	<5%	5-15%	16-30%	31-60%	>60%	0
If tillage is practiced, duration of tillage	1-2 yrs	3-5 yrs	6-10 yrs	>10 yrs		1
Intensity of impact score: maximum score of above scores						1.0
Magnitude of impact score of loss of organic sediments: (extent of impact score (Table 3.13A) /100) × intensity of impact score						0.8

Indirect indicators

Table 3.15: Indirect indicators (not clearly visible) reflecting the intensity of diminished integrity of organic sediments in the HGM unit.

	0	1	2	3	4	Intensity score
Level of desiccation of the region of the HGM unit in which peat accumulation is taking place*	Unmodified	Largely natural	Moderately modified	Largely modified	Serously / critically modified	0
Magnitude of impact score: extent of impact score (Table 3.13B)/100 × intensity of impact score						0.0

Overall magnitude of impact: Organic sediment

Table 3.16: Magnitude of impact score for organic sediments expressed as a proportion of the area of the entire HGM unit

	Overall magnitude of impact score: organic sediments
Sum of magnitude scores in Tables 3.14 and 3.15	**0.8**

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

Table 3.17: Derivation of overall magnitude-of-impact scores through combining the scores obtained from individual assessments.

Impact category	Score	To include?
1. Magnitude of impact of dams (Table 3.4)	N/A	No
2. Magnitude of impact of channel straightening (Table 3.5)	0.2	Yes
3. Magnitude of impact of infilling (Table 3.6)	0.1	Yes
4. Magnitude of impact of changes in runoff characteristics (Table 3.7)	0.0	Yes
5. Magnitude of impact for erosional features (Table 3.9)	0.0	Yes
6. Magnitude of impact for depositional features (Table 3.12)	0.0	Yes
7. Magnitude of impact for loss of organic sediment (Table 3.16)	0.8	Yes
Overall Present Geomorphic State = Sum of three highest scores	**1.1**	

Wet-Health

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PAGE 1: SUMMARY PAGE

STEP 1: MAP AND DETERMINE THE EXTENT OF EACH HGM UNIT

HGM Unit	HGM Type	Ha	Extent (%)*
1	Valley-bottom with a channel	5.4	100
	Total	**5.4**	**100**

Legend
Enter information

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: DETERMINE THE PRESENT VEGATATION STATE OF WETLAND VEGETATION IN EACH HGM UNIT

STEP 3: DETERMINE THE OVERALL PRESENT VEGETATION STATE FOR THE WETLAND

Table 4.7: Summary impact score for each HGM and assessment of overall Present Vegetation State of the wetland

HGM Unit	Area (ha)	HGM unit extent (%)	HGM unit magnitude of impact score (from Table 4.6)	Area weighted impact score*	Present Vegetation State category
1	5.4	100	8.4	8.4	
		100	**Overall weighted impact score****	**8.4**	**F**

*Area weighted impact score = HGM extent /100 x impact score

**Overall area weighted impact score = sum of individual area weighted scores for each HGM unit

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE HGM SHEETS)

STEP 4B: DETERMINE THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION IN THE WETLAND AS A WHOLE

Table 4.11: Evaluation of Trajectory of Change of vegetation in the entire wetland.

HGM Unit	Description of relevant sources of change	HGM unit extent (%) (Table 4.7)	HGM Change score*	Area-weighted change score**
1	Increasing alien vegetation	100	0	0.0
			Overall weighted threat score***	**0.0**

*Calculated for each HGM unit – See Table 4.10 in individual assessments

**Area weighted changescore = HGM extent /100 x HGM change score

***Overall area weighted change score = sum of individual area weighted scores for each HGM unit

STEP 5: DESCRIBE THE OVERALL VEGETATION HEALTH OF THE WETLAND BASED ON PRESENT VEGETATION STATE AND TRAJECTORY OF CHANGE

Vegetation Health

Present Vegetation State	F	see Table 4.8
Trajectory of change	→	see Table 4.9

STEP 6: RECORD THE ALIEN VEGETATION THAT IS PRESENT IN THE WETLAND

Table 4.12: Alien species identified and suspected factors contributing to current infestation levels.

HGM Unit	List the alien species present	Aerial extent of invasion (%)*	Suspected factors contributing to increased abundance
1	Lantana camara, Bamboo, Schinus terebinthifolius, Solanum mauritianum, Ricinus communis, Tagese minuta, Ageratum conyzoides, Canna indica, Arundo donax, Mangifera indica, Melia azedarach	22	Disturbance and lack of fire
		Threat of further invasion, given the current management:	**Low**

* Use Table 4.3 as a guide for estimating the total extent of alien plant cover in each HGM unit

Note: The above table is used to capture to combined extent of all listed alien species in each HGM unit. Where necessary – such as where a detailed weed control strategy must be developed - this table may be expanded to include separate extent estimates for each species present.

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PAGE 2: HGM UNIT 1

STEP 2: DETERMINE THE PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 2A: FAMILIARISATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 2B: IDENTIFY AND ESTIMATE THE EXTENT OF EACH DISTURBANCE CLASS IN THE HGM UNIT

Table 4.2: Description and extent of each disturbance class within the HGM unit

Disturbance class	Brief description of disturbance class	Extent (ha)*	Extent (%)
1	Alien vegetation	1.20	22.22
2	Cropland-sugarcane	4.00	74.07
3	Untransformed	0.20	3.70
		5.40	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

Table 4.6: Calculation of the HGM magnitude of impact score based on an area weighted magnitude of impact score for each disturbance class.

Disturbance class	Disturbance class extent (%) (from Table 4.2)	Intensity of impact score (from Table 4.5)	Magnitude of impact score*	Factors contributing to impact
1	22	8	1.8	
2	74	9	6.7	
3	4	0	0.0	
		HGM Magnitude of impact score**	**8.4**	

* Magnitude of impact score is calculated as extent / 100 x intensity of impact
** Overall magnitude of impact score for the HGM unit = sum of magnitude scores for each disturbance class.

STEP 2D: DETERMINE THE MAGNITUDE OF IMPACT SCORE AND PRESENT VEGETATION STATE OF EACH HGM UNIT

Calculated in Table 4.6 above

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

Table 4.10: Evaluation of Trajectory of Change of vegetation within an HGM.

Disturbance class	Source of change	Disturbance class extent (%) (Table 4.2)	Change score (Table 4.9)	Area-weighted change score*
1	Incorrect management of alien vegetation	22	0	0.0
2	Stable	74	0	0.0
3	Stable	4	0	0.0
			HGM change score**	0.0

*Area weighted change score = Disturbance Class extent /100 x change score

**HGM change score = sum of individual area weighted scores for each disturbance unit

PAGE 2: HGM UNIT 1

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 2A: EVALUATE CHANGES TO WATER INPUT CHARACTERISTICS FROM THE CATCHMENT

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes
Reduction in flows (water inputs)	Table 5.1	-4	
Increase in flows (water inputs)	Table 5.1	1	
Combined impact Score		**-3**	
Change in flood patterns (peaks)	Table 5.2	-1	
Magnitude of impact Score	Table 5.3	**3.5**	Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.

STEP 2B: EVALUATE CHANGES TO WATER DISTRIBUTION & RETENTION PATTERNS WITHIN THE WETLAND

	Intensity rating guidelines	Extent (%)[1]	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Gullies and artificial drainage channels	Table 5.5	0	0	0	
Modifications to existing channels	Table 5.6	0	0	0	
Reduced roughness	Table 5.7	0	0	0	
Impeding features (e.g. dams) – upstream effects	Table 5.8	0	0	0	
Impeding features – downstream effects	Table 5.9	0	0	0	
Increased on-site water use	Table 5.10	75	6	4.5	
Deposition/infilling or excavation	Table 5.11	0	0	0	
Combined impact Score [3]				**4.5**	

STEP 2C: DETERMINE THE OVERALL HYDROLOGICAL IMPACT SCORE OF THE HGM UNIT BASED ON INTEGRATING THE ASSESSMENTS FROM STEPS 2A AND 2B

Changes to water distribution & retention patterns	**Table Reference**	**4.5**	**Any additional notes**
Changes to Water Input charachteristics		**3.5**	
Combined Hydrology Impact Score	Table 5.12	**6.5**	

STEP 2D: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates hydrological impact scores from each HGM unit

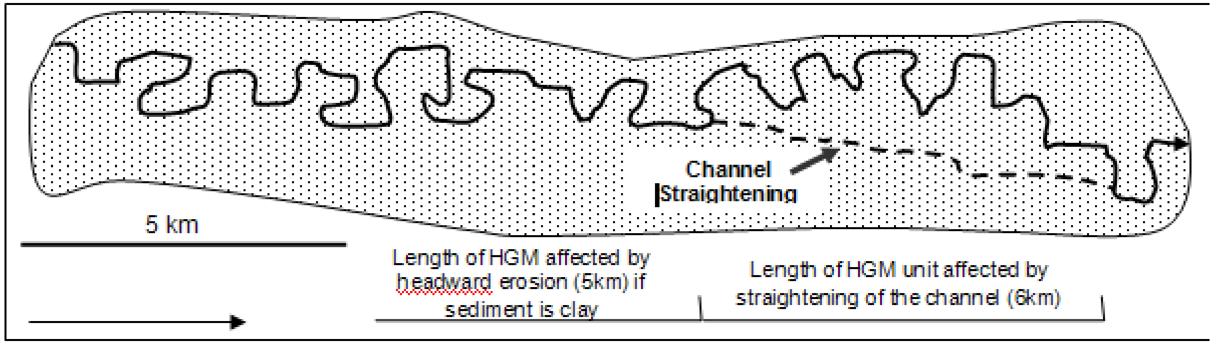
STEP 2E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND HYDROLOGY

HGM Trajectory of Change score	Table 5.27	-1

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 3A: DETERMINE THE PRESENT GEOMORPHIC STATE OF INDIVIDUAL HGM UNITS

Impact type	Applicability to HGM type	Extent rating guidelines	Extent (%)[1]	Intensity rating guidelines	Intensity (0 - 10)	Magnitude [2]	Land-use factors contributing to impacts, and any additional notes
Daignostic component							
(1) Upstream dams	Floodplain	See below [3]	0	Table 5.14	0	0.0	
(2) Stream diversion/shortening	Floodplain, Channeled VB	See below [4]	0	Table 5.15	0	0.0	
(3) Infilling	Floodplain, Channeled VB	See below [5]	0	See below [5]	0	0.0	
(4) Increased runoff	Non-floodplain HGMs	Table 5.16	0	Table 5.16	0	0.0	
Indicator-based component							
(5) Erosional features	All non-floodplain HGMs	Table 5.17	0	Table 5.18	0	0.0	
(6) Depositional features	All non-floodplain HGMs	Table 5.19	0	Table 5.20	0	0.0	
(6) Loss of organic matter	All non-floodplain HGMs with peat	see below[6]	0	Table 5.21	0	0.0	
Combined Impact Score based on a sum of all magnitude scores[7]						0.0	



STEP 3B: DETERMINE THE OVERALL PRESENT GEOMORPHIC STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates geomorphic impact scores from each HGM unit

STEP 3C: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND GEOMORPHOLOGY

HGM Trajectory of Change score	Table 5.27	**0**

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 4A: FAMILIARIZATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 4B: IDENTIFY AND ESTIMATE THE EXTENT OF DISTURBANCE CLASSES

See Column 2 in Table below

STEP 4C: ASSESS THE CHANGES TO VEGETATION COMPOSITION IN EACH CLASS, AND INTEGRATE THESE FOR THE OVERALL WETLAND

Disturbance Class	Extent (%)	Table references	Intensity [1] (0 - 10)	Magnitude [2]	Additional Notes
Infrastructure	0	Table 5.22 (Descriptions) & Table 5.23 (Typical intensity Scores)	10	0.0	
Deep flooding by dams	0		10	0.0	
Shallow flooding by dams	0		6	0.0	
Crop lands	0		9	0.0	
Commercial plantations	0		9	0.0	
Annual pastures	20		9	1.8	
Perennial pastures	0		8	0.0	
Dense Alien vegetation patches.	75		7	5.3	
Sports fields	0		9	0.0	
Gardens	0		8	0.0	
Areas of sediment deposition/ infilling & excavation	0		8	0.0	
Eroded areas	0		7	0.0	
Old / abandoned lands (Recent)	0		7	0.0	
Old / abandoned lands (Old)	0		5	0.0	
Seepage below dams	0		3	0.0	
Untransformed areas	5		0	0.0	
Overall weighted impact score [3]				7.1	

1 Default scores are provided which should be adjusted based on field investigations or local knowledge

2 Magnitude of impact score is calculated as extent / 100 x intensity of impact.

3 The overall magnitude of impact score for the HGM unit is the sum of magnitude cores for each disturbance class

STEP 4D: DETERMINE THE PRESENT OVERALL VEGETATION STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates vegetation impact scores from each HGM unit

STEP 4E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND VEGETATION

HGM Trajectory of Change score	Table 5.27	**-1**

PAGE 3: HGM UNIT 2

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 2A: EVALUATE CHANGES TO WATER INPUT CHARACTERISTICS FROM THE CATCHMENT

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes
Reduction in flows (water inputs)	Table 5.1	0.5	
Increase in flows (water inputs)	Table 5.1	3	
Combined impact Score		**3.5**	
Change in flood patterns (peaks)	Table 5.2	2	
Magnitude of impact Score	Table 5.3	**1.0**	Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.

STEP 2B: EVALUATE CHANGES TO WATER DISTRIBUTION & RETENTION PATTERNS WITHIN THE WETLAND

	Intensity rating guidelines	Extent (%)[1]	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts,

					and any additional notes
Gullies and artificial drainage channels	Table 5.5	0	0	0	
Modifications to existing channels	Table 5.6	0	0	0	
Reduced roughness	Table 5.7	0	0	0	
Impeding features (e.g. dams) – upstream effects	Table 5.8	0	0	0	
Impeding features – downstream effects	Table 5.9	0	0	0	
Increased on-site water use	Table 5.10	20	1.5	0.3	
Deposition/infilling or excavation	Table 5.11	20	3	0.6	
Combined impact Score [3]				**0.9**	

STEP 2C: DETERMINE THE OVERALL HYDROLOGICAL IMPACT SCORE OF THE HGM UNIT BASED ON INTEGRATING THE ASSESSMENTS FROM STEPS 2A AND 2B

Changes to water distribution & retention patterns	**Table Reference**	**0.9**	**Any additional notes**
Changes to Water Input charachteristics		**1.0**	
Combined Hydrology Impact Score	Table 5.12	**1.0**	

STEP 2D: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates hydrological impact scores from each HGM unit

STEP 2E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND HYDROLOGY

HGM Trajectory of Change score	Table 5.27	**-1**

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 3A: DETERMINE THE PRESENT GEOMORPHIC STATE OF INDIVIDUAL HGM UNITS

Impact type	Applicability to HGM type	Extent rating guidelines	Extent (%)[1]	Intensity rating guidelines	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Daignostic component							
(1) Upstream dams	Floodplain	See below [3]	0	Table 5.14	0	0.0	
(2) Stream diversion/shortening	Floodplain, Channeled VB	See below [4]	0	Table 5.15	0	0.0	
(3) Infilling	Floodplain, Channeled VB	See below [5]	0	See below [5]	0	0.0	
(4) Increased runoff	Non-floodplain HGMs	Table 5.16	0	Table 5.16	0	0.0	
Indicator-based component							
(5) Erosional features	All non-floodplain HGMs	Table 5.17	0	Table 5.18	0	0.0	
(6) Depositional features	All non-floodplain HGMs	Table 5.19	0	Table 5.20	0	0.0	
(6) Loss of organic matter	All non-floodplain HGMs with peat	see below[6]	0	Table 5.21	0	0.0	
Combined Impact Score based on a sum of all magnitude scores[7]						0.0	

STEP 3B: DETERMINE THE OVERALL PRESENT GEOMORPHIC STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates geomorphic impact scores from each HGM unit

STEP 3C: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND GEOMORPHOLOGY

HGM Trajectory of Change score	Table 5.27	0

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 4A: FAMILIARIZATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 4B: IDENTIFY AND ESTIMATE THE EXTENT OF DISTURBANCE CLASSES

See Column 2 in Table below

STEP 4C: ASSESS THE CHANGES TO VEGETATION COMPOSITION IN EACH CLASS, AND INTEGRATE THESE FOR THE OVERALL WETLAND

Disturbance Class	Extent (%)	Table references	Intensity [1] (0 - 10)	Magnitude [2]	Additional Notes
Infrastructure	1	Table 5.22 (Descriptions) & Table 5.23 (Typical intensity Scores)	9	0.1	
Deep flooding by dams	0		10	0.0	
Shallow flooding by dams	0		6	0.0	
Crop lands	0		9	0.0	
Commercial plantations	0		9	0.0	
Annual pastures	0		9	0.0	
Perennial pastures	0		8	0.0	
Dense Alien vegetation patches.	20		8	1.6	
Sports fields	0		9	0.0	
Gardens	0		8	0.0	
Areas of sediment deposition/ infilling & excavation	20		8	1.6	

Eroded areas	0		7	0.0	
Old / abandoned lands (Recent)	0		7	0.0	
Old / abandoned lands (Old)	0		5	0.0	
Seepage below dams	0		3	0.0	
Untransformed areas	59		0	0.0	
Overall weighted impact score [3]				3.3	

STEP 4D: DETERMINE THE PRESENT OVERALL VEGETATION STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates vegetation impact scores from each HGM unit

STEP 4E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND VEGETATION

HGM Trajectory of Change score	Table 5.27	-1

Wet-Health — Le Mercy Wetland Hydrology Module — Level 2

PAGE 1: SUMMARY PAGE

STEP 1: IDENTIFY HGM UNITS IN THE WETLAND AND DESCRIBE THE LOCAL CLIMATE

STEP 1A: IDENTIFY THE HGM TYPES IN THE WETLAND AND DIVIDE THE WETLAND INTO HGM UNITS

HGM Unit	HGM Type	Ha	Extent (%)*
1	Hillslope seepage linked to a stream channel	6.7	53

Legend
Enter information

2	Valley-bottom without a channel	6.0	47
	Total	**12.6**	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

STEP 1B: ASSESS THE VULNERABILITY OF THE HGM UNIT TO ALTERED WATER INPUTS BASED ON LOCAL CLIMATE

Table 2.1: Hydrological vulnerability factor based on the MAP:PET

MAP to PET ratio	>0.6	0.50-0.59	0.40-0.49	0.30-0.39	<0.3
Vulnerability factor	0.9	0.95	1	1.05	1.1
Vulnerability factor	0.9				

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: WATER INPUTS: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE UNIT FROM ITS UPSTREAM CATCHMENT.

STEP 3: WATER DISTRIBUTION AND RETENTION: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE HGM UNIT HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES.

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF EACH HGM UNIT BASED ON INTEGRATING THE SCORES FROM STEPS 2 AND 3.

STEP 5: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE FOR THE WETLAND BY INTEGRATING THE SCORES OF INDIVIDUAL HGM UNITS IN THE WETLAND.

Table 2.6: Health categories used by WET-Health for describing the hydrological integrity of wetlands

Table 2.18: Derivation of the overall impact score for the wetland being considered.

HGM Unit	Area (ha)	Extent (%)	Overall impact score for HGM unit	Area weighted HGM score*	Present Hydrological State category
1	7	53	6.5	3.4	
2	6	47	3.0	1.4	
Total		**100**	**Overall weighted impact score****	**4.8**	**D**

*Area weighted impact score = HGM extent /100 x impact score
** Overall area weighted impact score = sum of individual area weighted scores for each HGM unit

STEP 6: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF WETLAND HYDROLOGY.

Table 2.21: Evaluation of threats within each HGM unit.

HGM Unit	Description of sources of change	HGM extent	Change score*	Area-weighted score**
1	Increasing alien veg, possibly increasing pastures	53	-1	-0.5
2	Increasing alien veg and possibly more infilling	47	-1	-0.5
			Overall weighted threat score***:	**-1.0**

STEP 7: DESCRIBE THE OVERALL HYDROLOGICAL HEALTH OF THE WETLAND BASED ON PRESENT HYDROLOGICAL STATE AND TRAJECTORY OF CHANGE

Hydrological Health

Present Hydrological State	D	see Table 2.6
Trajectory of Change	↓	see Table 2.20

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PAGE 2: HGM UNIT 1

STEP 2: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE WETLAND

Vulnerability factor	0.9

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STEP 2A: IDENTIFY, MAP AND ASSESS IMPACT OF LAND-USE ACTIVITIES THAT REDUCE THE INFLOW QUANTITY TO THE HGM UNIT

Table 2.2: Different land-use types and activities potentially altering inflow quantities to the HGM unit from its upstream catchment, and the magnitude of their collective effect (1)

Reduced Flows

Land-use activity descriptors		Low High					Scores	Intensity of water loss (2)	Extent (%)	Magnitude (3)
		0	-2	-5	-8	-10				
Irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	Seasonal	Year-round	-5	-5.9	5	-0.3
	(2) Prevalence of water conserving practices[R]		High	Intermediate	Low		-8			
Other abstractions not used for irrigation in the catchment (4)										
Alien plants	(1) plant type[R]			Shrubs	Trees		-7	-5.4	25	-1.4
	(2) Distribution of alien woody plants in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-5			
Plantations	(1) Tree type[R]				Wattle & pine	Eucalyptus	0	0.0	0	0.0
	(2) Distribution of tree plantations in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			

Sugar (5)	(1) Crop type[R]		Sugar				-2	-1.8	25	-0.5
	(2) Distribution in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-2			
Dams: specific allowance for releasing low flows within the operating rules of the dam[R]				Allowance made	No allowance		0	0.0	0	0.0
Overall magnitude of reduction in water inputs to the HGM unit as the sum of all the above impact magnitudes:										**-2.1**

Increased Flows

Description of the level of increase	**Magnitude score**
Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).	10
Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.	7
Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).	3
No increase, or flow is increased by a negligible amount.	0
Magnitude of impact associated with increases in water inputs	0

Combined score: Increased flows score + Decreased flows score The combined score will range from -10 to +10, depending on the magnitude of the factors causing an increase or decrease in flow respectively	**-2.1**

STEP 2B: ASSESS THE INTENSITY OF IMPACT OF FACTORS POTENTIALLY ALTERING FLOW PATTERNS TO THE HGM UNIT

Table 2.3: Factors potentially contributing to a decrease or increase of floodpeak magnitude and/or frequency received by the HGM unit

Level of reduction	**Low**				**High**	**Score**
	0	**-2**	**-5**	**-8**	**-10**	

(1) Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R*]	<20%	20-35%	36-60%	60-120%	>120%	0
(2) Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	High	0
(3) Specific allowance for natural floods within the operating rules of the dam[R] **	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	0
Level of increase	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
(4) Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	0
(5) Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R***]	<10%	11-40%	41-80%	>80%		0
Combined Score: [Ave of (1), (2) and (3)] + (4) + (5)] adjusted**						**0.0**

STEP 2C: ASSESS THE COMBINED MAGNITUDE OF IMPACT OF ALTERED QUANTITY AND PATTERN OF INPUTS, ACCOUNTING FOR THE WETLAND UNIT'S VULNERABILITY

Reduction in quantity of water inputs (Table 2.2):	**-2.1**

Alteration to floodpeaks (Table 2.3):	**0.0**

Table 2.5: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs.

(a) Floodplains and channeled valley bottoms driven primarily by over-bank flooding

	Alteration to floodpeaks (Score from Table 2.3)						
Change in quantity of	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrea

water inflows (Score from Table 2.2)							se
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to	(-4 to -6)	(<-6)
> 9	7	6	5	4	5	6	7
4 - 9	5	4	3	3	4	6	7
1-3.9 (Increase)	3	2	1	1	2.5	4.5	7
-0.9- +0.9 (Negligible)	1	1	0	0	1	5	7.5
-1- -1.9 (Decrease)	2	1.5	1	1	2.5	5	7.5
-2- -3.9	3	2.5	2	2	4	6	8
-4- -5.9	4	3.5	3	3	5	7	8.5
-6- -7.9	-**	-**	-**	4	6	8	9
-8- -9	-**	-**	-**	-**	-**	9	9.5
< -9	-**	-**	-**	-**	-**	-**	10

(b) Other hydro-geomorphic settings, including floodplains and channeled valley bottoms driven primarily by lateral inputs (e.g. from tributaries)

Change in quantity of water inflows (Score from Table 2.2)	Alteration to floodpeaks (Table 2.4)						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to -3.9)	(-4 to -6)	(<-6)
> 9	6	5	4	3	3	3.5	4
4 - 9	4.5	4	3	2	3	3	3
1-3.9 (Increase)	3	2	1	1	1	2	2.5
-0.9- +0.9 (Negligible)	2.5	1.5	0.5	0	0.5	1	1.5
-1- -1.9 (Decrease)	3.5	2.5	1.5	1	1.5	2	2.5
-2-3.9	4.5	3.5	2.5	2	2.5	3	3.5
-4- -5.9	6	5	4	3.5	4	4.5	5
-6- -7.9	-**	-**	-**	5	5.5	6	6.5
-8- -9	-**	-**	-**	-**	-**	7.5	8
< -9	-**	-**	-**	-**	-**	-**	10

Magnitude of impact based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs:	**2**
Magnitude of impact adjusted to account for any change in seasonality:***	**2**

***If seasonality has been changed moderately then increase the magnitude of impact score by 1 and if it has been changed greatly then increase the magnitude of impact score by 2.

STEP 3: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE HGM UNIT HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES

STEP 3A: ASSESS MAGNITUDE OF IMPACT OF CANALIZATION AND STREAM MODIFICATION

Canalization

Note: Where more than one section of a HGM unit is affected by canalization, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.7: Characteristics affecting the impact of canalization on the distribution and retention of water in the HGM unit

Extent of HGM unit affected by canalization	ha	%
	0	0

Factors	Low				High	Score
	0	2	5	8	10	
Characteristics of the wetland						
(1) Slope of the wetland	<0.5%	0.5-0.9%	1-1.9%	2-3%	>3%	5
(2a) Texture of mineral soil, if present*	Clay	Clay loam	Loam	Sandy loam	Sand/loamy sand	2
(2b) Degree of humification of organic soil, if present*	Completely amorphous (like humus)	Somewhat amorphous	Intermediate	Somewhat fibrous	Very fibrous	
(3) Natural level of wetness	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	2
Characteristics of the drains/gullies						
(4) Depth of the drains/gullies	<0.20 m	0.20-0.50 m	0.51-0.80 m	0.81-1.10	>1.10 m	0

Note: Leave either 2a OR 2b blank

(5) Density of drains (meters of drain per hectare of wetland)**	<25 m/ ha	26-100 m/ha	101-200 m/ha	201-400 m/ha	>400 m/ha	0
(6) Location of drains/gullies in relation to flows into and through the wetland[R]. Drains/gullies are located such that flows are:	Very poorly intercepted	Moderately poorly intercepted	Intermediately intercepted	Moderately well intercepted	Very well intercepted	0
(7) Obstructions in the drains/ gullies	Complete obstruction	High obstruction	Moderate obstruction	Low obstruction	No obstruction	10
Calculate the mean score for factors 1, 2a or 2b, 3, 4 and 5						1.8
Multiply the score for factor 5 by the flow alteration factor (Table 2.1)						0.0
Mean score for above two scores						0.9
Intensity of impact for canalization: Divide the score for factor 7 by 10 and multiply this by the mean score derived in previous row						0.9
Magnitude of impact of canalization: Extent of impact/100 × intensity of impact calculated in the row above						**0.0**

Stream channel modification

Note: Where more than one section of a HGM unit is affected by stream channel modification, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.8: Characteristics affecting the impact on the distribution and retention of water in the HGM unit through the modification of a stream channel

	%
Extent of HGM unit affected by stream channel modification*	0
HGM weighting factor	0

Characteristics of stream channel	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
(1) Reduction in length of stream per unit valley length[D]	<5%	5 – 25%	25 – 50%	50 – 75%	75 – 100%	0
(2) % increase in cross sectional area of the stream[F]	<5%	5 – 25%	26 – 50%	51 – 75%	>75%	0

(3) Change in surface roughness in relation to the surface roughness of the channel in its natural state (see Table 2.9 for description of roughness classes)	Roughness is increased or is unchanged[1]	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: use the maximum score of factors 1 to 3 x HGM weighting factor*						**0**
Magnitude score of impact of stream channel modification: extent of impact/100 × intensity of impact						**0.0**

Table 2.10: Calculation of the magnitude of impact of canalization and modification of a stream channel on the distribution and retention of water in a wetland HGM unit

Overall magnitude of impact score: canalization and stream channel modification	**Score**
Calculate the sum of scores from Tables 2.7 and 2.8.	**0.0**

STEP 3B: ASSESS MAGNITUDE OF IMPACT OF IMPEDING FEATURES

Note: Where more than one section of a HGM unit is affected by an impeding feature, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.11: Typical changes in water-distribution and -retention patterns within an HGM unit as a result of impeding structures

result of impeding structures

(a) Upstream impact of flooding

Extent Assessment	**ha**	**%**
(a) Extent of HGM unit affected by flooding **upstream** of the impeding structure	0.0	0

Descriptor	**Low High**					**Score**
	0	**2**	**5**	**8**	**10**	
Representation of different hydrological zones prior to flooding by the dam[R]	-	Seasonal and permanent zone both present and collectively >30%	Permanent and seasonal zones both present but collectively <30%	Seasonal zone present but permanent zone absent	Permanent and seasonal zones lacking (i.e. only the temporary zone	0

					present)	
Intensity of impact: score for above factor X 0.8						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

(b) Downstream impact on quantity and timing of flows to downstream portion of the HGM unit

Extent Assessment	**ha**	**%**
(b) Extent of HGM unit affected by flooding **downstream** of the impeding structure	0.0	0

	Low				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
Extent to which dams or roads interrupt low flows to downstream areas [R]	No interruption (e.g., many culverts through a road embankment)	Slight interruption (e.g., a moderate number of culverts through a road embankment)	Intermediate interruption (e.g. earth dam with very high seepage or road embankment with no/ very limited culverts)	Moderately high interruption (e.g. earth dam with some seepage/ flow releases)	High interruption (e.g. a concrete dam with no seepage and no low flow releases)	0
Level of abstraction from the dam/s [R]	Low	Moderately low	Intermediate	Moderately high	High	0
Location of dam/s relative to the affected area's catchment- proportion of catchment flows intercepted [D]	Dam intercepts <20% of the affected area's catchment	Dam intercepts 21-40% of the affected area's catchment	Dam intercepts 41-60% of the affected area's catchment	Dam intercepts 61-80% of the affected area's catchment	Dam intercepts >80% of the affected area's catchment	0

Collective volume of dam/s in relation to MAR of the affected area[D]	<20%	20-35%	36-60%	60-120%	>120%	0
Intensity of impact: mean score of the two highest scoring factors x 0.8						0.0
Magnitude-of-impact score: extent of impact /100 × intensity of impact						**0.0**

(c) Combined impact

Combined impact: Magnitude of impact for upstream + Magnitude of impact for downstream	**0.0**

STEP 3C: ASSESS MAGNITUDE OF IMPACT OF ALTERED SURFACE ROUGHNESS

Table 2.12: Comparison of surface roughness of an HGM unit in its current state compared with its natural state

Extent of HGM unit affected by change in surface roughness	ha	%
	0	0

Class	Descriptor	Current	Historic
Low	Smooth surface with little or no vegetation to offer resistance to water flow	High	Moderate
Moderately low	Vegetation is present but short (i.e. < 500mm) and not robust (e.g. rye grass)		
Moderate	Vegetation offering slight resistance to water flow, generally consisting of short plants (i.e. < 1 m tall)		
Moderately high	Robust vegetation (e.g. dense stand of reeds) or hummocks offering high resistance to water flow		
High	Vegetation very robust (e.g. dense swamp forest with a dense under storey) and offering high resistance to water flow.		

Note: Where roughness varies across the HGM unit, take the average condition, and where roughness varies over time (e.g. areas which are regularly cut short) take the average condition during the wet season.

Descriptor	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	

Change in surface roughness in relation to the surface roughness of the wetland in its natural state[F]	Roughness increased or is unchanged*	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: score for the above row X 0.6						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

*It is considered to be of greater consequence to water retention and distribution if the surface roughness of a wetland is decreased than if it is increased, therefore the focus of this assessment is primarily on a decrease in surface roughness.

STEP 3D: ASSESS THE IMPACT OF DIRECT WATER LOSSES

Table 2.13: Evaluating the effect of alien woody plants, commercial plantations and sugarcane growing in the HGM unit on water loss

Land-use activity descriptors	Low			High		Score	Intensity of water loss*	Extent (%)	Magnitude**
	0	2	5	8	10				
(1) Alien woody plant type[F]			Shrubs	Trees		7	6.3	75	5.3
(1) Plantation tree type[F]				Wattle & pine	Eucalyptus	0	0	0	0.0
(1) Sugarcane Growth[F]		Poor growth	Good growth			0	0	0	0.0
(4) Direct water abstractions		Low	Moderately low	Moderately high	High	0	0	0	0.0
Overall magnitude of increased water loss: (sum of (1), (2), (3) and (4)) x 0.8									**4.2**

*Intensity= Score x Vulnerability factor (from Table 2.1) **Magnitude=Intensity x Extent (%)/100

Note: When assessing extent, remember that the extent of the impact may extend beyond the direct area in which the alien woody plants or plantations occur in the HGM unit to also include a downstream portion subject to reduced flows. If this is the case, adjust the score accordingly with documented justification.

STEP 3E: ASSESS THE MAGNITUDE OF IMPACT OF RECENT DEPOSITION, INFILLING OR EXCAVATION

Table 2.14 Magnitude of impact of recent deposition, infilling or excavation

Extent Assessment	ha	%
Extent of HGM unit affected by deposition or excavation	0.0	0

Descriptor	Low				High	Score	
	0	2	5	8	10		
Effect on vertical drainage properties of the uppermost soil layer	No effect	Rendered somewhat free-draining	Intermediate	Rendered free-draining	Rendered very well- drained*	0	*i.e. drainage is so free that the area no longer has any wetland characteristics
Effect on the horizontal movement of water	No effect	Moderate modification	Large modification	Serious modification		0	
Intensity of impact: use the highest score for the above two factors						0	
Magnitude of impact score: extent of impact (%)/100 x intensity of impact x 1						**0**	

STEP 3F: DETERMINE COMBINED MAGNITUDE OF IMPACT OF ON-SITE ACTIVITIES

Table 2.15: Overall magnitude of impacts of on-site activities on water distribution and retention patterns n the HGM unit

Activity	Magnitude of impact	Justification for any modifications made
(1) Calculated magnitude of impact of canalization and stream channel modification from Table 2.10	**0.0**	
(2) Calculated magnitude of impact of impeding features from Table 2.11	**0.0**	
(3) Calculated magnitude of impact of altered surface roughness from Table 2.12	**0.0**	
(4) Calculated magnitude of impact of aliens, timber and/or sugarcane in the wetland from Table 2.13	**4.2**	
(5)) Calculated magnitude of impact of recent deposition/excavation from Table 2.14	**0.0**	
Total score of magnitude of on-site activities in the HGM unit (sum of the above scores)*	**4.2**	* If score is > 10, then magnitude of impact = 10

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF THE HGM UNIT THROUGH INTEGRATING THE ASSESSMENTS FROM STEPS 2 AND 3

Changes to water distribution & retention patterns (Table 2.15):	4.2

Changes to Water Inputs (Table 2.5):	2

Table 2.16: Derivation of overall magnitude-of-impact scores through combining the scores obtained from the catchment and within-wetland assessments. The colour codes correspond to the impact categories given in Table 2.17.

			Water Inputs (Step 2 - Table 2.5)					
			None	Small	Moderate	Large	Serious	Critical
			0-0.9	1-1.9	2-3.9	4-5.9	6-7.9	8 - 10
Water distribution & retention patterns (Step 3, Table2.18)	None	0-0.9	0	1	3	5	6.5	8.5
	Small	1-1.9	1	1.5	3.5	6	7	9
	Moderate	2-3.9	3	3.5	4	6.5	7.5	9
	Large	4-5.9	5	6	6.5	7	8	9.5
	Serious	6-7.9	6.5	7	7.5	8	9	10
	Critical	8 - 10	8.5	9	9	9.5	10	10

Combined magnitude score as a result of impacts on hydrological functioning	6.5

PAGE 1: SUMMARY PAGE

STEP 1: MAP EACH HGM UNIT AND IDENTIFY WHICH INDIVIDUAL ASSESSMENTS ARE REQUIRED

HGM Unit	HGM Type	Ha	Extent (%)*
1	Hillslope seepage linked to a stream channel	6.7	53
2	Valley-bottom without a channel	6.0	47
Total		**12.6**	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

Legend
Enter information

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

STEP 5: DETERMINE OVERALL PRESENT GEOMORPHIC STATE FOR THE WETLAND BY INTEGRATING SCORES OF INDIVIDUAL HGM UNITS

Table 3.19: Derivation of the overall Present Geomorphic State for the wetland being considered

HGM Unit number	Area (ha)	HGM unit extent (%)	HGM unit impact score (Table 3.17)	Area weighted impact score*	Present Geomorphic State Category
1	7	53	0.3	0.2	
2	6	47	0.4	0.2	
Total		**0**	**Overall weighted impact score****	**0.3**	**A**

*Area weighted impact score = HGM extent /100 x impact score

**Overall area weighted impact score = sum of individual area weighted scores for each HGM unit

STEP 6: ASSESS VULNERABILITY AND TRAJECTORY OF CHANGE DUE TO EROSION

STEP 6A: ASSESS VULNERABILITY TO EROSION OF EACH HGM UNIT

HGM unit no.	Slope (%)	Area (ha)
1	1.7	6.7
2	1.2	6.0
6		12.6

Table 3.21: Tabulation of the geomorphic vulnerability of each HGM unit of the wetland

HGM unit no.	HGM unit type	Vulnerability score*	Extent of predicted headcut advancement (%)**	Comments (optional)
1	Hillslope seepage linked to a stream channel			
2	Valley-bottom without a channel			

* A score of 0 suggests that no change is likely, a score of 2 or 5 indicates that change may proceed slowly and dissipate a relatively short distance upstream, while a score of 8 or 10 suggests that headcut advance will be rapid and lead to substantial deterioration.

** Extent is determined by considering the length, width and number of gullies in relation to the extent of the wetland. We assume that the number of branches and their width will be the same as presently exist, but length will increase in an upstream direction until an obstacle to erosion is encountered (See Fig 3.9).

STEP 6B: DESCRIBE THE INCREASED EXTENT OF GULLIES IN RELATION TO ANY EXTERNAL CONTROLS

STEP 6C: ASSESS THE LIKELY TRAJECTORY OF CHANGE OF GEOMORPHIC STATE

Table 3.23: Evaluation of likely Trajectory of Change of geomorphic condition of the entire wetland.

HGM Unit	**Description of relevant sources of change**	**HGM unit extent (%)**	**HGM Unit Change score***	**Area-weighted change score****
1		53	0	0.0
2		47	-1	-0.5

Overall weighted threat score:***	-0.5

STEP 7: DESCRIBE OVERALL GEOMORPHOLOGICAL HEALTH OF THE WETLAND BASED ON PRESENT GEOMORPHIC STATE AND TRAJECTORY OF CHANGE

Geomorphogical Health

Present Geomorphic State	A	see Table 3.18
Trajectory of Change	↓	see Table 3.22

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PAGE 2: HGM UNIT 1

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

Table 3.1: Guideline for assessing the impacts of activities according to HGM type

HGM type to assess	Activity/Indicator that should be assessed
Diagnostic component	
Floodplain	Dams upstream of or within floodplains (see Step 2A)
Floodplain, channeled valley bottom	Stream shortening or straightening (see Step 2B)
Floodplain, channeled valley bottom	Infilling that leads to narrowing of the wetland (see Step 2C)
All non-floodplain HGM's	Changes in runoff characteristics (see Step 2D)
Indicator-based component	
All non-floodplain HGM's	Erosional features (see Step 3A)
All non-floodplain HGM's*	Depositional features (see Step 3A)
All non-floodplain HGM's	Loss of organic sediment (see Step 3B)

* Consider floodplains if there are large alluvial fans impinging on the floodplain laterally to it (from the side).

HGM Type
Hillslope seepage linked to a stream channel
If floodplain, are there large alluvial fans impinging laterally on the floodplain (from the side of the floodplain)?
Note: Steps that need to be completed are indicated with a "Yes" based on the HGM type selected in the summary page.

