Volume 3: Annexure C
Wetland Specialist Report

Lesotho Highlands Development Authority

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Wetland Consulting Services (Pty.) Ltd.

LHDA

Revision History

Version	Issue Date	Description of Changes
00	3 May 2017	First Draft
01	4 Oct. 2017	Final

Abbreviations, Definitions and Acronyms

AoI	Area of Influence
BBOP	Business and Biodiversity Offset Programme
BMP	Biodiversity Management Plan
CES	Coastal & Environmental Services
CITES	Convention on International Trade in Endangered Species
CR	Critically Endangered
DD	Data deficient (relates to species on the IUCN Red Data Species List)
DFID	Department for International Development
DoE	Department of Environment
DWAF	South African Department of Water Affairs and Forestry
DWS	South African Department of Water and Sanitation
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMP	Environmental Management Plan
EN	Endangered (relates to species on the IUCN Red Data Species List)
ERM	Environmental Resources Management Southern Africa (Pty) Ltd
ESIA	Environmental and Social Impact Assessment
ESIS	Environmental and Social Impact Statement
FSL	Full Supply Level
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPS	Geographic Positioning System
ha	Hectares
HGM	Hydrogeomorphic
ICM	Integrated Catchment Management
IEI	Integrated Environmental Importance
IFC	International Finance Corporation
INR	Institute of Natural Resources
IS	Importance and sensitivity
IUCN	International Union for Conservation of Nature
LC	Least Concern
LHDA	Lesotho Highlands Development Authority
LHWC	Lesotho Highlands Water Commission
LHWP	Lesotho Highlands Water Project
LHWP2	Phase II of the Lesotho Highlands Water Project
LIDAR	Light Detection and Ranging
LMS	Lesotho Meteorological Service
LWSP	Lesotho Water and Sanitation Policy
masl	Metres above sea level
m amsl	Metres above mean sea level
MCC	Millennium Challenge Corporation
MDTP	Maloti Drakensberg Transfrontier Programme
NT	Near Threatened (relates to species on the IUCN Red Data Species List)
ORASECOM	Orange-Senqu River Commission
PES	Present Ecological State
pH	Potential of hydrogen – a numeric scale used to specify the acidity or basicity of an aqueous solution
ppm	Parts per million
PRAI	Polihali Reservoir and Associated Infrastructure
PS	Performance Standard
RSAP IV	Regional Strategic and Action Plan
SADC	Southern African Development Community
SANBI	South African National Biodiversity Institute
SCI	Socio-Cultural Importance
TBM	Tunnel Boring Machine
TDS	Total dissolved solids

ToR	Terms of Reference
VU	Vulnerable (relates to species on the IUCN Red Data Species List)
WCS	Wetland Consulting Services (Pty) Ltd
WGS 1984	World Geodetic System developed in 1984 and updated in 2004. It is an Earth-centred, Earth-fixed terrestrial reference system and geodetic datum. WGS84 is based on a consistent set of constants and model parameters that describe the Earth's size, shape, and gravity and geomagnetic fields.

Glossary of Technical Terms

Technical Term	Definition
Biodiversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.
Biodiversity Offset	Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from development plans or projects after appropriate prevention and mitigation measures have been taken.
Critical Habitat	Areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered (CR) and/or Endangered (EN) species; (ii) habitat of significant importance to endemic and / or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and / or unique ecosystems; and/or (v) areas associated with key evolutionary processes (see IFC PS6, Paragraph 16).
Critically Endangered	A taxon is Critically Endangered (CR) when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by IUCN criteria (www.iucnredlist.org).
Ecological Importance and Sensitivity (EIS)	With reference to wetlands, the EIS of a wetland provides an indication of how important the wetland is in terms of certain ecological criteria. It also provides an indication of the sensitivity of the wetland to impacts such as changes in flow for example. It is determined based on a qualitative assessment and scoring of the ecological criteria. As with Importance and Sensitivity (IS), it is also indicated as Very High, High, Moderate or Low/Marginal.
Ecoregion	An ecoregion is defined as a "relatively large unit of land or water containing a characteristic set of natural communities that share a large majority of their species, dynamics, and environmental conditions".
Ecosystem Services	Defined as the benefits that people obtain from nature. These are typically divided into four categories. • Provisioning services are the goods or products obtained from ecosystems, such as food, timber, medicines, fibre, and freshwater. • Regulating services are the benefits obtained from an ecosystem's control of natural processes, such as climate, disease, erosion, water flows, and pollination, as well as protection from natural hazards. • Cultural services are the nonmaterial benefits obtained from ecosystems, such as recreation, spiritual values, and aesthetic enjoyment. • Supporting services are the natural processes that maintain the other ecosystem services, such as nutrient cycling and primary production.
Endangered	A taxon is Endangered (EN) when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by the IUCN criteria (www.iucnredlist.org) or provisionally assessed by an expert group.
Endemic	A species that has ≥ 95% of its global range inside the country or region of