Step 2A: Impacts of dams upstream of and/or on floodplains	To assess?	No	See Table 3.1

Dams in the floodplain catchment

Table 3.2: Extent, intensity and magnitude of impacts of impoundments in the catchment

Extent of impact of dams situated above floodplains						Extent (%)	
Extent: For dams upstream of floodplains extent is assumed to be 100%. If a dam is also situated on the floodplain, extent of impact for the dam above the floodplain is determined as the length of the floodplain above the dam / total floodplain length, expressed as a percentage							
Intensity of impact score – size of dams and nature of sediment transported							
Determine the size of dam/s on the stream and the nature of sediment load being transported							
	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	**Score**	
Suspended load dominated	0.5	1	1.5	2	2.5		
Mixed load	1	2	3	4	5		Enter single score
Bedload dominated	2	3	4	5	5		
Intensity of impact score – location of dams in the catchment							
Score	**1**	**2**	**3**	**4**	**5**	**Score**	
Location of dam/s	Dams on minor tributary stream or on trunk stream far upstream of floodplain	Intermediate between descriptions for scores 0 and 5	Dams on major tributary or on trunk stream a moderate distance upstream of floodplain	Intermediate between descriptions for scores 5 and 10	Dam on trunk stream immediately above floodplain		
Overall intensity of impact score for dams situated above floodplains: mean of above 2 scores						0.0	
Magnitude of impact score for dams situated above floodplains: (extent of impact score/ 100) x overall intensity of impact score						0.0	

Dams on the floodplain

Table 3.3: Extent, intensity and magnitude of impact of impoundments within the floodplain.

Extent of impact of dams situated within floodplains	Extent (%)

Extent: The percentage of the floodplain valley length flooded by the dam and below the dam wall						
Intensity of impact of dams situated within floodplains						
SCORE	**1**	**2**	**3**	**4**	**5**	**Score**
Size of dam	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	
Configuration of spillway/s			Baseflows to floodplain stream: peak flows to backswamp	Baseflows and peak flows to floodplain stream **OR** baseflows to backswamp and peak flows to floodplain stream	Baseflows and peak flows to backswamp	
Overall intensity of impact score for dams situated within floodplains: mean of above 2 scores						0
Magnitude of impact score for dams situated within floodplains: (extent of impact score / 100) x overall intensity of impact score						0.0

Combining impacts of dams in the catchment and on the floodplain

Table 3.4: Combining the magnitude of impact scores of impoundments upstream of and on the floodplain.

Magnitude of impact score for dams upstream of and on the floodplain	
Magnitude of impact score for dam/s located in the catchment (Table 3.2)	0.0
Magnitude of impact score for dam/s located within the floodplain (Table 3.3)	0.0
Overall magnitude of impact for floodplain wetlands with dams upstream of and on the floodplain = sum of above two rows	**0.0**

Impacts of channel straightening

To assess?	No

See Table 3.1

Table 3.5: Extent, intensity and magnitude of impacts of channel straightening

Extent of impact of channel straightening.	**Extent (%)**
Extent: the length of modification plus THE LESSER OF 10km for sandy stream beds OR 5km for silty/clayey stream beds OR the distance to the head of the floodplain OR to a dam wall (if present), expressed as a percentage of floodplain length[R]	
Intensity of impact of channel straightening	

	0	1	2	3	4	Intensity
Reduction in stream length per unit valley length[R]	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of channel straightening: (extent of impact score/ 100) x intensity of impact score						**0.0**

Figure 3.2: Illustration of the calculation of extent of impact of channel straightening if the channel bed is silt or clay.

Step 2C: Impacts of artificial wetland infilling	**To assess?**	**No**	See Table 3.1

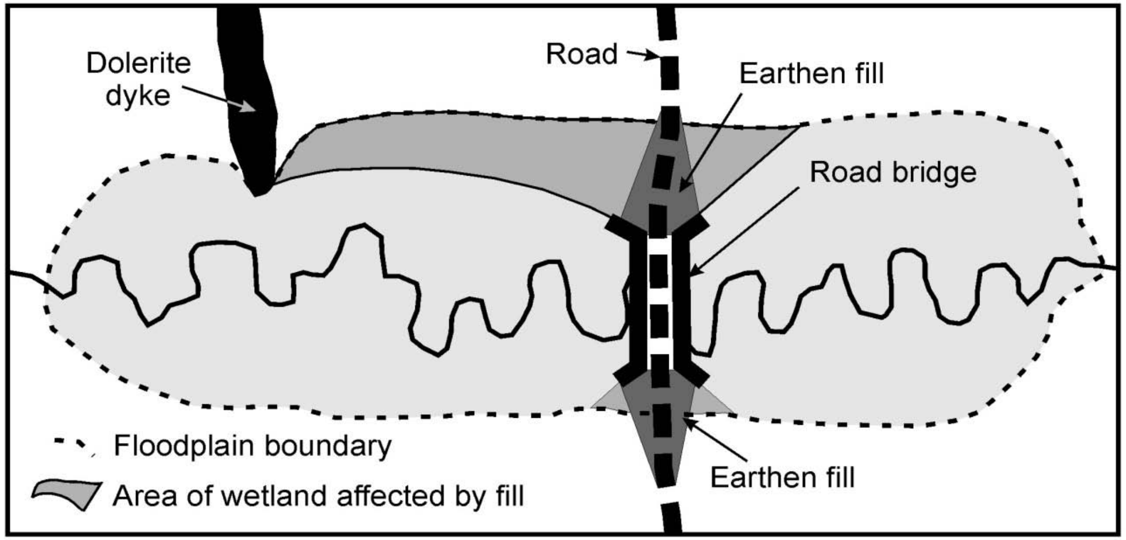

Figure 3.3: Illustr lley bottom wetlands.

Table 3.6: Extent

						Extent (%)
Extent of impact of i deposition, as a percentage of wetland area.						
Intensity of impact of infilling						
	0	**1**	**2**	**3**	**4**	**Score**
Reduction in active wetland width at point of infillingR	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of infilling: (extent of impact score / 100) x intensity of impact score.						**0**

Step 2D: Impacts of changes in runoff characteristics

To assess?	Yes	See Table 3.1

Table 3.7: Effect of altered water inputs (increased flows and floodpeaks) on wetland geomorphological integrity

Extent of impact of altered water inputs						Extent (%)
Extent calculated based on length of wetland affected by increased flow as a proportion (%) of the entire wetland length.						3
Intensity of impact of altered water inputs						
		Increased floodpeaks (combined score in Table 2.3)				
		No effect (0-2)	Small increase (2.1-4)	Moderate increase (4.1-7)	Large increase (>7)	
Increased flows (increased flow score in Table 2.2)	No increase (0-2)	0	1	2	3.5*	
	Small increase (2.1-4)	1	1.5	3	4	
	Moderate increase (4.1-7)	2	3	4	4.5	
	Large increase (>7)	3.5*	4	4.5	5	
					Change Score	3.5
Magnitude of impact score: (extent of impact score/100) x intensity of impact score (from above rows)						**0.1**

* Unlikely to occur

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

Step 3A: Impacts of erosion and/or deposition

Erosional features

To assess?	Yes	See Table 3.1

Table 3.8: Estimation of extent of impact of erosional features

		Length of wetland occupied by gully/ies as a percentage of the length of HGM[R]				
		0-20%	21-40%	41-60%	51-80%	>80%
Average gully width (sum of gully widths if more than 1 gully present) in relation to wetland width[R]	< 5%	5%	10%	15%	20%	25%
	5-10%	10%	15%	25%	35%	45%
	11-20%	15%	25%	40%	55%	65%
	21-50%	20%	30%	50%	70%	80%
	>50%	25%	40%	60%	80%	100%

Extent (%)
0

Table 3.9: Intensity and magnitude of impact of erosional features. The scores for rows 2 and 3 are unscaled for any natural recovery that may have taken place. Factors to use to scale the intensity of impact of erosional features for natural recovery are presented in rows 7 and 8.

Factor	1	2	3	4	5	Unscaled score
Mean depth of gullies[F]	<0.50m	0.50-1.00m	1.01-2.00m	2.00-3.00m	>3.00m	0
Mean width of gullies[F]	<2m	2-5m	5.1-8m	8.1-16m	>16m	0
Number of headcuts present[F]	1	2	3	4	>4	0
Unscaled intensity of impact score: mean score of above 3 rows						0.0
Scaling factor	**0.4**	**0.5**	**0.7**	**0.9**	**1**	**Factor**
Extent to which sediment from the gully is deposited within the HGM or wetland downstream of the HGM unit (as opposed to being exported)[F]	Entirely deposited	Mainly deposited	Intermediate	Mainly exported	Entirely exported	0
Extent to which the bed and sides of the gully have been colonized by vegetation and/or show signs of natural recovery[F]	Complete	High	Moderate	Low	None	0
Scaling factor score: mean of above 2 rows (value is between 0 and 1)						0.0
Scaled intensity of impact score = unscaled intensity of impact score x scaling factor score						0.0
Magnitude of impact score for erosional features: (extent of impact score (see Table 3.8)/100) × scaled intensity of impact score						**0.0**

Depositional features

To assess? **Yes** See Table 3.1

Table 3.10: Estimation of the extent of impact of depositional features for known depositional features in the HGM unit.

Extent of depositional features in relation to area of HGM unit being considered	0.2-1.9%	2-10%	11-25%	26-50%	>50%	
Score for "extent" to be used in the estimation of magnitude of impacts	5	20	50	75	100	5

Table 3.11: Estimation of extent of depositional features based on indirect indicators of recent anthropogenic activity leading to excessive deposition.

Indicator	0	1	2	3	4	Score

Presence, size and distribution of gullies or active erosion of drains within the catchment or wetland	None or very small	Limited extent and size	Moderate size and distribution	Large size or widespread distribution	Very large size or widespread distribution	0
Presence / extent of dirt roads in the catchment	None / few	Moderate	Many / extensive			0
Breaching of upstream dams in the catchment or wetland	None	Very small earthen dams	Small earthen dams	Large earthen dams		0
Extent of decreased vegetation cover in the catchment	Slight	Moderate	High			0
Mean of two highest scores from the above						0.0
Extent of impact score of depositional features as a percentage is calculated as the score from the above multiplied by 10.						0

Table 3.12: Intensity and magnitude of impact of depositional features

Indicator	0	1	2	3	Score
The position of fan-like deposits within the wetland[R]		Toe	Middle	Upper	0
Impact of depositional features on existing wetland features[D]	Not evident	Minor destruction of features	Moderate destruction of features	Large impact on existing features	0
Intensity of impact score of depositional features: mean of two rows above					0
Magnitude of impact score of depositional features: (extent of impact score (Table 3.10 or 3.11) / 100) x intensity of impact score					**0.0**

Step 3B: Impacts of the loss of organic sediment

To assess? **Yes** See Table 3.1

Table 3.13: Extent of impact of the loss of organic sediment for direct indicators (A) and indirect indicators (B). Express results as a proportion of the total area of the HGM unit.

A. Extent of impact score based on direct indicators (if present)	20	%
B. Additional extent of impact score based on indirect indicators (if present)	0	%

To determine the intensity of impact in the affected area of the wetland, see Tables 3.14 and 3.15 for direct and indirect indicators respectively.

Direct indicators

Table 3.14: Macroscopic features (clearly visible direct indicators) determining the intensity of impact of the loss of organic sediments

Activity	1	2	3	4	5	Score
Depth of the peat fires or extraction of peat relative to the depth of the peat deposit	<5%	5-15%	16-30%	31-60%	>60%	0
If tillage is practiced, duration of tillage	1-2 yrs	3-5 yrs	6-10 yrs	>10 yrs		1
Intensity of impact score: maximum score of above scores						1.0
Magnitude of impact score of loss of organic sediments: (extent of impact score (Table 3.13A) /100) × intensity of impact score						0.2

Indirect indicators

Table 3.15: Indirect indicators (not clearly visible) reflecting the intensity of diminished integrity of organic sediments in the HGM unit.

	0	1	2	3	4	Intensity score
Level of desiccation of the region of the HGM unit in which peat accumulation is taking place*	Unmodified	Largely natural	Moderately modified	Largely modified	Serously / critically modified	0
Magnitude of impact score: extent of impact score (Table 3.13B)/100 × intensity of impact score						0.0

Overall magnitude of impact: Organic sediment

Table 3.16: Magnitude of impact score for organic sediments expressed as a proportion of the area of the entire HGM unit

	Overall magnitude of impact score: organic sediments
Sum of magnitude scores in Tables 3.14 and 3.15	**0.2**

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

Table 3.17: Derivation of overall magnitude-of-impact scores through combining the scores obtained from individual assessments.

Impact category	Score	To include?
1. Magnitude of impact of dams (Table 3.4)	N/A	No
2. Magnitude of impact of channel straightening (Table 3.5)	N/A	No
3. Magnitude of impact of infilling (Table 3.6)	N/A	No

4. Magnitude of impact of changes in runoff characteristics (Table 3.7)	0.1	Yes
5. Magnitude of impact for erosional features (Table 3.9)	0.0	Yes
6. Magnitude of impact for depositional features (Table 3.12)	0.0	Yes
7. Magnitude of impact for loss of organic sediment (Table 3.16)	0.2	Yes
Overall Present Geomorphic State = Sum of three highest scores	**0.3**	

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PAGE 1: SUMMARY PAGE

STEP 1: MAP AND DETERMINE THE EXTENT OF EACH HGM UNIT

HGM Unit	HGM Type	Ha	Extent (%)*
1	Hillslope seepage linked to a stream channel	6.7	53
2	Valley-bottom without a channel	6.0	47
	Total	**12.6**	**100**

Legend
Enter information

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: DETERMINE THE PRESENT VEGATATION STATE OF WETLAND VEGETATION IN EACH HGM UNIT

STEP 3: DETERMINE THE OVERALL PRESENT VEGETATION STATE FOR THE WETLAND

Table 4.7: Summary impact score for each HGM and assessment of overall Present Vegetation State of the wetland

HGM Unit	Area (ha)	HGM unit extent (%)	HGM unit magnitude of impact score (from Table 4.6)	Area weighted impact score*	Present Vegetation State category
1	6.7	53	7.0	3.7	
2	6.0	47	0.6	0.3	
3	0.0	0	0.0	0.0	
4	0.0	0	0.0	0.0	
5	0.0	0	0.0	0.0	
		100	Overall weighted impact score**	4.0	C

*Area weighted impact score = HGM extent /100 x impact score

**Overall area weighted impact score = sum of individual area weighted scores for each HGM unit

Table 4.8: Present Vegetation State categories used to define health of wetland vegetation.

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE HGM SHEETS)

STEP 4B: DETERMINE THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION IN THE WETLAND AS A WHOLE

Table 4.11: Evaluation of Trajectory of Change of vegetation in the entire wetland.

HGM Unit	Description of relevant sources of change	HGM unit extent (%) (Table 4.7)	HGM Change score*	Area-weighted change score**
1	Increasing spread of alien vegetation and more annual pastures	53	-0.8	-0.4
2	Infilling	47	-0.2	-0.1
			Overall weighted threat score***	-0.5

STEP 5: DESCRIBE THE OVERALL VEGETATION HEALTH OF THE WETLAND BASED ON PRESENT VEGETATION STATE AND TRAJECTORY OF CHANGE

Vegetation Health

Present Vegetation State	C	see Table 4.8

Trajectory of change	↓	see Table 4.9

Table 4.8: Present Vegetation State categories used to define health of wetland vegetation.

DESCRIPTION	IMPACT SCORE	PRESENT VEGETATION STATE CATEGORY
Vegetation composition appears natural.	0-0.9	A

STEP 6: RECORD THE ALIEN VEGETATION THAT IS PRESENT IN THE WETLAND

Table 4.12: Alien species identified and suspected factors contributing to current infestation levels.

HGM Unit	List the alien species present	Aerial extent of invasion (%)*	Suspected factors contributing to increased abundance
1	Schinus terebinthifolius, Ricinus communis, Lantana camara, Solanum mauritianum, Tagese minuta, Canna indica, Senna didymobotrya, Melia azedarach,Cardiospermum grandiflorum, Chromolaena odoarta,Arundo donax, Ipomoea indica, Tecoma stans, Ageratum conzoides, Bidens Pilosa	75	Lack of fire-bad management, disturbance due to annual pastures
2	Brazillian pepper, Arundo donax, Solanum mauritianum, Bidens Pilosa	20	Infilling causing dessication and burst sewage pump
Threat of further invasion, given the current management:			**Low**

* Use Table 4.3 as a guide for estimating the total extent of alien plant cover in each HGM unit

Note: The above table is used to capture to combined extent of all listed alien species in each HGM unit. Where necessary – such as where a detailed weed control strategy must be developed - this table may be expanded to include separate extent estimates for each species present.

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PAGE 2: HGM UNIT 1

STEP 2: DETERMINE THE PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 2A: FAMILIARISATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 2B: IDENTIFY AND ESTIMATE THE EXTENT OF EACH DISTURBANCE CLASS IN THE HGM UNIT

Table 4.2: Description and extent of each disturbance class within the HGM unit

Disturbance class	Brief description of disturbance class	Extent (ha)*	Extent (%)
1	Annual pastures	1.33	20
2	Alien vegetation	4.33	65
3	Untransformed	1.00	15
		6.66	

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

STEP 2C: ASSESS THE INTENSITY AND MAGNITUDE OF IMPACT FOR EACH DISTURBANCE CLASS

Table 4.6: Calculation of the HGM magnitude of impact score based on an area weighted magnitude of impact score for each disturbance class.

Disturbance class	Disturbance class extent (%) (from Table 4.2)	Intensity of impact score (from Table 4.5)	Magnitude of impact score*	Factors contributing to impact
1	20	9	1.8	
2	65	8	5.2	
3	15	0	0.0	
HGM Magnitude of impact score**			7.0	

* Magnitude of impact score is calculated as extent / 100 x intensity of impact
** Overall magnitude of impact score for the HGM unit = sum of magnitude scores for each disturbance class.

STEP 2D: DETERMINE THE MAGNITUDE OF IMPACT SCORE AND PRESENT VEGETATION STATE OF EACH HGM UNIT

Calculated in Table 4.6 above

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

Table 4.10: Evaluation of Trajectory of Change of vegetation within an HGM.

Disturbance class	Source of change	Disturbance class extent (%) (Table 4.2)	Change score (Table 4.9)	Area-weighted change score*
1	Stable	20	0	0.0
2	Spreading alien vegetation	65	-1	-0.7
3	Increasing alien vegetation and increased human density	15	-1	-0.2
			HGM change score**	**-0.8**

*Area weighted change score = Disturbance Class extent /100 x change score

**HGM change score = sum of individual area weighted scores for each disturbance unit

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PAGE 3: HGM UNIT 2

STEP 2: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE WETLAND

Vulnerability factor	0.9

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STEP 2A: IDENTIFY, MAP AND ASSESS IMPACT OF LAND-USE ACTIVITIES THAT REDUCE THE INFLOW QUANTITY TO THE HGM UNIT

Table 2.2: Different land-use types and activities potentially altering inflow quantities to the HGM unit from its upstream catchment, and the

magnitude of their collective effect (1)

Reduced Flows

Land-use activity descriptors		Low High 0	-2	-5	-8	-10	Scores	Intensity of water loss (2)	Extent (%)	Magnitude (3)
Irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	Seasonal	Year-round	0	0.0	0	0.0
	(2) Prevalence of water conserving practices[R]		High	Intermediate	Low		0			
Other abstractions not used for irrigation in the catchment (4)										
Alien plants	(1) plant type[R]			Shrubs	Trees		-6	-3.6	20	-0.7
	(2) Distribution of alien woody plants in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-2			
Plantations	(1) Tree type[R]				Wattle & pine	Eucalyptus	0	0.0	0	0.0
	(2) Distribution of tree plantations in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Sugar (5)	(1) Crop type[R]		Sugar				0	0.0	0	0.0
	(2) Distribution in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Dams: specific allowance for releasing low flows within the operating rules of the dam[R]				Allowance made	No allowance		0	0.0	0	0.0
Overall magnitude of reduction in water inputs to the HGM unit as the sum of all the above impact magnitudes:										**-0.7**

Increased Flows

Description of the level of increase	Magnitude score
Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).	10
Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.	7
Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).	3
No increase, or flow is increased by a negligible amount.	0
Magnitude of impact associated with increases in water inputs	0

Combined score: Increased flows score + Decreased flows score The combined score will range from -10 to +10, depending on the magnitude of the factors causing an increase or decrease in flow respectively	**-0.7**

STEP 2B: ASSESS THE INTENSITY OF IMPACT OF FACTORS POTENTIALLY ALTERING FLOW PATTERNS TO THE HGM UNIT

Table 2.3: Factors potentially contributing to a decrease or increase of floodpeak magnitude and/or frequency received by the HGM unit

Level of reduction	**Low**				**High**	**Score**
	0	**-2**	**-5**	**-8**	**-10**	
(1) Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R*]	<20%	20-35%	36-60%	60-120%	>120%	0
(2) Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	High	0
(3) Specific allowance for natural floods within the operating rules of the dam[R] **	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	0
Level of increase	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	

(4) Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	2
(5) Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R]***	<10%	11-40%	41-80%	>80%		0
Combined Score: [Ave of (1), (2) and (3)] + (4) + (5)] adjusted****						**2.0**

STEP 2C: ASSESS THE COMBINED MAGNITUDE OF IMPACT OF ALTERED QUANTITY AND PATTERN OF INPUTS, ACCOUNTING FOR THE WETLAND UNIT'S VULNERABILITY

Change in quantity of water inputs (Table 2.3):	**-0.7**

Alteration to floodpeaks (Table 2.4):	**2.0**

Table 2.5: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs.

(a) Floodplains and channeled valley bottoms driven primarily by over-bank flooding

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Score from Table 2.4)**						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to	(-4 to -6)	(<-6)
> 9	7	6	5	4	5	6	7
4 - 9	5	4	3	3	4	6	7
1-3.9 (Increase)	3	2	1	1	2.5	4.5	7
-0.9- +0.9 (Negligible)	1	1	0	0	1	5	7.5
-1- -1.9 (Decrease)	2	1.5	1	1	2.5	5	7.5
-2- -3.9	3	2.5	2	2	4	6	8
-4- -5.9	4	3.5	3	3	5	7	8.5
-6- -7.9	-**	-**	-**	4	6	8	9
-8- -9	-**	-**	-**	-**	-**	9	9.5

< -9	-**	-**	-**	-**	-**	-**	10

(b) Other hydro-geomorphic settings, including floodplains and channeled valley bottoms driven primarily by lateral inputs (e.g. from tributaries)

Change in quantity of water inflows (Score from Table 2.2)	Alteration to floodpeaks (Table 2.4)						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to -3.9)	(-4 to -6)	(<-6)
> 9	6	5	4	3	3	3.5	4
4 - 9	4.5	4	3	2	3	3	3
1-3.9 (Increase)	3	2	1	1	1	2	2.5
-0.9- +0.9 (Negligible)	2.5	1.5	0.5	0	0.5	1	1.5
-1- -1.9 (Decrease)	3.5	2.5	1.5	1	1.5	2	2.5
-1 - -3.9	4.5	3.5	2.5	2	2.5	3	3.5
-2 - -3.9	6	5	4	3.5	4	4.5	5
-4- -5.9	-**	-**	-**	5	5.5	6	6.5
-6- -7.9	-**	-**	-**	-**	-**	7.5	8
< -9	-**	-**	-**	-**	-**	-**	10

**These classes are unlikely, given that when there is a high level of reduction of quantity of inputs then there would be insufficient water to maintain unaltered or increased floodpeaks (i.e. a decrease in floodpeaks would be inevitable).

Magnitude of impact based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs:	0.5
Magnitude of impact adjusted to account for any change in seasonality:***	0.5

***If seasonality has been changed moderately then increase the magnitude of impact score by 1 and if it has been changed greatly then increase the magnitude of impact score by 2.

STEP 3: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE HGM UNIT HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES

STEP 3A: ASSESS MAGNITUDE OF IMPACT OF CANALIZATION AND STREAM MODIFICATION

Canalization Note: Where more than one section of a HGM unit is affected by canalization, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.7: Characteristics affecting the impact of canalization on the distribution and retention of water in the HGM unit

Extent of HGM unit affected by canalization	ha	%
	0	0

Factors	Low				High	Score
	0	2	5	8	10	
Characteristics of the wetland						
(1) Slope of the wetland	<0.5%	0.5-0.9%	1-1.9%	2-3%	>3%	5
(2a) Texture of mineral soil, if present*	Clay	Clay loam	Loam	Sandy loam	Sand/loamy sand	2
(2b) Degree of humification of organic soil, if present*	Completely amorphous (like humus)	Somewhat amorphous	Intermediate	Somewhat fibrous	Very fibrous	
(3) Natural level of wetness	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	8
Characteristics of the drains/gullies						
(4) Depth of the drains/gullies	<0.20 m	0.20-0.50 m	0.51-0.80 m	0.81-1.10	>1.10 m	0
(5) Density of drains (meters of drain per hectare of wetland)**	<25 m/ ha	26-100 m/ha	101-200 m/ha	201-400 m/ha	>400 m/ha	0
(6) Location of drains/gullies in relation to flows into and through the wetland[R]. Drains/gullies are located such that flows are:	Very poorly intercepted	Moderately poorly intercepted	Intermediately intercepted	Moderately well intercepted	Very well intercepted	0
(7) Obstructions in the drains/ gullies	Complete obstruction	High obstruction	Moderate obstruction	Low obstruction	No obstruction	10
Calculate the mean score for factors 1, 2a or 2b, 3, 4 and 5						3.0
Multiply the score for factor 5 by the flow alteration factor (Table 2.1)						0.0

Note: Leave either 2a OR 2b blank

Mean score for above two scores	1.5
Intensity of impact for canalization: Divide the score for factor 7 by 10 and multiply this by the mean score derived in previous row	1.5
Magnitude of impact of canalization: Extent of impact/100 × intensity of impact calculated in the row above	**0.0**

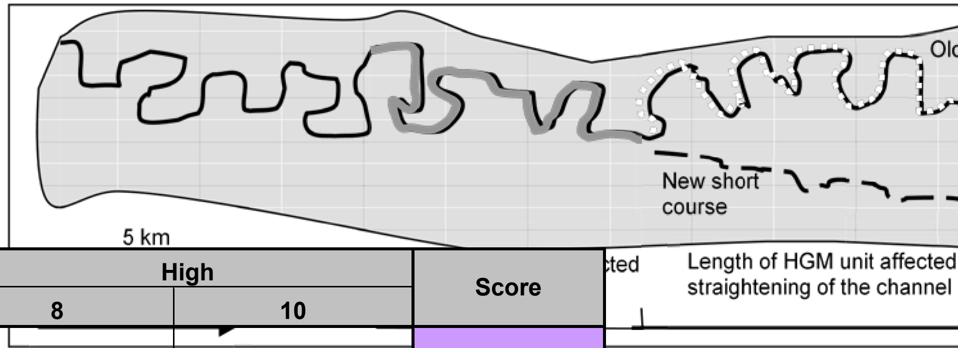
Stream channel modification

Note: Where more than one section of a HGM unit is affected by stream channel modification, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.8: Characteristics affecting the impact on the distribution and retention of water in the HGM unit through the modification of a stream channel

	%
Extent of HGM unit affected by stream channel modification*	0
HGM weighting factor	0

*should be expressed as a percentage of the length of the HGM unit (See diagram alongside)



Characteristics of stream channel	Low			High		Score
	0	2	5	8	10	
(1) Reduction in length of stream per unit valley length[D]	<5%	5 – 25%	25 – 50%	50 – 75%	75 – 100%	0
(2) % increase in cross sectional area of the stream[F]	<5%	5 – 25%	26 – 50%	51 – 75%	>75%	0
(3) Change in surface roughness in relation to the surface roughness of the channel in its natural state (see Table 2.9 for description of roughness classes)	Roughness is increased or is unchanged[1]	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: use the maximum score of factors 1 to 3 x HGM weighting factor*						**0**
Magnitude score of impact of stream channel modification: extent of impact/100 × intensity of impact						**0.0**

Table 2.9: Estimate of wetland surface roughness for a channel of the HGM unit

Class	Descriptor

Table 2.10: Calculation of the magnitude of impact of canalization and modification of a stream channel on the distribution and retention of water in a wetland HGM unit

Overall magnitude of impact score: canalization and stream channel modification	Score
Calculate the sum of scores from Tables 2.7 and 2.8.	0.0

STEP 3B: ASSESS MAGNITUDE OF IMPACT OF IMPEDING FEATURES

Note: Where more than one section of a HGM unit is affected by an impeding feature, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.11: Typical changes in water-distribution and -retention patterns within an HGM unit as a result of impeding structures

result of impeding structures

(a) Upstream impact of flooding

Extent Assessment	ha	%
(a) Extent of HGM unit affected by flooding **upstream** of the impeding structure	0.0	0

Descriptor	Low High					Score
	0	2	5	8	10	
Representation of different hydrological zones prior to flooding by the dam[R]	-	Seasonal and permanent zone both present and collectively >30%	Permanent and seasonal zones both present but collectively <30%	Seasonal zone present but permanent zone absent	Permanent and seasonal zones lacking (i.e. only the temporary zone present)	0
Intensity of impact: score for above factor X 0.8						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

(b) Downstream impact on quantity and timing of flows to downstream portion of the HGM unit

Extent Assessment	ha	%
(b) Extent of HGM unit affected by flooding **downstream** of the impeding structure	0.0	0

	Low				High	Score
	0	2	5	8	10	
Extent to which dams or roads interrupt low flows to downstream areas [R]	No interruption (e.g., many culverts through a road embankment)	Slight interruption (e.g., a moderate number of culverts through a road embankment)	Intermediate interruption (e.g. earth dam with very high seepage or road embankment with no/ very limited culverts)	Moderately high interruption (e.g. earth dam with some seepage/ flow releases)	High interruption (e.g. a concrete dam with no seepage and no low flow releases)	0
Level of abstraction from the dam/s [R]	Low	Moderately low	Intermediate	Moderately high	High	0
Location of dam/s relative to the affected area's catchment- proportion of catchment flows intercepted [D]	Dam intercepts <20% of the affected area's catchment	Dam intercepts 21-40% of the affected area's catchment	Dam intercepts 41-60% of the affected area's catchment	Dam intercepts 61-80% of the affected area's catchment	Dam intercepts >80% of the affected area's catchment	0
Collective volume of dam/s in relation to MAR of the affected area[D]	<20%	20-35%	36-60%	60-120%	>120%	0
Intensity of impact: mean score of the THREE highest scoring factors x 0.8						0.0
Magnitude-of-impact score: extent of impact /100 × intensity of impact						**0.0**

(c) Combined impact

Combined impact: Magnitude of impact for upstream + Magnitude of impact for downstream	**0.0**

STEP 3C: ASSESS MAGNITUDE OF IMPACT OF ALTERED SURFACE ROUGHNESS

Table 2.12: Comparison of surface roughness of an HGM unit in its current state compared with its natural state

Extent of HGM unit affected by change in surface roughness	ha	%
	1.79	30

Class	Descriptor	Current	Historic
Low	Smooth surface with little or no vegetation to offer resistance to water flow	High	Moderately high
Moderately low	Vegetation is present but short (i.e. < 500mm) and not robust (e.g. rye grass)		
Moderate	Vegetation offering slight resistance to water flow, generally consisting of short plants (i.e. < 1 m tall)		
Moderately high	Robust vegetation (e.g. dense stand of reeds) or hummocks offering high resistance to water flow		
High	Vegetation very robust (e.g. dense swamp forest with a dense under storey) and offering high resistance to water flow.		

Note: Where roughness varies across the HGM unit, take the average condition, and where roughness varies over time (e.g. areas which are regularly cut short) take the average condition during the wet season.

Descriptor	Low 0	2	5	8	High 10	Score
Change in surface roughness in relation to the surface roughness of the wetland in its natural state[F]	Roughness increased or is unchanged*	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: score for the above row X 0.6						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

*It is considered to be of greater consequence to water retention and distribution if the surface roughness of a wetland is decreased than if it is increased, therefore the focus of this assessment is primarily on a decrease in surface roughness.

STEP 3D: ASSESS THE IMPACT OF DIRECT WATER LOSSES

Table 2.13: Evaluating the effect of alien woody plants, commercial plantations and sugarcane growing in the HGM unit on water loss

Land-use activity descriptors	Low 0	2	5	8	High 10	Score	Intensity of water loss*	Extent (%)	Magnitude**
(1) Alien woody plant type[F]			Shrubs	Trees		8	7.2	20	1.6
(1) Plantation tree type[F]				Wattle & pine	Eucalyptus	0	0	0	0.0
(1) Sugarcane Growth[F]		Poor growth	Good growth			0	0	0	0.0
(4) Direct water abstractions		Low	Moderately low	Moderately high	High	0	0	0	0.0
Overall magnitude of increased water loss: (sum of (1), (2), (3) and (4)) x 0.8									**1.3**

*Intensity= Score x Vulnerability factor (from Table 2.1) **Magnitude=Intensity x Extent (%)/100

Note: When assessing extent, remember that the extent of the impact may extend beyond the direct area in which the alien woody plants or plantations occur in the HGM unit to also include a downstream portion subject to reduced flows. If this is the case, adjust the score accordingly with documented justification.

STEP 3E: ASSESS THE MAGNITUDE OF IMPACT OF RECENT DEPOSITION, INFILLING OR EXCAVATION

Table 2.14 Magnitude of impact of recent deposition, infilling or excavation

Extent Assessment	ha	%
Extent of HGM unit affected by deposition or excavation	1.2	20

Descriptor	Low 0	2	5	8	High 10	Score
Effect on vertical drainage properties of the uppermost soil layer	No effect	Rendered somewhat free-draining	Intermediate	Rendered free-draining	Rendered very well- drained*	8
Effect on the horizontal movement of water	No effect	Moderate modification	Large modification	Serious modification		2
Intensity of impact: use the highest score for the above two factors						8
Magnitude of impact score: extent of impact (%)/100 x intensity of impact x 1						**1.6**

*i.e. drainage is so free that the area no longer has any wetland characteristics

STEP 3F: DETERMINE COMBINED MAGNITUDE OF IMPACT OF ON-SITE ACTIVITIES

Table 2.15: Overall magnitude of impacts of on-site activities on water distribution and retention patterns n the HGM unit

Activity	Magnitude of impact	Justification for any modifications made
(1) Calculated magnitude of impact of canalization and stream channel modification from Table 2.10	0.0	
(2) Calculated magnitude of impact of impeding features from Table 2.11	0.0	
(3) Calculated magnitude of impact of altered surface roughness from Table 2.12	0.0	
(4) Calculated magnitude of impact of aliens, timber and/or sugarcane in the wetland from Table 2.13	1.3	
(5)) Calculated magnitude of impact of recent deposition/excavation from Table 2.14	1.6	
Total score of magnitude of on-site activities in the HGM unit (sum of the above scores)*	2.9	* If score is > 10, then magnitude of impact = 10

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF THE HGM UNIT THROUGH INTEGRATING THE ASSESSMENTS FROM STEPS 2 AND 3

Changes to water distribution & retention patterns (Table 2.15):	2.9

Changes to Water Inputs (Table 2.5):	0.5

Table 2.16: Derivation of overall magnitude-of-impact scores through combining the scores obtained from the catchment and within-wetland assessments. The colour codes correspond to the impact categories given in Table 2.17.

			Water Inputs (Step 2 - Table 2.5)					
			None	Small	Moderate	Large	Serious	Critical
			0-0.9	1-1.9	2-3.9	4-5.9	6-7.9	8 - 10
Water distribution & retention patterns (Step 3, Table2.15)	None	0-0.9	0	1	3	5	6.5	8.5
	Small	1-1.9	1	1.5	3.5	6	7	9

	Moderate	2-3.9	3	3.5	4	6.5	7.5	9
	Large	4-5.9	5	6	6.5	7	8	9.5
	Serious	6-7.9	6.5	7	7.5	8	9	10
	Critical	8 - 10	8.5	9	9	9.5	10	10

Combined magnitude score as a result of impacts on hydrological functioning	**3**

Wet-Health **Le Mercy Wetland Geomorphology Module** **Level 2**

PAGE 2: HGM UNIT 2

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

Table 3.1: Guideline for assessing the impacts of activities according to HGM type

HGM type to assess	Activity/Indicator that should be assessed
Diagnostic component	
Floodplain	Dams upstream of or within floodplains (see Step 2A)
Floodplain, channeled valley bottom	Stream shortening or straightening (see Step 2B)
Floodplain, channeled valley bottom	Infilling that leads to narrowing of the wetland (see Step 2C)
All non-floodplain HGM's	Changes in runoff characteristics (see Step 2D)
Indicator-based component	
All non-floodplain HGM's	Erosional features (see Step 3A)
All non-floodplain HGM's*	Depositional features (see Step 3A)
All non-floodplain HGM's	Loss of organic sediment (see Step 3B)

* Consider floodplains if there are large alluvial fans impinging on the floodplain laterally to it (from the side).

HGM Type
Valley-bottom without a channel
If floodplain, are there large alluvial fans impinging laterally on the floodplain (from the side of the floodplain)?
No
Note: Steps that need to be completed are indicated with a "Yes" based on the HGM type selected in the summary page.

Step 2A: Impacts of dams upstream of and/or on floodplains	**To assess?**	**No**	See Table 3.1

Dams in the floodplain catchment

Table 3.2: Extent, intensity and magnitude of impacts of impoundments in the catchment

Extent of impact of dams situated above floodplains						**Extent (%)**
Extent: For dams upstream of floodplains extent is assumed to be 100%. If a dam is also situated on the floodplain, extent of impact for the dam above the floodplain is determined as the length of the floodplain above the dam / total floodplain length, expressed as a percentage						0
Intensity of impact score – size of dams and nature of sediment transported						
Determine the size of dam/s on the stream and the nature of sediment load being transported						
	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	**Score**
Suspended load dominated	0.5	1	1.5	2	2.5	0
Mixed load	1	2	3	4	5	0
Bedload dominated	2	3	4	5	5	0
Intensity of impact score – location of dams in the catchment						
Score	**1**	**2**	**3**	**4**	**5**	**Score**
Location of dam/s	Dams on minor tributary stream or on trunk stream far upstream of floodplain	Intermediate between descriptions for scores 0 and 5	Dams on major tributary or on trunk stream a moderate distance upstream of floodplain	Intermediate between descriptions for scores 5 and 10	Dam on trunk stream immediately above floodplain	
Overall intensity of impact score for dams situated above floodplains: mean of above 2 scores						0.0
Magnitude of impact score for dams situated above floodplains: (extent of impact score/ 100) x overall intensity of impact score						0.0

Enter single score

Dams on the floodplain

Table 3.3: Extent, intensity and magnitude of impact of impoundments within the floodplain.

Extent of impact of dams situated within floodplains						**Extent (%)**
Extent: The percentage of the floodplain valley length flooded by the dam and below the dam wall						
Intensity of impact of dams situated within floodplains						
SCORE	**1**	**2**	**3**	**4**	**5**	**Score**

Size of dam	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	
Configuration of spillway/s			Baseflows to floodplain stream: peak flows to backswamp	Baseflows and peak flows to floodplain stream **OR** baseflows to backswamp and peak flows to floodplain stream	Baseflows and peak flows to backswamp	
Overall intensity of impact score for dams situated within floodplains: mean of above 2 scores						0
Magnitude of impact score for dams situated within floodplains: (extent of impact score / 100) x overall intensity of impact score						0.0

Combining impacts of dams in the catchment and on the floodplain

Table 3.4: Combining the magnitude of impact scores of impoundments upstream of and on the floodplain.

Magnitude of impact score for dams upstream of and on the floodplain	
Magnitude of impact score for dam/s located in the catchment (Table 3.2)	0.0
Magnitude of impact score for dam/s located within the floodplain (Table 3.3)	0.0
Overall magnitude of impact for floodplain wetlands with dams upstream of and on the floodplain = sum of above two rows	**0.0**

Impacts of channel straightening

To assess? | **No** | See Table 3.1

Table 3.5: Extent, intensity and magnitude of impacts of channel straightening

Extent of impact of channel straightening.	**Extent (%)**
Extent: the length of modification plus THE LESSER OF 10km for sandy stream beds OR 5km for silty/clayey stream beds OR the distance to the head of the floodplain OR to a dam wall (if present), expressed as a percentage of floodplain length[R]	
Intensity of impact of channel straightening	

	0	1	2	3	4	Intensity
Reduction in stream length per unit valley length[R]	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of channel straightening: (extent of impact score/ 100) x intensity of impact score						**0.0**

Figure 3.2: Illustration of the calculation of extent of impact of channel straightening if the channel bed is silt or clay.

Step 2C: Impacts of artificial wetland infilling

To assess? **Yes** See Table 3.1

Table 3.6: Extent, intensity and magnitude of impact of infilling of floodplains and channeled valley bottom wetlands.

Extent of impact of infilling.						**Extent (%)**
Extent of impact of infilling as determined by establishing the area of wetland that will not be subjected to normal erosion and / or deposition, as a percentage of wetland area.						20
Intensity of impact of infilling						
	0	**1**	**2**	**3**	**4**	**Score**
Reduction in active wetland width at point of infillingR	<5%	6-25%	26-50%	51-75%	>75%	2
Magnitude of impact of infilling: (extent of impact score / 100) x intensity of impact score.						**0.4**

Step 2D: Impacts of changes in runoff characteristics

To assess? **Yes** See Table 3.1

Table 3.7: Effect of altered water inputs (increased flows and floodpeaks) on wetland geomorphological integrity

Extent of impact of altered water inputs						**Extent (%)**
Extent calculated based on length of wetland affected by increased flow as a proportion (%) of the entire wetland length.						45
Intensity of impact of altered water inputs						
		Increased floodpeaks (combined score in Table 2.3)				
		No effect	Small increase	Moderate increase	Large increase	
		(0-2)	(2.1-4)	(4.1-7)	(>7)	
Increased flows	No increase (0-2)	0	1	2	3.5*	

(increased flow score in Table 2.2)	Small increase (2.1-4)	1	1.5	3	4
	Moderate increase (4.1-7)	2	3	4	4.5
	Large increase (>7)	3.5*	4	4.5	5
				Change Score	0
Magnitude of impact score: (extent of impact score/100) x intensity of impact score (from above rows)					0.0

* Unlikely to occur

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

Step 3A: Impacts of erosion and/or deposition

Erosional features

To assess?	Yes	See Table 3.1

Table 3.8: Estimation of extent of impact of erosional features

		Length of wetland occupied by gully/ies as a percentage of the length of HGM[R]					
		0-20%	21-40%	41-60%	51-80%	>80%	
Average gully width (sum of gully widths if more than 1 gully present) in relation to wetland width[R]	< 5%	5%	10%	15%	20%	25%	
	5-10%	10%	15%	25%	35%	45%	
	11-20%	15%	25%	40%	55%	65%	
	21-50%	20%	30%	50%	70%	80%	Extent (%)
	>50%	25%	40%	60%	80%	100%	0

Table 3.9: Intensity and magnitude of impact of erosional features. The scores for rows 2 and 3 are unscaled for any natural recovery that may have taken place. Factors to use to scale the intensity of impact of erosional features for natural recovery are presented in rows 7 and 8.

Factor	1	2	3	4	5	Unscaled score
Mean depth of gullies[F]	<0.50m	0.50-1.00m	1.01-2.00m	2.00-3.00m	>3.00m	0
Mean width of gullies[F]	<2m	2-5m	5.1-8m	8.1-16m	>16m	0
Number of headcuts present[F]	1	2	3	4	>4	0
Unscaled intensity of impact score: mean score of above 3 rows						0.0
Scaling factor	0.4	0.5	0.7	0.9	1	Factor

Extent to which sediment from the gully is deposited within the HGM or wetland downstream of the HGM unit (as opposed to being exported)[F]	Entirely deposited	Mainly deposited	Intermediate	Mainly exported	Entirely exported	0
Extent to which the bed and sides of the gully have been colonized by vegetation and/or show signs of natural recovery[F]	Complete	High	Moderate	Low	None	0
Scaling factor score: mean of above 2 rows (value is between 0 and 1)						0.0
Scaled intensity of impact score = unscaled intensity of impact score x scaling factor score						0.0
Magnitude of impact score for erosional features: (extent of impact score (see Table 3.8)/100) × scaled intensity of impact score						**0.0**

Depositional features

To assess?	**Yes**	See Table 3.1

We are only interested here in recent depositional features. If the user feels confident in being able to map depositional features that can be attributed directly to recent human activity, then extent should be established directly using Table 3.10, but if they are not confident that they can do this, indirect indicators can be used as outlined in Table 3.11. Users may wish to use a combination of approaches by using the indirect indicators to assist in the location and mapping of depositional features in the wetland of interest, following which they may map depositional features directly, but ideally, one would only map these features directly.

Table 3.10: Estimation of the extent of impact of depositional features for known depositional features in the HGM unit.

Extent of depositional features in relation to area of HGM unit being considered	0.2-1.9%	2-10%	11-25%	26-50%	>50%	
Score for "extent" to be used in the estimation of magnitude of impacts	5	20	50	75	100	0

Table 3.11: Estimation of extent of depositional features based on indirect indicators of recent anthropogenic activity leading to excessive deposition.

Indicator	0	1	2	3	4	Score
Presence, size and distribution of gullies or active erosion of drains within the catchment or wetland	None or very small	Limited extent and size	Moderate size and distribution	Large size or widespread distribution	Very large size or widespread distribution	0
Presence / extent of dirt roads in the catchment	None / few	Moderate	Many / extensive			0
Breaching of upstream dams in the catchment or wetland	None	Very small earthen dams	Small earthen dams	Large earthen dams		0

Extent of decreased vegetation cover in the catchment	Slight	Moderate	High				0
Mean of two highest scores from the above							0.0
Extent of impact score of depositional features as a percentage is calculated as the score from the above multiplied by 10.							0

Table 3.12: Intensity and magnitude of impact of depositional features

Indicator	0	1	2	3	Score
The position of fan-like deposits within the wetland[R]		Toe	Middle	Upper	0
Impact of depositional features on existing wetland features[D]	Not evident	Minor destruction of features	Moderate destruction of features	Large impact on existing features	0
Intensity of impact score of depositional features: mean of two rows above					0
Magnitude of impact score of depositional features: (extent of impact score (Table 3.10 or 3.11) / 100) x intensity of impact score					**0.0**

Step 3B: Impacts of the loss of organic sediment

To assess? **Yes** See Table 3.1

Table 3.13: Extent of impact of the loss of organic sediment for direct indicators (A) and indirect indicators (B). Express results as a proportion of the total area of the HGM unit.

A. Extent of impact score based on direct indicators (if present)	0	%
B. Additional extent of impact score based on indirect indicators (if present)	0	%

To determine the intensity of impact in the affected area of the wetland, see Tables 3.14 and 3.15 for direct and indirect indicators respectively.

Direct indicators

Table 3.14: Macroscopic features (clearly visible direct indicators) determining the intensity of impact of the loss of organic sediments

Activity	1	2	3	4	5	Score
Depth of the peat fires or extraction of peat relative to the depth of the peat deposit	<5%	5-15%	16-30%	31-60%	>60%	0
If tillage is practiced, duration of tillage	1-2 yrs	3-5 yrs	6-10 yrs	>10 yrs		0
Intensity of impact score: maximum score of above scores						0.0
Magnitude of impact score of loss of organic sediments: (extent of impact score (Table 3.13A) /100) × intensity of impact score						0.0

Indirect indicators

Table 3.15: Indirect indicators (not clearly visible) reflecting the intensity of diminished integrity of organic sediments in the HGM unit.

	0	**1**	**2**	**3**	**4**	**Intensity score**
Level of desiccation of the region of the HGM unit in which peat accumulation is taking place*	Unmodified	Largely natural	Moderately modified	Largely modified	Serously / critically modified	0
Magnitude of impact score: extent of impact score (Table 3.13B)/100 × intensity of impact score						0.0

Overall magnitude of impact: Organic sediment

Table 3.16: Magnitude of impact score for organic sediments expressed as a proportion of the area of the entire HGM unit

	Overall magnitude of impact score: organic sediments
Sum of magnitude scores in Tables 3.14 and 3.15	**0.0**

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

Table 3.17: Derivation of overall magnitude-of-impact scores through combining the scores obtained from individual assessments.

Impact category	**Score**	**To include?**
1. Magnitude of impact of dams (Table 3.4)	N/A	No
2. Magnitude of impact of channel straightening (Table 3.5)	N/A	No
3. Magnitude of impact of infilling (Table 3.6)	0.4	Yes
4. Magnitude of impact of changes in runoff characteristics (Table 3.7)	0.0	Yes
5. Magnitude of impact for erosional features (Table 3.9)	0.0	Yes
6. Magnitude of impact for depositional features (Table 3.12)	0.0	Yes
7. Magnitude of impact for loss of organic sediment (Table 3.16)	0.0	Yes

Overall Present Geomorphic State = Sum of three highest scores	0.4

Wet-Health — Le Mercy Wetland Vegetation Module — Level 2

PAGE 2: HGM UNIT 2

STEP 2: DETERMINE THE PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 2A: FAMILIARISATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 2B: IDENTIFY AND ESTIMATE THE EXTENT OF EACH DISTURBANCE CLASS IN THE HGM UNIT

Table 4.2: Description and extent of each disturbance class within the HGM unit

Disturbance class	Brief description of disturbance class	Extent (ha)*	Extent (%)
1	Alien Vegetation	1.20	20
2	Untransformed	4.80	80
		6.00	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

STEP 2C: ASSESS THE INTENSITY AND MAGNITUDE OF IMPACT FOR EACH DISTURBANCE CLASS

Table 4.6: Calculation of the HGM magnitude of impact score based on an area weighted magnitude of impact score for each disturbance class.

Disturbance class	Disturbance class extent (%) (from Table 4.2)	Intensity of impact score (from Table 4.5)	Magnitude of impact score*	Factors contributing to impact
1	20	3	0.6	
2	80	0	0.0	
HGM Magnitude of impact score**			**0.6**	

STEP 2D: DETERMINE THE MAGNITUDE OF IMPACT SCORE AND PRESENT VEGETATION STATE OF EACH HGM UNIT

Calculated in Table 4.6 above

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

Table 4.10: Evaluation of Trajectory of Change of vegetation within an HGM.

Disturbance class	Source of change	Disturbance class extent (%) (Table 4.2)	Change score (Table 4.9)	Area-weighted change score*
1	Spreading alien vegetation	20	-1	-0.2
2	Development prospectives and increasing alien vegetation	80	-1	-0.8
			HGM change score**	**-0.2**

*Area weighted change score = Disturbance Class extent /100 x change score

**HGM change score = sum of individual area weighted scores for each disturbance unit

WET-Health Lake Victoria Barn Swallow Roosting Site Wetland Level 1

PAGE 1: SUMMARY PAGE

STEP 1: IDENTIFY THE HGM TYPES IN THE WETLAND AND DIVIDE THE WETLAND INTO HGM UNITS

HGM Unit	HGM Type	Ha	Extent (%)*
1	Valley-bottom with a channel	6.4	34
2	Valley-bottom without a channel	11.0	59
3	Hillslope seepage linked to a stream channel	0.3	1
4	Isolated Hillslope seepage _1	0.6	3

Legend
Enter information

5	Isolated Hillslope seepage_2	0.6	3
Total		**18.8**	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated. If this is the case, "1" must be included in the Ha column to ensure that calculations in the summary table still work.

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 5: REPRESENT THE HEALTH SCORES FOR THE OVERALL WETLAND

Table 5.28. Summary of the overall health of the wetland based on impact score and change score.

HGM Unit	Ha	Extent (%)	Hydrology		Geomorphology		Vegetation	
			Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
1	6	34	6.0	0	0.1	0	5.8	-1
2	11	59	0.5	0	0.0	0	2.1	0
3	0	1	6.0	0	0.0	0	0.6	0
4	1	3	8.0	0	0.0	0	7.8	-1
5	1	3	9.5	0	0.0	0	8.0	0
Area weighted impact scores*			**2.9**	**0.0**	**0.0**	**0.0**	**3.7**	**-0.4**
PES Category (See Table 5.29)			**C**	→	**A**	→	**C**	↓

* The total impact score for the wetland as a whole is calculated by summing the area-weighted HGM scores for each HGM unit.

HGM Unit	Threat descriptions		
	Hydrology	Geomorphology	Vegetation
1	Alien veg seedlings appearing (guava)	None	Increasing alien plant density
2	Drain on lower portionif deepened could drain the system	None	Increasing alien plant density
3	Increasing alien vegetation	None	Increasing alien plant density
4	Increasing alien plant density	None	Increasing alien plant density
5	Increasing alien plant density	None	Increasing alien plant density

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PAGE 2: HGM UNIT 1

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 2A: EVALUATE CHANGES TO WATER INPUT CHARACTERISTICS FROM THE CATCHMENT

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes
Reduction in flows (water inputs)	Table 5.1	-3	
Increase in flows (water inputs)	Table 5.1	7	
Combined impact Score		**4**	

Change in flood patterns (peaks)	Table 5.2	4	
Magnitude of impact Score	Table 5.3	**4.0**	Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.

STEP 2B: EVALUATE CHANGES TO WATER DISTRIBUTION & RETENTION PATTERNS WITHIN THE WETLAND

	Intensity rating guidelines	**Extent (%)**[1]	**Intensity (0 - 10)**	**Magnitude**[2]	**Land-use factors contributing to impacts, and any additional notes**
Gullies and artificial drainage channels	Table 5.5	16	5	0.8	Rigde and furrow
Modifications to existing channels	Table 5.6	0	0	0	
Reduced roughness	Table 5.7	0	0	0	
Impeding features (e.g. dams) – upstream effects	Table 5.8	0	0	0	
Impeding features – downstream effects	Table 5.9	0	0	0	
Increased on-site water use	Table 5.10	25	4	1	
Deposition/infilling or excavation	Table 5.11	0	0	0	
Combined impact Score [3]				**1.8**	

STEP 2C: DETERMINE THE OVERALL HYDROLOGICAL IMPACT SCORE OF THE HGM UNIT BASED ON INTEGRATING THE ASSESSMENTS FROM STEPS 2A AND 2B

Changes to water distribution & retention patterns	**Table Reference**	**1.8**	**Any additional notes**
Changes to Water Input charachteristics		**4.0**	
Combined Hydrology Impact Score	Table 5.12	**6.0**	

STEP 2D: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates hydrological impact scores from each HGM unit

STEP 2E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND HYDROLOGY

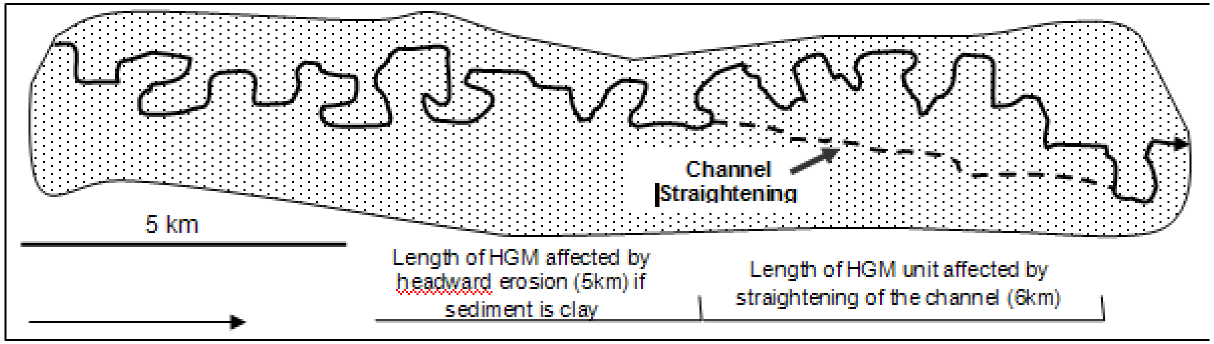
HGM Trajectory of Change score	Table 5.27	-1

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 3A: DETERMINE THE PRESENT GEOMORPHIC STATE OF INDIVIDUAL HGM UNITS

Impact type	Applicability to HGM type	Extent rating guidelines	Extent (%)[1]	Intensity rating guidelines	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Daignostic component							
(1) Upstream dams	Floodplain	See below[3]	0	Table 5.14	0	0.0	
(2) Stream diversion/shortening	Floodplain, Channeled VB	See below[4]	0	Table 5.15	0	0.0	
(3) Infilling	Floodplain, Channeled VB	See below[5]	0	See below[5]	0	0.0	
(4) Increased runoff	Non-floodplain HGMs	Table 5.16	0	Table 5.16	0	0.0	
Indicator-based component							
(5) Erosional features	All non-floodplain HGMs	Table 5.17	0	Table 5.18	0	0.0	

(6) Depositional features	All non-floodplain HGMs	Table 5.19	25	Table 5.20	1	0.3	
(6) Loss of organic matter	All non-floodplain HGMs with peat	see below[6]	0	Table 5.21	0	0.0	
Combined Impact Score based on a sum of all magnitude scores[7]						**0.1**	



STEP 3B: DETERMINE THE OVERALL PRESENT GEOMORPHIC STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates geomorphic impact scores from each HGM unit

STEP 3C: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND GEOMORPHOLOGY

HGM Trajectory of Change score	Table 5.27	**0**

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 4A: FAMILIARIZATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 4B: IDENTIFY AND ESTIMATE THE EXTENT OF DISTURBANCE CLASSES

See Column 2 in Table below

STEP 4C: ASSESS THE CHANGES TO VEGETATION COMPOSITION IN EACH CLASS, AND INTEGRATE THESE FOR THE OVERALL WETLAND

Disturbance Class	Extent (%)	Table references	Intensity [1] (0 - 10)	Magnitude [2]	Additional Notes
Infrastructure	0	Table 5.22 (Descriptions) & Table 5.23 (Typical intensity Scores)	10	0.0	
Deep flooding by dams	0		10	0.0	
Shallow flooding by dams	0		6	0.0	
Crop lands	0		9	0.0	
Commercial plantations	0		9	0.0	
Annual pastures	0		9	0.0	
Perennial pastures	0		8	0.0	
Dense Alien vegetation patches.	25		7	1.8	
Sports fields	0		9	0.0	
Gardens	0		8	0.0	
Areas of sediment deposition/ infilling & excavation	20		8	1.6	
Eroded areas	0		7	0.0	
Old / abandoned lands (Recent)	35		7	2.5	
Old / abandoned lands (Old)	0		5	0.0	
Seepage below dams	0		3	0.0	
Untransformed areas	20		0	0.0	
Overall weighted impact score [3]				**5.8**	

STEP 4D: DETERMINE THE PRESENT OVERALL VEGETATION STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates vegetation impact scores from each HGM unit

STEP 4E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND VEGETATION

HGM Trajectory of Change score	Table 5.27	**-1**

PAGE 3: HGM UNIT 2

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 2A: EVALUATE CHANGES TO WATER INPUT CHARACTERISTICS FROM THE CATCHMENT

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes
Reduction in flows (water inputs)	Table 5.1	-1.5	
Increase in flows (water inputs)	Table 5.1	0	
Combined impact Score		**-1.5**	
Change in flood patterns (peaks)	Table 5.2	2	
Magnitude of impact Score	Table 5.3	**2.0**	Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.

STEP 2B: EVALUATE CHANGES TO WATER DISTRIBUTION & RETENTION PATTERNS WITHIN THE WETLAND

	Intensity rating guidelines	Extent (%)[1]	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Gullies and artificial drainage channels	Table 5.5	0	0	0	
Modifications to existing channels	Table 5.6	0	0	0	
Reduced roughness	Table 5.7	0	0	0	
Impeding features (e.g. dams) – upstream effects	Table 5.8	0	0	0	
Impeding features – downstream effects	Table 5.9	0	0	0	
Increased on-site water use	Table 5.10	30	1	0.3	
Deposition/infilling or excavation	Table 5.11	0	0	0	
Combined impact Score [3]				**0.3**	

STEP 2C: DETERMINE THE OVERALL HYDROLOGICAL IMPACT SCORE OF THE HGM UNIT BASED ON INTEGRATING THE ASSESSMENTS FROM STEPS 2A AND 2B

Changes to water distribution & retention patterns	**Table Reference**	**0.3**	**Any additional notes**
Changes to Water Input charachteristics		**2.0**	
Combined Hydrology Impact Score	Table 5.12	**0.5**	

STEP 2D: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates hydrological impact scores from each HGM unit

STEP 2E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND HYDROLOGY

HGM Trajectory of Change score	Table 5.27	**0**

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 3A: DETERMINE THE PRESENT GEOMORPHIC STATE OF INDIVIDUAL HGM UNITS

Impact type	Applicability to HGM type	Extent rating guidelines	Extent (%)[1]	Intensity rating guidelines	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Daignostic component							
(1) Upstream dams	Floodplain	See below [3]	0	Table 5.14	0	0.0	
(2) Stream diversion/shortening	Floodplain, Channeled VB	See below [4]	0	Table 5.15	0	0.0	
(3) Infilling	Floodplain, Channeled VB	See below [5]	0	See below [5]	0	0.0	
(4) Increased runoff	Non-floodplain HGMs	Table 5.16	0	Table 5.16	0	0.0	
Indicator-based component							
(5) Erosional features	All non-floodplain HGMs	Table 5.17	0	Table 5.18	0	0.0	
(6) Depositional features	All non-floodplain HGMs	Table 5.19	0	Table 5.20	0	0.0	
(6) Loss of organic matter	All non-floodplain HGMs with peat	see below[6]	0	Table 5.21	0	0.0	
Combined Impact Score based on a sum of all magnitude scores[7]						**0.0**	

STEP 3B: DETERMINE THE OVERALL PRESENT GEOMORPHIC STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates geomorphic impact scores from each HGM unit

STEP 3C: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND GEOMORPHOLOGY

HGM Trajectory of Change score	Table 5.27	**0**

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 4A: FAMILIARIZATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 4B: IDENTIFY AND ESTIMATE THE EXTENT OF DISTURBANCE CLASSES

See Column 2 in Table below

STEP 4C: ASSESS THE CHANGES TO VEGETATION COMPOSITION IN EACH CLASS, AND INTEGRATE THESE FOR THE OVERALL WETLAND

Disturbance Class	Extent (%)	Table references	Intensity [1] (0 - 10)	Magnitude [2]	Additional Notes
Infrastructure	0	Table 5.22 (Descriptions) & Table 5.23 (Typical intensity Scores)	10	0.0	
Deep flooding by dams	0		10	0.0	
Shallow flooding by dams	0		6	0.0	
Crop lands	0		9	0.0	
Commercial plantations	0		9	0.0	
Annual pastures	0		9	0.0	
Perennial pastures	0		8	0.0	
Dense Alien vegetation patches.	30		7	2.1	
Sports fields	0		9	0.0	

Gardens	0		8	0.0	
Areas of sediment deposition/ infilling & excavation	0		8	0.0	
Eroded areas	0		7	0.0	
Old / abandoned lands (Recent)	0		7	0.0	
Old / abandoned lands (Old)	0		5	0.0	
Seepage below dams	0		3	0.0	
Untransformed areas	70		0	0.0	
Overall weighted impact score [3]				**2.1**	

STEP 4D: DETERMINE THE PRESENT OVERALL VEGETATION STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates vegetation impact scores from each HGM unit

STEP 4E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND VEGETATION

HGM Trajectory of Change score	Table 5.27	**0**

Wet-Health Lake Victoria Barn Swallow Roosting Site Wetland Level 1

PAGE 4: HGM UNIT 3

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 2A: EVALUATE CHANGES TO WATER INPUT CHARACTERISTICS FROM THE CATCHMENT

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes

Reduction in flows (water inputs)	Table 5.1	-3	
Increase in flows (water inputs)	Table 5.1	7	
Combined impact Score		**4**	
Change in flood patterns (peaks)	Table 5.2	4	
Magnitude of impact Score	Table 5.3	**4.0**	Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.

STEP 2B: EVALUATE CHANGES TO WATER DISTRIBUTION & RETENTION PATTERNS WITHIN THE WETLAND

	Intensity rating guidelines	Extent (%)[1]	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Gullies and artificial drainage channels	Table 5.5	0	0	0	
Modifications to existing channels	Table 5.6	0	0	0	
Reduced roughness	Table 5.7	60	1.5	0.9	
Impeding features (e.g. dams) – upstream effects	Table 5.8	0	0	0	
Impeding features – downstream effects	Table 5.9	0	0	0	
Increased on-site water use	Table 5.10	10	1	0.1	
Deposition/infilling or excavation	Table 5.11	0	0	0	
Combined impact Score [3]				**1.0**	

STEP 2C: DETERMINE THE OVERALL HYDROLOGICAL IMPACT SCORE OF THE HGM UNIT BASED ON INTEGRATING THE ASSESSMENTS FROM STEPS 2A AND 2B

	Table Reference		Any additional notes
Changes to water distribution & retention patterns		1.0	
Changes to Water Input charachteristics		4.0	
Combined Hydrology Impact Score	Table 5.12	6.0	

STEP 2D: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates hydrological impact scores from each HGM unit

STEP 2E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND HYDROLOGY

HGM Trajectory of Change score	Table 5.27	0

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 3A: DETERMINE THE PRESENT GEOMORPHIC STATE OF INDIVIDUAL HGM UNITS

Impact type	Applicability to HGM type	Extent rating guidelines	Extent (%)[1]	Intensity rating guidelines	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Daignostic component							
(1) Upstream dams	Floodplain	See below [3]	0	Table 5.14	0	0.0	
(2) Stream diversion/shortening	Floodplain, Channeled VB	See below [4]	0	Table 5.15	0	0.0	
(3) Infilling	Floodplain, Channeled VB	See below [5]	0	See below [5]	0	0.0	
(4) Increased runoff	Non-floodplain HGMs	Table 5.16	0	Table 5.16	0	0.0	
Indicator-based component							

(5) Erosional features	All non-floodplain HGMs	Table 5.17	0	Table 5.18	0	0.0	
(6) Depositional features	All non-floodplain HGMs	Table 5.19	0	Table 5.20	0	0.0	
(6) Loss of organic matter	All non-floodplain HGMs with peat	see below[6]	0	Table 5.21	0	0.0	
Combined Impact Score based on a sum of all magnitude scores[7]						0.0	

STEP 3B: DETERMINE THE OVERALL PRESENT GEOMORPHIC STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates geomorphic impact scores from each HGM unit

STEP 3C: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND GEOMORPHOLOGY

HGM Trajectory of Change score	Table 5.27	0

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 4A: FAMILIARIZATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 4B: IDENTIFY AND ESTIMATE THE EXTENT OF DISTURBANCE CLASSES

See Column 2 in Table below

STEP 4C: ASSESS THE CHANGES TO VEGETATION COMPOSITION IN EACH CLASS, AND INTEGRATE THESE FOR THE OVERALL WETLAND

Disturbance Class	Extent (%)	Table references	Intensity [1] (0 - 10)	Magnitude [2]	Additional Notes
Infrastructure	0	ns) & Tabl e 5.23 (Typ	10	0.0	

Deep flooding by dams	0		10	0.0	
Shallow flooding by dams	0		6	0.0	
Crop lands	0		9	0.0	
Commercial plantations	0		9	0.0	
Annual pastures	0		9	0.0	
Perennial pastures	0		8	0.0	
Dense Alien vegetation patches.	30		2	0.6	
Sports fields	0		9	0.0	
Gardens	0		8	0.0	
Areas of sediment deposition/ infilling & excavation	0		8	0.0	
Eroded areas	0		7	0.0	
Old / abandoned lands (Recent)	0		7	0.0	
Old / abandoned lands (Old)	0		5	0.0	
Seepage below dams	0		3	0.0	
Untransformed areas	70		0	0.0	
Overall weighted impact score [3]				**0.6**	

STEP 4D: DETERMINE THE PRESENT OVERALL VEGETATION STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates vegetation impact scores from each HGM unit

STEP 4E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND VEGETATION

HGM Trajectory of Change score	Table 5.27	**0**

PAGE 5: HGM UNIT 4

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 2A: EVALUATE CHANGES TO WATER INPUT CHARACTERISTICS FROM THE CATCHMENT

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes
Reduction in flows (water inputs)	Table 5.1	-3	
Increase in flows (water inputs)	Table 5.1	7	
Combined impact Score		**4**	
Change in flood patterns (peaks)	Table 5.2	4	
Magnitude of impact Score	Table 5.3	**4.0**	Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.

STEP 2B: EVALUATE CHANGES TO WATER DISTRIBUTION & RETENTION PATTERNS WITHIN THE WETLAND

	Intensity rating guidelines	Extent (%)[1]	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Gullies and artificial drainage channels	Table 5.5	0	0	0	
Modifications to existing channels	Table 5.6	0	0	0	
Reduced roughness	Table 5.7	0	0	0	

Impeding features (e.g. dams) – upstream effects	Table 5.8	0	0	0	
Impeding features – downstream effects	Table 5.9	0	0	0	
Increased on-site water use	Table 5.10	80	8	6.4	
Deposition/infilling or excavation	Table 5.11	0	0	0	
Combined impact Score [3]				**6.4**	

STEP 2C: DETERMINE THE OVERALL HYDROLOGICAL IMPACT SCORE OF THE HGM UNIT BASED ON INTEGRATING THE ASSESSMENTS FROM STEPS 2A AND 2B

Changes to water distribution & retention patterns	**Table Reference**	**6.4**	**Any additional notes**
Changes to Water Input charachteristics		**4.0**	
Combined Hydrology Impact Score	Table 5.12	**8.0**	

STEP 2D: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates hydrological impact scores from each HGM unit

STEP 2E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND HYDROLOGY

HGM Trajectory of Change score	Table 5.27	**0**

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 3A: DETERMINE THE PRESENT GEOMORPHIC STATE OF INDIVIDUAL HGM UNITS

Impact type	Applicability to HGM type	Extent rating guidelines	Extent (%)[1]	Intensity rating guidelines	Intensity (0 - 10)	Magnitude[2]	Land-use factors contributing to impacts, and any additional notes
Daignostic component							
(1) Upstream dams	Floodplain	See below [3]	0	Table 5.14	0	0.0	
(2) Stream diversion/shortening	Floodplain, Channeled VB	See below [4]	0	Table 5.15	0	0.0	
(3) Infilling	Floodplain, Channeled VB	See below [5]	0	See below [5]	0	0.0	
(4) Increased runoff	Non-floodplain HGMs	Table 5.16	0	Table 5.16	0	0.0	
Indicator-based component							
(5) Erosional features	All non-floodplain HGMs	Table 5.17	0	Table 5.18	0	0.0	
(6) Depositional features	All non-floodplain HGMs	Table 5.19	0	Table 5.20	0	0.0	
(6) Loss of organic matter	All non-floodplain HGMs with peat	see below[6]	0	Table 5.21	0	0.0	
Combined Impact Score based on a sum of all magnitude scores[7]						**0.0**	

STEP 3B: DETERMINE THE OVERALL PRESENT GEOMORPHIC STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates geomorphic impact scores from each HGM unit

STEP 3C: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND GEOMORPHOLOGY

HGM Trajectory of Change score	Table 5.27	**0**

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 4A: FAMILIARIZATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 4B: IDENTIFY AND ESTIMATE THE EXTENT OF DISTURBANCE CLASSES

See Column 2 in Table below

STEP 4C: ASSESS THE CHANGES TO VEGETATION COMPOSITION IN EACH CLASS, AND INTEGRATE THESE FOR THE OVERALL WETLAND

Disturbance Class	Extent (%)	Table references	Intensity [1] (0 - 10)	Magnitude [2]	Additional Notes
Infrastructure	0	Table 5.22 (Descriptions) & Table 5.23 (Typical intensity Scores)	10	0.0	
Deep flooding by dams	0		10	0.0	
Shallow flooding by dams	0		6	0.0	
Crop lands	0		9	0.0	
Commercial plantations	0		9	0.0	
Annual pastures	0		9	0.0	
Perennial pastures	0		8	0.0	
Dense Alien vegetation patches.	80		8	6.4	
Sports fields	0		9	0.0	
Gardens	0		8	0.0	
Areas of sediment deposition/ infilling & excavation	0		8	0.0	
Eroded areas	0		7	0.0	
Old / abandoned lands (Recent)	20		7	1.4	
Old / abandoned lands (Old)	0		5	0.0	
Seepage below dams	0		3	0.0	

Untransformed areas	0		1	0.0	
Overall weighted impact score [3]				**7.8**	

STEP 4D: DETERMINE THE PRESENT OVERALL VEGETATION STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates vegetation impact scores from each HGM unit

STEP 4E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND VEGETATION

HGM Trajectory of Change score	Table 5.27	**-1**

PAGE 6: HGM UNIT 5

STEP 2: ASSESS HYDROLOGICAL HEALTH OF THE WETLAND

STEP 2A: EVALUATE CHANGES TO WATER INPUT CHARACTERISTICS FROM THE CATCHMENT

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Land-use factors contributing to impacts, and any additional notes
Reduction in flows (water inputs)	Table 5.1	-3	
Increase in flows (water inputs)	Table 5.1	7	
Combined impact Score		**4**	
Change in flood patterns (peaks)	Table 5.2	4	

Magnitude of impact Score	Table 5.3	**4.0**	Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.

STEP 2B: EVALUATE CHANGES TO WATER DISTRIBUTION & RETENTION PATTERNS WITHIN THE WETLAND

	Intensity rating guidelines	**Extent (%)**[1]	**Intensity (0 - 10)**	**Magnitude**[2]	**Land-use factors contributing to impacts, and any additional notes**
Gullies and artificial drainage channels	Table 5.5	0	0	0	
Modifications to existing channels	Table 5.6	0	0	0	
Reduced roughness	Table 5.7	0	0	0	
Impeding features (e.g. dams) – upstream effects	Table 5.8	0	0	0	
Impeding features – downstream effects	Table 5.9	0	0	0	
Increased on-site water use	Table 5.10	100	8.5	8.5	
Deposition/infilling or excavation	Table 5.11	0	0	0	
Combined impact Score [3]				**8.5**	

1 Extent refers to the extent of the HGM unit affected by the modification expressed as a percentage of the total area of the HGM unit

2 Magnitude = Extent /100 x Intensity

3 Calculated as the sum of magnitude scores across all modifications

STEP 2C: DETERMINE THE OVERALL HYDROLOGICAL IMPACT SCORE OF THE HGM UNIT BASED ON INTEGRATING THE ASSESSMENTS FROM STEPS 2A AND 2B

Changes to water distribution & retention patterns	**Table Reference**	**8.5**	**Any additional notes**
Changes to Water Input charachteristics		**4.0**	

Combined Hydrology Impact Score	Table 5.12	**9.5**	

STEP 2D: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates hydrological impact scores from each HGM unit

STEP 2E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND HYDROLOGY

HGM Trajectory of Change score	Table 5.27	**0**

STEP 3: ASSESS GEOMORPHOLOGICAL HEALTH OF THE WETLAND

STEP 3A: DETERMINE THE PRESENT GEOMORPHIC STATE OF INDIVIDUAL HGM UNITS

Impact type	Applicability to HGM type	Extent rating guidelines	Extent (%)[1]	Intensity rating guidelines	Intensity (0 - 10)	Magnitude [2]	Land-use factors contributing to impacts, and any additional notes
Daignostic component							
(1) Upstream dams	Floodplain	See below [3]	0	Table 5.14	0	0.0	
(2) Stream diversion/shortening	Floodplain, Channeled VB	See below [4]	0	Table 5.15	0	0.0	
(3) Infilling	Floodplain, Channeled VB	See below [5]	0	See below [5]	0	0.0	
(4) Increased runoff	Non-floodplain HGMs	Table 5.16	0	Table 5.16	0	0.0	
Indicator-based component							
(5) Erosional features	All non-floodplain HGMs	Table 5.17	0	Table 5.18	0	0.0	

(6) Depositional features	All non-floodplain HGMs	Table 5.19	0	Table 5.20	0	0.0	
(6) Loss of organic matter	All non-floodplain HGMs with peat	see below[6]	0	Table 5.21	0	0.0	
Combined Impact Score based on a sum of all magnitude scores[7]						**0.0**	

STEP 3B: DETERMINE THE OVERALL PRESENT GEOMORPHIC STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates geomorphic impact scores from each HGM unit

STEP 3C: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND GEOMORPHOLOGY

HGM Trajectory of Change score	Table 5.27	**0**

STEP 4: ASSESS VEGETATION HEALTH OF THE WETLAND

STEP 4A: FAMILIARIZATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 4B: IDENTIFY AND ESTIMATE THE EXTENT OF DISTURBANCE CLASSES

See Column 2 in Table below

STEP 4C: ASSESS THE CHANGES TO VEGETATION COMPOSITION IN EACH CLASS, AND INTEGRATE THESE FOR THE OVERALL WETLAND

Disturbance Class	Extent (%)	Table references	Intensity [1] (0 - 10)	Magnitude [2]	Additional Notes
Infrastructure	0	5.22 (Descriptions) & Table 5.23 (Typical intensit	10	0.0	
Deep flooding by dams	0		10	0.0	

Shallow flooding by dams	0		6	0.0	
Crop lands	0		9	0.0	
Commercial plantations	0		9	0.0	
Annual pastures	0		9	0.0	
Perennial pastures	0		8	0.0	
Dense Alien vegetation patches.	100		8	8.0	
Sports fields	0		9	0.0	
Gardens	0		8	0.0	
Areas of sediment deposition/ infilling & excavation	0		8	0.0	
Eroded areas	0		7	0.0	
Old / abandoned lands (Recent)	0		7	0.0	
Old / abandoned lands (Old)	0		5	0.0	
Seepage below dams	0		3	0.0	
Untransformed areas	0		1	0.0	
Overall weighted impact score [3]				**8.0**	

STEP 4D: DETERMINE THE PRESENT OVERALL VEGETATION STATE OF THE WETLAND BASED ON INTEGRATING SCORES FROM INDIVIDUAL HGM UNITS

See summary page Table 5.28 - integrates vegetation impact scores from each HGM unit

STEP 4E: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF THE WETLAND VEGETATION

HGM Trajectory of Change score	Table 5.27	**0**

PAGE 1: SUMMARY PAGE

STEP 1: IDENTIFY HGM UNITS IN THE WETLAND AND DESCRIBE THE LOCAL CLIMATE

STEP 1A: IDENTIFY THE HGM TYPES IN THE WETLAND AND DIVIDE THE WETLAND INTO HGM UNITS

HGM Unit	HGM Type	Ha	Extent (%)*
1	Valley-bottom with a channel	11.0	59
2	Valley-bottom without a channel	6.4	34
3	Hillslope seepage linked to a stream channel	0.3	1
4	Isolated Hillslope seepage	0.6	3
5	Isolated Hillslope seepage	0.6	3
	Total	**18.8**	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

Legend
Enter information

STEP 1B: ASSESS THE VULNERABILITY OF THE HGM UNIT TO ALTERED WATER INPUTS BASED ON LOCAL CLIMATE

Table 2.1: Hydrological vulnerability factor based on the MAP:PET

MAP to PET ratio	>0.6	0.50-0.59	0.40-0.49	0.30-0.39	<0.3
Vulnerability factor	0.9	0.95	1	1.05	1.1
Vulnerability factor	0.9				

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: WATER INPUTS: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE UNIT FROM ITS UPSTREAM CATCHMENT.

STEP 3: WATER DISTRIBUTION AND RETENTION: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE HGM UNIT HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES.

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF EACH HGM UNIT BASED ON INTEGRATING THE SCORES FROM STEPS 2 AND 3.

STEP 5: DETERMINE THE OVERALL PRESENT HYDROLOGICAL STATE FOR THE WETLAND BY INTEGRATING THE SCORES OF INDIVIDUAL HGM UNITS IN THE WETLAND.

Table 2.18: Derivation of the overall impact score for the wetland being considered.

HGM Unit	Area (ha)	Extent (%)	Overall impact score for HGM unit	Area weighted HGM score*	Present Hydrological State category
1	11	59	3.0	1.8	
2	6	34	1.5	0.5	
3	0	1	6.0	0.1	
4	1	3	5.0	0.2	
5	1	3	7.0	0.2	
Total		**100**	**Overall weighted impact score****	**2.7**	**C**

*Area weighted impact score = HGM extent /100 x impact score
** Overall area weighted impact score = sum of individual area weighted scores for each HGM unit

STEP 6: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE OF WETLAND HYDROLOGY.

Table 2.21: Evaluation of threats within each HGM unit.

HGM Unit	Description of sources of change	HGM extent	Change score*	Area-weighted score**
1	Increasing alien vegetation	59	-1	-0.6
2	Increasing alien vegetation, Drain south of wetland potential threat if deepened.	34	0	0.0
3	Increasing alien vegetation	1	0	0.0
4	Increasing alien vegetation	3	0	0.0
5	Increasing alien vegetation	3	0	0.0
			Overall weighted threat score***:	**-0.6**

STEP 7: DESCRIBE THE OVERALL HYDROLOGICAL HEALTH OF THE WETLAND BASED ON PRESENT HYDROLOGICAL STATE AND TRAJECTORY OF CHANGE

Hydrological Health

Present Hydrological State	C	see Table 2.6
Trajectory of Change	↓	see Table 2.20

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PAGE 2: HGM UNIT 1

STEP 2: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE WETLAND

Vulnerability factor	0.9

Legend

Enter information

STEP 2A: IDENTIFY, MAP AND ASSESS IMPACT OF LAND-USE ACTIVITIES THAT REDUCE THE INFLOW QUANTITY TO THE HGM UNIT

Table 2.2: Different land-use types and activities potentially altering inflow quantities to the HGM unit from its upstream catchment, and the magnitude of their collective effect (1)

Reduced Flows

Land-use activity descriptors		Low / High					Scores	Intensity of water loss (2)	Extent (%)	Magnitude (3)
		0	-2	-5	-8	-10				
Irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	Seasonal	Year-round	-8	-5.9	50	-2.9
	(2) Prevalence of water conserving practices[R]		High	Intermediate	Low		-5			
Other abstractions not used for irrigation in the catchment (4)										
Alien plants	(1) plant type[R]			Shrubs	Trees		-8	-5.9	40	-2.3
	(2) Distribution of alien woody plants in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-5			
Plantations	(1) Tree type[R]				Wattle & pine	Eucalyptus	0	0.0	0	0.0
	(2) Distribution of tree plantations in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Sugar (5)	(1) Crop type[R]		Sugar				-2	-1.8	45	-0.8
	(2) Distribution in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-2			

Dams: specific allowance for releasing low flows within the operating rules of the dam[R]			Allowance made	No allowance		0	0.0	0	0.0
Overall magnitude of reduction in water inputs to the HGM unit as the sum of all the above impact magnitudes:									**-6.1**

Increased Flows

Description of the level of increase	Magnitude score
Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).	10
Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.	7
Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).	3
No increase, or flow is increased by a negligible amount.	0
Magnitude of impact associated with increases in water inputs	7

Combined score: Increased flows score + Decreased flows score The combined score will range from -10 to +10, depending on the magnitude of the factors causing an increase or decrease in flow respectively	**0.9**

STEP 2B: ASSESS THE INTENSITY OF IMPACT OF FACTORS POTENTIALLY ALTERING FLOW PATTERNS TO THE HGM UNIT

Table 2.3: Factors potentially contributing to a decrease or increase of floodpeak magnitude and/or frequency received by the HGM unit

Level of reduction	Low				High	Score
	0	-2	-5	-8	-10	
(1) Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R*]	<20%	20-35%	36-60%	60-120%	>120%	0
(2) Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	High	0

(3) Specific allowance for natural floods within the operating rules of the dam[R] **	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	0
Level of increase	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
(4) Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	2
(5) Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R]***	<10%	11-40%	41-80%	>80%		0
Combined Score: [Ave of (1), (2) and (3)] + (4) + (5)] adjusted****						**2.0**

STEP 2C: ASSESS THE COMBINED MAGNITUDE OF IMPACT OF ALTERED QUANTITY AND PATTERN OF INPUTS, ACCOUNTING FOR THE WETLAND UNIT'S VULNERABILITY

Reduction in quantity of water inputs (Table 2.2):	**0.9**

Alteration to floodpeaks (Table 2.3):	**2.0**

Table 2.5: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs.

(a) Floodplains and channeled valley bottoms driven primarily by over-bank flooding

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Score from Table 2.3)**						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to	(-4 to -6)	(<-6)
> 9	7	6	5	4	5	6	7
4 - 9	5	4	3	3	4	6	7
1-3.9 (Increase)	3	2	1	1	2.5	4.5	7
-0.9- +0.9 (Negligible)	1	1	0	0	1	5	7.5

-1- -1.9 (Decrease)	2	1.5	1	1	2.5	5	7.5
-2- -3.9	3	2.5	2	2	4	6	8
-4- -5.9	4	3.5	3	3	5	7	8.5
-6- -7.9	-**	-**	-**	4	6	8	9
-8- -9	-**	-**	-**	-**	-**	9	9.5
< -9	-**	-**	-**	-**	-**	-**	10

(b) Other hydro-geomorphic settings, including floodplains and channeled valley bottoms driven primarily by lateral inputs (e.g. from tributaries)

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Table 2.4)**						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to -3.9)	(-4 to -6)	(<-6)
> 9	6	5	4	3	3	3.5	4
4 - 9	4.5	4	3	2	3	3	3
1-3.9 (Increase)	3	2	1	1	1	2	2.5
-0.9- +0.9 (Negligible)	2.5	1.5	0.5	0	0.5	1	1.5
-1- -1.9 (Decrease)	3.5	2.5	1.5	1	1.5	2	2.5
-1 - -3.9	4.5	3.5	2.5	2	2.5	3	3.5
-2 - -3.9	6	5	4	3.5	4	4.5	5
-4- -5.9	-**	-**	-**	5	5.5	6	6.5
-6- -7.9	-**	-**	-**	-**	-**	7.5	8
< -9	-**	-**	-**	-**	-**	-**	10

**These classes are unlikely, given that when there is a high level of reduction of quantity of inputs then there would be insufficient water to maintain unaltered or increased floodpeaks (i.e. a decrease in floodpeaks would be inevitable).

Magnitude of impact based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs:	**0.5**
Magnitude of impact adjusted to account for any change in seasonality:***	**0.5**

***If seasonality has been changed moderately then increase the magnitude of impact score by 1 and if it has been changed greatly then increase the magnitude of impact score by 2.

STEP 3: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE HGM UNIT HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES

STEP 3A: ASSESS MAGNITUDE OF IMPACT OF CANALIZATION AND STREAM MODIFICATION

Canalization

Note: Where more than one section of a HGM unit is affected by canalization, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.7: Characteristics affecting the impact of canalization on the distribution and retention of water in the HGM unit

	ha	%
Extent of HGM unit affected by canalization	0	0

Factors	Low 0	2	5	8	High 10	Score
Characteristics of the wetland						
(1) Slope of the wetland	<0.5%	0.5-0.9%	1-1.9%	2-3%	>3%	10
(2a) Texture of mineral soil, if present*	Clay	Clay loam	Loam	Sandy loam	Sand/loamy sand	5
(2b) Degree of humification of organic soil, if present*	Completely amorphous (like humus)	Somewhat amorphous	Intermediate	Somewhat fibrous	Very fibrous	
(3) Natural level of wetness	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	5
Characteristics of the drains/gullies						
(4) Depth of the drains/gullies	<0.20 m	0.20-0.50 m	0.51-0.80 m	0.81-1.10	>1.10 m	2
(5) Density of drains (meters of drain per hectare of wetland)**	<25 m/ ha	26-100 m/ha	101-200 m/ha	201-400 m/ha	>400 m/ha	0
(6) Location of drains/gullies in relation to flows into and through the wetland[R]. Drains/gullies are located such that flows are:	Very poorly intercepted	Moderately poorly intercepted	Intermediately intercepted	Moderately well intercepted	Very well intercepted	8

Note: Leave either 2a OR 2b blank

(7) Obstructions in the drains/ gullies	Complete obstruction	High obstruction	Moderate obstruction	Low obstruction	No obstruction	10
Calculate the mean score for factors 1, 2a or 2b, 3, 4 and 5						4.4
Multiply the score for factor 5 by the flow alteration factor (Table 2.1)						7.2
Mean score for above two scores						5.8
Intensity of impact for canalization: Divide the score for factor 7 by 10 and multiply this by the mean score derived in previous row						5.8
Magnitude of impact of canalization: Extent of impact/100 × intensity of impact calculated in the row above						**0.0**

Stream channel modification

Note: Where more than one section of a HGM unit is affected by stream channel modification, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.8: Characteristics affecting the impact on the distribution and retention of water in the HGM unit through the modification of a stream channel

	%
Extent of HGM unit affected by stream channel modification*	0
HGM weighting factor	0

*should be expressed as a percentage of the length of the HGM unit (See diagram alongside)

Characteristics of stream channel	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
(1) Reduction in length of stream per unit valley length[D]	<5%	5 – 25%	25 – 50%	50 – 75%	75 – 100%	0
(2) % increase in cross sectional area of the stream[F]	<5%	5 – 25%	26 – 50%	51 – 75%	>75%	0
(3) Change in surface roughness in relation to the surface roughness of the channel in its natural state (see Table 2.9 for description of roughness classes)	Roughness is increased or is unchanged[1]	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: use the maximum score of factors 1 to 3 x HGM weighting factor*						**0**
Magnitude score of impact of stream channel modification: extent of impact/100 × intensity of impact						**0.0**

Overall magnitude of impact score: canalization and stream channel modification	Score
Calculate the sum of scores from Tables 2.7 and 2.8.	0.0

STEP 3B: ASSESS MAGNITUDE OF IMPACT OF IMPEDING FEATURES

Note: Where more than one section of a HGM unit is affected by an impeding feature, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.11: Typical changes in water-distribution and -retention patterns within an HGM unit as a result of impeding structures

result of impeding structures

(a) Upstream impact of flooding

Extent Assessment	ha	%
(a) Extent of HGM unit affected by flooding **upstream** of the impeding structure	0.0	0

Descriptor	Low				High	Score
	0	2	5	8	10	
Representation of different hydrological zones prior to flooding by the dam[R]	-	Seasonal and permanent zone both present and collectively >30%	Permanent and seasonal zones both present but collectively <30%	Seasonal zone present but permanent zone absent	Permanent and seasonal zones lacking (i.e. only the temporary zone present)	0
Intensity of impact: score for above factor X 0.8						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

(b) Downstream impact on quantity and timing of flows to downstream portion of the HGM unit

Extent Assessment	ha	%
(b) Extent of HGM unit affected by flooding **downstream** of the impeding structure	0.0	0

	Low				High	Score
	0	2	5	8	10	

Extent to which dams or roads interrupt low flows to downstream areas [R]	No interruption (e.g., many culverts through a road embankment)	Slight interruption (e.g., a moderate number of culverts through a road embankment)	Intermediate interruption (e.g. earth dam with very high seepage or road embankment with no/ very limited culverts)	Moderately high interruption (e.g. earth dam with some seepage/ flow releases)	High interruption (e.g. a concrete dam with no seepage and no low flow releases)	2
Level of abstraction from the dam/s [R]	Low	Moderately low	Intermediate	Moderately high	High	0
Location of dam/s relative to the affected area's catchment- proportion of catchment flows intercepted [D]	Dam intercepts <20% of the affected area's catchment	Dam intercepts 21-40% of the affected area's catchment	Dam intercepts 41-60% of the affected area's catchment	Dam intercepts 61-80% of the affected area's catchment	Dam intercepts >80% of the affected area's catchment	0
Collective volume of dam/s in relation to MAR of the affected area[D]	<20%	20-35%	36-60%	60-120%	>120%	0
Intensity of impact: mean score of the two highest scoring factors x 0.8						0.7
Magnitude-of-impact score: extent of impact /100 × intensity of impact						**0.0**

(c) Combined impact

Combined impact: Magnitude of impact for upstream + Magnitude of impact for downstream	**0.0**

STEP 3C: ASSESS MAGNITUDE OF IMPACT OF ALTERED SURFACE ROUGHNESS

Table 2.12: Comparison of surface roughness of an HGM unit in its current state compared with its natural state

Extent of HGM unit affected by change in surface roughness	ha	%

	2.6	40

Class	Descriptor	Current	Historic
Low	Smooth surface with little or no vegetation to offer resistance to water flow	Moderately high	Moderate
Moderately low	Vegetation is present but short (i.e. < 500mm) and not robust (e.g. rye grass)		
Moderate	Vegetation offering slight resistance to water flow, generally consisting of short plants (i.e. < 1 m tall)		
Moderately high	Robust vegetation (e.g. dense stand of reeds) or hummocks offering high resistance to water flow		
High	Vegetation very robust (e.g. dense swamp forest with a dense under storey) and offering high resistance to water flow.		

Note: Where roughness varies across the HGM unit, take the average condition, and where roughness varies over time (e.g. areas which are regularly cut short) take the average condition during the wet season.

Descriptor	Low			High		Score
	0	2	5	8	10	
Change in surface roughness in relation to the surface roughness of the wetland in its natural state[F]	Roughness increased or is unchanged*	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: score for the above row X 0.6						0
Magnitude of impact score: extent of impact /100 × intensity of impact						0.0

*It is considered to be of greater consequence to water retention and distribution if the surface roughness of a wetland is decreased than if it is increased, therefore the focus of this assessment is primarily on a decrease in surface roughness.

STEP 3D: ASSESS THE IMPACT OF DIRECT WATER LOSSES

Table 2.13: Evaluating the effect of alien woody plants, commercial plantations and sugarcane growing in the HGM unit on water loss

Land-use activity descriptors	Low				High	Score	Intensity of water loss*	Extent (%)	Magnitude**
	0	2	5	8	10				
(1) Alien woody plant type[F]			Shrubs	Trees		8	5	50	4.0

(1) Plantation tree type[F]				Wattle & pine	Eucalyptus	0	0	0	0.0
(1) Sugarcane Growth[F]		Poor growth	Good growth			2	3	45	0.9
(4) Direct water abstractions		Low	Moderately low	Moderately high	High	0	0	0	0.0
Overall magnitude of increased water loss: (sum of (1), (2), (3) and (4)) x 0.8									**3.9**

*Intensity= Score x Vulnerability factor (from Table 2.1) **Magnitude=Intensity x Extent (%)/100

Note: When assessing extent, remember that the extent of the impact may extend beyond the direct area in which the alien woody plants or plantations occur in the HGM unit to also include a downstream portion subject to reduced flows. If this is the case, adjust the score accordingly with documented justification.

STEP 3E: ASSESS THE MAGNITUDE OF IMPACT OF RECENT DEPOSITION, INFILLING OR EXCAVATION

Table 2.14 Magnitude of impact of recent deposition, infilling or excavation

Extent Assessment	**ha**	**%**
Extent of HGM unit affected by deposition or excavation	0.0	0

Descriptor	**Low**			**High**		**Score**
	0	**2**	**5**	**8**	**10**	
Effect on vertical drainage properties of the uppermost soil layer	No effect	Rendered somewhat free-draining	Intermediate	Rendered free-draining	Rendered very well- drained*	0
Effect on the horizontal movement of water	No effect	Moderate modification	Large modification	Serious modification		0
Intensity of impact: use the highest score for the above two factors						0
Magnitude of impact score: extent of impact (%)/100 x intensity of impact x 1						**0**

*i.e. drainage is so free that the area no longer has any wetland characteristics

STEP 3F: DETERMINE COMBINED MAGNITUDE OF IMPACT OF ON-SITE ACTIVITIES

Table 2.15: Overall magnitude of impacts of on-site activities on water distribution and retention patterns n the HGM unit

Activity	Magnitude of impact	Justification for any modifications made
(1) Calculated magnitude of impact of canalization and stream channel modification from Table 2.10	0.0	
(2) Calculated magnitude of impact of impeding features from Table 2.11	0.0	
(3) Calculated magnitude of impact of altered surface roughness from Table 2.12	0.0	
(4) Calculated magnitude of impact of aliens, timber and/or sugarcane in the wetland from Table 2.13	3.9	
(5)) Calculated magnitude of impact of recent deposition/excavation from Table 2.14	0.0	
Total score of magnitude of on-site activities in the HGM unit (sum of the above scores)*	3.9	* If score is > 10, then magnitude of impact = 10

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF THE HGM UNIT THROUGH INTEGRATING THE ASSESSMENTS FROM STEPS 2 AND 3

Changes to water distribution & retention patterns (Table 2.15):	3.9	Changes to Water Inputs (Table 2.5):	0.5

Combined magnitude score as a result of impacts on hydrological functioning	3

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PAGE 1: SUMMARY PAGE

STEP 1: MAP EACH HGM UNIT AND IDENTIFY WHICH INDIVIDUAL ASSESSMENTS ARE REQUIRED

HGM Unit	HGM Type	Ha	Extent (%)*
1	Valley-bottom with a channel	6.4	34
2	Valley-bottom without a channel	11.0	59

Legend
Enter information

3	Hillslope seepage linked to a stream channel	0.3	1
4	Isolated Hillslope seepage	0.6	3
5	Isolated Hillslope seepage	0.6	3
Total		**18.8**	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES
STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

STEP 5: DETERMINE OVERALL PRESENT GEOMORPHIC STATE FOR THE WETLAND BY INTEGRATING SCORES OF INDIVIDUAL HGM UNITS

Table 3.19: Derivation of the overall Present Geomorphic State for the wetland being considered

HGM Unit number	Area (ha)	HGM unit extent (%)	HGM unit impact score (Table 3.17)	Area weighted impact score*	Present Geomorphic State Category
1	6	34	1.0	0.3	
2	11	59	0.0	0.0	
3	0	1	1.0	0.0	
4	1	3	0.0	0.0	
5	1	3	0.0	0.0	
Total		**0**	**Overall weighted impact score****	**0.4**	**A**

*Area weighted impact score = HGM extent /100 x impact score

**Overall area weighted impact score = sum of individual area weighted scores for each HGM unit

STEP 6: ASSESS VULNERABILITY AND TRAJECTORY OF CHANGE DUE TO EROSION

STEP 6A: ASSESS VULNERABILITY TO EROSION OF EACH HGM UNIT

HGM unit no.	Slope (%)	Area (ha)
1	3.12	6.4
2	0.34	11.0
3	8.69	0.3
4	4.74	0.6
5	4.40	0.6
6		18.8

Table 3.21: Tabulation of the geomorphic vulnerability of each HGM unit of the wetland

HGM unit no.	HGM unit type	Vulnerability score*	Extent of predicted headcut advancement (%)**	Comments (optional)
1	Valley-bottom with a channel	2	0	
2	Valley-bottom without a channel	0	0	
3	Hillslope seepage linked to a stream channel	5	0	
4	Isolated Hillslope seepage	2	0	
5	Isolated Hillslope seepage	2	0	

STEP 6B: DESCRIBE THE INCREASED EXTENT OF GULLIES IN RELATION TO ANY EXTERNAL CONTROLS

STEP 6C: ASSESS THE LIKELY TRAJECTORY OF CHANGE OF GEOMORPHIC STATE

Table 3.23: Evaluation of likely Trajectory of Change of geomorphic condition of the entire wetland.

HGM Unit	Description of relevant sources of change	HGM unit extent (%)	HGM Unit Change score*	Area-weighted change score**
1		34	0	0.0
2		59	0	0.0
3		1	0	0.0
4		3	0	0.0
5		3	0	0.0
			Overall weighted threat score:***	**0.0**

STEP 7: DESCRIBE OVERALL GEOMORPHOLOGICAL HEALTH OF THE WETLAND BASED ON PRESENT GEOMORPHIC STATE AND TRAJECTORY OF CHANGE

Geomorphogical Health

Present Geomorphic State	A	see Table 3.18
Trajectory of Change	→	see Table 3.22

WET-Health Lake Victoria Barn Swallow Roosting Site Wetland Geomorphology Module Level 2

PAGE 2: HGM UNIT 1

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

Table 3.1: Guideline for assessing the impacts of activities according to HGM type

HGM type to assess	Activity/Indicator that should be assessed
Diagnostic component	
Floodplain	Dams upstream of or within floodplains (see Step 2A)
Floodplain, channeled valley bottom	Stream shortening or straightening (see Step 2B)
Floodplain, channeled valley bottom	Infilling that leads to narrowing of the wetland (see Step 2C)
All non-floodplain HGM's	Changes in runoff characteristics (see Step 2D)
Indicator-based component	
All non-floodplain HGM's	Erosional features (see Step 3A)
All non-floodplain HGM's*	Depositional features (see Step 3A)
All non-floodplain HGM's	Loss of organic sediment (see Step 3B)

* Consider floodplains if there are large alluvial fans impinging on the floodplain laterally to it (from the side).

HGM Type
Valley-bottom with a channel

If floodplain, are there large alluvial fans impinging laterally on the floodplain (from the side of the floodplain)?

Note: Steps that need to be completed are indicated with a "Yes" based on the HGM type selected in the summary page.

Step 2A: Impacts of dams upstream of and/or on floodplains

To assess?	No

See Table 3.1

Dams in the floodplain catchment

Table 3.2: Extent, intensity and magnitude of impacts of impoundments in the catchment

Extent of impact of dams situated above floodplains						**Extent (%)**
Extent: For dams upstream of floodplains extent is assumed to be 100%. If a dam is also situated on the floodplain, extent of impact for the dam above the floodplain is determined as the length of the floodplain above the dam / total floodplain length, expressed as a percentage						
Intensity of impact score – size of dams and nature of sediment transported						
Determine the size of dam/s on the stream and the nature of sediment load being transported						
	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	**Score**
Suspended load dominated	0.5	1	1.5	2	2.5	
Mixed load	1	2	3	4	5	
Bedload dominated	2	3	4	5	5	
Intensity of impact score – location of dams in the catchment						

Enter single score

Score	1	2	3	4	5	Score
Location of dam/s	Dams on minor tributary stream or on trunk stream far upstream of floodplain	Intermediate between descriptions for scores 0 and 5	Dams on major tributary or on trunk stream a moderate distance upstream of floodplain	Intermediate between descriptions for scores 5 and 10	Dam on trunk stream immediately above floodplain	
Overall intensity of impact score for dams situated above floodplains: mean of above 2 scores						0.0
Magnitude of impact score for dams situated above floodplains: (extent of impact score/ 100) x overall intensity of impact score						0.0

Dams on the floodplain

Table 3.3: Extent, intensity and magnitude of impact of impoundments within the floodplain.

Extent of impact of dams situated within floodplains						**Extent (%)**
Extent: The percentage of the floodplain valley length flooded by the dam and below the dam wall						
Intensity of impact of dams situated within floodplains						
SCORE	**1**	**2**	**3**	**4**	**5**	**Score**
Size of dam	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	
Configuration of spillway/s			Baseflows to floodplain stream: peak flows to backswamp	Baseflows and peak flows to floodplain stream **OR** baseflows to backswamp and peak flows to floodplain stream	Baseflows and peak flows to backswamp	
Overall intensity of impact score for dams situated within floodplains: mean of above 2 scores						0
Magnitude of impact score for dams situated within floodplains: (extent of impact score / 100) x overall intensity of impact score						0.0

Combining impacts of dams in the catchment and on the floodplain

Table 3.4: Combining the magnitude of impact scores of impoundments upstream of and on the floodplain.

Magnitude of impact score for dams upstream of and on the floodplain	
Magnitude of impact score for dam/s located in the catchment (Table 3.2)	0.0
Magnitude of impact score for dam/s located within the floodplain (Table 3.3)	0.0
Overall magnitude of impact for floodplain wetlands with dams upstream of and on the floodplain = sum of above two rows	**0.0**

Impacts of channel straightening	**To assess?**	**Yes**	See Table 3.1

Table 3.5: Extent, intensity and magnitude of impacts of channel straightening

Extent of impact of channel straightening.						**Extent (%)**
Extent: the length of modification plus THE LESSER OF 10km for sandy stream beds OR 5km for silty/clayey stream beds OR the distance to the head of the floodplain OR to a dam wall (if present), expressed as a percentage of floodplain length[R]						0
Intensity of impact of channel straightening						
	0	**1**	**2**	**3**	**4**	Intensity
Reduction in stream length per unit valley length[R]	<5%	6-25%	26-50%	51-75%	>75%	0
Magnitude of impact of channel straightening: (extent of impact score/ 100) x intensity of impact score						**0.0**

Step 2C: Impacts of artificial wetland infilling	**To assess?**	**Yes**	See Table 3.1

Table 3.6: Extent, intensity and magnitude of impact of infilling of floodplains and channeled valley bottom wetlands.

Extent of impact of infilling.						**Extent (%)**
Extent of impact of infilling as determined by establishing the area of wetland that will not be subjected to normal erosion and / or deposition, as a percentage of wetland area.						0
Intensity of impact of infilling						
	0	**1**	**2**	**3**	**4**	**Score**

Reduction in active wetland width at point of infillingR	<5%	6-25%	26-50%	51-75%	>75%	0
Magnitude of impact of infilling: (extent of impact score / 100) x intensity of impact score.						**0**

Step 2D: Impacts of changes in runoff characteristics

To assess? **Yes** See Table 3.1

Table 3.7: Effect of altered water inputs (increased flows and floodpeaks) on wetland geomorphological integrity

Extent of impact of altered water inputs						**Extent (%)**
Extent calculated based on length of wetland affected by increased flow as a proportion (%) of the entire wetland length.						50
Intensity of impact of altered water inputs						
		Increased floodpeaks (combined score in Table 2.3)				
		No effect (0-2)	Small increase (2.1-4)	Moderate increase (4.1-7)	Large increase (>7)	
Increased flows (increased flow score in Table 2.2)	No increase (0-2)	0	1	2	3.5*	
	Small increase (2.1-4)	1	1.5	3	4	
	Moderate increase (4.1-7)	2	3	4	4.5	
	Large increase (>7)	3.5*	4	4.5	5	
Change Score						2
Magnitude of impact score: (extent of impact score/100) x intensity of impact score (from above rows)						**1.0**

* Unlikely to occur

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

Step 3A: Impacts of erosion and/or deposition

Erosional features

To assess? **Yes** See Table 3.1

Table 3.8: Estimation of extent of impact of erosional features

	Length of wetland occupied by gully/ies as a percentage of the length of HGM[R]				
	0-20%	21-40%	41-60%	51-80%	>80%

Average gully width (sum of gully widths if more than 1 gully present) in relation to wetland width[R]	< 5%	5%	10%	15%	20%	25%	
	5-10%	10%	15%	25%	35%	45%	
	11-20%	15%	25%	40%	55%	65%	
	21-50%	20%	30%	50%	70%	80%	**Extent (%)**
	>50%	25%	40%	60%	80%	100%	0

Table 3.9: Intensity and magnitude of impact of erosional features. The scores for rows 2 and 3 are unscaled for any natural recovery that may have taken place. Factors to use to scale the intensity of impact of erosional features for natural recovery are presented in rows 7 and 8.

Factor	1	2	3	4	5	Unscaled score
Mean depth of gullies[F]	<0.50m	0.50-1.00m	1.01-2.00m	2.00-3.00m	>3.00m	0
Mean width of gullies[F]	<2m	2-5m	5.1-8m	8.1-16m	>16m	0
Number of headcuts present[F]	1	2	3	4	>4	0
Unscaled intensity of impact score: mean score of above 3 rows						0.0
Scaling factor	**0.4**	**0.5**	**0.7**	**0.9**	**1**	**Factor**
Extent to which sediment from the gully is deposited within the HGM or wetland downstream of the HGM unit (as opposed to being exported)[F]	Entirely deposited	Mainly deposited	Intermediate	Mainly exported	Entirely exported	0
Extent to which the bed and sides of the gully have been colonized by vegetation and/or show signs of natural recovery[F]	Complete	High	Moderate	Low	None	0
Scaling factor score: mean of above 2 rows (value is between 0 and 1)						0.0
Scaled intensity of impact score = unscaled intensity of impact score x scaling factor score						0.0
Magnitude of impact score for erosional features: (extent of impact score (see Table 3.8)/100) × scaled intensity of impact score						**0.0**

Depositional features

To assess?	**Yes**	See Table 3.1

We are only interested here in recent depositional features. If the user feels confident in being able to map depositional features that can be attributed directly to recent human activity, then extent should be established directly using Table 3.10, but if they are not confident that they can do this, indirect indicators can be used as outlined in Table 3.11. Users may wish to use a combination of approaches by using the indirect indicators to assist in the location and mapping of depositional features in the wetland of interest, following which they may map depositional features directly, but ideally, one would only map these features directly.

Table 3.10: Estimation of the extent of impact of depositional features for known depositional features in the HGM unit.

Extent of depositional features in relation to area of HGM unit being considered	0.2-1.9%	2-10%	11-25%	26-50%	>50%	
Score for “extent” to be used in the estimation of magnitude of impacts	5	20	50	75	100	0

Table 3.11: Estimation of extent of depositional features based on indirect indicators of recent anthropogenic activity leading to excessive deposition.

Indicator	0	1	2	3	4	Score
Presence, size and distribution of gullies or active erosion of drains within the catchment or wetland	None or very small	Limited extent and size	Moderate size and distribution	Large size or widespread distribution	Very large size or widespread distribution	2
Presence / extent of dirt roads in the catchment	None / few	Moderate	Many / extensive			0
Breaching of upstream dams in the catchment or wetland	None	Very small earthen dams	Small earthen dams	Large earthen dams		0
Extent of decreased vegetation cover in the catchment	Slight	Moderate	High			0
Mean of two highest scores from the above						1.0
Extent of impact score of depositional features as a percentage is calculated as the score from the above multiplied by 10.						10

Table 3.12: Intensity and magnitude of impact of depositional features

Indicator	0	1	2	3	Score
The position of fan-like deposits within the wetland[R]		Toe	Middle	Upper	0
Impact of depositional features on existing wetland features[D]	Not evident	Minor destruction of features	Moderate destruction of features	Large impact on existing features	0
Intensity of impact score of depositional features: mean of two rows above					0
Magnitude of impact score of depositional features: (extent of impact score (Table 3.10 or 3.11) / 100) x intensity of impact score					**0.0**

Step 3B: Impacts of the loss of organic sediment	**To assess?**	**Yes**	See Table 3.1

A. Extent of impact score based on direct indicators (if present)	0	%
B. Additional extent of impact score based on indirect indicators (if present)	0	%

To determine the intensity of impact in the affected area of the wetland, see Tables 3.14 and 3.15 for direct and indirect indicators respectively.

Direct indicators

Table 3.14: Macroscopic features (clearly visible direct indicators) determining the intensity of impact of the loss of organic sediments

Activity	1	2	3	4	5	Score
Depth of the peat fires or extraction of peat relative to the depth of the peat deposit	<5%	5-15%	16-30%	31-60%	>60%	0
If tillage is practiced, duration of tillage	1-2 yrs	3-5 yrs	6-10 yrs	>10 yrs		0
Intensity of impact score: maximum score of above scores						0.0
Magnitude of impact score of loss of organic sediments: (extent of impact score (Table 3.13A) /100) × intensity of impact score						0.0

Indirect indicators

Table 3.15: Indirect indicators (not clearly visible) reflecting the intensity of diminished integrity of organic sediments in the HGM unit.

	0	1	2	3	4	Intensity score
Level of desiccation of the region of the HGM unit in which peat accumulation is taking place*	Unmodified	Largely natural	Moderately modified	Largely modified	Serously / critically modified	0
Magnitude of impact score: extent of impact score (Table 3.13B)/100 × intensity of impact score						0.0

Overall magnitude of impact: Organic sediment

Table 3.16: Magnitude of impact score for organic sediments expressed as a proportion of the area of the entire HGM unit

	Overall magnitude of impact score: organic sediments
Sum of magnitude scores in Tables 3.14 and 3.15	**0.0**

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

Table 3.17: Derivation of overall magnitude-of-impact scores through combining the scores obtained from individual assessments.

Impact category	Score	To include?
1. Magnitude of impact of dams (Table 3.4)	N/A	No
2. Magnitude of impact of channel straightening (Table 3.5)	0.0	Yes
3. Magnitude of impact of infilling (Table 3.6)	0.0	Yes
4. Magnitude of impact of changes in runoff characteristics (Table 3.7)	1.0	Yes
5. Magnitude of impact for erosional features (Table 3.9)	0.0	Yes
6. Magnitude of impact for depositional features (Table 3.12)	0.0	Yes
7. Magnitude of impact for loss of organic sediment (Table 3.16)	0.0	Yes
Overall Present Geomorphic State = Sum of three highest scores	**1.0**	

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PAGE 1: SUMMARY PAGE

STEP 1: MAP AND DETERMINE THE EXTENT OF EACH HGM UNIT

HGM Unit	HGM Type	Ha	Extent (%)*
1	Valley-bottom with a channel	6.41	34
2	Valley-bottom without a channel	11.02	59
3	Hillslope seepage linked to a stream channel	0.26	1
4	Isolated Hillslope seepage	0.58	3
5	Isolated Hillslope seepage	0.56	3
Total		**18.83**	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

Legend
Enter information

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE SHEETS PROVIDED)

STEP 2: DETERMINE THE PRESENT VEGATATION STATE OF WETLAND VEGETATION IN EACH HGM UNIT

STEP 3: DETERMINE THE OVERALL PRESENT VEGETATION STATE FOR THE WETLAND

Table 4.7: Summary impact score for each HGM and assessment of overall Present Vegetation State of the wetland

HGM Unit	Area (ha)	HGM unit extent (%)	HGM unit magnitude of impact score (from Table 4.6)	Area weighted impact score*	Present Vegetation State category
1	6.4	34	**7.3**	2.5	
2	11.0	59	**0.5**	0.3	
3	0.3	1	**2.1**	0.0	
4	0.6	3	**8.0**	0.2	
5	0.6	3	**9.0**	0.3	
		100	**Overall weighted impact score****	**3.3**	**C**

*Area weighted impact score = HGM extent /100 x impact score
**Overall area weighted impact score = sum of individual area weighted scores for each HGM unit

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

INDIVIDUAL ASSESSMENT OF EACH HGM UNIT (SEE HGM SHEETS)

STEP 4B: DETERMINE THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION IN THE WETLAND AS A WHOLE

Table 4.11: Evaluation of Trajectory of Change of vegetation in the entire wetland.

HGM Unit	Description of relevant sources of change	HGM unit extent (%) (Table 4.7)	HGM Change score*	Area-weighted change score**
1	Increasing alien vegetation	34	-0.25	-0.1
2	Increasing alien vegetation	59	-0.15	-0.1
3	Stable	1	0	0.0
4	Increasing alien vegetation	3	0	0.0
5	Cant get any worse	3	0	0.0
			Overall weighted threat score***	**-0.2**

STEP 5: DESCRIBE THE OVERALL VEGETATION HEALTH OF THE WETLAND BASED ON PRESENT VEGETATION STATE AND TRAJECTORY OF CHANGE

Vegetation Health

Present Vegetation State	C	see Table 4.8
Trajectory of change	→	see Table 4.9

STEP 6: RECORD THE ALIEN VEGETATION THAT IS PRESENT IN THE WETLAND

Table 4.12: Alien species identified and suspected factors contributing to current infestation levels.

HGM Unit	List the alien species present	Aerial extent of invasion (%)*	Suspected factors contributing to increased abundance
1	Schinus terebinthifolius, Psidium cattleianum, Lantana camara	65	Bad management following the disturbance of land use change
2	Canna indica, Lantana camara, Cardiospermum gradiflorum, Solanum mauritianum, Chromolaena odorata, Schinus terebinthifolius	15	If the unit becomes drained, the Bp would spread
3	Schinus terebinthifolius	30	Stable
4	Schinus terebinthifolius, Psidium cattleianum	80	Increasing alien vegetation in the recently abandoned cropland
5	Schinus terebinthifolius	100	It cannot get any worse

Threat of further invasion, given the current management:	**Medium**

PAGE 2: HGM UNIT 1

STEP 2: DETERMINE THE PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 2A: FAMILIARISATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 2B: IDENTIFY AND ESTIMATE THE EXTENT OF EACH DISTURBANCE CLASS IN THE HGM UNIT

Note: Scattered alien plants may occur in most of the above disturbance classes. Where this occurs, alien plants are considered as part of the larger disturbance class of which they are part (e.g. scattered bramble occurring within an old land), and the intensity of disturbance score is modified to account for the fine grain disturbances within them.

Table 4.2: Description and extent of each disturbance class within the HGM unit

Disturbance class	Brief description of disturbance class	Extent (ha)*	Extent (%)
1	Recently abandoned croplands	1.92	30
2	Alien Vegetation	4.16	65
3	Untransformed	0.32	5
		6.40	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

STEP 2C: ASSESS THE INTENSITY AND MAGNITUDE OF IMPACT FOR EACH DISTURBANCE CLASS

Table 4.6: Calculation of the HGM magnitude of impact score based on an area weighted magnitude of impact score for each disturbance class.

Disturbance class	Disturbance class extent (%) (from Table 4.2)	Intensity of impact score (from Table 4.5)	Magnitude of impact score*	Factors contributing to impact
1	30	7	2.1	
2	65	8	5.2	
3	5	0	0.0	
		HGM Magnitude of impact score**	7.3	

STEP 2D: DETERMINE THE MAGNITUDE OF IMPACT SCORE AND PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

Table 4.10: Evaluation of Trajectory of Change of vegetation within an HGM.

Disturbance class	Source of change	Disturbance class extent (%) (Table 4.2)	Change score (Table 4.9)	Area-weighted change score*
1	Entry of alien vegetation and lack of management	30	-1	-0.3
2	Increasing alien vegetation	65	0	0.0
3	natural succession	5	1	0.1
			HGM change score**	-0.3

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Vulnerability factor	0.9

STEP 2A: IDENTIFY, MAP AND ASSESS IMPACT OF LAND-USE ACTIVITIES THAT REDUCE THE INFLOW QUANTITY TO THE HGM UNIT

Table 2.2: Different land-use types and activities potentially altering inflow quantities to the HGM unit from its upstream catchment, and the magnitude of their collective effect (1)

Reduced Flows

Land-use activity descriptors		Low High 0	-2	-5	-8	-10	Scores	Intensity of water loss (2)	Extent (%)	Magnitude (3)
Irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	Seasonal	Year-round	0	0.0	0	0.0
	(2) Prevalence of water conserving practices[R]		High	Intermediate	Low		0			
Other abstractions not used for irrigation in the catchment (4)										
Alien plants	(1) plant type[R]			Shrubs	Trees		-8	-5.9	20	-1.2
	(2) Distribution of alien woody plants in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-5			
Plantations	(1) Tree type[R]				Wattle & pine	Eucalyptus	0	0.0	0	0.0
	(2) Distribution of tree plantations in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Sugar (5)	(1) Crop type[R]		Sugar				0	0.0	0	0.0
	(2) Distribution in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Dams: specific allowance for releasing low flows within the operating rules of the dam[R]				Allowance made	No allowance		0	0.0	0	0.0
Overall magnitude of reduction in water inputs to the HGM unit as the sum of all the above impact magnitudes:										**-1.2**

Increased

Flows

Description of the level of increase	Magnitude score
Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).	10
Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.	7
Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).	3
No increase, or flow is increased by a negligible amount.	0
Magnitude of impact associated with increases in water inputs	0

Combined score: Increased flows score + Decreased flows score The combined score will range from -10 to +10, depending on the magnitude of the factors causing an increase or decrease in flow respectively	**-1.2**

STEP 2B: ASSESS THE INTENSITY OF IMPACT OF FACTORS POTENTIALLY ALTERING FLOW PATTERNS TO THE HGM UNIT

Table 2.3: Factors potentially contributing to a decrease or increase of floodpeak magnitude and/or frequency received by the HGM unit

Level of reduction	Low				High	Score
	0	**-2**	**-5**	**-8**	**-10**	
(1) Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R*]	<20%	20-35%	36-60%	60-120%	>120%	0
(2) Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	High	0
(3) Specific allowance for natural floods within the operating rules of the dam[R] **	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	0
Level of	**Low**				**High**	**Score**

increase	0	2	5	8	10	
(4) Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	2
(5) Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R]***	<10%	11-40%	41-80%	>80%		0
Combined Score: [Ave of (1), (2) and (3)] + (4) + (5)] adjusted****						**2.0**

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PAGE 2: HGM UNIT 2

STEP 2: DETERMINE THE PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 2A: FAMILIARISATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 2B: IDENTIFY AND ESTIMATE THE EXTENT OF EACH DISTURBANCE CLASS IN THE HGM UNIT

Table 4.2: Description and extent of each disturbance class within the HGM unit

Disturbance class	Brief description of disturbance class	Extent (ha)*	Extent (%)
1	Untransformed	9.37	85
2	Alien Vegetation	1.65	15
		11.02	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

STEP 2C: ASSESS THE INTENSITY AND MAGNITUDE OF IMPACT FOR EACH DISTURBANCE CLASS

Table 4.6: Calculation of the HGM magnitude of impact score based on an area weighted magnitude of impact score for each disturbance class.

Disturbance class	Disturbance class extent (%) (from Table 4.2)	Intensity of impact score (from Table 4.5)	Magnitude of impact score*	Factors contributing to impact
1	85	0	0.0	
2	15	3	0.5	
		HGM Magnitude of impact score**	**0.5**	

* Magnitude of impact score is calculated as extent / 100 x intensity of impact
** Overall magnitude of impact score for the HGM unit = sum of magnitude scores for each disturbance class.

STEP 2D: DETERMINE THE MAGNITUDE OF IMPACT SCORE AND PRESENT VEGETATION STATE OF EACH HGM UNIT

Calculated in Table 4.6 above

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

Table 4.10: Evaluation of Trajectory of Change of vegetation within an HGM.

Disturbance class	Source of change	Disturbance class extent (%) (Table 4.2)	Change score (Table 4.9)	Area-weighted change score*
1	None	85	0	0.0
2	Increasing brazillian pepper swamp	15	-1	-0.2
			HGM change score**	**-0.2**

*Area weighted change score = Disturbance Class extent /100 x change score

**HGM change score = sum of individual area weighted scores for each disturbance unit

PAGE 4: HGM UNIT 3

STEP 2: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE WETLAND

Vulnerability factor	0.9

Legend
Enter information

STEP 2A: IDENTIFY, MAP AND ASSESS IMPACT OF LAND-USE ACTIVITIES THAT REDUCE THE INFLOW QUANTITY TO THE HGM UNIT

Table 2.2: Different land-use types and activities potentially altering inflow quantities to the HGM unit from its upstream catchment, and the magnitude of their collective effect (1)

Reduced Flows

Land-use activity descriptors		Low High					Scores	Intensity of water loss (2)	Extent (%)	Magnitude (3)
		0	-2	-5	-8	-10				
Irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	Seasonal	Year-round	-8	-5.9	40	-2.3
	(2) Prevalence of water conserving practices[R]		High	Intermediate	Low		-5			
				.						
Alien plants	(1) plant type[R]			Shrubs	Trees		-8	-5.9	35	-2.0
	(2) Distribution of alien woody plants in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-5			
Plantations	(1) Tree type[R]				Wattle & pine	Eucalyptus	0	0.0	0	0.0
	(2) Distribution of tree plantations in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			

Sugar (5)	(1) Crop type[R]		Sugar				-2	-3.2	25	-0.8
	(2) Distribution in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-5			
Dams: specific allowance for releasing low flows within the operating rules of the dam[R]				Allowance made	No allowance		0	0.0	0	0.0
Overall magnitude of reduction in water inputs to the HGM unit as the sum of all the above impact magnitudes:										**-5.2**

Increased Flows

Description of the level of increase	**Magnitude score**
Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).	10
Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.	7
Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).	3
No increase, or flow is increased by a negligible amount.	0
Magnitude of impact associated with increases in water inputs	0

Combined score: Increased flows score + Decreased flows score The combined score will range from -10 to +10, depending on the magnitude of the factors causing an increase or decrease in flow respectively	**-5.2**

STEP 2B: ASSESS THE INTENSITY OF IMPACT OF FACTORS POTENTIALLY ALTERING FLOW PATTERNS TO THE HGM UNIT

Table 2.3: Factors potentially contributing to a decrease or increase of floodpeak magnitude and/or frequency received by the HGM unit

Level of reduction	**Low**				**High**	**Score**
	0	**-2**	**-5**	**-8**	**-10**	

(1) Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R*]	<20%	20-35%	36-60%	60-120%	>120%	0
(2) Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	High	0
(3) Specific allowance for natural floods within the operating rules of the dam[R] **	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	0
Level of increase	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
(4) Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	2
(5) Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R***]	<10%	11-40%	41-80%	>80%		0
Combined Score: [Ave of (1), (2) and (3)] + (4) + (5)] adjusted****						**2.0**

STEP 2C: ASSESS THE COMBINED MAGNITUDE OF IMPACT OF ALTERED QUANTITY AND PATTERN OF INPUTS, ACCOUNTING FOR THE WETLAND UNIT'S VULNERABILITY

Change in quantity of water inputs (Table 2.3):	**-5.2**

Alteration to floodpeaks (Table 2.4):	**2.0**

Table 2.5: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs.

(a) Floodplains and channeled valley bottoms driven primarily by over-bank flooding

	Alteration to floodpeaks (Score from Table 2.4)						
Change in quantity of	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease

water inflows (Score from Table 2.2)	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to	(-4 to -6)	(<-6)
> 9	7	6	5	4	5	6	7
4 - 9	5	4	3	3	4	6	7
1-3.9 (Increase)	3	2	1	1	2.5	4.5	7
-0.9- +0.9 (Negligible)	1	1	0	0	1	5	7.5
-1- -1.9 (Decrease)	2	1.5	1	1	2.5	5	7.5
-2- -3.9	3	2.5	2	2	4	6	8
-4- -5.9	4	3.5	3	3	5	7	8.5
-6- -7.9	-**	-**	-**	4	6	8	9
-8- -9	-**	-**	-**	-**	-**	9	9.5
< -9	-**	-**	-**	-**	-**	-**	10

(b) Other hydro-geomorphic settings, including floodplains and channeled valley bottoms driven primarily by lateral inputs (e.g. from tributaries)

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Table 2.4)**						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to -3.9)	(-4 to -6)	(<-6)
> 9	6	5	4	3	3	3.5	4
4 - 9	4.5	4	3	2	3	3	3
1-3.9 (Increase)	3	2	1	1	1	2	2.5
-0.9- +0.9 (Negligible)	2.5	1.5	0.5	0	0.5	1	1.5
-1- -1.9 (Decrease)	3.5	2.5	1.5	1	1.5	2	2.5
-1 - -3.9	4.5	3.5	2.5	2	2.5	3	3.5
-2 - -3.9	6	5	4	3.5	4	4.5	5
-4- -5.9	-**	-**	-**	5	5.5	6	6.5
-6- -7.9	-**	-**	-**	-**	-**	7.5	8
< -9	-**	-**	-**	-**	-**	-**	10

**These classes are unlikely, given that when there is a high level of reduction of quantity of inputs then there would be insufficient water to maintain unaltered or increased floodpeaks (i.e. a decrease in floodpeaks would be inevitable).

Magnitude of impact based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs:	4
Magnitude of impact adjusted to account for any change in seasonality:***	4

***If seasonality has been changed moderately then increase the magnitude of impact score by 1 and if it has been changed greatly then increase the magnitude of impact score by 2.

STEP 3: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE HGM UNIT HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES

STEP 3A: ASSESS MAGNITUDE OF IMPACT OF CANALIZATION AND STREAM MODIFICATION

Canalization

Note: Where more than one section of a HGM unit is affected by canalization, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.7: Characteristics affecting the impact of canalization on the distribution and retention of water in the HGM unit

Extent of HGM unit affected by canalization	ha	%
	0	0

Factors	Low				High	Score
	0	2	5	8	10	
Characteristics of the wetland						
(1) Slope of the wetland	<0.5%	0.5-0.9%	1-1.9%	2-3%	>3%	10
(2a) Texture of mineral soil, if present*	Clay	Clay loam	Loam	Sandy loam	Sand/loamy sand	5
(2b) Degree of humification of organic soil, if present*	Completely amorphous (like humus)	Somewhat amorphous	Intermediate	Somewhat fibrous	Very fibrous	
(3) Natural level of wetness	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	5
Characteristics of the drains/gullies						
(4) Depth of the drains/gullies	<0.20 m	0.20-0.50 m	0.51-0.80 m	0.81-1.10	>1.10 m	0

Note: Leave either 2a OR 2b blank

(5) Density of drains (meters of drain per hectare of wetland)**	<25 m/ ha	26-100 m/ha	101-200 m/ha	201-400 m/ha	>400 m/ha	0
(6) Location of drains/gullies in relation to flows into and through the wetland[R]. Drains/gullies are located such that flows are:	Very poorly intercepted	Moderately poorly intercepted	Intermediately intercepted	Moderately well intercepted	Very well intercepted	0
(7) Obstructions in the drains/ gullies	Complete obstruction	High obstruction	Moderate obstruction	Low obstruction	No obstruction	10
Calculate the mean score for factors 1, 2a or 2b, 3, 4 and 5						4.0
Multiply the score for factor 5 by the flow alteration factor (Table 2.1)						0.0
Mean score for above two scores						2.0
Intensity of impact for canalization: Divide the score for factor 7 by 10 and multiply this by the mean score derived in previous row						2.0
Magnitude of impact of canalization: Extent of impact/100 × intensity of impact calculated in the row above						**0.0**

Stream channel modification

Note: Where more than one section of a HGM unit is affected by stream channel modification, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.8: Characteristics affecting the impact on the distribution and retention of water in the HGM unit through the modification of a stream channel

	%
Extent of HGM unit affected by stream channel modification*	0
HGM weighting factor	0

*should be expressed as a percentage of the length of the HGM unit (See diagram alongside)

Characteristics of stream channel	**Low**				**High**	**Score**
(1) Reduction in length of stream per unit valley length[D]	**0**	**2**	**5**	**8**	**10**	
(2) % increase in cross sectional area of the stream[F]	<5%	5 – 25%	25 – 50%	50 – 75%	75 – 100%	0
(3) Change in surface roughness in relation to the surface roughness of the channel in its natural state (see Table 2.9 for description of roughness classes)	<5%	5 – 25%	26 – 50%	51 – 75%	>75%	0

Intensity of impact: use the maximum score of factors 1 to 3 x HGM weighting factor*	Roughness is increased or is unchanged[1]	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Magnitude score of impact of stream channel modification: extent of impact/100 × intensity of impact						**0**

Table 2.10: Calculation of the magnitude of impact of canalization and modification of a stream channel on the distribution and retention of water in a wetland HGM unit

Overall magnitude of impact score: canalization and stream channel modification	**Score**
Calculate the sum of scores from Tables 2.7 and 2.8.	**0.0**

STEP 3B: ASSESS MAGNITUDE OF IMPACT OF IMPEDING FEATURES

Note: Where more than one section of a HGM unit is affected by an impeding feature, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.11: Typical changes in water-distribution and -retention patterns within an HGM unit as a result of impeding structures

result of impeding structures

(a) Upstream impact of flooding

Extent Assessment	**ha**	**%**
(a) Extent of HGM unit affected by flooding **upstream** of the impeding structure	0.0	0

Descriptor	**Low High**					**Score**
	0	**2**	**5**	**8**	**10**	
Representation of different hydrological zones prior to flooding by the dam[R]	-	Seasonal and permanent zone both present and collectively >30%	Permanent and seasonal zones both present but collectively <30%	Seasonal zone present but permanent zone absent	Permanent and seasonal zones lacking (i.e. only the temporary zone present)	0
Intensity of impact: score for above factor X 0.8						0

Magnitude of impact score: extent of impact /100 × intensity of impact	0.0

(b) Downstream impact on quantity and timing of flows to downstream portion of the HGM unit

Extent Assessment	**ha**	**%**
(b) Extent of HGM unit affected by flooding **downstream** of the impeding structure	0.0	0

	Low				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
Extent to which dams or roads interrupt low flows to downstream areas [R]	No interruption (e.g., many culverts through a road embankment)	Slight interruption (e.g., a moderate number of culverts through a road embankment)	Intermediate interruption (e.g. earth dam with very high seepage or road embankment with no/ very limited culverts)	Moderately high interruption (e.g. earth dam with some seepage/ flow releases)	High interruption (e.g. a concrete dam with no seepage and no low flow releases)	2
Level of abstraction from the dam/s [R]	Low	Moderately low	Intermediate	Moderately high	High	0
Location of dam/s relative to the affected area's catchment- proportion of catchment flows intercepted [D]	Dam intercepts <20% of the affected area's catchment	Dam intercepts 21-40% of the affected area's catchment	Dam intercepts 41-60% of the affected area's catchment	Dam intercepts 61-80% of the affected area's catchment	Dam intercepts >80% of the affected area's catchment	0
Collective volume of dam/s in relation to MAR of the affected area[D]	<20%	20-35%	36-60%	60-120%	>120%	0
Intensity of impact: mean score of the THREE highest scoring factors x 0.8						0.7
Magnitude-of-impact score: extent of impact /100 × intensity of impact						**0.0**

(c) Combined impact

Combined impact: Magnitude of impact for upstream + Magnitude of impact for downstream	0.0

STEP 3C: ASSESS MAGNITUDE OF IMPACT OF ALTERED SURFACE ROUGHNESS

Table 2.12: Comparison of surface roughness of an HGM unit in its current state compared with its natural state

Extent of HGM unit affected by change in surface roughness	ha	%
	0.13	50

Class	Descriptor	Current	Historic
Low	Smooth surface with little or no vegetation to offer resistance to water flow	Moderate	Moderately low
Moderately low	Vegetation is present but short (i.e. < 500mm) and not robust (e.g. rye grass)		
Moderate	Vegetation offering slight resistance to water flow, generally consisting of short plants (i.e. < 1 m tall)		
Moderately high	Robust vegetation (e.g. dense stand of reeds) or hummocks offering high resistance to water flow		
High	Vegetation very robust (e.g. dense swamp forest with a dense under storey) and offering high resistance to water flow.		

Note: Where roughness varies across the HGM unit, take the average condition, and where roughness varies over time (e.g. areas which are regularly cut short) take the average condition during the wet season.

Descriptor	Low 0	2	5	8	High 10	Score
Change in surface roughness in relation to the surface roughness of the wetland in its natural state[F]	Roughness increased or is unchanged*	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: score for the above row X 0.6						0

Magnitude of impact score: extent of impact /100 × intensity of impact	0.0

*It is considered to be of greater consequence to water retention and distribution if the surface roughness of a wetland is decreased than if it is increased, therefore the focus of this assessment is primarily on a decrease in surface roughness.

STEP 3D: ASSESS THE IMPACT OF DIRECT WATER LOSSES

Table 2.13: Evaluating the effect of alien woody plants, commercial plantations and sugarcane growing in the HGM unit on water loss

Land-use activity descriptors	Low				High	Score	Intensity of water loss*	Extent (%)	Magnitude**
	0	2	5	8	10				
(1) Alien woody plant type[F]			Shrubs	Trees		8	4	30	2.4
(1) Plantation tree type[F]				Wattle & pine	Eucalyptus	0	0	0	0.0
(1) Sugarcane Growth[F]		Poor growth	Good growth			2	0	25	0.5
(4) Direct water abstractions		Low	Moderately low	Moderately high	High	0	0	0	0.0
Overall magnitude of increased water loss: (sum of (1), (2), (3) and (4)) x 0.8									2.3

*Intensity= Score x Vulnerability factor (from Table 2.1)

**Magnitude=Intensity x Extent (%)/100

Note: When assessing extent, remember that the extent of the impact may extend beyond the direct area in which the alien woody plants or plantations occur in the HGM unit to also include a downstream portion subject to reduced flows. If this is the case, adjust the score accordingly with documented justification.

STEP 3E: ASSESS THE MAGNITUDE OF IMPACT OF RECENT DEPOSITION, INFILLING OR EXCAVATION

Table 2.14 Magnitude of impact of recent deposition, infilling or excavation

Extent Assessment	ha	%
Extent of HGM unit affected by deposition or excavation	0.0	0

Descriptor	Low				High	Score
	0	2	5	8	10	

Effect on vertical drainage properties of the uppermost soil layer	No effect	Rendered somewhat free-draining	Intermediate	Rendered free-draining	Rendered very well- drained*	0	*i.e. drainage is so free that the area no longer has any wetland characteristics
Effect on the horizontal movement of water	No effect	Moderate modification	Large modification	Serious modification		0	
Intensity of impact: use the highest score for the above two factors						0	
Magnitude of impact score: extent of impact (%)/100 x intensity of impact x 1						**0**	

STEP 3F: DETERMINE COMBINED MAGNITUDE OF IMPACT OF ON-SITE ACTIVITIES

Table 2.15: Overall magnitude of impacts of on-site activities on water distribution and retention patterns n the HGM unit

Activity	Magnitude of impact	Justification for any modifications made
(1) Calculated magnitude of impact of canalization and stream channel modification from Table 2.10	**0.0**	
(2) Calculated magnitude of impact of impeding features from Table 2.11	**0.0**	
(3) Calculated magnitude of impact of altered surface roughness from Table 2.12	**0.0**	
(4) Calculated magnitude of impact of aliens, timber and/or sugarcane in the wetland from Table 2.13	**2.3**	
(5)) Calculated magnitude of impact of recent deposition/excavation from Table 2.14	**0.0**	
Total score of magnitude of on-site activities in the HGM unit (sum of the above scores)*	**2.3**	* If score is > 10, then magnitude of impact = 10

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF THE HGM UNIT THROUGH INTEGRATING THE ASSESSMENTS FROM STEPS 2 AND 3

Changes to water distribution & retention patterns (Table 2.15):	**2.3**		Changes to Water Inputs (Table 2.5):	**4**

Table 2.16: Derivation of overall magnitude-of-impact scores through combining the scores obtained from the catchment and within-wetland assessments. The colour codes correspond to the impact categories given in Table 2.17.

			Water Inputs (Step 2 - Table 2.5)					
			None	Small	Moderate	Large	Serious	Critical
			0-0.9	1-1.9	2-3.9	4-5.9	6-7.9	8 - 10
Water distribution & retention patterns (Step 3, Table2.18)	None	0-0.9	0	1	3	5	6.5	8.5
	Small	1-1.9	1	1.5	3.5	6	7	9
	Moderate	2-3.9	3	3.5	4	6.5	7.5	9
	Large	4-5.9	5	6	6.5	7	8	9.5
	Serious	6-7.9	6.5	7	7.5	8	9	10
	Critical	8 - 10	8.5	9	9	9.5	10	10

Combined magnitude score as a result of impacts on hydrological functioning	**6**

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PAGE 2: HGM UNIT 3

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

Table 3.1: Guideline for assessing the impacts of activities according to HGM type

HGM type to assess	Activity/Indicator that should be assessed
Diagnostic component	
Floodplain	Dams upstream of or within floodplains (see Step 2A)
Floodplain, channeled valley bottom	Stream shortening or straightening (see Step 2B)
Floodplain, channeled valley bottom	Infilling that leads to narrowing of the wetland (see Step 2C)
All non-floodplain HGM's	Changes in runoff characteristics (see Step 2D)
Indicator-based component	

HGM Type
Hillslope seepage linked to a stream channel
If floodplain, are there large alluvial fans impinging laterally on the floodplain (from the side of the floodplain)?

All non-floodplain HGM's	Erosional features (see Step 3A)
All non-floodplain HGM's*	Depositional features (see Step 3A)
All non-floodplain HGM's	Loss of organic sediment (see Step 3B)

* Consider floodplains if there are large alluvial fans impinging on the floodplain laterally to it (from the side).

Note: Steps that need to be completed are indicated with a "Yes" based on the HGM type selected in the summary page.

Step 2A: Impacts of dams upstream of and/or on floodplains

To assess?	No

See Table 3.1

Dams in the floodplain catchment

Table 3.2: Extent, intensity and magnitude of impacts of impoundments in the catchment

Extent of impact of dams situated above floodplains						**Extent (%)**
Extent: For dams upstream of floodplains extent is assumed to be 100%. If a dam is also situated on the floodplain, extent of impact for the dam above the floodplain is determined as the length of the floodplain above the dam / total floodplain length, expressed as a percentage						
Intensity of impact score – size of dams and nature of sediment transported						
Determine the size of dam/s on the stream and the nature of sediment load being transported						
	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	**Score**
Suspended load dominated	0.5	1	1.5	2	2.5	
Mixed load	1	2	3	4	5	
Bedload dominated	2	3	4	5	5	
Intensity of impact score – location of dams in the catchment						
Score	**1**	**2**	**3**	**4**	**5**	**Score**
Location of dam/s	Dams on minor tributary stream or on trunk stream far upstream of floodplain	Intermediate between descriptions for scores 0 and 5	Dams on major tributary or on trunk stream a moderate distance upstream of floodplain	Intermediate between descriptions for scores 5 and 10	Dam on trunk stream immediately above floodplain	
Overall intensity of impact score for dams situated above floodplains: mean of above 2 scores						0.0

Enter single score

Magnitude of impact score for dams situated above floodplains: (extent of impact score/ 100) x overall intensity of impact score	0.0

Dams on the floodplain

Table 3.3: Extent, intensity and magnitude of impact of impoundments within the floodplain.

Extent of impact of dams situated within floodplains						**Extent (%)**
Extent: The percentage of the floodplain valley length flooded by the dam and below the dam wall						
Intensity of impact of dams situated within floodplains						
SCORE	**1**	**2**	**3**	**4**	**5**	**Score**
Size of dam	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	
Configuration of spillway/s			Baseflows to floodplain stream: peak flows to backswamp	Baseflows and peak flows to floodplain stream **OR** baseflows to backswamp and peak flows to floodplain stream	Baseflows and peak flows to backswamp	
Overall intensity of impact score for dams situated within floodplains: mean of above 2 scores						0
Magnitude of impact score for dams situated within floodplains: (extent of impact score / 100) x overall intensity of impact score						0.0

Combining impacts of dams in the catchment and on the floodplain

Table 3.4: Combining the magnitude of impact scores of impoundments upstream of and on the floodplain.

Magnitude of impact score for dams upstream of and on the floodplain	
Magnitude of impact score for dam/s located in the catchment (Table 3.2)	0.0
Magnitude of impact score for dam/s located within the floodplain (Table 3.3)	0.0
Overall magnitude of impact for floodplain wetlands with dams upstream of and on the floodplain = sum of above two rows	**0.0**

Impacts of channel straightening	To assess?	No	See Table 3.1

Table 3.5: Extent, intensity and magnitude of impacts of channel straightening

Extent of impact of channel straightening.						Extent (%)
Extent: the length of modification plus THE LESSER OF 10km for sandy stream beds OR 5km for silty/clayey stream beds OR the distance to the head of the floodplain OR to a dam wall (if present), expressed as a percentage of floodplain length[R]						
Intensity of impact of channel straightening						
	0	**1**	**2**	**3**	**4**	Intensity
Reduction in stream length per unit valley length[R]	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of channel straightening: (extent of impact score/ 100) x intensity of impact score						**0.0**

Step 2C: Impacts of artificial wetland infilling	To assess?	No	See Table 3.1

Table 3.6: Extent, intensity and magnitude of impact of infilling of floodplains and channeled valley bottom wetlands.

Extent of impact of infilling.						Extent (%)
Extent of impact of infilling as determined by establishing the area of wetland that will not be subjected to normal erosion and / or deposition, as a percentage of wetland area.						
Intensity of impact of infilling						
	0	**1**	**2**	**3**	**4**	**Score**
Reduction in active wetland width at point of infillingR	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of infilling: (extent of impact score / 100) x intensity of impact score.						**0**

Step 2D: Impacts of changes in runoff characteristics	To assess?	Yes	See Table 3.1

Table 3.7: Effect of altered water inputs (increased flows and floodpeaks) on wetland geomorphological integrity

Extent of impact of altered water inputs	Extent (%)

Extent calculated based on length of wetland affected by increased flow as a proportion (%) of the entire wetland length.					100
Intensity of impact of altered water inputs					
		Increased floodpeaks (combined score in Table 2.3)			
		No effect (0-2)	Small increase (2.1-4)	Moderate increase (4.1-7)	Large increase (>7)
Increased flows (increased flow score in Table 2.2)	No increase (0-2)	0	1	2	3.5*
	Small increase (2.1-4)	1	1.5	3	4
	Moderate increase (4.1-7)	2	3	4	4.5
	Large increase (>7)	3.5*	4	4.5	5
				Change Score	1
Magnitude of impact score: (extent of impact score/100) x intensity of impact score (from above rows)					**1.0**

* Unlikely to occur

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

Step 3A: Impacts of erosion and/or deposition

Erosional features

To assess?	**Yes**	See Table 3.1

Table 3.8: Estimation of extent of impact of erosional features

		Length of wetland occupied by gully/ies as a percentage of the length of HGM[R]					
		0-20%	21-40%	41-60%	51-80%	>80%	
Average gully width (sum of gully widths if more than 1 gully present) in relation to wetland width[R]	< 5%	5%	10%	15%	20%	25%	
	5-10%	10%	15%	25%	35%	45%	
	11-20%	15%	25%	40%	55%	65%	
	21-50%	20%	30%	50%	70%	80%	**Extent (%)**
	>50%	25%	40%	60%	80%	100%	0

Table 3.9: Intensity and magnitude of impact of erosional features. The scores for rows 2 and 3 are unscaled for any natural recovery that may have taken place. Factors to use to scale the intensity of impact of erosional features for natural recovery are presented in rows 7 and 8.

Factor	1	2	3	4	5	Unscaled score

Mean depth of gullies[F]	<0.50m	0.50-1.00m	1.01-2.00m	2.00-3.00m	>3.00m	0
Mean width of gullies[F]	<2m	2-5m	5.1-8m	8.1-16m	>16m	0
Number of headcuts present[F]	1	2	3	4	>4	0
Unscaled intensity of impact score: mean score of above 3 rows						0.0
Scaling factor	**0.4**	**0.5**	**0.7**	**0.9**	**1**	**Factor**
Extent to which sediment from the gully is deposited within the HGM or wetland downstream of the HGM unit (as opposed to being exported)[F]	Entirely deposited	Mainly deposited	Intermediate	Mainly exported	Entirely exported	0
Extent to which the bed and sides of the gully have been colonized by vegetation and/or show signs of natural recovery[F]	Complete	High	Moderate	Low	None	0
Scaling factor score: mean of above 2 rows (value is between 0 and 1)						0.0
Scaled intensity of impact score = unscaled intensity of impact score x scaling factor score						0.0
Magnitude of impact score for erosional features: (extent of impact score (see Table 3.8)/100) × scaled intensity of impact score						**0.0**

Depositional features

To assess?	**Yes**	See Table 3.1

We are only interested here in recent depositional features. If the user feels confident in being able to map depositional features that can be attributed directly to recent human activity, then extent should be established directly using Table 3.10, but if they are not confident that they can do this, indirect indicators can be used as outlined in Table 3.11. Users may wish to use a combination of approaches by using the indirect indicators to assist in the location and mapping of depositional features in the wetland of interest, following which they may map depositional features directly, but ideally, one would only map these features directly.

Table 3.10: Estimation of the extent of impact of depositional features for known depositional features in the HGM unit.

Extent of depositional features in relation to area of HGM unit being considered	0.2-1.9%	2-10%	11-25%	26-50%	>50%	
Score for “extent” to be used in the estimation of magnitude of impacts	5	20	50	75	100	0

Table 3.11: Estimation of extent of depositional features based on indirect indicators of recent anthropogenic activity leading to excessive deposition.

Indicator	**0**	**1**	**2**	**3**	**4**	**Score**

Presence, size and distribution of gullies or active erosion of drains within the catchment or wetland	None or very small	Limited extent and size	Moderate size and distribution	Large size or widespread distribution	Very large size or widespread distribution	0
Presence / extent of dirt roads in the catchment	None / few	Moderate	Many / extensive			0
Breaching of upstream dams in the catchment or wetland	None	Very small earthen dams	Small earthen dams	Large earthen dams		0
Extent of decreased vegetation cover in the catchment	Slight	Moderate	High			0
Mean of two highest scores from the above						0.0
Extent of impact score of depositional features as a percentage is calculated as the score from the above multiplied by 10.						0

Table 3.12: Intensity and magnitude of impact of depositional features

Indicator	0	1	2	3	Score
The position of fan-like deposits within the wetland[R]		Toe	Middle	Upper	0
Impact of depositional features on existing wetland features[D]	Not evident	Minor destruction of features	Moderate destruction of features	Large impact on existing features	0
Intensity of impact score of depositional features: mean of two rows above					0
Magnitude of impact score of depositional features: (extent of impact score (Table 3.10 or 3.11) / 100) x intensity of impact score					**0.0**

Step 3B: Impacts of the loss of organic sediment

To assess?	**Yes**	See Table 3.1

Table 3.13: Extent of impact of the loss of organic sediment for direct indicators (A) and indirect indicators (B). Express results as a proportion of the total area of the HGM unit.

A. Extent of impact score based on direct indicators (if present)	0	%
B. Additional extent of impact score based on indirect indicators (if present)	0	%

To determine the intensity of impact in the affected area of the wetland, see Tables 3.14 and 3.15 for direct and indirect indicators respectively.

Direct indicators

Table 3.14: Macroscopic features (clearly visible direct indicators) determining the intensity of impact of the loss of organic sediments

Activity	1	2	3	4	5	Score
Depth of the peat fires or extraction of peat relative to the depth of the peat deposit	<5%	5-15%	16-30%	31-60%	>60%	0
If tillage is practiced, duration of tillage	1-2 yrs	3-5 yrs	6-10 yrs	>10 yrs		0
Intensity of impact score: maximum score of above scores						0.0
Magnitude of impact score of loss of organic sediments: (extent of impact score (Table 3.13A) /100) × intensity of impact score						0.0

Indirect indicators

Table 3.15: Indirect indicators (not clearly visible) reflecting the intensity of diminished integrity of organic sediments in the HGM unit.

	0	1	2	3	4	Intensity score
Level of desiccation of the region of the HGM unit in which peat accumulation is taking place*	Unmodified	Largely natural	Moderately modified	Largely modified	Serously / critically modified	0
Magnitude of impact score: extent of impact score (Table 3.13B)/100 × intensity of impact score						0.0

Overall magnitude of impact: Organic sediment

Table 3.16: Magnitude of impact score for organic sediments expressed as a proportion of the area of the entire HGM unit

	Overall magnitude of impact score: organic sediments
Sum of magnitude scores in Tables 3.14 and 3.15	**0.0**

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

Table 3.17: Derivation of overall magnitude-of-impact scores through combining the scores obtained from individual assessments.

Impact category	Score	To include?

1. Magnitude of impact of dams (Table 3.4)	N/A	No
2. Magnitude of impact of channel straightening (Table 3.5)	N/A	No
3. Magnitude of impact of infilling (Table 3.6)	N/A	No
4. Magnitude of impact of changes in runoff characteristics (Table 3.7)	1.0	Yes
5. Magnitude of impact for erosional features (Table 3.9)	0.0	Yes
6. Magnitude of impact for depositional features (Table 3.12)	0.0	Yes
7. Magnitude of impact for loss of organic sediment (Table 3.16)	0.0	Yes
Overall Present Geomorphic State = Sum of three highest scores	**1.0**	

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PAGE 2: HGM UNIT 3

STEP 2: DETERMINE THE PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 2A: FAMILIARISATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 2B: IDENTIFY AND ESTIMATE THE EXTENT OF EACH DISTURBANCE CLASS IN THE HGM UNIT

Table 4.2: Description and extent of each disturbance class within the HGM unit

Disturbance class	Brief description of disturbance class	Extent (ha)*	Extent (%)
1	Alien vegetation	0.17	30
2	Untransformed	0.41	70
		0.58	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

STEP 2C: ASSESS THE INTENSITY AND MAGNITUDE OF IMPACT FOR EACH DISTURBANCE CLASS

Table 4.6: Calculation of the HGM magnitude of impact score based on an area weighted magnitude of impact score for each disturbance class.

Disturbance class	Disturbance class extent (%) (from Table 4.2)	Intensity of impact score (from Table 4.5)	Magnitude of impact score*	Factors contributing to impact
1	30	7	2.1	
2	70	0	0.0	
		HGM Magnitude of impact score**	**2.1**	

* Magnitude of impact score is calculated as extent / 100 x intensity of impact
** Overall magnitude of impact score for the HGM unit = sum of magnitude scores for each disturbance class.

STEP 2D: DETERMINE THE MAGNITUDE OF IMPACT SCORE AND PRESENT VEGETATION STATE OF EACH HGM UNIT

Calculated in Table 4.6 above

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

Table 4.10: Evaluation of Trajectory of Change of vegetation within an HGM.

Disturbance class	Source of change	Disturbance class extent (%) (Table 4.2)	Change score (Table 4.9)	Area-weighted change score*
1	Stable (Possibility of the indigenous veg increasing)	30	0	0.0
2	Stable	70	0	0.0
			HGM change score**	**0.0**

*Area weighted change score = Disturbance Class extent /100 x change score
**HGM change score = sum of individual area weighted scores for each disturbance unit

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PAGE 5: HGM UNIT 4

STEP 2: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE WETLAND

Vulnerability factor	0.9

Legend
Enter information

STEP 2A: IDENTIFY, MAP AND ASSESS IMPACT OF LAND-USE ACTIVITIES THAT REDUCE THE INFLOW QUANTITY TO THE HGM UNIT

Table 2.2: Different land-use types and activities potentially altering inflow quantities to the HGM unit from its upstream catchment, and the magnitude of their collective effect (1)

Reduced Flows

Land-use activity descriptors		Low → High: 0	-2	-5	-8	-10	Scores	Intensity of water loss (2)	Extent (%)	Magnitude (3)
Irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	Seasonal	Year-round	0	0.0	0	0.0
	(2) Prevalence of water conserving practices[R]		High	Intermediate	Low		0			
Other abstractions not used for irrigation in the catchment (4)										
Alien plants	(1) plant type[R]			Shrubs	Trees		-8	-5.9	80	-4.7
	(2) Distribution of alien woody plants in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-5			
Plantations	(1) Tree type[R]				Wattle & pine	Eucalyptus	0	0.0	0	0.0
	(2) Distribution of tree plantations in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Sugar (5)	(1) Crop type[R]		Sugar				-2	-1.8	20	-0.4
	(2) Distribution in riparian areas[R]		Confined to non- riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-2			

Dams: specific allowance for releasing low flows within the operating rules of the dam[R]			Allowance made	No allowance		0	0.0	0	0.0
Overall magnitude of reduction in water inputs to the HGM unit as the sum of all the above impact magnitudes:									**-5.0**

Increased Flows

Description of the level of increase	Magnitude score
Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).	10
Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.	7
Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).	3
No increase, or flow is increased by a negligible amount.	0
Magnitude of impact associated with increases in water inputs	0

Combined score: Increased flows score + Decreased flows score The combined score will range from -10 to +10, depending on the magnitude of the factors causing an increase or decrease in flow respectively	**-5.0**

STEP 2B: ASSESS THE INTENSITY OF IMPACT OF FACTORS POTENTIALLY ALTERING FLOW PATTERNS TO THE HGM UNIT

Table 2.3: Factors potentially contributing to a decrease or increase of floodpeak magnitude and/or frequency received by the HGM unit

Level of reduction	Low				High	Score
	0	**-2**	**-5**	**-8**	**-10**	
(1) Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R*]	<20%	20-35%	36-60%	60-120%	>120%	0
(2) Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	High	0

(3) Specific allowance for natural floods within the operating rules of the dam[R] **	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	0
Level of increase	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
(4) Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	2
(5) Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R]***	<10%	11-40%	41-80%	>80%		0
Combined Score: [Ave of (1), (2) and (3)] + (4) + (5)] adjusted** **						**2.0**

STEP 2C: ASSESS THE COMBINED MAGNITUDE OF IMPACT OF ALTERED QUANTITY AND PATTERN OF INPUTS, ACCOUNTING FOR THE WETLAND UNIT'S VULNERABILITY

Change in quantity of water inputs (Table 2.3):	**-5.0**

Alteration to floodpeaks (Table 2.4):	**2.0**

Table 2.5: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs.

(a) Floodplains and channeled valley bottoms driven primarily by over-bank flooding

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Score from Table 2.4)**						
	Large increase (>6)	Moderate increase (4-6)	Small increase (1.6-3.9)	No effect (-1.5 to 1.5)	Small decrease (-1.6 to	Moderate decrease (-4 to -6)	Large decrease (<-6)
> 9	7	6	5	4	5	6	7
4 - 9	5	4	3	3	4	6	7
1-3.9 (Increase)	3	2	1	1	2.5	4.5	7
-0.9- +0.9 (Negligible)	1	1	0	0	1	5	7.5
-1- -1.9 (Decrease)	2	1.5	1	1	2.5	5	7.5

-2- -3.9	3	2.5	2	2	4	6	8
-4- -5.9	4	3.5	3	3	5	7	8.5
-6- -7.9	-**	-**	-**	4	6	8	9
-8- -9	-**	-**	-**	-**	-**	9	9.5
< -9	-**	-**	-**	-**	-**	-**	10

(b) Other hydro-geomorphic settings, including floodplains and channeled valley bottoms driven primarily by lateral inputs (e.g. from tributaries)

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Table 2.4)**						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to -3.9)	(-4 to -6)	(<-6)
> 9	6	5	4	3	3	3.5	4
4 - 9	4.5	4	3	2	3	3	3
1-3.9 (Increase)	3	2	1	1	1	2	2.5
-0.9- +0.9 (Negligible)	2.5	1.5	0.5	0	0.5	1	1.5
-1- -1.9 (Decrease)	3.5	2.5	1.5	1	1.5	2	2.5
-1 - -3.9	4.5	3.5	2.5	2	2.5	3	3.5
-2 - -3.9	6	5	4	3.5	4	4.5	5
-4- -5.9	-**	-**	-**	5	5.5	6	6.5
-6- -7.9	-**	-**	-**	-**	-**	7.5	8
< -9	-**	-**	-**	-**	-**	-**	10

**These classes are unlikely, given that when there is a high level of reduction of quantity of inputs then there would be insufficient water to maintain unaltered or increased floodpeaks (i.e. a decrease in floodpeaks would be inevitable).

Magnitude of impact based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs:	4
Magnitude of impact adjusted to account for any change in seasonality:***	4

***If seasonality has been changed moderately then increase the magnitude of impact score by 1 and if it has been changed greatly then increase the magnitude of impact score by 2.

STEP 3A: ASSESS MAGNITUDE OF IMPACT OF CANALIZATION AND STREAM MODIFICATION

Canalization

Note: Where more than one section of a HGM unit is affected by canalization, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.7: Characteristics affecting the impact of canalization on the distribution and retention of water in the HGM unit

Extent of HGM unit affected by canalization	ha	%
	0	0

Factors	Low				High	Score
	0	2	5	8	10	
Characteristics of the wetland						
(1) Slope of the wetland	<0.5%	0.5-0.9%	1-1.9%	2-3%	>3%	10
(2a) Texture of mineral soil, if present*	Clay	Clay loam	Loam	Sandy loam	Sand/loamy sand	5
(2b) Degree of humification of organic soil, if present*	Completely amorphous (like humus)	Somewhat amorphous	Intermediate	Somewhat fibrous	Very fibrous	
(3) Natural level of wetness	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	0
Characteristics of the drains/gullies						
(4) Depth of the drains/gullies	<0.20 m	0.20-0.50 m	0.51-0.80 m	0.81-1.10	>1.10 m	0
(5) Density of drains (meters of drain per hectare of wetland)**	<25 m/ ha	26-100 m/ha	101-200 m/ha	201-400 m/ha	>400 m/ha	0
(6) Location of drains/gullies in relation to flows into and through the wetland[R]. Drains/gullies are located such that flows are:	Very poorly intercepted	Moderately poorly intercepted	Intermediately intercepted	Moderately well intercepted	Very well intercepted	0
(7) Obstructions in the drains/ gullies	Complete obstruction	High obstruction	Moderate obstruction	Low obstruction	No obstruction	10
Calculate the mean score for factors 1, 2a or 2b, 3, 4 and 5						3.0
Multiply the score for factor 5 by the flow alteration factor (Table 2.1)						0.0
Mean score for above two scores						1.5

Note: Leave either 2a OR 2b blank

Intensity of impact for canalization: Divide the score for factor 7 by 10 and multiply this by the mean score derived in previous row	1.5
Magnitude of impact of canalization: Extent of impact/100 × intensity of impact calculated in the row above	0.0

Stream channel modification

Note: Where more than one section of a HGM unit is affected by stream channel modification, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.8: Characteristics affecting the impact on the distribution and retention of water in the HGM unit through the modification of a stream channel

	%
Extent of HGM unit affected by stream channel modification*	0
HGM weighting factor	0

*should be expressed as a percentage of the length of the HGM unit (See diagram alongside)

Characteristics of stream channel	Low				High	Score
	0	2	5	8	10	
(1) Reduction in length of stream per unit valley length[D]	<5%	5 – 25%	25 – 50%	50 – 75%	75 – 100%	0
(2) % increase in cross sectional area of the stream[F]	<5%	5 – 25%	26 – 50%	51 – 75%	>75%	0
(3) Change in surface roughness in relation to the surface roughness of the channel in its natural state (see Table 2.9 for description of roughness classes)	Roughness is increased or is unchanged[1]	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: use the maximum score of factors 1 to 3 x HGM weighting factor*						**0**
Magnitude score of impact of stream channel modification: extent of impact/100 × intensity of impact						**0.0**

Table 2.10: Calculation of the magnitude of impact of canalization and modification of a stream channel on the distribution and retention of water in a wetland HGM unit

Overall magnitude of impact score: canalization and stream channel modification	Score
Calculate the sum of scores from Tables 2.7 and 2.8.	0.0

STEP 3B: ASSESS MAGNITUDE OF IMPACT OF IMPEDING FEATURES

Note: Where more than one section of a HGM unit is affected by an impeding feature, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.11: Typical changes in water-distribution and -retention patterns within an HGM unit as a result of impeding structures

result of impeding structures

(a) Upstream impact of flooding

Extent Assessment	ha	%
(a) Extent of HGM unit affected by flooding **upstream** of the impeding structure	0.0	0

Descriptor	Low				High	Score
	0	2	5	8	10	
Representation of different hydrological zones prior to flooding by the dam[R]	-	Seasonal and permanent zone both present and collectively >30%	Permanent and seasonal zones both present but collectively <30%	Seasonal zone present but permanent zone absent	Permanent and seasonal zones lacking (i.e. only the temporary zone present)	0
Intensity of impact: score for above factor X 0.8						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

(b) Downstream impact on quantity and timing of flows to downstream portion of the HGM unit

Extent Assessment	ha	%
(b) Extent of HGM unit affected by flooding **downstream** of the impeding structure	0.0	0

	Low				High	Score
	0	2	5	8	10	

Extent to which dams or roads interrupt low flows to downstream areas R	No interruption (e.g., many culverts through a road embankment)	Slight interruption (e.g., a moderate number of culverts through a road embankment)	Intermediate interruption (e.g. earth dam with very high seepage or road embankment with no/ very limited culverts)	Moderately high interruption (e.g. earth dam with some seepage/ flow releases)	High interruption (e.g. a concrete dam with no seepage and no low flow releases)	0
Level of abstraction from the dam/s R	Low	Moderately low	Intermediate	Moderately high	High	0
Location of dam/s relative to the affected area's catchment- proportion of catchment flows intercepted D	Dam intercepts <20% of the affected area's catchment	Dam intercepts 21-40% of the affected area's catchment	Dam intercepts 41-60% of the affected area's catchment	Dam intercepts 61-80% of the affected area's catchment	Dam intercepts >80% of the affected area's catchment	0
Collective volume of dam/s in relation to MAR of the affected area D	<20%	20-35%	36-60%	60-120%	>120%	0
Intensity of impact: mean score of the THREE highest scoring factors x 0.8						0.0
Magnitude-of-impact score: extent of impact /100 × intensity of impact						**0.0**

(c) Combined impact

Combined impact: Magnitude of impact for upstream + Magnitude of impact for downstream	**0.0**

STEP 3C: ASSESS MAGNITUDE OF IMPACT OF ALTERED SURFACE ROUGHNESS

Table 2.12: Comparison of surface roughness of an HGM unit in its current state compared with its natural state

Extent of HGM unit affected by change in surface roughness	ha	%
	0.41	70

Class	Descriptor	Current	Historic
Low	Smooth surface with little or no vegetation to offer resistance to water flow	Moderately high	Moderately low
Moderately low	Vegetation is present but short (i.e. < 500mm) and not robust (e.g. rye grass)		
Moderate	Vegetation offering slight resistance to water flow, generally consisting of short plants (i.e. < 1 m tall)		
Moderately high	Robust vegetation (e.g. dense stand of reeds) or hummocks offering high resistance to water flow		
High	Vegetation very robust (e.g. dense swamp forest with a dense under storey) and offering high resistance to water flow.		

Note: Where roughness varies across the HGM unit, take the average condition, and where roughness varies over time (e.g. areas which are regularly cut short) take the average condition during the wet season.

Descriptor	Low 0	2	5	8	High 10	Score
Change in surface roughness in relation to the surface roughness of the wetland in its natural state[F]	Roughness increased or is unchanged*	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: score for the above row X 0.6						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

*It is considered to be of greater consequence to water retention and distribution if the surface roughness of a wetland is decreased than if it is increased, therefore the focus of this assessment is primarily on a decrease in surface roughness.

STEP 3D: ASSESS THE IMPACT OF DIRECT WATER LOSSES

Table 2.13: Evaluating the effect of alien woody plants, commercial plantations and sugarcane growing in the HGM unit on water loss

Land-use activity	Low	High	Score	Intensit	Extent	Magnitude*

descriptors	0	2	5	8	10		y of water loss*	(%)	*
(1) Alien woody plant type[F]			Shrubs	Trees		8	8	70	5.6
(1) Plantation tree type[F]				Wattle & pine	Eucalyptus	0	0		0.0
(1) Sugarcane Growth[F]		Poor growth	Good growth			2	3	20	0.4
(4) Direct water abstractions		Low	Moderately low	Moderately high	High	0	0	0	0.0
Overall magnitude of increased water loss: (sum of (1), (2), (3) and (4)) x 0.8									**4.8**

*Intensity= Score x Vulnerability factor (from Table 2.1) **Magnitude=Intensity x Extent (%)/100

Note: When assessing extent, remember that the extent of the impact may extend beyond the direct area in which the alien woody plants or plantations occur in the HGM unit to also include a downstream portion subject to reduced flows. If this is the case, adjust the score accordingly with documented justification.

STEP 3E: ASSESS THE MAGNITUDE OF IMPACT OF RECENT DEPOSITION, INFILLING OR EXCAVATION

Table 2.14 Magnitude of impact of recent deposition, infilling or excavation

Extent Assessment	**ha**	**%**
Extent of HGM unit affected by deposition or excavation	0.0	0

Descriptor	**Low**			**High**		**Score**
	0	**2**	**5**	**8**	**10**	
Effect on vertical drainage properties of the uppermost soil layer	No effect	Rendered somewhat free-draining	Intermediate	Rendered free-draining	Rendered very well- drained*	0
Effect on the horizontal movement of water	No effect	Moderate modification	Large modification	Serious modification		0
Intensity of impact: use the highest score for the above two factors						0
Magnitude of impact score: extent of impact (%)/100 x intensity of impact x 1						**0**

*i.e. drainage is so free that the area no longer has any wetland characteristics

STEP 3F: DETERMINE COMBINED MAGNITUDE OF IMPACT OF ON-SITE ACTIVITIES

Table 2.15: Overall magnitude of impacts of on-site activities on water distribution and retention patterns n the HGM unit

Activity	Magnitude of impact	Justification for any modifications made
(1) Calculated magnitude of impact of canalization and stream channel modification from Table 2.10	0.0	
(2) Calculated magnitude of impact of impeding features from Table 2.11	0.0	
(3) Calculated magnitude of impact of altered surface roughness from Table 2.12	0.0	
(4) Calculated magnitude of impact of aliens, timber and/or sugarcane in the wetland from Table 2.13	4.8	
(5)) Calculated magnitude of impact of recent deposition/excavation from Table 2.14	0.0	
Total score of magnitude of on-site activities in the HGM unit (sum of the above scores)*	4.8	* If score is > 10, then magnitude of impact = 10

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF THE HGM UNIT THROUGH INTEGRATING THE ASSESSMENTS FROM STEPS 2 AND 3

Changes to water distribution & retention patterns (Table 2.15):	4.8

Changes to Water Inputs (Table 2.5):	0

Table 2.16: Derivation of overall magnitude-of-impact scores through combining the scores obtained from the catchment and within-wetland assessments. The colour codes correspond to the impact categories given in Table 2.17.

			Water Inputs (Step 2 - Table 2.5)					
			None	Small	Moderate	Large	Serious	Critical
			0-0.9	1-1.9	2-3.9	4-5.9	6-7.9	8 - 10
Water distribution & retention patterns (Step 3, Table2.18)	None	0-0.9	0	1	3	5	6.5	8.5
	Small	1-1.9	1	1.5	3.5	6	7	9
	Moderate	2-3.9	3	3.5	4	6.5	7.5	9

	Large	4-5.9	5	6	6.5	7	8	9.5
	Serious	6-7.9	6.5	7	7.5	8	9	10
	Critical	8 - 10	8.5	9	9	9.5	10	10

Combined magnitude score as a result of impacts on hydrological functioning	5

PAGE 2: HGM UNIT 4

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

Table 3.1: Guideline for assessing the impacts of activities according to HGM type

HGM type to assess	Activity/Indicator that should be assessed
Diagnostic component	
Floodplain	Dams upstream of or within floodplains (see Step 2A)
Floodplain, channeled valley bottom	Stream shortening or straightening (see Step 2B)
Floodplain, channeled valley bottom	Infilling that leads to narrowing of the wetland (see Step 2C)
All non-floodplain HGM's	Changes in runoff characteristics (see Step 2D)
Indicator-based component	
All non-floodplain HGM's	Erosional features (see Step 3A)
All non-floodplain HGM's*	Depositional features (see Step 3A)
All non-floodplain HGM's	Loss of organic sediment (see Step 3B)

* Consider floodplains if there are large alluvial fans impinging on the floodplain laterally to it (from the side).

HGM Type
Isolated Hillslope seepage
If floodplain, are there large alluvial fans impinging laterally on the floodplain (from the side of the floodplain)?
Note: Steps that need to be completed are indicated with a "Yes" based on the HGM type selected in the summary page.

Step 2A: Impacts of dams upstream of and/or on floodplains	To assess?	No	See Table 3.1

Dams in the floodplain catchment

Table 3.2: Extent, intensity and magnitude of impacts of impoundments in the catchment

Extent of impact of dams situated above floodplains						**Extent (%)**
Extent: For dams upstream of floodplains extent is assumed to be 100%. If a dam is also situated on the floodplain, extent of impact for the dam above the floodplain is determined as the length of the floodplain above the dam / total floodplain length, expressed as a percentage						
Intensity of impact score – size of dams and nature of sediment transported						
Determine the size of dam/s on the stream and the nature of sediment load being transported						
	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	**Score**
Suspended load dominated	0.5	1	1.5	2	2.5	
Mixed load	1	2	3	4	5	
Bedload dominated	2	3	4	5	5	
Intensity of impact score – location of dams in the catchment						
Score	**1**	**2**	**3**	**4**	**5**	**Score**
Location of dam/s	Dams on minor tributary stream or on trunk stream far upstream of floodplain	Intermediate between descriptions for scores 0 and 5	Dams on major tributary or on trunk stream a moderate distance upstream of floodplain	Intermediate between descriptions for scores 5 and 10	Dam on trunk stream immediately above floodplain	
Overall intensity of impact score for dams situated above floodplains: mean of above 2 scores						0.0
Magnitude of impact score for dams situated above floodplains: (extent of impact score/ 100) x overall intensity of impact score						0.0

Enter single score

Dams on the floodplain

Table 3.3: Extent, intensity and magnitude of impact of impoundments within the floodplain.

Extent of impact of dams situated within floodplains	**Extent (%)**
Extent: The percentage of the floodplain valley length flooded by the dam and below the dam wall	
Intensity of impact of dams situated within floodplains	

SCORE	1	2	3	4	5	Score
Size of dam	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	
Configuration of spillway/s			Baseflows to floodplain stream: peak flows to backswamp	Baseflows and peak flows to floodplain stream **OR** baseflows to backswamp and peak flows to floodplain stream	Baseflows and peak flows to backswamp	
Overall intensity of impact score for dams situated within floodplains: mean of above 2 scores						0
Magnitude of impact score for dams situated within floodplains: (extent of impact score / 100) x overall intensity of impact score						0.0

Combining impacts of dams in the catchment and on the floodplain

Table 3.4: Combining the magnitude of impact scores of impoundments upstream of and on the floodplain.

Magnitude of impact score for dams upstream of and on the floodplain	
Magnitude of impact score for dam/s located in the catchment (Table 3.2)	0.0
Magnitude of impact score for dam/s located within the floodplain (Table 3.3)	0.0
Overall magnitude of impact for floodplain wetlands with dams upstream of and on the floodplain = sum of above two rows	**0.0**

Impacts of channel straightening

To assess? **No** See Table 3.1

Table 3.5: Extent, intensity and magnitude of impacts of channel straightening

Extent of impact of channel straightening.						**Extent (%)**
Extent: the length of modification plus THE LESSER OF 10km for sandy stream beds OR 5km for silty/clayey stream beds OR the distance to the head of the floodplain OR to a dam wall (if present), expressed as a percentage of floodplain length[R]						
Intensity of impact of channel straightening						
	0	**1**	**2**	**3**	**4**	Intensity

Reduction in stream length per unit valley length[R]	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of channel straightening: (extent of impact score/ 100) x intensity of impact score						**0.0**

Step 2C: Impacts of artificial wetland infilling

To assess? **No** See Table 3.1

Table 3.6: Extent, intensity and magnitude of impact of infilling of floodplains and channeled valley bottom wetlands.

Extent of impact of infilling.						**Extent (%)**
Extent of impact of infilling as determined by establishing the area of wetland that will not be subjected to normal erosion and / or deposition, as a percentage of wetland area.						
Intensity of impact of infilling						
	0	**1**	**2**	**3**	**4**	**Score**
Reduction in active wetland width at point of infillingR	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of infilling: (extent of impact score / 100) x intensity of impact score.						**0**

Step 2D: Impacts of changes in runoff characteristics

To assess? **Yes** See Table 3.1

Table 3.7: Effect of altered water inputs (increased flows and floodpeaks) on wetland geomorphological integrity

Extent of impact of altered water inputs					**Extent (%)**
Extent calculated based on length of wetland affected by increased flow as a proportion (%) of the entire wetland length.					0
Intensity of impact of altered water inputs					
		Increased floodpeaks (combined score in Table 2.3)			
		No effect (0-2)	Small increase (2.1-4)	Moderate increase (4.1-7)	Large increase (>7)
Increased flows (increased flow score in Table 2.2)	No increase (0-2)	0	1	2	3.5*
	Small increase (2.1-4)	1	1.5	3	4
	Moderate increase (4.1-7)	2	3	4	4.5

	Large increase (>7)	3.5*	4	4.5	5
				Change Score	0
Magnitude of impact score: (extent of impact score/100) x intensity of impact score (from above rows)					**0.0**

* Unlikely to occur

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

Step 3A: Impacts of erosion and/or deposition

Erosional features

To assess?	**Yes**	See Table 3.1

Table 3.8: Estimation of extent of impact of erosional features

		Length of wetland occupied by gully/ies as a percentage of the length of HGM[R]					
		0-20%	21-40%	41-60%	51-80%	>80%	
Average gully width (sum of gully widths if more than 1 gully present) in relation to wetland width[R]	< 5%	5%	10%	15%	20%	25%	
	5-10%	10%	15%	25%	35%	45%	
	11-20%	15%	25%	40%	55%	65%	
	21-50%	20%	30%	50%	70%	80%	**Extent (%)**
	>50%	25%	40%	60%	80%	100%	0

Table 3.9: Intensity and magnitude of impact of erosional features. The scores for rows 2 and 3 are unscaled for any natural recovery that may have taken place. Factors to use to scale the intensity of impact of erosional features for natural recovery are presented in rows 7 and 8.

Factor	**1**	**2**	**3**	**4**	**5**	**Unscaled score**
Mean depth of gullies[F]	<0.50m	0.50-1.00m	1.01-2.00m	2.00-3.00m	>3.00m	0
Mean width of gullies[F]	<2m	2-5m	5.1-8m	8.1-16m	>16m	0
Number of headcuts present[F]	1	2	3	4	>4	0
Unscaled intensity of impact score: mean score of above 3 rows						0.0
Scaling factor	**0.4**	**0.5**	**0.7**	**0.9**	**1**	**Factor**

Extent to which sediment from the gully is deposited within the HGM or wetland downstream of the HGM unit (as opposed to being exported)[F]	Entirely deposited	Mainly deposited	Intermediate	Mainly exported	Entirely exported	0
Extent to which the bed and sides of the gully have been colonized by vegetation and/or show signs of natural recovery[F]	Complete	High	Moderate	Low	None	0
Scaling factor score: mean of above 2 rows (value is between 0 and 1)						0.0
Scaled intensity of impact score = unscaled intensity of impact score x scaling factor score						0.0
Magnitude of impact score for erosional features: (extent of impact score (see Table 3.8)/100) × scaled intensity of impact score						**0.0**

Depositional features

To assess?	**Yes**	See Table 3.1

We are only interested here in recent depositional features. If the user feels confident in being able to map depositional features that can be attributed directly to recent human activity, then extent should be established directly using Table 3.10, but if they are not confident that they can do this, indirect indicators can be used as outlined in Table 3.11. Users may wish to use a combination of approaches by using the indirect indicators to assist in the location and mapping of depositional features in the wetland of interest, following which they may map depositional features directly, but ideally, one would only map these features directly.

Table 3.10: Estimation of the extent of impact of depositional features for known depositional features in the HGM unit.

Extent of depositional features in relation to area of HGM unit being considered	0.2-1.9%	2-10%	11-25%	26-50%	>50%	
Score for "extent" to be used in the estimation of magnitude of impacts	5	20	50	75	100	0

Table 3.11: Estimation of extent of depositional features based on indirect indicators of recent anthropogenic activity leading to excessive deposition.

Indicator	0	1	2	3	4	Score
Presence, size and distribution of gullies or active erosion of drains within the catchment or wetland	None or very small	Limited extent and size	Moderate size and distribution	Large size or widespread distribution	Very large size or widespread distribution	0
Presence / extent of dirt roads in the catchment	None / few	Moderate	Many / extensive			0
Breaching of upstream dams in the catchment or wetland	None	Very small earthen dams	Small earthen dams	Large earthen dams		0

Extent of decreased vegetation cover in the catchment	Slight	Moderate	High			0
Mean of two highest scores from the above						0.0
Extent of impact score of depositional features as a percentage is calculated as the score from the above multiplied by 10.						0

Table 3.12: Intensity and magnitude of impact of depositional features

Indicator	0	1	2	3	Score
The position of fan-like deposits within the wetland[R]		Toe	Middle	Upper	0
Impact of depositional features on existing wetland features[D]	Not evident	Minor destruction of features	Moderate destruction of features	Large impact on existing features	0
Intensity of impact score of depositional features: mean of two rows above					0
Magnitude of impact score of depositional features: (extent of impact score (Table 3.10 or 3.11) / 100) x intensity of impact score					**0.0**

Step 3B: Impacts of the loss of organic sediment

To assess? **Yes** See Table 3.1

Table 3.13: Extent of impact of the loss of organic sediment for direct indicators (A) and indirect indicators (B). Express results as a proportion of the total area of the HGM unit.

A. Extent of impact score based on direct indicators (if present)	0	%
B. Additional extent of impact score based on indirect indicators (if present)	0	%

To determine the intensity of impact in the affected area of the wetland, see Tables 3.14 and 3.15 for direct and indirect indicators respectively.

Direct indicators

Table 3.14: Macroscopic features (clearly visible direct indicators) determining the intensity of impact of the loss of organic sediments

Activity	1	2	3	4	5	Score
Depth of the peat fires or extraction of peat relative to the depth of the peat deposit	<5%	5-15%	16-30%	31-60%	>60%	0
If tillage is practiced, duration of tillage	1-2 yrs	3-5 yrs	6-10 yrs	>10 yrs		0
Intensity of impact score: maximum score of above scores						0.0
Magnitude of impact score of loss of organic sediments: (extent of impact score (Table 3.13A) /100) × intensity of impact score						0.0

Indirect indicators

Table 3.15: Indirect indicators (not clearly visible) reflecting the intensity of diminished integrity of organic sediments in the HGM unit.

	0	**1**	**2**	**3**	**4**	**Intensity score**
Level of desiccation of the region of the HGM unit in which peat accumulation is taking place*	Unmodified	Largely natural	Moderately modified	Largely modified	Serously / critically modified	0
Magnitude of impact score: extent of impact score (Table 3.13B)/100 × intensity of impact score						0.0

Overall magnitude of impact: Organic sediment

Table 3.16: Magnitude of impact score for organic sediments expressed as a proportion of the area of the entire HGM unit

	Overall magnitude of impact score: organic sediments
Sum of magnitude scores in Tables 3.14 and 3.15	**0.0**

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

Table 3.17: Derivation of overall magnitude-of-impact scores through combining the scores obtained from individual assessments.

Impact category	**Score**	**To include?**
1. Magnitude of impact of dams (Table 3.4)	N/A	No
2. Magnitude of impact of channel straightening (Table 3.5)	N/A	No
3. Magnitude of impact of infilling (Table 3.6)	N/A	No
4. Magnitude of impact of changes in runoff characteristics (Table 3.7)	0.0	Yes
5. Magnitude of impact for erosional features (Table 3.9)	0.0	Yes
6. Magnitude of impact for depositional features (Table 3.12)	0.0	Yes
7. Magnitude of impact for loss of organic sediment (Table 3.16)	0.0	Yes

Overall Present Geomorphic State = Sum of three highest scores	0.0

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STEP 2: DETERMINE THE PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 2A: FAMILIARISATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 2B: IDENTIFY AND ESTIMATE THE EXTENT OF EACH DISTURBANCE CLASS IN THE HGM UNIT

Table 4.2: Description and extent of each disturbance class within the HGM unit

Disturbance class	Brief description of disturbance class	Extent (ha)*	Extent (%)
1	Alien Vegetation	0.46	80
2	Recently abandoned cropland	0.12	20
		0.58	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

Table 4.6: Calculation of the HGM magnitude of impact score based on an area weighted magnitude of impact score for each disturbance class.

Disturbance class	Disturbance class extent (%) (from Table 4.2)	Intensity of impact score (from Table 4.5)	Magnitude of impact score*	Factors contributing to impact
1	80	8	6.4	
2	20	8	1.6	
		HGM Magnitude of impact score**	**8.0**	

*   Magnitude of impact score is calculated as extent / 100 x intensity of impact
** Overall magnitude of impact score for the HGM unit = sum of magnitude scores for each disturbance class.

STEP 2D: DETERMINE THE MAGNITUDE OF IMPACT SCORE AND PRESENT VEGETATION STATE OF EACH HGM UNIT

Calculated in Table 4.6 above

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

Table 4.10: Evaluation of Trajectory of Change of vegetation within an HGM.

Disturbance class	Source of change	Disturbance class extent (%) (Table 4.2)	Change score (Table 4.9)	Area-weighted change score*
1	Increasing alien vegetation	80	0	0.0
2	Entry of alien vegetation	20	0	0.0
			HGM change score**	**0.0**

*Area weighted change score = Disturbance Class extent /100 x change score
**HGM change score = sum of individual area weighted scores for each disturbance unit

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STEP 2: ASSESS IMPACT OF CHANGES IN QUANTITY AND PATTERN OF WATER INPUTS TO THE WETLAND

Vulnerability factor	0.9

STEP 2A: IDENTIFY, MAP AND ASSESS IMPACT OF LAND-USE ACTIVITIES THAT REDUCE THE INFLOW QUANTITY TO THE HGM UNIT

Table 2.2: Different land-use types and activities potentially altering inflow quantities to the HGM unit from its upstream catchment, and the magnitude of their collective

effect (1)

Reduced Flows

Land-use activity descriptors		Low High 0	-2	-5	-8	-10	Scores	Intensity of water loss (2)	Extent (%)	Magnitude (3)
Irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	Seasonal	Year-round	0	0.0	0	0.0
	(2) Prevalence of water conserving practices[R]		High	Intermediate	Low		0			
Other abstractions not used for irrigation in the catchment (4)										
Alien plants	(1) plant type[R]			Shrubs	Trees		-8	-5.9	100	-5.9
	(2) Distribution of alien woody plants in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		-5			
Plantations	(1) Tree type[R]				Wattle & pine	Eucalyptus	0	0.0	0	0.0
	(2) Distribution of tree plantations in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Sugar (5)	(1) Crop type[R]		Sugar				0	0.0	0	0.0
	(2) Distribution in riparian areas[R]		Confined to non-riparian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas		0			
Dams: specific allowance for releasing low flows within the operating rules of the dam[R]				Allowance made	No allowance		0	0.0	0	0.0
Overall magnitude of reduction in water inputs to the HGM unit as the sum of all the above impact magnitudes:										**-5.9**

Increased Flows

Description of the level of increase	**Magnitude score**

Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).	10
Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.	7
Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).	3
No increase, or flow is increased by a negligible amount.	0
Magnitude of impact associated with increases in water inputs	0

Combined score: Increased flows score + Decreased flows score The combined score will range from -10 to +10, depending on the magnitude of the factors causing an increase or decrease in flow respectively	**-5.9**

STEP 2B: ASSESS THE INTENSITY OF IMPACT OF FACTORS POTENTIALLY ALTERING FLOW PATTERNS TO THE HGM UNIT

Table 2.3: Factors potentially contributing to a decrease or increase of floodpeak magnitude and/or frequency received by the HGM unit

Level of reduction	Low				High	Score
	0	-2	-5	-8	-10	
(1) Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R*]	<20%	20-35%	36-60%	60-120%	>120%	0
(2) Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	High	0
(3) Specific allowance for natural floods within the operating rules of the dam[R] **	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	0
Level of increase	**Low**				**High**	**Score**
	0	**2**	**5**	**8**	**10**	
(4) Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	2

(5) Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R]***	<10%	11-40%	41-80%	>80%		0
Combined Score: [Ave of (1), (2) and (3)] + (4) + (5)] adjusted****						**2.0**

STEP 2C: ASSESS THE COMBINED MAGNITUDE OF IMPACT OF ALTERED QUANTITY AND PATTERN OF INPUTS, ACCOUNTING FOR THE WETLAND UNIT'S VULNERABILITY

Change in quantity of water inputs (Table 2.2):	**-5.9**

Alteration to floodpeaks (Table 2.3):	**2.0**

Table 2.5: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs.

(a) Floodplains and channeled valley bottoms driven primarily by over-bank flooding

Change in quantity of water inflows (Score from Table 2.2)	**Alteration to floodpeaks (Score from Table 2.4)**						
	Large increase (>6)	Moderate increase (4-6)	Small increase (1.6-3.9)	No effect (-1.5 to 1.5)	Small decrease (-1.6 to	Moderate decrease (-4 to -6)	Large decrease (<-6)
> 9	7	6	5	4	5	6	7
4 - 9	5	4	3	3	4	6	7
1-3.9 (Increase)	3	2	1	1	2.5	4.5	7
-0.9- +0.9 (Negligible)	1	1	0	0	1	5	7.5
-1- -1.9 (Decrease)	2	1.5	1	1	2.5	5	7.5
-2- -3.9	3	2.5	2	2	4	6	8
-4- -5.9	4	3.5	3	3	5	7	8.5
-6- -7.9	_**	_**	_**	4	6	8	9
-8- -9	_**	_**	_**	_**	_**	9	9.5
< -9	_**	_**	_**	_**	_**	_**	10

(b) Other hydro-geomorphic settings, including floodplains and channeled valley bottoms driven primarily by lateral inputs (e.g. from tributaries)

Change in quantity of water inflows (Score from Table 2.2)	Alteration to floodpeaks (Table 2.4)						
	Large increase	Moderate increase	Small increase	No effect	Small decrease	Moderate decrease	Large decrease
	(>6)	(4-6)	(1.6-3.9)	(-1.5 to 1.5)	(-1.6 to -3.9)	(-4 to -6)	(<-6)
> 9	6	5	4	3	3	3.5	4
4 - 9	4.5	4	3	2	3	3	3
1-3.9 (Increase)	3	2	1	1	1	2	2.5
-0.9- +0.9 (Negligible)	2.5	1.5	0.5	0	0.5	1	1.5
-1- -1.9 (Decrease)	3.5	2.5	1.5	1	1.5	2	2.5
-1 - -3.9	4.5	3.5	2.5	2	2.5	3	3.5
-2 - -3.9	6	5	4	3.5	4	4.5	5
-4- -5.9	-**	-**	-**	5	5.5	6	6.5
-6- -7.9	-**	-**	-**	-**	-**	7.5	8
< -9	-**	-**	-**	-**	-**	-**	10

**These classes are unlikely, given that when there is a high level of reduction of quantity of inputs then there would be insufficient water to maintain unaltered or increased floodpeaks (i.e. a decrease in floodpeaks would be inevitable).

Magnitude of impact based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs:	4
Magnitude of impact adjusted to account for any change in seasonality:***	4

***If seasonality has been changed moderately then increase the magnitude of impact score by 1 and if it has been changed greatly then increase the magnitude of impact score by 2.

STEP 3: ASSESS THE DEGREE TO WHICH NATURAL WATER DISTRIBUTION AND RETENTION PATTERNS WITHIN THE HGM UNIT HAVE BEEN ALTERED AS A RESULT OF ON-SITE ACTIVITIES

STEP 3A: ASSESS MAGNITUDE OF IMPACT OF CANALIZATION AND STREAM MODIFICATION

Canalization

Note: Where more than one section of a HGM unit is affected by canalization, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.7: Characteristics affecting the impact of canalization on the distribution and retention of water in the HGM unit

Extent of HGM unit affected by canalization	ha	%
	0	0

Factors	Low				High	Score
	0	2	5	8	10	
Characteristics of the wetland						
(1) Slope of the wetland	<0.5%	0.5-0.9%	1-1.9%	2-3%	>3%	10
(2a) Texture of mineral soil, if present*	Clay	Clay loam	Loam	Sandy loam	Sand/loamy sand	2
(2b) Degree of humification of organic soil, if present*	Completely amorphous (like humus)	Somewhat amorphous	Intermediate	Somewhat fibrous	Very fibrous	
(3) Natural level of wetness	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	2
Characteristics of the drains/gullies						
(4) Depth of the drains/gullies	<0.20 m	0.20-0.50 m	0.51-0.80 m	0.81-1.10	>1.10 m	0
(5) Density of drains (meters of drain per hectare of wetland)**	<25 m/ ha	26-100 m/ha	101-200 m/ha	201-400 m/ha	>400 m/ha	0
(6) Location of drains/gullies in relation to flows into and through the wetland[R]. Drains/gullies are located such that flows are:	Very poorly intercepted	Moderately poorly intercepted	Intermediately intercepted	Moderately well intercepted	Very well intercepted	0
(7) Obstructions in the drains/ gullies	Complete obstruction	High obstruction	Moderate obstruction	Low obstruction	No obstruction	10
Calculate the mean score for factors 1, 2a or 2b, 3, 4 and 5						2.8
Multiply the score for factor 5 by the flow alteration factor (Table 2.1)						0.0
Mean score for above two scores						1.4
Intensity of impact for canalization: Divide the score for factor 7 by 10 and multiply this by the mean score derived in previous row						1.4
Magnitude of impact of canalization: Extent of impact/100 × intensity of impact calculated in the row above						**0.0**

Note: Leave either 2a OR 2b blank

Stream channel modification

Note: Where more than one section of a HGM unit is affected by stream channel modification, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.8: Characteristics affecting the impact on the distribution and retention of water in the HGM unit through the modification of a stream channel

	%
Extent of HGM unit affected by stream channel modification*	0
HGM weighting factor	0

*should be expressed as a percentage of the length of the HGM unit (See diagram alongside)

Characteristics of stream channel	Low				High	Score
	0	2	5	8	10	
(1) Reduction in length of stream per unit valley length[D]	<5%	5 – 25%	25 – 50%	50 – 75%	75 – 100%	0
(2) % increase in cross sectional area of the stream[F]	<5%	5 – 25%	26 – 50%	51 – 75%	>75%	0
(3) Change in surface roughness in relation to the surface roughness of the channel in its natural state (see Table 2.9 for description of roughness classes)	Roughness is increased or is unchanged[1]	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: use the maximum score of factors 1 to 3 x HGM weighting factor*						**0**
Magnitude score of impact of stream channel modification: extent of impact/100 × intensity of impact						**0.0**

Table 2.10: Calculation of the magnitude of impact of canalization and modification of a stream channel on the distribution and retention of water in a wetland HGM unit

Overall magnitude of impact score: canalization and stream channel modification	**Score**
Calculate the sum of scores from Tables 2.7 and 2.8.	**0.0**

STEP 3B: ASSESS MAGNITUDE OF IMPACT OF IMPEDING FEATURES

Note: Where more than one section of a HGM unit is affected by an impeding feature, undertake seporate evaluations for each section and sum the resultant scores.

Table 2.11: Typical changes in water-distribution and -retention patterns within an HGM unit as a result of impeding structures

result of impeding structures

(a) Upstream impact of flooding

Extent Assessment	**ha**	**%**
(a) Extent of HGM unit affected by flooding **upstream** of the impeding structure	0.0	0

Descriptor	**Low High**					**Score**
	0	**2**	**5**	**8**	**10**	
Representation of different hydrological zones prior to flooding by the dam[R]	-	Seasonal and permanent zone both present and collectively >30%	Permanent and seasonal zones both present but collectively <30%	Seasonal zone present but permanent zone absent	Permanent and seasonal zones lacking (i.e. only the temporary zone present)	0
Intensity of impact: score for above factor X 0.8						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

(b) Downstream impact on quantity and timing of flows to downstream portion of the HGM unit

Extent Assessment	**ha**	**%**
(b) Extent of HGM unit affected by flooding **downstream** of the impeding structure		0

	Low				**High**	**Score**
	0	**2**	**5**	**8**	**10**	

Extent to which dams or roads interrupt low flows to downstream areas [R]	No interruption (e.g., many culverts through a road embankment)	Slight interruption (e.g., a moderate number of culverts through a road embankment)	Intermediate interruption (e.g. earth dam with very high seepage or road embankment with no/ very limited culverts)	Moderately high interruption (e.g. earth dam with some seepage/ flow releases)	High interruption (e.g. a concrete dam with no seepage and no low flow releases)	0
Level of abstraction from the dam/s [R]	Low	Moderately low	Intermediate	Moderately high	High	0
Location of dam/s relative to the affected area's catchment- proportion of catchment flows intercepted [D]	Dam intercepts <20% of the affected area's catchment	Dam intercepts 21-40% of the affected area's catchment	Dam intercepts 41-60% of the affected area's catchment	Dam intercepts 61-80% of the affected area's catchment	Dam intercepts >80% of the affected area's catchment	0
Collective volume of dam/s in relation to MAR of the affected area[D]	<20%	20-35%	36-60%	60-120%	>120%	0
Intensity of impact: mean score of the THREE highest scoring factors x 0.8						0.0
Magnitude-of-impact score: extent of impact /100 × intensity of impact						**0.0**

(c) Combined impact

Combined impact: Magnitude of impact for upstream + Magnitude of impact for downstream	**0.0**

STEP 3C: ASSESS MAGNITUDE OF IMPACT OF ALTERED SURFACE ROUGHNESS

Table 2.12: Comparison of surface roughness of an HGM unit in its current state compared with its natural state

Extent of HGM unit affected by change in surface roughness	ha	%

	0.5	80

Class	Descriptor	Current	Historic
Low	Smooth surface with little or no vegetation to offer resistance to water flow	High	Moderately low
Moderately low	Vegetation is present but short (i.e. < 500mm) and not robust (e.g. rye grass)		
Moderate	Vegetation offering slight resistance to water flow, generally consisting of short plants (i.e. < 1 m tall)		
Moderately high	Robust vegetation (e.g. dense stand of reeds) or hummocks offering high resistance to water flow		
High	Vegetation very robust (e.g. dense swamp forest with a dense under storey) and offering high resistance to water flow.		

Note: Where roughness varies across the HGM unit, take the average condition, and where roughness varies over time (e.g. areas which are regularly cut short) take the average condition during the wet season.

Descriptor	Low 0	2	5	8	High 10	Score
Change in surface roughness in relation to the surface roughness of the wetland in its natural state[F]	Roughness increased or is unchanged*	Decrease in roughness is moderate (i.e. by one class)	Decrease in roughness is high (i.e. by two classes)	Decrease in roughness is very high (i.e. by three or more classes)		0
Intensity of impact: score for the above row X 0.6						0
Magnitude of impact score: extent of impact /100 × intensity of impact						**0.0**

*It is considered to be of greater consequence to water retention and distribution if the surface roughness of a wetland is decreased than if it is increased, therefore the focus of this assessment is primarily on a decrease in surface roughness.

STEP 3D: ASSESS THE IMPACT OF DIRECT WATER LOSSES

Table 2.13: Evaluating the effect of alien woody plants, commercial plantations and sugarcane growing in the HGM unit on water loss

Land-use activity	Low	High	Score	Intensit	Extent	Magnitude*

descriptors	0	2	5	8	10		y of water loss*	(%)	*
(1) Alien woody plant type[F]			Shrubs	Trees		8	8	80	6.4
(1) Plantation tree type[F]				Wattle & pine	Eucalyptus	0	0	0	0.0
(1) Sugarcane Growth[F]		Poor growth	Good growth			0	0	0	0.0
(4) Direct water abstractions		Low	Moderately low	Moderately high	High	0	0	0	0.0
Overall magnitude of increased water loss: (sum of (1), (2), (3) and (4)) x 0.8									5.1

*Intensity= Score x Vulnerability factor (from Table 2.1) **Magnitude=Intensity x Extent (%)/100

Note: When assessing extent, remember that the extent of the impact may extend beyond the direct area in which the alien woody plants or plantations occur in the HGM unit to also include a downstream portion subject to reduced flows. If this is the case, adjust the score accordingly with documented justification.

STEP 3E: ASSESS THE MAGNITUDE OF IMPACT OF RECENT DEPOSITION, INFILLING OR EXCAVATION

Table 2.14 Magnitude of impact of recent deposition, infilling or excavation

Extent Assessment	ha	%
Extent of HGM unit affected by deposition or excavation	0.0	0

Descriptor	Low				High	Score
	0	2	5	8	10	
Effect on vertical drainage properties of the uppermost soil layer	No effect	Rendered somewhat free-draining	Intermediate	Rendered free-draining	Rendered very well- drained*	0
Effect on the horizontal movement of water	No effect	Moderate modification	Large modification	Serious modification		0
Intensity of impact: use the highest score for the above two factors						0
Magnitude of impact score: extent of impact (%)/100 x intensity of impact x 1						0

*i.e. drainage is so free that the area no longer has any wetland characteristics

STEP 3F: DETERMINE COMBINED MAGNITUDE OF IMPACT OF ON-SITE ACTIVITIES

Table 2.15: Overall magnitude of impacts of on-site activities on water distribution and retention patterns n the HGM unit

Activity	Magnitude of impact	Justification for any modifications made
(1) Calculated magnitude of impact of canalization and stream channel modification from Table 2.10	0.0	
(2) Calculated magnitude of impact of impeding features from Table 2.11	0.0	
(3) Calculated magnitude of impact of altered surface roughness from Table 2.12	0.0	
(4) Calculated magnitude of impact of aliens, timber and/or sugarcane in the wetland from Table 2.13	5.1	
(5)) Calculated magnitude of impact of recent deposition/excavation from Table 2.14	0.0	
Total score of magnitude of on-site activities in the HGM unit (sum of the above scores)*	5.1	* If score is > 10, then magnitude of impact = 10

STEP 4: DETERMINE THE PRESENT HYDROLOGICAL STATE OF THE HGM UNIT THROUGH INTEGRATING THE ASSESSMENTS FROM STEPS 2 AND 3

Changes to water distribution & retention patterns (Table 2.15):	5.1

Changes to Water Inputs (Table 2.5):	4

Table 2.16: Derivation of overall magnitude-of-impact scores through combining the scores obtained from the catchment and within-wetland assessments. The colour codes correspond to the impact categories given in Table 2.17.

			Water Inputs (Step 2 - Table 2.5)					
			None	Small	Moderate	Large	Serious	Critical
			0-0.9	1-1.9	2-3.9	4-5.9	6-7.9	8 - 10
Water distribution & retention patterns (Step 3, Table2.18)	None	0-0.9	0	1	3	5	6.5	8.5
	Small	1-1.9	1	1.5	3.5	6	7	9
	Moderate	2-3.9	3	3.5	4	6.5	7.5	9

	Large	4-5.9	5	6	6.5	7	8	9.5
	Serious	6-7.9	6.5	7	7.5	8	9	10
	Critical	8 - 10	8.5	9	9	9.5	10	10

Combined magnitude score as a result of impacts on hydrological functioning	7

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PAGE 2: HGM UNIT 5

STEP 2: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON DIAGNOSTIC FEATURES

Table 3.1: Guideline for assessing the impacts of activities according to HGM type

HGM type to assess	Activity/Indicator that should be assessed
Diagnostic component	
Floodplain	Dams upstream of or within floodplains (see Step 2A)
Floodplain, channeled valley bottom	Stream shortening or straightening (see Step 2B)
Floodplain, channeled valley bottom	Infilling that leads to narrowing of the wetland (see Step 2C)
All non-floodplain HGM's	Changes in runoff characteristics (see Step 2D)
Indicator-based component	
All non-floodplain HGM's	Erosional features (see Step 3A)
All non-floodplain HGM's*	Depositional features (see Step 3A)
All non-floodplain HGM's	Loss of organic sediment (see Step 3B)

* Consider floodplains if there are large alluvial fans impinging on the floodplain laterally to it (from the side).

HGM Type
Isolated Hillslope seepage
If floodplain, are there large alluvial fans impinging laterally on the floodplain (from the side of the floodplain)?
Note: Steps that need to be completed are indicated with a "Yes" based on the HGM type selected in the summary page.

Step 2A: Impacts of dams upstream of and/or on floodplains	To assess?	No	See Table 3.1

Dams in the floodplain catchment

Table 3.2: Extent, intensity and magnitude of impacts of impoundments in the catchment

Extent of impact of dams situated above floodplains						**Extent (%)**
Extent: For dams upstream of floodplains extent is assumed to be 100%. If a dam is also situated on the floodplain, extent of impact for the dam above the floodplain is determined as the length of the floodplain above the dam / total floodplain length, expressed as a percentage						
Intensity of impact score – size of dams and nature of sediment transported						
Determine the size of dam/s on the stream and the nature of sediment load being transported						
	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	**Score**
Suspended load dominated	0.5	1	1.5	2	2.5	
Mixed load	1	2	3	4	5	
Bedload dominated	2	3	4	5	5	
Intensity of impact score – location of dams in the catchment						
Score	**1**	**2**	**3**	**4**	**5**	**Score**
Location of dam/s	Dams on minor tributary stream or on trunk stream far upstream of floodplain	Intermediate between descriptions for scores 0 and 5	Dams on major tributary or on trunk stream a moderate distance upstream of floodplain	Intermediate between descriptions for scores 5 and 10	Dam on trunk stream immediately above floodplain	
Overall intensity of impact score for dams situated above floodplains: mean of above 2 scores						0.0
Magnitude of impact score for dams situated above floodplains: (extent of impact score/ 100) x overall intensity of impact score						0.0

Enter single score

Dams on the floodplain

Table 3.3: Extent, intensity and magnitude of impact of impoundments within the floodplain.

Extent of impact of dams situated within floodplains	**Extent (%)**
Extent: The percentage of the floodplain valley length flooded by the dam and below the dam wall	
Intensity of impact of dams situated within floodplains	

SCORE	1	2	3	4	5	Score
Size of dam	Small (<10 % MAR)	Modest (10-20% MAR)	Medium (20-40% MAR)	Large (40-80% MAR)	Very large (>80% MAR)	
Configuration of spillway/s			Baseflows to floodplain stream: peak flows to backswamp	Baseflows and peak flows to floodplain stream **OR** baseflows to backswamp and peak flows to floodplain stream	Baseflows and peak flows to backswamp	
Overall intensity of impact score for dams situated within floodplains: mean of above 2 scores						0
Magnitude of impact score for dams situated within floodplains: (extent of impact score / 100) x overall intensity of impact score						0.0

Combining impacts of dams in the catchment and on the floodplain

Table 3.4: Combining the magnitude of impact scores of impoundments upstream of and on the floodplain.

Magnitude of impact score for dams upstream of and on the floodplain	
Magnitude of impact score for dam/s located in the catchment (Table 3.2)	0.0
Magnitude of impact score for dam/s located within the floodplain (Table 3.3)	0.0
Overall magnitude of impact for floodplain wetlands with dams upstream of and on the floodplain = sum of above two rows	**0.0**

Impacts of channel straightening

To assess?	No

See Table 3.1

Table 3.5: Extent, intensity and magnitude of impacts of channel straightening

Extent of impact of channel straightening.						**Extent (%)**
Extent: the length of modification plus THE LESSER OF 10km for sandy stream beds OR 5km for silty/clayey stream beds OR the distance to the head of the floodplain OR to a dam wall (if present), expressed as a percentage of floodplain length[R]						
Intensity of impact of channel straightening						
	0	**1**	**2**	**3**	**4**	Intensity

Reduction in stream length per unit valley length[R]	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of channel straightening: (extent of impact score/ 100) x intensity of impact score						**0.0**

Step 2C: Impacts of artificial wetland infilling

To assess? **No** See Table 3.1

Table 3.6: Extent, intensity and magnitude of impact of infilling of floodplains and channeled valley bottom wetlands.

Extent of impact of infilling.						**Extent (%)**
Extent of impact of infilling as determined by establishing the area of wetland that will not be subjected to normal erosion and / or deposition, as a percentage of wetland area.						
Intensity of impact of infilling						
	0	**1**	**2**	**3**	**4**	**Score**
Reduction in active wetland width at point of infillingR	<5%	6-25%	26-50%	51-75%	>75%	
Magnitude of impact of infilling: (extent of impact score / 100) x intensity of impact score.						**0**

Step 2D: Impacts of changes in runoff characteristics

To assess? **Yes** See Table 3.1

Table 3.7: Effect of altered water inputs (increased flows and floodpeaks) on wetland geomorphological integrity

Extent of impact of altered water inputs					**Extent (%)**
Extent calculated based on length of wetland affected by increased flow as a proportion (%) of the entire wetland length.					0
Intensity of impact of altered water inputs					
		Increased floodpeaks (combined score in Table 2.3)			
		No effect (0-2)	Small increase (2.1-4)	Moderate increase (4.1-7)	Large increase (>7)
Increased flows (increased flow score in Table 2.2)	No increase (0-2)	0	1	2	3.5*
	Small increase (2.1-4)	1	1.5	3	4
	Moderate increase (4.1-7)	2	3	4	4.5
	Large increase (>7)	3.5*	4	4.5	5

Change Score	0
Magnitude of impact score: (extent of impact score/100) x intensity of impact score (from above rows)	**0.0**

* Unlikely to occur

STEP 3: CONDUCT INDIVIDUAL ASSESSMENTS BASED ON INDICATORS

Step 3A: Impacts of erosion and/or deposition

Erosional features

To assess?	**Yes**	See Table 3.1

Table 3.8: Estimation of extent of impact of erosional features

		Length of wetland occupied by gully/ies as a percentage of the length of HGM[R]					
		0-20%	21-40%	41-60%	51-80%	>80%	
Average gully width (sum of gully widths if more than 1 gully present) in relation to wetland width[R]	< 5%	5%	10%	15%	20%	25%	
	5-10%	10%	15%	25%	35%	45%	
	11-20%	15%	25%	40%	55%	65%	
	21-50%	20%	30%	50%	70%	80%	**Extent (%)**
	>50%	25%	40%	60%	80%	100%	0

Table 3.9: Intensity and magnitude of impact of erosional features. The scores for rows 2 and 3 are unscaled for any natural recovery that may have taken place. Factors to use to scale the intensity of impact of erosional features for natural recovery are presented in rows 7 and 8.

Factor	**1**	**2**	**3**	**4**	**5**	**Unscaled score**
Mean depth of gullies[F]	<0.50m	0.50-1.00m	1.01-2.00m	2.00-3.00m	>3.00m	0
Mean width of gullies[F]	<2m	2-5m	5.1-8m	8.1-16m	>16m	0
Number of headcuts present[F]	1	2	3	4	>4	0
Unscaled intensity of impact score: mean score of above 3 rows						0.0
Scaling factor	**0.4**	**0.5**	**0.7**	**0.9**	**1**	**Factor**
Extent to which sediment from the gully is deposited within the HGM or wetland downstream of the HGM unit (as opposed to being exported)[F]	Entirely deposited	Mainly deposited	Intermediate	Mainly exported	Entirely exported	0

Extent to which the bed and sides of the gully have been colonized by vegetation and/or show signs of natural recovery[F]	Complete	High	Moderate	Low	None	0
Scaling factor score: mean of above 2 rows (value is between 0 and 1)						0.0
Scaled intensity of impact score = unscaled intensity of impact score x scaling factor score						0.0
Magnitude of impact score for erosional features: (extent of impact score (see Table 3.8)/100) × scaled intensity of impact score						**0.0**

Depositional features

To assess?	**Yes**	See Table 3.1

We are only interested here in recent depositional features. If the user feels confident in being able to map depositional features that can be attributed directly to recent human activity, then extent should be established directly using Table 3.10, but if they are not confident that they can do this, indirect indicators can be used as outlined in Table 3.11. Users may wish to use a combination of approaches by using the indirect indicators to assist in the location and mapping of depositional features in the wetland of interest, following which they may map depositional features directly, but ideally, one would only map these features directly.

Table 3.10: Estimation of the extent of impact of depositional features for known depositional features in the HGM unit.

Extent of depositional features in relation to area of HGM unit being considered	0.2-1.9%	2-10%	11-25%	26-50%	>50%	
Score for "extent" to be used in the estimation of magnitude of impacts	5	20	50	75	100	0

Table 3.11: Estimation of extent of depositional features based on indirect indicators of recent anthropogenic activity leading to excessive deposition.

Indicator	0	1	2	3	4	Score
Presence, size and distribution of gullies or active erosion of drains within the catchment or wetland	None or very small	Limited extent and size	Moderate size and distribution	Large size or widespread distribution	Very large size or widespread distribution	0
Presence / extent of dirt roads in the catchment	None / few	Moderate	Many / extensive			0
Breaching of upstream dams in the catchment or wetland	None	Very small earthen dams	Small earthen dams	Large earthen dams		0
Extent of decreased vegetation cover in the catchment	Slight	Moderate	High			0
Mean of two highest scores from the above						0.0
Extent of impact score of depositional features as a percentage is calculated as the score from the above multiplied by 10.						0

Table 3.12: Intensity and magnitude of impact of depositional features

Indicator	0	1	2	3	Score
The position of fan-like deposits within the wetland[R]		Toe	Middle	Upper	0
Impact of depositional features on existing wetland features[D]	Not evident	Minor destruction of features	Moderate destruction of features	Large impact on existing features	0
Intensity of impact score of depositional features: mean of two rows above					0
Magnitude of impact score of depositional features: (extent of impact score (Table 3.10 or 3.11) / 100) x intensity of impact score					**0.0**

Step 3B: Impacts of the loss of organic sediment

To assess? **Yes** See Table 3.1

Table 3.13: Extent of impact of the loss of organic sediment for direct indicators (A) and indirect indicators (B). Express results as a proportion of the total area of the HGM unit.

A. Extent of impact score based on direct indicators (if present)	0	%
B. Additional extent of impact score based on indirect indicators (if present)	0	%

To determine the intensity of impact in the affected area of the wetland, see Tables 3.14 and 3.15 for direct and indirect indicators respectively.

Direct indicators

Table 3.14: Macroscopic features (clearly visible direct indicators) determining the intensity of impact of the loss of organic sediments

Activity	1	2	3	4	5	Score
Depth of the peat fires or extraction of peat relative to the depth of the peat deposit	<5%	5-15%	16-30%	31-60%	>60%	0
If tillage is practiced, duration of tillage	1-2 yrs	3-5 yrs	6-10 yrs	>10 yrs		0
Intensity of impact score: maximum score of above scores						0.0
Magnitude of impact score of loss of organic sediments: (extent of impact score (Table 3.13A) /100) × intensity of impact score						0.0

Indirect indicators

Table 3.15: Indirect indicators (not clearly visible) reflecting the intensity of diminished integrity of organic sediments in the

HGM unit.

	0	1	2	3	4	Intensity score
Level of desiccation of the region of the HGM unit in which peat accumulation is taking place*	Unmodified	Largely natural	Moderately modified	Largely modified	Serously / critically modified	0
Magnitude of impact score: extent of impact score (Table 3.13B)/100 × intensity of impact score						0.0

Overall magnitude of impact: Organic sediment

Table 3.16: Magnitude of impact score for organic sediments expressed as a proportion of the area of the entire HGM unit

	Overall magnitude of impact score: organic sediments
Sum of magnitude scores in Tables 3.14 and 3.15	**0.0**

STEP 4: DETERMINE THE PRESENT GEOMORPHIC STATE OF EACH HGM UNIT BY COMBINING DIAGNOSTIC (STEP 2) AND INDICATOR-BASED (STEP 3) ANALYSES.

Table 3.17: Derivation of overall magnitude-of-impact scores through combining the scores obtained from individual assessments.

Impact category	Score	To include?
1. Magnitude of impact of dams (Table 3.4)	N/A	No
2. Magnitude of impact of channel straightening (Table 3.5)	N/A	No
3. Magnitude of impact of infilling (Table 3.6)	N/A	No
4. Magnitude of impact of changes in runoff characteristics (Table 3.7)	0.0	Yes
5. Magnitude of impact for erosional features (Table 3.9)	0.0	Yes
6. Magnitude of impact for depositional features (Table 3.12)	0.0	Yes
7. Magnitude of impact for loss of organic sediment (Table 3.16)	0.0	Yes
Overall Present Geomorphic State = Sum of three highest scores	**0.0**	

PAGE 2: HGM UNIT 5

STEP 2: DETERMINE THE PRESENT VEGETATION STATE OF EACH HGM UNIT

STEP 2A: FAMILIARISATION WITH THE GENERAL STRUCTURE AND COMPOSITION OF WETLAND VEGETATION IN THE AREA

STEP 2B: IDENTIFY AND ESTIMATE THE EXTENT OF EACH DISTURBANCE CLASS IN THE HGM UNIT

Table 4.2: Description and extent of each disturbance class within the HGM unit

Disturbance class	Brief description of disturbance class	Extent (ha)*	Extent (%)
1	Alien Vegetation	0.56	100
		0.56	**100**

* Extent can simply be estimated as a % if actual extent (ha) is not available or easily calculated

STEP 2C: ASSESS THE INTENSITY AND MAGNITUDE OF IMPACT FOR EACH DISTURBANCE CLASS

Table 4.6: Calculation of the HGM magnitude of impact score based on an area weighted magnitude of impact score for each disturbance class.

Disturbance class	Disturbance class extent (%) (from Table 4.2)	Intensity of impact score (from Table 4.5)	Magnitude of impact score*	Factors contributing to impact
1	100	9	9.0	
		HGM Magnitude of impact score**	**9.0**	

* Magnitude of impact score is calculated as extent / 100 x intensity of impact
** Overall magnitude of impact score for the HGM unit = sum of magnitude scores for each disturbance class.

STEP 2D: DETERMINE THE MAGNITUDE OF IMPACT SCORE AND PRESENT VEGETATION STATE OF EACH HGM UNIT

Calculated in Table 4.6 above

STEP 4: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION

STEP 4A: ASSESS THE ANTICIPATED TRAJECTORY OF CHANGE TO WETLAND VEGETATION WITHIN IN EACH HGM UNIT

Table 4.10: Evaluation of Trajectory of Change of vegetation within an HGM.

Disturbance class	Source of change	Disturbance class extent (%) (Table 4.2)	Change score (Table 4.9)	Area-weighted change score*
1	Stable	100	0	0.0
			HGM change score**	**0.0**

*Area weighted change score = Disturbance Class extent /100 x change score

**HGM change score = sum of individual area weighted scores for each disturbance unit

Appendix 3: WET-EcoServices Assessments

Please not that All Tables are adapted directly from the WET-EcoServices guidebook except for the results which was completed for the particular study sites in this research (Kotze, Marneweck, Batchelor, Lindley and Collins: 2008)

Contents, importance and relevance

Appendix 3 contains all the WET-EcoServices data that was collected from field work and was computed into the excel spreadsheets which are provided by the WET-EcoServices guidebook. This information is useful in this study as not only is wetland condition determined but the goods and services supplied by the wetlands also outlined. This is important to municipalities since they would need to validate where and why resources should be allocated into specific areas. If the wetlands are providing useful services to either a local community or acting as a flood controlling agent in the landscape then it may be worth restoring, manageing and preserving.

Robert Armstrong Wetland: HGM unit one							
Size (hectares)							
O=Data should be obtained in the office through desktop investigation prior to the field assessment. R=Data may be available through desktop investigation but is likely to be revised/refined in the field	0	1	2	3	4		
HGM UNIT'S CATCHMENT						**Score**	**Confidence**
Average slope of the HGM unit's catchment	<3%	3-5%	6-8%	9-11%	>11%	0	3
Inherent runoff potential of the soils in the HGM unit's catchment	Low	Mod low		Mod high	High	1	2
Contribution of catchment land-uses to changing runoff intensity from the natural condition	Decrease	Negligible effect	Slight increase	Moderate increase	Marked increase	0	2
Rainfall intensity	Low (Zone I)	Moderately low (Zone II)		Mod. high (Zone III)	High (Zone IV)	4	4
Extent to which dams are reducing the input of sediment to the HGM unit	High	Mod high	Intermediate	Mod low	Low	2	1
Extent of sediment sources delivering sediment to the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of other potential sources of phosphates in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	1	1
Extent of nitrate sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	1	2

Extent of toxicant sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2
HGM unit							
Size of HGM unit relative to the HGM unit's catchment	<1%	1%-2%	3-5%	6-10%	>10%	3	3
Slope of the HGM unit (%)	>5%	2-5%	1-1.9%	0.5-0.9%	<0.5%	1	3
Surface roughness of the HGM unit	Low	Mod. low		Mod. high	High	3	3
Depressions	None	Present but few or remain permanently filled close to capacity	Intermediate	Moderately abundant	Abundant	0	3
Frequency with which stormflows are spread across the HGM unit	Never	Occasionally but less frequently than every 5 years		1 to 5 year frequency	More than once a year	1	1
Sinuosity of the stream channel	Low	Moderately low	Intermediate	Mod. high	High	3	3
Representation of different hydrological zones	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	2	3
Link to the stream network	No link (i.e. hydrologically isolated)				Linked to the stream system	0	2
Presence of fibrous peat or unconsolidated sediments below a floating marsh	Absent	Present but limited in extent/depth		Moderately abundant	Extensive and relatively deep (>1.5 m)	0	4
Reduction in evapotranspiration through frosting back of the wetland vegetation	Low	Moderately low	Intermediate	Moderately high	High	4	1
HGM unit occurs on underlying geology with strong surface-groundwater linkages	No		Underlying geology quartzite	Underlying geology sanstone	Underlying geology dolomite	3	4
Direct evidence of sediment deposition in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Flow patterns of low flows within the wetland	Strongly channelled	Moderately channelled	Intermediate	Moderately diffuse	Very diffuse	0	2
Extent of vegetation cover in the HGM unit	Low	Mod low	Intermediate	Mod high	High	3	3
Contribution of sub-surface water inputs relative to surface water inputs	Low (<10%)	Moderately low (10-	Intermediate (20-35%)	Moderately high (36-	High (>50%)	0	1

		20%)		50%)			
Application of fertilizers/biocides in the HGM unit	High	Mod high	Intermediate	Mod low	Low	3	3
Direct evidence of erosion	High	Mod high	Intermediate	Mod low	Low	4	4
Current level of physical disturbance of the soil in the HGM unit	High	Mod high	Intermediate	Mod low	Low	3	3
Erodibility of the soil in the HGM unit	Low	Mod low	Intermediate	Mod high	High	1	2
Abundance of peat	Absent	Present but limited in extent/depth	Intermediate	Moderately abundant	Extensive and relatively deep (>0.5 m)	0	3
HGM unit is of a rare type or is of a wetland type or vegetation type subjected to a high level of cumulative loss	No				Yes	0	2
Red Data species or suitable habitat for Red Data species	No				Yes	0	1
Level of significance of other special natural features	None	Mod low	Intermediate	Mod high	High	0	3
Alteration of hydrological regime	High	Mod high	Intermediate	Mod low	Low/negligible	1	3
Complete removal of indigenous vegetation	>50%	25-50%	5-25%	1-5%	<1%	0	4
Invasive and pioneers species encroachment	>50%	25-50%	5-25%	1-5%	<1%	2	4
Presence of hazardous/restrictive barriers	High	Mod high	Intermediate	Mod low	Low/negligible	4	3
Current level of use of water for agriculture or industry	No use	Mod low	Intermediate	Mod high	High	4	4
Current level of use of water for domestic purposes	No use	Mod low	Intermediate	Mod high	High	0	3
Number of dependent households that depend on the direct provision of water from the wetland	None	1-2	3-4	5-6	>6	0	3
Substitutability of the water resource from the HGM unit	High	Mod high	Intermediate	Mod low	Low	3	1
Number of different resources used	None	1		2-3	>3	3	3
Is the wetland in a rural communal area?	No				yes	0	4
Level of poverty in the area	Low/ negligible	Mod low	Intermediate	Mod high	High	0	4
Number of households who depend on the natural resources in the HGM unit	None	1	2-3	4-5	>6	1	2
Substitutability of the natural resources obtained from the wetland	High	Mod high	Intermediate	Mod low	Low	0	1
Total number of different crops cultivated in the HGM unit	None	1		2-3	>3	1	4
Number of households who depend on the crops cultivated in the HGM unit	None	1	2-3	4-6	>6	1	2

Substitutability of the crops cultivated in the wetland	High	Mod high	Intermediate	Mod low	Low	1	3
Registered SAHRA site	No				Yes	0	4
Known local cultural practices in the HGM unit	None	Historically present but no longer practised		Present but practised to a limited extent	Present & still actively & widely practised	0	3
Known local taboos or beliefs relating to the HGM unit	None	Historically present but no longer so		Present but held to a limited extent	Present & still actively & widely held	0	3
Scenic beauty of the HGM unit	Low/negligible	Mod low	Intermediate	Mod high	High	0	3
Presence of charismatic species	None present	Very seldom seen	Occasionally present	Generally present	Always present	0	3
Current use for tourism or recreation	No use	Mod low use	Intermediate use	Mod high use	High	0	4
Availability of other natural areas providing similar experiences to the HGM unit	High	Mod high	Intermediate	Mod low	Low	1	3
Location within an existing tourism route	Low/negligible	Mod low	Intermediate	Mod high	High	0	3
Recreational hunting and fishing and birding opportunities	None	Mod low	Intermediate	Mod high	High	0	3
Extent of open water	None	Present, but very limited		Extent somewhat limited	Extensive	1	3
Current use for education/research purposes	No use	Mod low	Intermediate	Mod high	High	1	3
Reference site suitability	Low	Mod low	Intermediate	Mod high	High	0	3
Existing data & research	None	Mod low	Intermediate detail/ time period	Mod high	Comp-rehensive data over long period	0	1
Accessibility	Very inaccessible	Moderately inaccessible	Intermediate	Moderately accessible	Very accessible	3	3
DOWNSTREAM OF HGM unit							
Extent of floodable property	Low/ negligible	Moderately low		Moderately high	High	1	3
Presence of any important wetlands or aquatic systems downstream	None		Intermediate importance		High importance	4	3
THE LANDSCAPE IN WHICH THE HGM UNIT IS LOCATED							
Extent of buffer around wetland	Low	Mod low	Intermediate	Mod high	High	0	3
Connectivity of wetland in landscape	Low	Mod low	Intermediate	Mod high	High	1	3

Level of cumulative loss of wetlands in overall catchment	Low	Mod low	Intermediate	Mod high	High	3	3
THREATS & OPPORTUNITIES							
Level of threat to existing ecosystem services supplied by the wetland	Low	Moderately low	Intermediate	Moderately high	High	1	2
Level of future opportunities for enhancing the supply of ecosystem services	Low	Moderately low	Intermediate	Moderately high	High	1	2

DERIVED CHARACTERISTICS		
These are characteristics that are derived from other characterisitcs and therefore do not need to be entered directly		
Runoff intensity from the HGM unit's catchment	1	3
Alteration of sediment regime	2	2
Alteration of nutrient/toxicant regime	3	2

Le Mercy Wetland: HGM unit one							
Size (hectares)							
O=Data should be obtained in the office through desktop investigation prior to the field assessment. R=Data may be available through desktop investigation but is likely to be revised/refined in the field	0	1	2	3	4		
HGM UNIT'S CATCHMENT						**Score**	**Confidence**
Average slope of the HGM unit's catchment	<3%	3-5%	6-8%	9-11%	>11%	2	3
Inherent runoff potential of the soils in the HGM unit's catchment	Low	Mod low		Mod high	High	0	2
Contribution of catchment land-uses to changing runoff intensity from the natural condition	Decrease	Negligible effect	Slight increase	Moderate increase	Marked increase	0	2
Rainfall intensity	Low (Zone I)	Moderately low (Zone II)		Mod. high (Zone III)	High (Zone IV)	4	4
Extent to which dams are reducing the input of sediment to the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	4
Extent of sediment sources delivering sediment to the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of other potential sources of phosphates in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	2	2
Extent of nitrate sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	1	2
Extent of toxicant sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2

HGM unit							
Size of HGM unit relative to the HGM unit's catchment	<1%	1%-2%	3-5%	6-10%	>10%	3	3
Slope of the HGM unit (%)	>5%	2-5%	1-1.9%	0.5-0.9%	<0.5%	0	3
Surface roughness of the HGM unit	Low	Mod. low		Mod. high	High	4	3
Depressions	None	Present but few or remain permanently filled close to capacity	Intermediate	Moderately abundant	Abundant	0	3
Frequency with which stormflows are spread across the HGM unit	Never	Occasionally but less frequently than every 5 years		1 to 5 year frequency	More than once a year	0	1
Sinuosity of the stream channel	Low	Moderately low	Intermediate	Mod. high	High	0	3
Representation of different hydrological zones	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	2	3
Link to the stream network	No link (i.e. hydrologically isolated)				Linked to the stream system	4	1
Presence of fibrous peat or unconsolidated sediments below a floating marsh	Absent	Present but limited in extent/depth		Moderately abundant	Extensive and relatively deep (>1.5 m)	0	4
Reduction in evapotranspiration through frosting back of the wetland vegetation	Low	Moderately low	Intermediate	Moderately high	High	4	1
HGM unit occurs on underlying geology with strong surface-groundwater linkages	No		Underlying geology quartzite	Underlying geology sanstone	Underlying geology dolomite	3	3
Direct evidence of sediment deposition in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Flow patterns of low flows within the wetland	Strongly channelled	Moderately channelled	Intermediate	Moderately diffuse	Very diffuse	0	2
Extent of vegetation cover in the HGM unit	Low	Mod low	Intermediate	Mod high	High	4	3
Contribution of sub-surface water inputs relative to surface water inputs	Low (<10%)	Moderately low (10-20%)	Intermediate (20-35%)	Moderately high (36-50%)	High (>50%)	0	2
Application of fertilizers/biocides in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Direct evidence of erosion	High	Mod high	Intermediate	Mod low	Low	4	3

Current level of physical disturbance of the soil in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Erodibility of the soil in the HGM unit	Low	Mod low	Intermediate	Mod high	High	1	2
Abundance of peat	Absent	Present but limited in extent/depth	Intermediate	Moderately abundant	Extensive and relatively deep (>0.5 m)	0	4
HGM unit is of a rare type or is of a wetland type or vegetation type subjected to a high level of cumulative loss	No				Yes	0	1
Red Data species or suitable habitat for Red Data species	No				Yes	0	1
Level of significance of other special natural features	None	Mod low	Intermediate	Mod high	High	0	2
Alteration of hydrological regime	High	Mod high	Intermediate	Mod low	Low/negligible	0	3
Complete removal of indigenous vegetation	>50%	25-50%	5-25%	1-5%	<1%	0	3
Invasive and pioneers species encroachment	>50%	25-50%	5-25%	1-5%	<1%	0	3
Presence of hazardous/restrictive barriers	High	Mod high	Intermediate	Mod low	Low/negligible	4	3
Current level of use of water for agriculture or industry	No use	Mod low	Intermediate	Mod high	High	0	2
Current level of use of water for domestic purposes	No use	Mod low	Intermediate	Mod high	High	0	2
Number of dependent households that depend on the direct provision of water from the wetland	None	1-2	3-4	5-6	>6	0	1
Substitutability of the water resource from the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	1
Number of different resources used	None	1		2-3	>3	3	3
Is the wetland in a rural communal area?	No				yes	0	4
Level of poverty in the area	Low/ negligible	Mod low	Intermediate	Mod high	High	0	4
Number of households who depend on the natural resources in the HGM unit	None	1	2-3	4-5	>6	1	2
Substitutability of the natural resources obtained from the wetland	High	Mod high	Intermediate	Mod low	Low	0	1
Total number of different crops cultivated in the HGM unit	None	1		2-3	>3	3	3
Number of households who depend on the crops cultivated in the HGM unit	None	1	2-3	4-6	>6	2	1
Substitutability of the crops cultivated in the wetland	High	Mod high	Intermediate	Mod low	Low	1	3
Registered SAHRA site	No				Yes	0	4

Known local cultural practices in the HGM unit	None	Historically present but no longer practised		Present but practised to a limited extent	Present & still actively & widely practised	3	3
Known local taboos or beliefs relating to the HGM unit	None	Historically present but no longer so		Present but held to a limited extent	Present & still actively & widely held	0	3
Scenic beauty of the HGM unit	Low/negligible	Mod low	Intermediate	Mod high	High	0	4
Presence of charismatic species	None present	Very seldom seen	Occasionally present	Generally present	Always present	0	2
Current use for tourism or recreation	No use	Mod low use	Intermediate use	Mod high use	High	0	2
Availability of other natural areas providing similar experiences to the HGM unit	High	Mod high	Intermediate	Mod low	Low	0	3
Location within an existing tourism route	Low/negligible	Mod low	Intermediate	Mod high	High	0	2
Recreational hunting and fishing and birding opportunities	None	Mod low	Intermediate	Mod high	High	0	3
Extent of open water	None	Present, but very limited		Extent somewhat limited	Extensive	1	3
Current use for education/research purposes	No use	Mod low	Intermediate	Mod high	High	1	2
Reference site suitability	Low	Mod low	Intermediate	Mod high	High	0	3
Existing data & research	None	Mod low	Intermediate detail/ time period	Mod high	Comp-rehensive data over long period	0	2
Accessibility	Very inaccessible	Moderately inaccessible	Intermediate	Moderately accessible	Very accessible	3	3
DOWNSTREAM OF HGM unit							
Extent of floodable property	Low/ negligible	Moderately low		Moderately high	High	1	2
Presence of any important wetlands or aquatic systems downstream	None		Intermediate importance		High importance	4	3
THE LANDSCAPE IN WHICH THE HGM UNIT IS LOCATED							
Extent of buffer around wetland	Low	Mod low	Intermediate	Mod high	High	0	3
Connectivity of wetland in landscape	Low	Mod low	Intermediate	Mod high	High	0	3
Level of cumulative loss of wetlands in overall catchment	Low	Mod low	Intermediate	Mod high	High	3	3
THREATS & OPPORTUNITIES							

Level of threat to existing ecosystem services supplied by the wetland	Low	Moderately low	Intermediate	Moderately high	High	3	3
Level of future opportunities for enhancing the supply of ecosystem services	Low	Moderately low	Intermediate	Moderately high	High	0	2

DERIVED CHARACTERISTICS		
These are characteristics that are derived from other characterisitcs and therefore do not need to be entered directly		
Runoff intensity from the HGM unit's catchment	2	3
Alteration of sediment regime	4	3
Alteration of nutrient/toxicant regime	2	2

Le Mercy Wetland: HGM unit two							
Size (hectares)							
O=Data should be obtained in the office through desktop investigation prior to the field assessment. R=Data may be available through desktop investigation but is likely to be revised/refined in the field	0	1	2	3	4		
HGM UNIT'S CATCHMENT						**Score**	**Confidence**
Average slope of the HGM unit's catchment	<3%	3-5%	6-8%	9-11%	>11%	0	3
Inherent runoff potential of the soils in the HGM unit's catchment	Low	Mod low		Mod high	High	0	2
Contribution of catchment land-uses to changing runoff intensity from the natural condition	Decrease	Negligible effect	Slight increase	Moderate increase	Marked increase	1	2
Rainfall intensity	Low (Zone I)	Moderately low (Zone II)		Mod. high (Zone III)	High (Zone IV)	4	4
Extent to which dams are reducing the input of sediment to the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	4
Extent of sediment sources delivering sediment to the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of other potential sources of phosphates in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	1	2
Extent of nitrate sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2
Extent of toxicant sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2
HGM unit							
Size of HGM unit relative to the HGM unit's catchment	<1%	1%-2%	3-5%	6-10%	>10%	2	2
Slope of the HGM unit (%)	>5%	2-5%	1-1.9%	0.5-0.9%	<0.5%	0	3

Surface roughness of the HGM unit	Low	Mod. low		Mod. high	High	4	3
Depressions	None	Present but few or remain permanently filled close to capacity	Intermediate	Moderately abundant	Abundant	0	3
Frequency with which stormflows are spread across the HGM unit	Never	Occasionally but less frequently than every 5 years		1 to 5 year frequency	More than once a year	4	2
Sinuosity of the stream channel	Low	Moderately low	Intermediate	Mod. high	High	0	3
Representation of different hydrological zones	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	4	3
Link to the stream network	No link (i.e. hydrologically isolated)				Linked to the stream system	0	3
Presence of fibrous peat or unconsolidated sediments below a floating marsh	Absent	Present but limited in extent/depth		Moderately abundant	Extensive and relatively deep (>1.5 m)	0	4
Reduction in evapotranspiration through frosting back of the wetland vegetation	Low	Moderately low	Intermediate	Moderately high	High	4	1
HGM unit occurs on underlying geology with strong surface-groundwater linkages	No		Underlying geology quartzite	Underlying geology sanstone	Underlying geology dolomite	3	3
Direct evidence of sediment deposition in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Flow patterns of low flows within the wetland	Strongly channelled	Moderately channelled	Intermediate	Moderately diffuse	Very diffuse	3	2
Extent of vegetation cover in the HGM unit	Low	Mod low	Intermediate	Mod high	High	4	3
Contribution of sub-surface water inputs relative to surface water inputs	Low (<10%)	Moderately low (10-20%)	Intermediate (20-35%)	Moderately high (36-50%)	High (>50%)	0	2
Application of fertilizers/biocides in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Direct evidence of erosion	High	Mod high	Intermediate	Mod low	Low	4	3
Current level of physical disturbance of the soil in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Erodibility of the soil in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	2
Abundance of peat	Absent	Present but	Intermediate	Moderately	Extensive and	0	4

		limited in extent/depth		abundant	relatively deep (>0.5 m)		
HGM unit is of a rare type or is of a wetland type or vegetation type subjected to a high level of cumulative loss	No				Yes	0	1
Red Data species or suitable habitat for Red Data species	No				Yes	0	1
Level of significance of other special natural features	None	Mod low	Intermediate	Mod high	High	0	2
Alteration of hydrological regime	High	Mod high	Intermediate	Mod low	Low/negligible	3	3
Complete removal of indigenous vegetation	>50%	25-50%	5-25%	1-5%	<1%	3	3
Invasive and pioneers species encroachment	>50%	25-50%	5-25%	1-5%	<1%	2	3
Presence of hazardous/restrictive barriers	High	Mod high	Intermediate	Mod low	Low/negligible	4	3
Current level of use of water for agriculture or industry	No use	Mod low	Intermediate	Mod high	High	0	2
Current level of use of water for domestic purposes	No use	Mod low	Intermediate	Mod high	High	0	2
Number of dependent households that depend on the direct provision of water from the wetland	None	1-2	3-4	5-6	>6	0	1
Substitutability of the water resource from the HGM unit	High	Mod high	Intermediate	Mod low	Low	3	1
Number of different resources used	None	1		2-3	>3	0	3
Is the wetland in a rural communal area?	No				yes	0	4
Level of poverty in the area	Low/ negligible	Mod low	Intermediate	Mod high	High	0	4
Number of households who depend on the natural resources in the HGM unit	None	1	2-3	4-5	>6	0	3
Substitutability of the natural resources obtained from the wetland	High	Mod high	Intermediate	Mod low	Low	3	1
Total number of different crops cultivated in the HGM unit	None	1		2-3	>3	0	3
Number of households who depend on the crops cultivated in the HGM unit	None	1	2-3	4-6	>6	0	3
Substitutability of the crops cultivated in the wetland	High	Mod high	Intermediate	Mod low	Low	4	3
Registered SAHRA site	No				Yes	0	4
Known local cultural practices in the HGM unit	None	Historically present but no longer practised		Present but practised to a limited extent	Present & still actively & widely practised	0	3

Known local taboos or beliefs relating to the HGM unit	None	Historically present but no longer so		Present but held to a limited extent	Present & still actively & widely held	0	3
Scenic beauty of the HGM unit	Low/negligible	Mod low	Intermediate	Mod high	High	1	3
Presence of charismatic species	None present	Very seldom seen	Occasionally present	Generally present	Always present	0	2
Current use for tourism or recreation	No use	Mod low use	Intermediate use	Mod high use	High	0	2
Availability of other natural areas providing similar experiences to the HGM unit	High	Mod high	Intermediate	Mod low	Low	1	2
Location within an existing tourism route	Low/negligible	Mod low	Intermediate	Mod high	High	0	2
Recreational hunting and fishing and birding opportunities	None	Mod low	Intermediate	Mod high	High	0	3
Extent of open water	None	Present, but very limited		Extent somewhat limited	Extensive	0	3
Current use for education/research purposes	No use	Mod low	Intermediate	Mod high	High	1	2
Reference site suitability	Low	Mod low	Intermediate	Mod high	High	0	3
Existing data & research	None	Mod low	Intermediate detail/ time period	Mod high	Comp-rehensive data over long period	0	2
Accessibility	Very inaccessible	Moderately inaccessible	Intermediate	Moderately accessible	Very accessible	4	3
DOWNSTREAM OF HGM unit							
Extent of floodable property	Low/ negligible	Moderately low		Moderately high	High	0	2
Presence of any important wetlands or aquatic systems downstream	None		Intermediate importance		High importance	4	3
THE LANDSCAPE IN WHICH THE HGM UNIT IS LOCATED							
Extent of buffer around wetland	Low	Mod low	Intermediate	Mod high	High	0	3
Connectivity of wetland in landscape	Low	Mod low	Intermediate	Mod high	High	0	3
Level of cumulative loss of wetlands in overall catchment	Low	Mod low	Intermediate	Mod high	High	3	3
THREATS & OPPORTUNITIES							
Level of threat to existing ecosystem services supplied by the wetland	Low	Moderately low	Intermediate	Moderately high	High	2	3
Level of future opportunities for enhancing the supply of ecosystem services	Low	Moderately low	Intermediate	Moderately high	High	0	2

DERIVED CHARACTERISTICS		
These are characteristics that are derived from other characterisitcs and therefore do not need to be entered directly		
Runoff intensity from the HGM unit's catchment	1	3
Alteration of sediment regime	4	3
Alteration of nutrient/toxicant regime	3	2

Lake Victoria Barn Swallow Roosting Site Wetland: HGM unit one							
Size (hectares)							
O=Data should be obtained in the office through desktop investigation prior to the field assessment. R=Data may be available through desktop investigation but is likely to be revised/refined in the field	0	1	2	3	4		
HGM UNIT'S CATCHMENT						**Score**	**Confidence**
Average slope of the HGM unit's catchment	<3%	3-5%	6-8%	9-11%	>11%	2	3
Inherent runoff potential of the soils in the HGM unit's catchment	Low	Mod low		Mod high	High	0	2
Contribution of catchment land-uses to changing runoff intensity from the natural condition	Decrease	Negligible effect	Slight increase	Moderate increase	Marked increase	3	2
Rainfall intensity	Low (Zone I)	Moderately low (Zone II)		Mod. high (Zone III)	High (Zone IV)	4	4
Extent to which dams are reducing the input of sediment to the HGM unit	High	Mod high	Intermediate	Mod low	Low	0	4
Extent of sediment sources delivering sediment to the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of other potential sources of phosphates in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of nitrate sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of toxicant sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2
HGM unit							
Size of HGM unit relative to the HGM unit's catchment	<1%	1%-2%	3-5%	6-10%	>10%	0	3
Slope of the HGM unit (%)	>5%	2-5%	1-1.9%	0.5-0.9%	<0.5%	1	3
Surface roughness of the HGM unit	Low	Mod. low		Mod. high	High	3	3
Depressions	None	Present but few or remain	Intermediate	Moderately abundant	Abundant	0	3

		permanently filled close to capacity					
Frequency with which stormflows are spread across the HGM unit	Never	Occasionally but less frequently than every 5 years		1 to 5 year frequency	More than once a year	1	1
Sinuosity of the stream channel	Low	Moderately low	Intermediate	Mod. high	High	1	3
Representation of different hydrological zones	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	2	3
Link to the stream network	No link (i.e. hydrologically isolated)				Linked to the stream system	4	3
Presence of fibrous peat or unconsolidated sediments below a floating marsh	Absent	Present but limited in extent/depth		Moderately abundant	Extensive and relatively deep (>1.5 m)	0	4
Reduction in evapotranspiration through frosting back of the wetland vegetation	Low	Moderately low	Intermediate	Moderately high	High	4	1
HGM unit occurs on underlying geology with strong surface-groundwater linkages	No		Underlying geology quartzite	Underlying geology sanstone	Underlying geology dolomite	3	3
Direct evidence of sediment deposition in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Flow patterns of low flows within the wetland	Strongly channelled	Moderately channelled	Intermediate	Moderately diffuse	Very diffuse	0	3
Extent of vegetation cover in the HGM unit	Low	Mod low	Intermediate	Mod high	High	4	3
Contribution of sub-surface water inputs relative to surface water inputs	Low (<10%)	Moderately low (10-20%)	Intermediate (20-35%)	Moderately high (36-50%)	High (>50%)	0	2
Application of fertilizers/biocides in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Direct evidence of erosion	High	Mod high	Intermediate	Mod low	Low	4	3
Current level of physical disturbance of the soil in the HGM unit	High	Mod high	Intermediate	Mod low	Low	3	2
Erodibility of the soil in the HGM unit	Low	Mod low	Intermediate	Mod high	High	1	2
Abundance of peat	Absent	Present but limited in extent/depth	Intermediate	Moderately abundant	Extensive and relatively deep (>0.5 m)	0	3
HGM unit is of a rare type or is of a wetland type or vegetation type subjected to a high level of cumulative loss	No				Yes	0	3

Red Data species or suitable habitat for Red Data species	No				Yes	0	2
Level of significance of other special natural features	None	Mod low	Intermediate	Mod high	High	1	2
Alteration of hydrological regime	High	Mod high	Intermediate	Mod low	Low/negligible	2	3
Complete removal of indigenous vegetation	>50%	25-50%	5-25%	1-5%	<1%	1	3
Invasive and pioneers species encroachment	>50%	25-50%	5-25%	1-5%	<1%	2	2
Presence of hazardous/restrictive barriers	High	Mod high	Intermediate	Mod low	Low/negligible	4	3
Current level of use of water for agriculture or industry	No use	Mod low	Intermediate	Mod high	High	0	3
Current level of use of water for domestic purposes	No use	Mod low	Intermediate	Mod high	High	0	3
Number of dependent households that depend on the direct provision of water from the wetland	None	1-2	3-4	5-6	>6	0	4
Substitutability of the water resource from the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Number of different resources used	None	1		2-3	>3	0	3
Is the wetland in a rural communal area?	No				yes	0	4
Level of poverty in the area	Low/ negligible	Mod low	Intermediate	Mod high	High	0	4
Number of households who depend on the natural resources in the HGM unit	None	1	2-3	4-5	>6	0	4
Substitutability of the natural resources obtained from the wetland	High	Mod high	Intermediate	Mod low	Low	4	3
Total number of different crops cultivated in the HGM unit	None	1		2-3	>3	0	3
Number of households who depend on the crops cultivated in the HGM unit	None	1	2-3	4-6	>6	0	4
Substitutability of the crops cultivated in the wetland	High	Mod high	Intermediate	Mod low	Low	0	3
Registered SAHRA site	No				Yes	0	3
Known local cultural practices in the HGM unit	None	Historically present but no longer practised		Present but practised to a limited extent	Present & still actively & widely practised	0	3
Known local taboos or beliefs relating to the HGM unit	None	Historically present but no longer so		Present but held to a limited extent	Present & still actively & widely held	0	3

Scenic beauty of the HGM unit	Low/negligible	Mod low	Intermediate	Mod high	High	1	3
Presence of charismatic species	None present	Very seldom seen	Occasionally present	Generally present	Always present	0	2
Current use for tourism or recreation	No use	Mod low use	Intermediate use	Mod high use	High	0	3
Availability of other natural areas providing similar experiences to the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Location within an existing tourism route	Low/negligible	Mod low	Intermediate	Mod high	High	3	3
Recreational hunting and fishing and birding opportunities	None	Mod low	Intermediate	Mod high	High	0	4
Extent of open water	None	Present, but very limited		Extent somewhat limited	Extensive	1	3
Current use for education/research purposes	No use	Mod low	Intermediate	Mod high	High	1	2
Reference site suitability	Low	Mod low	Intermediate	Mod high	High	0	2
Existing data & research	None	Mod low	Intermediate detail/ time period	Mod high	Comp-rehensive data over long period	0	2
Accessibility	Very inaccessible	Moderately inaccessible	Intermediate	Moderately accessible	Very accessible	2	3
DOWNSTREAM OF HGM unit							
Extent of floodable property	Low/ negligible	Moderately low		Moderately high	High	0	3
Presence of any important wetlands or aquatic systems downstream	None		Intermediate importance		High importance	4	3
THE LANDSCAPE IN WHICH THE HGM UNIT IS LOCATED							
Extent of buffer around wetland	Low	Mod low	Intermediate	Mod high	High	2	2
Connectivity of wetland in landscape	Low	Mod low	Intermediate	Mod high	High	1	3
Level of cumulative loss of wetlands in overall catchment	Low	Mod low	Intermediate	Mod high	High	3	3
THREATS & OPPORTUNITIES							
Level of threat to existing ecosystem services supplied by the wetland	Low	Moderately low	Intermediate	Moderately high	High	1	2
Level of future opportunities for enhancing the supply of ecosystem services	Low	Moderately low	Intermediate	Moderately high	High	1	2

DERIVED CHARACTERISTICS
These are characteristics that are derived from other characterisitcs and therefore do not need to be entered directly

Runoff intensity from the HGM unit's catchment	2	3
Alteration of sediment regime	0	3
Alteration of nutrient/toxicant regime	4	3

Lake Victoria Barn Swallow Roosting Site Wetland: HGM unit two							
Size (hectares)							
O=Data should be obtained in the office through desktop investigation prior to the field assessment. R=Data may be available through desktop investigation but is likely to be revised/refined in the field	0	1	2	3	4		
HGM UNIT'S CATCHMENT						**Score**	**Confidence**
Average slope of the HGM unit's catchment	<3%	3-5%	6-8%	9-11%	>11%	1	3
Inherent runoff potential of the soils in the HGM unit's catchment	Low	Mod low		Mod high	High	0	2
Contribution of catchment land-uses to changing runoff intensity from the natural condition	Decrease	Negligible effect	Slight increase	Moderate increase	Marked increase	1	3
Rainfall intensity	Low (Zone I)	Moderately low (Zone II)		Mod. high (Zone III)	High (Zone IV)	4	4
Extent to which dams are reducing the input of sediment to the HGM unit	High	Mod high	Intermediate	Mod low	Low	0	4
Extent of sediment sources delivering sediment to the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of other potential sources of phosphates in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of nitrate sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of toxicant sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2
HGM unit							
Size of HGM unit relative to the HGM unit's catchment	<1%	1%-2%	3-5%	6-10%	>10%	1	3
Slope of the HGM unit (%)	>5%	2-5%	1-1.9%	0.5-0.9%	<0.5%	0	3
Surface roughness of the HGM unit	Low	Mod. low		Mod. high	High	3	3
Depressions	None	Present but few or remain permanently filled close to capacity	Intermediate	Moderately abundant	Abundant	0	3
Frequency with which stormflows are spread across the HGM unit	Never	Occasionally		1 to 5 year	More than	4	1

		but less frequently than every 5 years		frequency	once a year		
Sinuosity of the stream channel	Low	Moderately low	Intermediate	Mod. high	High	0	3
Representation of different hydrological zones	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	4	3
Link to the stream network	No link (i.e. hydrologically isolated)				Linked to the stream system	4	3
Presence of fibrous peat or unconsolidated sediments below a floating marsh	Absent	Present but limited in extent/depth		Moderately abundant	Extensive and relatively deep (>1.5 m)	0	4
Reduction in evapotranspiration through frosting back of the wetland vegetation	Low	Moderately low	Intermediate	Moderately high	High	4	1
HGM unit occurs on underlying geology with strong surface-groundwater linkages	No		Underlying geology quartzite	Underlying geology sanstone	Underlying geology dolomite	3	3
Direct evidence of sediment deposition in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Flow patterns of low flows within the wetland	Strongly channelled	Moderately channelled	Intermediate	Moderately diffuse	Very diffuse	4	3
Extent of vegetation cover in the HGM unit	Low	Mod low	Intermediate	Mod high	High	4	3
Contribution of sub-surface water inputs relative to surface water inputs	Low (<10%)	Moderately low (10-20%)	Intermediate (20-35%)	Moderately high (36-50%)	High (>50%)	4	3
Application of fertilizers/biocides in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Direct evidence of erosion	High	Mod high	Intermediate	Mod low	Low	4	3
Current level of physical disturbance of the soil in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Erodibility of the soil in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	2
Abundance of peat	Absent	Present but limited in extent/depth	Intermediate	Moderately abundant	Extensive and relatively deep (>0.5 m)	0	3
HGM unit is of a rare type or is of a wetland type or vegetation type subjected to a high level of cumulative loss	No				Yes	0	3

Red Data species or suitable habitat for Red Data species	No				Yes	4	4
Level of significance of other special natural features	None	Mod low	Intermediate	Mod high	High	4	2
Alteration of hydrological regime	High	Mod high	Intermediate	Mod low	Low/negligible	4	3
Complete removal of indigenous vegetation	>50%	25-50%	5-25%	1-5%	<1%	3	3
Invasive and pioneers species encroachment	>50%	25-50%	5-25%	1-5%	<1%	2	3
Presence of hazardous/restrictive barriers	High	Mod high	Intermediate	Mod low	Low/negligible	4	3
Current level of use of water for agriculture or industry	No use	Mod low	Intermediate	Mod high	High	0	3
Current level of use of water for domestic purposes	No use	Mod low	Intermediate	Mod high	High	0	3
Number of dependent households that depend on the direct provision of water from the wetland	None	1-2	3-4	5-6	>6	0	3
Substitutability of the water resource from the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Number of different resources used	None	1		2-3	>3	0	3
Is the wetland in a rural communal area?	No				yes	0	4
Level of poverty in the area	Low/ negligible	Mod low	Intermediate	Mod high	High	0	4
Number of households who depend on the natural resources in the HGM unit	None	1	2-3	4-5	>6	0	4
Substitutability of the natural resources obtained from the wetland	High	Mod high	Intermediate	Mod low	Low	4	3
Total number of different crops cultivated in the HGM unit	None	1		2-3	>3	0	3
Number of households who depend on the crops cultivated in the HGM unit	None	1	2-3	4-6	>6	0	4
Substitutability of the crops cultivated in the wetland	High	Mod high	Intermediate	Mod low	Low	0	3
Registered SAHRA site	No				Yes	0	3
Known local cultural practices in the HGM unit	None	Historically present but no longer practised		Present but practised to a limited extent	Present & still actively & widely practised	0	3
Known local taboos or beliefs relating to the HGM unit	None	Historically present but no longer so		Present but held to a limited extent	Present & still actively & widely held	0	3
Scenic beauty of the HGM unit	Low/negligible	Mod low	Intermediate	Mod high	High	3	3
Presence of charismatic species	None present	Very seldom seen	Occasionally present	Generally present	Always present	2	3

Current use for tourism or recreation	No use	Mod low use	Intermediate use	Mod high use	High	4	4
Availability of other natural areas providing similar experiences to the HGM unit	High	Mod high	Intermediate	Mod low	Low	0	4
Location within an existing tourism route	Low/negligible	Mod low	Intermediate	Mod high	High	4	4
Recreational hunting and fishing and birding opportunities	None	Mod low	Intermediate	Mod high	High	4	4
Extent of open water	None	Present, but very limited		Extent somewhat limited	Extensive	4	4
Current use for education/research purposes	No use	Mod low	Intermediate	Mod high	High	2	3
Reference site suitability	Low	Mod low	Intermediate	Mod high	High	3	3
Existing data & research	None	Mod low	Intermediate detail/ time period	Mod high	Comp-rehensive data over long period	2	3
Accessibility	Very inaccessible	Moderately inaccessible	Intermediate	Moderately accessible	Very accessible	2	3
DOWNSTREAM OF HGM unit							
Extent of floodable property	Low/ negligible	Moderately low		Moderately high	High	0	3
Presence of any important wetlands or aquatic systems downstream	None		Intermediate importance		High importance	4	3
THE LANDSCAPE IN WHICH THE HGM UNIT IS LOCATED							
Extent of buffer around wetland	Low	Mod low	Intermediate	Mod high	High	2	2
Connectivity of wetland in landscape	Low	Mod low	Intermediate	Mod high	High	1	3
Level of cumulative loss of wetlands in overall catchment	Low	Mod low	Intermediate	Mod high	High	3	3
THREATS & OPPORTUNITIES							
Level of threat to existing ecosystem services supplied by the wetland	Low	Moderately low	Intermediate	Moderately high	High	3	3
Level of future opportunities for enhancing the supply of ecosystem services	Low	Moderately low	Intermediate	Moderately high	High	1	2

DERIVED CHARACTERISTICS		
These are characteristics that are derived from other characterisitcs and therefore do not need to be entered directly		
Runoff intensity from the HGM unit's catchment	2	3
Alteration of sediment regime	0	3
Alteration of nutrient/toxicant regime	4	3

Lake Victoria Barn Swallow Roosting Site Wetland: HGM unit three							
Size (hectares)							
O=Data should be obtained in the office through desktop investigation prior to the field assessment. R=Data may be available through desktop investigation but is likely to be revised/refined in the field	0	1	2	3	4		
HGM UNIT'S CATCHMENT						**Score**	**Confidence**
Average slope of the HGM unit's catchment	<3%	3-5%	6-8%	9-11%	>11%	4	3
Inherent runoff potential of the soils in the HGM unit's catchment	Low	Mod low		Mod high	High	0	2
Contribution of catchment land-uses to changing runoff intensity from the natural condition	Decrease	Negligible effect	Slight increase	Moderate increase	Marked increase	2	3
Rainfall intensity	Low (Zone I)	Moderately low (Zone II)		Mod. high (Zone III)	High (Zone IV)	4	4
Extent to which dams are reducing the input of sediment to the HGM unit	High	Mod high	Intermediate	Mod low	Low	0	4
Extent of sediment sources delivering sediment to the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of other potential sources of phosphates in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	1	3
Extent of nitrate sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	1	3
Extent of toxicant sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2
HGM unit							
Size of HGM unit relative to the HGM unit's catchment	<1%	1%-2%	3-5%	6-10%	>10%	0	3
Slope of the HGM unit (%)	>5%	2-5%	1-1.9%	0.5-0.9%	<0.5%	3	3
Surface roughness of the HGM unit	Low	Mod. low		Mod. high	High	3	3
Depressions	None	Present but few or remain permanently filled close to capacity	Intermediate	Moderately abundant	Abundant	0	3
Frequency with which stormflows are spread across the HGM unit	Never	Occasionally but less frequently than every 5 years		1 to 5 year frequency	More than once a year	4	1

Sinuosity of the stream channel	Low	Moderately low	Intermediate	Mod. high	High	0	3
Representation of different hydrological zones	Permanent & seasonal zones lacking (i.e. only the temporary zone present)	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively <30%	Seasonal & permanent zone both present & collectively 30-60%	Seasonal & permanent zone both present & collectively >60% of total HGM unit area	4	2
Link to the stream network	No link (i.e. hydrologically isolated)				Linked to the stream system	4	3
Presence of fibrous peat or unconsolidated sediments below a floating marsh	Absent	Present but limited in extent/depth		Moderately abundant	Extensive and relatively deep (>1.5 m)	0	4
Reduction in evapotranspiration through frosting back of the wetland vegetation	Low	Moderately low	Intermediate	Moderately high	High	4	1
HGM unit occurs on underlying geology with strong surface-groundwater linkages	No		Underlying geology quartzite	Underlying geology sanstone	Underlying geology dolomite	3	3
Direct evidence of sediment deposition in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Flow patterns of low flows within the wetland	Strongly channelled	Moderately channelled	Intermediate	Moderately diffuse	Very diffuse	1	3
Extent of vegetation cover in the HGM unit	Low	Mod low	Intermediate	Mod high	High	4	3
Contribution of sub-surface water inputs relative to surface water inputs	Low (<10%)	Moderately low (10-20%)	Intermediate (20-35%)	Moderately high (36-50%)	High (>50%)	1	2
Application of fertilizers/biocides in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Direct evidence of erosion	High	Mod high	Intermediate	Mod low	Low	4	3
Current level of physical disturbance of the soil in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Erodibility of the soil in the HGM unit	Low	Mod low	Intermediate	Mod high	High	1	2
Abundance of peat	Absent	Present but limited in extent/depth	Intermediate	Moderately abundant	Extensive and relatively deep (>0.5 m)	0	3
HGM unit is of a rare type or is of a wetland type or vegetation type subjected to a high level of cumulative loss	No				Yes	0	3
Red Data species or suitable habitat for Red Data species	No				Yes	0	2
Level of significance of other special natural features	None	Mod low	Intermediate	Mod high	High	2	2

Alteration of hydrological regime	High	Mod high	Intermediate	Mod low	Low/negligible	4	2
Complete removal of indigenous vegetation	>50%	25-50%	5-25%	1-5%	<1%	3	3
Invasive and pioneers species encroachment	>50%	25-50%	5-25%	1-5%	<1%	2	2
Presence of hazardous/restrictive barriers	High	Mod high	Intermediate	Mod low	Low/negligible	4	3
Current level of use of water for agriculture or industry	No use	Mod low	Intermediate	Mod high	High	0	3
Current level of use of water for domestic purposes	No use	Mod low	Intermediate	Mod high	High	0	3
Number of dependent households that depend on the direct provision of water from the wetland	None	1-2	3-4	5-6	>6	0	3
Substitutability of the water resource from the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Number of different resources used	None	1		2-3	>3	0	3
Is the wetland in a rural communal area?	No				yes	0	4
Level of poverty in the area	Low/ negligible	Mod low	Intermediate	Mod high	High	0	4
Number of households who depend on the natural resources in the HGM unit	None	1	2-3	4-5	>6	0	4
Substitutability of the natural resources obtained from the wetland	High	Mod high	Intermediate	Mod low	Low	4	3
Total number of different crops cultivated in the HGM unit	None	1		2-3	>3	0	3
Number of households who depend on the crops cultivated in the HGM unit	None	1	2-3	4-6	>6	0	4
Substitutability of the crops cultivated in the wetland	High	Mod high	Intermediate	Mod low	Low	0	3
Registered SAHRA site	No				Yes	0	3
Known local cultural practices in the HGM unit	None	Historically present but no longer practised		Present but practised to a limited extent	Present & still actively & widely practised	0	3
Known local taboos or beliefs relating to the HGM unit	None	Historically present but no longer so		Present but held to a limited extent	Present & still actively & widely held	0	3
Scenic beauty of the HGM unit	Low/negligible	Mod low	Intermediate	Mod high	High	0	3
Presence of charismatic species	None present	Very seldom seen	Occasionally present	Generally present	Always present	0	2
Current use for tourism or recreation	No use	Mod low use	Intermediate use	Mod high use	High	0	3
Availability of other natural areas providing similar experiences to the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3

Location within an existing tourism route	Low/negligible	Mod low	Intermediate	Mod high	High	2	3
Recreational hunting and fishing and birding opportunities	None	Mod low	Intermediate	Mod high	High	0	3
Extent of open water	None	Present, but very limited		Extent somewhat limited	Extensive	1	3
Current use for education/research purposes	No use	Mod low	Intermediate	Mod high	High	1	2
Reference site suitability	Low	Mod low	Intermediate	Mod high	High	1	3
Existing data & research	None	Mod low	Intermediate detail/ time period	Mod high	Comp-rehensive data over long period	0	2
Accessibility	Very inaccessible	Moderately inaccessible	Intermediate	Moderately accessible	Very accessible	2	3
DOWNSTREAM OF HGM unit							
Extent of floodable property	Low/ negligible	Moderately low		Moderately high	High	0	3
Presence of any important wetlands or aquatic systems downstream	None		Intermediate importance		High importance	4	3
THE LANDSCAPE IN WHICH THE HGM UNIT IS LOCATED							
Extent of buffer around wetland	Low	Mod low	Intermediate	Mod high	High	2	2
Connectivity of wetland in landscape	Low	Mod low	Intermediate	Mod high	High	1	3
Level of cumulative loss of wetlands in overall catchment	Low	Mod low	Intermediate	Mod high	High	3	3
THREATS & OPPORTUNITIES							
Level of threat to existing ecosystem services supplied by the wetland	Low	Moderately low	Intermediate	Moderately high	High	1	2
Level of future opportunities for enhancing the supply of ecosystem services	Low	Moderately low	Intermediate	Moderately high	High	3	2

DERIVED CHARACTERISTICS		
These are characteristics that are derived from other characterisitcs and therefore do not need to be entered directly		
Runoff intensity from the HGM unit's catchment	3	3
Alteration of sediment regime	0	3
Alteration of nutrient/toxicant regime	3	3

Lake Victoria Barn Swallow Roosting Site Wetland: HGM unit four						

Size (hectares)							
O=Data should be obtained in the office through desktop investigation prior to the field assessment. R=Data may be available through desktop investigation but is likely to be revised/refined in the field	0	1	2	3	4		
HGM UNIT'S CATCHMENT						**Score**	**Confidence**
Average slope of the HGM unit's catchment	<3%	3-5%	6-8%	9-11%	>11%	3	3
Inherent runoff potential of the soils in the HGM unit's catchment	Low	Mod low		Mod high	High	0	2
Contribution of catchment land-uses to changing runoff intensity from the natural condition	Decrease	Negligible effect	Slight increase	Moderate increase	Marked increase	1	3
Rainfall intensity	Low (Zone I)	Moderately low (Zone II)		Mod. high (Zone III)	High (Zone IV)	4	4
Extent to which dams are reducing the input of sediment to the HGM unit	High	Mod high	Intermediate	Mod low	Low	0	4
Extent of sediment sources delivering sediment to the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of other potential sources of phosphates in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of nitrate sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of toxicant sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2
HGM unit							
Size of HGM unit relative to the HGM unit's catchment	<1%	1%-2%	3-5%	6-10%	>10%	0	3
Slope of the HGM unit (%)	>5%	2-5%	1-1.9%	0.5-0.9%	<0.5%	1	3
Surface roughness of the HGM unit	Low	Mod. low		Mod. high	High	4	3
Depressions	None	Present but few or remain permanently filled close to capacity	Intermediate	Moderately abundant	Abundant	0	3
Frequency with which stormflows are spread across the HGM unit	Never	Occasionally but less frequently than every 5 years		1 to 5 year frequency	More than once a year	4	1
Sinuosity of the stream channel	Low	Moderately low	Intermediate	Mod. high	High	0	3
Representation of different hydrological zones	Permanent & seasonal zones lacking	Seasonal zone present but	Permanent & seasonal zones both	Seasonal & permanent	Seasonal & permanent zone both	0	3

	(i.e. only the temporary zone present)	permanent zone absent	present but collectively <30%	zone both present & collectively 30-60%	present & collectively >60% of total HGM unit area		
Link to the stream network	No link (i.e. hydrologically isolated)				Linked to the stream system	0	3
Presence of fibrous peat or unconsolidated sediments below a floating marsh	Absent	Present but limited in extent/depth		Moderately abundant	Extensive and relatively deep (>1.5 m)	0	4
Reduction in evapotranspiration through frosting back of the wetland vegetation	Low	Moderately low	Intermediate	Moderately high	High	4	1
HGM unit occurs on underlying geology with strong surface-groundwater linkages	No		Underlying geology quartzite	Underlying geology sanstone	Underlying geology dolomite	3	3
Direct evidence of sediment deposition in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Flow patterns of low flows within the wetland	Strongly channelled	Moderately channelled	Intermediate	Moderately diffuse	Very diffuse	2	2
Extent of vegetation cover in the HGM unit	Low	Mod low	Intermediate	Mod high	High	4	3
Contribution of sub-surface water inputs relative to surface water inputs	Low (<10%)	Moderately low (10-20%)	Intermediate (20-35%)	Moderately high (36-50%)	High (>50%)	0	2
Application of fertilizers/biocides in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Direct evidence of erosion	High	Mod high	Intermediate	Mod low	Low	4	3
Current level of physical disturbance of the soil in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Erodibility of the soil in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	2
Abundance of peat	Absent	Present but limited in extent/depth	Intermediate	Moderately abundant	Extensive and relatively deep (>0.5 m)	0	3
HGM unit is of a rare type or is of a wetland type or vegetation type subjected to a high level of cumulative loss	No				Yes	0	3
Red Data species or suitable habitat for Red Data species	No				Yes	0	3
Level of significance of other special natural features	None	Mod low	Intermediate	Mod high	High	0	2
Alteration of hydrological regime	High	Mod high	Intermediate	Mod low	Low/negligible	4	2
Complete removal of indigenous vegetation	>50%	25-50%	5-25%	1-5%	<1%	0	3
Invasive and pioneers species encroachment	>50%	25-50%	5-25%	1-5%	<1%	0	2

Presence of hazardous/restrictive barriers	High	Mod high	Intermediate	Mod low	Low/negligible	4	2
Current level of use of water for agriculture or industry	No use	Mod low	Intermediate	Mod high	High	0	3
Current level of use of water for domestic purposes	No use	Mod low	Intermediate	Mod high	High	0	3
Number of dependent households that depend on the direct provision of water from the wetland	None	1-2	3-4	5-6	>6	0	3
Substitutability of the water resource from the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Number of different resources used	None	1		2-3	>3	0	3
Is the wetland in a rural communal area?	No				yes	0	4
Level of poverty in the area	Low/ negligible	Mod low	Intermediate	Mod high	High	0	4
Number of households who depend on the natural resources in the HGM unit	None	1	2-3	4-5	>6	0	4
Substitutability of the natural resources obtained from the wetland	High	Mod high	Intermediate	Mod low	Low	4	4
Total number of different crops cultivated in the HGM unit	None	1		2-3	>3	0	4
Number of households who depend on the crops cultivated in the HGM unit	None	1	2-3	4-6	>6	0	4
Substitutability of the crops cultivated in the wetland	High	Mod high	Intermediate	Mod low	Low	0	3
Registered SAHRA site	No				Yes	0	3
Known local cultural practices in the HGM unit	None	Historically present but no longer practised		Present but practised to a limited extent	Present & still actively & widely practised	0	3
Known local taboos or beliefs relating to the HGM unit	None	Historically present but no longer so		Present but held to a limited extent	Present & still actively & widely held	0	3
Scenic beauty of the HGM unit	Low/negligible	Mod low	Intermediate	Mod high	High	0	3
Presence of charismatic species	None present	Very seldom seen	Occasionally present	Generally present	Always present	0	2
Current use for tourism or recreation	No use	Mod low use	Intermediate use	Mod high use	High	0	4
Availability of other natural areas providing similar experiences to the HGM unit	High	Mod high	Intermediate	Mod low	Low	3	2
Location within an existing tourism route	Low/negligible	Mod low	Intermediate	Mod high	High	2	2
Recreational hunting and fishing and birding opportunities	None	Mod low	Intermediate	Mod high	High	0	3

Extent of open water	None	Present, but very limited		Extent somewhat limited	Extensive	0	3
Current use for education/research purposes	No use	Mod low	Intermediate	Mod high	High	1	2
Reference site suitability	Low	Mod low	Intermediate	Mod high	High	0	3
Existing data & research	None	Mod low	Intermediate detail/ time period	Mod high	Comp-rehensive data over long period	0	2
Accessibility	Very inaccessible	Moderately inaccessible	Intermediate	Moderately accessible	Very accessible	2	3
DOWNSTREAM OF HGM unit							
Extent of floodable property	Low/ negligible	Moderately low		Moderately high	High	0	3
Presence of any important wetlands or aquatic systems downstream	None		Intermediate importance		High importance	4	3
THE LANDSCAPE IN WHICH THE HGM UNIT IS LOCATED							
Extent of buffer around wetland	Low	Mod low	Intermediate	Mod high	High	2	2
Connectivity of wetland in landscape	Low	Mod low	Intermediate	Mod high	High	1	3
Level of cumulative loss of wetlands in overall catchment	Low	Mod low	Intermediate	Mod high	High	3	3
THREATS & OPPORTUNITIES							
Level of threat to existing ecosystem services supplied by the wetland	Low	Moderately low	Intermediate	Moderately high	High	0	2
Level of future opportunities for enhancing the supply of ecosystem services	Low	Moderately low	Intermediate	Moderately high	High	0	2

DERIVED CHARACTERISTICS		
These are characteristics that are derived from other characterisitcs and therefore do not need to be entered directly		
Runoff intensity from the HGM unit's catchment	2	3
Alteration of sediment regime	0	3
Alteration of nutrient/toxicant regime	4	3

Lake Victoria Barn Swallow Roosting Site Wetland: HGM unit five						
Size (hectares)						

O=Data should be obtained in the office through desktop investigation prior to the field assessment. R=Data may be available through desktop investigation but is likely to be revised/refined in the field	0	1	2	3	4		
HGM UNIT'S CATCHMENT						**Score**	**Confidence**
Average slope of the HGM unit's catchment	<3%	3-5%	6-8%	9-11%	>11%	2	3
Inherent runoff potential of the soils in the HGM unit's catchment	Low	Mod low		Mod high	High	0	2
Contribution of catchment land-uses to changing runoff intensity from the natural condition	Decrease	Negligible effect	Slight increase	Moderate increase	Marked increase	0	3
Rainfall intensity	Low (Zone I)	Moderately low (Zone II)		Mod. high (Zone III)	High (Zone IV)	4	4
Extent to which dams are reducing the input of sediment to the HGM unit	High	Mod high	Intermediate	Mod low	Low	0	4
Extent of sediment sources delivering sediment to the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of other potential sources of phosphates in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of nitrate sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	3
Extent of toxicant sources in the HGM unit's catchment	Low	Mod low	Intermediate	Mod high	High	0	2
HGM unit							
Size of HGM unit relative to the HGM unit's catchment	<1%	1%-2%	3-5%	6-10%	>10%	0	3
Slope of the HGM unit (%)	>5%	2-5%	1-1.9%	0.5-0.9%	<0.5%	1	3
Surface roughness of the HGM unit	Low	Mod. low		Mod. high	High	4	3
Depressions	None	Present but few or remain permanently filled close to capacity	Intermediate	Moderately abundant	Abundant	0	3
Frequency with which stormflows are spread across the HGM unit	Never	Occasionally but less frequently than every 5 years		1 to 5 year frequency	More than once a year	4	1
Sinuosity of the stream channel	Low	Moderately low	Intermediate	Mod. high	High	0	3
Representation of different hydrological zones	Permanent & seasonal zones lacking (i.e. only the temporary	Seasonal zone present but permanent zone absent	Permanent & seasonal zones both present but collectively	Seasonal & permanent zone both present &	Seasonal & permanent zone both present & collectively	0	3

	zone present)		<30%	collectively 30-60%	>60% of total HGM unit area		
Link to the stream network	No link (i.e. hydrologically isolated)				Linked to the stream system	0	3
Presence of fibrous peat or unconsolidated sediments below a floating marsh	Absent	Present but limited in extent/depth		Moderately abundant	Extensive and relatively deep (>1.5 m)	0	4
Reduction in evapotranspiration through frosting back of the wetland vegetation	Low	Moderately low	Intermediate	Moderately high	High	4	1
HGM unit occurs on underlying geology with strong surface-groundwater linkages	No		Underlying geology quartzite	Underlying geology sanstone	Underlying geology dolomite	3	3
Direct evidence of sediment deposition in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	3
Flow patterns of low flows within the wetland	Strongly channelled	Moderately channelled	Intermediate	Moderately diffuse	Very diffuse	2	2
Extent of vegetation cover in the HGM unit	Low	Mod low	Intermediate	Mod high	High	4	3
Contribution of sub-surface water inputs relative to surface water inputs	Low (<10%)	Moderately low (10-20%)	Intermediate (20-35%)	Moderately high (36-50%)	High (>50%)	0	2
Application of fertilizers/biocides in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	3
Direct evidence of erosion	High	Mod high	Intermediate	Mod low	Low	4	3
Current level of physical disturbance of the soil in the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Erodibility of the soil in the HGM unit	Low	Mod low	Intermediate	Mod high	High	0	2
Abundance of peat	Absent	Present but limited in extent/depth	Intermediate	Moderately abundant	Extensive and relatively deep (>0.5 m)	0	3
HGM unit is of a rare type or is of a wetland type or vegetation type subjected to a high level of cumulative loss	No				Yes	0	3
Red Data species or suitable habitat for Red Data species	No				Yes	0	3
Level of significance of other special natural features	None	Mod low	Intermediate	Mod high	High	0	2
Alteration of hydrological regime	High	Mod high	Intermediate	Mod low	Low/negligible	4	2
Complete removal of indigenous vegetation	>50%	25-50%	5-25%	1-5%	<1%	0	3
Invasive and pioneers species encroachment	>50%	25-50%	5-25%	1-5%	<1%	0	2
Presence of hazardous/restrictive barriers	High	Mod high	Intermediate	Mod low	Low/negligible	4	2
Current level of use of water for agriculture or industry	No use	Mod low	Intermediate	Mod high	High	0	3

Current level of use of water for domestic purposes	No use	Mod low	Intermediate	Mod high	High	0	3
Number of dependent households that depend on the direct provision of water from the wetland	None	1-2	3-4	5-6	>6	0	3
Substitutability of the water resource from the HGM unit	High	Mod high	Intermediate	Mod low	Low	4	2
Number of different resources used	None	1		2-3	>3	0	3
Is the wetland in a rural communal area?	No				yes	0	4
Level of poverty in the area	Low/ negligible	Mod low	Intermediate	Mod high	High	0	4
Number of households who depend on the natural resources in the HGM unit	None	1	2-3	4-5	>6	0	4
Substitutability of the natural resources obtained from the wetland	High	Mod high	Intermediate	Mod low	Low	4	4
Total number of different crops cultivated in the HGM unit	None	1		2-3	>3	0	4
Number of households who depend on the crops cultivated in the HGM unit	None	1	2-3	4-6	>6	0	4
Substitutability of the crops cultivated in the wetland	High	Mod high	Intermediate	Mod low	Low	0	3
Registered SAHRA site	No				Yes	0	3
Known local cultural practices in the HGM unit	None	Historically present but no longer practised		Present but practised to a limited extent	Present & still actively & widely practised	0	3
Known local taboos or beliefs relating to the HGM unit	None	Historically present but no longer so		Present but held to a limited extent	Present & still actively & widely held	0	3
Scenic beauty of the HGM unit	Low/negligible	Mod low	Intermediate	Mod high	High	0	3
Presence of charismatic species	None present	Very seldom seen	Occasionally present	Generally present	Always present	0	2
Current use for tourism or recreation	No use	Mod low use	Intermediate use	Mod high use	High	0	3
Availability of other natural areas providing similar experiences to the HGM unit	High	Mod high	Intermediate	Mod low	Low	3	2
Location within an existing tourism route	Low/negligible	Mod low	Intermediate	Mod high	High	2	3
Recreational hunting and fishing and birding opportunities	None	Mod low	Intermediate	Mod high	High	0	3
Extent of open water	None	Present, but very limited		Extent somewhat limited	Extensive	0	3
Current use for education/research purposes	No use	Mod low	Intermediate	Mod high	High	1	2

Reference site suitability	Low	Mod low	Intermediate	Mod high	High	0	3
Existing data & research	None	Mod low	Intermediate detail/ time period	Mod high	Comp-rehensive data over long period	0	2
Accessibility	Very inaccessible	Moderately inaccessible	Intermediate	Moderately accessible	Very accessible	2	3
DOWNSTREAM OF HGM unit							
Extent of floodable property	Low/ negligible	Moderately low		Moderately high	High	0	3
Presence of any important wetlands or aquatic systems downstream	None		Intermediate importance		High importance	4	3
THE LANDSCAPE IN WHICH THE HGM UNIT IS LOCATED							
Extent of buffer around wetland	Low	Mod low	Intermediate	Mod high	High	2	2
Connectivity of wetland in landscape	Low	Mod low	Intermediate	Mod high	High	1	3
Level of cumulative loss of wetlands in overall catchment	Low	Mod low	Intermediate	Mod high	High	3	3
THREATS & OPPORTUNITIES							
Level of threat to existing ecosystem services supplied by the wetland	Low	Moderately low	Intermediate	Moderately high	High	0	2
Level of future opportunities for enhancing the supply of ecosystem services	Low	Moderately low	Intermediate	Moderately high	High	0	2

DERIVED CHARACTERISTICS		
These are characteristics that are derived from other characterisitcs and therefore do not need to be entered directly		
Runoff intensity from the HGM unit's catchment	2	3
Alteration of sediment regime	0	3
Alteration of nutrient/toxicant regime	4	3

Condensed summary sheet	Wetland 1: HGM unit 1		Wetland 2: HGM unit 1		Wetland 2: HGM unit 2		Wetland 3: HGM unit 1		Wetland 3: HGM unit 2	
	Overall score	Confidence rating	Overall score	Confidence rating	Overall score	Confidence rating	Overall score	Confidence rating	Overall score	Confidence rating
Flood attenuation	1.5	2.8	1.1	2.7	1.4	2.7	1.4	2.8	1.1	2.8
Streamflow regulation	2.2	2.8	2.8	2.5	2.5	2.8	2.8	2.8	3.2	2.8
Sediment trapping	1.5	2.5	1.7	3.1	1.7	3.1	1.0	3.1	1.0	3.1
Phospahte trapping	1.7	2.6	2.1	2.7	2.3	2.7	1.7	3.0	2.2	3.0
Nitrate removal	2.1	2.4	2.3	2.6	2.5	2.6	2.0	2.9	3.0	3.0

Toxicant removal		1.6	2.6	1.7	3.0		2.2	3.0		1.7	3.1		2.3	3.1
Erosion control		2.2	2.6	2.4	2.4		2.2	2.4		2.5	2.3		2.1	2.3
Carbon storage		1.7	3.0	2.0	3.3		2.7	3.3		1.7	2.7		2.7	2.7
Maintenance of biodiversity		1.2	2.8	1.0	2.7		1.6	2.6		1.5	2.7		2.6	2.9
Water supply for human use		1.9	3.1	1.5	1.9		1.6	2.0		1.5	3.0		1.9	2.8
Natural resources		0.8	2.8	0.8	2.8		0.6	3.0		0.8	3.6		0.8	3.6
Cultivated foods		0.6	3.4	1.2	3.0		0.8	3.4		0.0	3.6		0.0	3.6
Cultural significance		0.0	3.5	0.8	3.5		0.0	3.5		0.0	3.3		0.0	3.3
Tourism and recreation		0.3	3.2	0.1	2.6		0.3	2.4		1.3	3.2		3.0	4.0
Education and research		1.0	2.5	1.0	2.5		1.3	2.5		0.8	2.3		2.3	3.0
Threats		1.0	2.0	3.0	3.0		2.0	3.0		1.0	2.0		3.0	3.0
Opportunities		1.0	2.0	0.0	2.0		0.0	2.0		1.0	2.0		1.0	2.0
Condensed summary sheet		Wetland 3: HGM unit 3		Wetland 3: HGM unit 4			Wetland 3: HGM unit 5							
		Overall score	Confidence rating	Overall score	Confidence rating		Overall score	Confidence rating						
Flood attenuation		1.5	2.8	1.5	2.8		1.4	2.8						
Streamflow regulation		2.2	2.7	1.8	2.8		1.8	2.8						
Sediment trapping		1.5	3.1	1.1	3.1		1.1	3.1						
Phospahte trapping		1.7	3.0	2.0	2.8		2.0	2.8						
Nitrate removal		2.1	2.7	2.0	2.7		2.0	2.7						
Toxicant removal		1.6	3.0	1.8	3.0		1.8	3.0						
Erosion control		2.2	2.3	2.5	2.3		2.4	2.3						
Carbon storage		1.7	2.3	1.3	2.7		1.3	2.7						
Maintenance of biodiversity		1.2	2.6	1.3	2.6		1.3	2.6						
Water supply for human use		1.9	2.6	1.0	2.8		1.0	2.8						
Natural resources		0.8	3.6	0.8	3.8		0.8	3.8						
Cultivated foods		0.6	3.6	0.0	3.8		0.0	3.8						
Cultural significance		0.0	3.3	0.0	3.3		0.0	3.3						
Tourism and recreation		0.3	3.0	0.7	2.8		0.7	2.8						
Education and research		1.0	2.5	0.8	2.5		0.8	2.5						
Threats		1.0	2.0	0.0	2.0		0.0	2.0						
Opportunities		1.0	2.0	0.0	2.0		0.0	2.0						