Technical Term	Definition
	analysis (IFC PS6 GN79).
Fen	Being a type of mire, Fens are open ended wetland systems (having surface water and groundwater inputs and outputs) that contain peat. In the Highlands of Lesotho characteristic features of the Fens are the lawns (meadows) of sedges and grasses, scattered pools and hollows, hummocks and meandering stream channels. In the alpine areas of Lesotho Fens generally do not occur below an altitude of approximately 2750 mamsl, although exceptions do occur. They are also usually dominated by minerals from surrounding soils (Moore and Ballamy, 1974; Mitsch and Gosselink, 1986).
Habitat	The environmental or ecological area in which an animal, plant species or other organism lives.
Humic soil	For a soil to be classified as a humic soil according to Soil Classification: A Taxonomic System for South Africa (1991), the soil must contain 1.8% or more organic carbon in a soil sample taken between the depths of 250 mm and 450 mm.
Humification Scale	As applied to peat, the humification scale is a representation or indicator of the degree of decomposition of peat (organic material). As applied in this study, the method involved the visual evaluation of freshly extracted peat based on the 10-point von Post humification scale (von Post and Granlund, 1926). This *in-situ* method gives a rapid description of the peat stratigraphy (analytical order, position and structure of the peat) along a peat profile or core.
Importance and Sensitivity (IS)	With reference to wetlands, the IS of a wetland provides an indication of how important the wetland is in terms certain ecological, hydrological and human benefit criteria. It also provides an indication of the sensitivity of the wetland to impacts such as changes in flow for example. It is determined based on a qualitative assessment and scoring of the Ecological Importance and Sensitivity, Hydro-functional Importance, and Direct Human Benefit Importance of the system. The assessment of each of the above is based on certain criteria and the IS is derived from the highest score of the three, indicated as Very High, High, Moderate or Low/Marginal.
Invasive Aliens	Species are identified as invasive aliens when (i) they are non-native to an ecosystem, and (ii) their introduction is liable to cause environmental harm, or harm to human health and livelihoods, because they spread rapidly and have negative effects on native species through competition, predation, or disease. Invasive species can be flora, fauna, or other organisms (e.g. microbes) but generally refer to plants.
IUCN Red List	This list has been developed by the International Union for Conservation of Nature (IUCN) and details the global conservation status of a wide range of biological species. The Red List website is http:/www.redlist.org.
Mire	A fresh water wetland which develop in areas where precipitation exceeds potential evapotranspiration and where the drainage of surface water is restricted, creating a net water surplus (Mitsch and Gosselink, 1986). Mires are also commonly called peatlands because the conditions under which they develop often results in the formation of organic or peat soil.
Modified Habitat	An area that may contain a large proportion of plant and/or animal species of non-native origin, and / or where human activity has substantially modified the primary ecological functions and species composition.

Technical Term	Definition
Natural Habitat	An area composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary functions and species composition.
Peat	Fibrous organic material composed of well-preserved plant remains that are readily identifiable, generally occurring in low energy, permanently saturated conditions in wetlands.
Project Area	The Area of Influence defined within a 5 km radius of the Full Supply Level (FSL) level within which the majority of project impacts are predicted to occur.
Present Ecological State (PES)	With reference to wetlands, PES is the current state, condition or health of a wetland system determined relative to its pristine or natural state. It usually involves a qualitative assessment of the changes to wetland hydrology, water quality, geomorphology, vegetation and fauna using indicators of such change based on certain criteria. It is indicated in categories ranging from A to F representing Natural or Pristine to Critically Modified respectively.
Restricted Range	Restricted range species include those with ranges in the following criteria: endemic to a site or found globally at fewer than 10 sites; animal species having a distribution range less than 50 000 km^2; or bird species with a global breeding range less than 50 000 km^2 (IFC PS6).
Vulnerable	A taxon is Vulnerable (VU) when it is not Critically Endangered (CR) or Endangered (EN) but is facing a high risk of extinction in the wild in the medium-term future, as defined by the IUCN criteria (www.iucnredlist.org).
Wetland	The National Water Act 36 of 1998 provides the legal wetland definition used in South Africa: "land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."

Non-technical Summary

Scope and Methods

Wetland Consulting Services (Pty) Ltd (WCS) was appointed by Environmental Resources Management Southern Africa (Pty) Ltd (ERM) to undertake the specialist wetland study for the Environmental and Social Impact Assessment (ESIA) study being undertaken for the Polihali Reservoir and Associated Infrastructure (PRAI) project.

The status of wetlands in Lesotho has received significant attention through detailed studies conducted during baseline and monitoring studies for Phase 1 of the Lesotho Highlands Water Project (LHWP) as well as during the Millennium Challenge Corporation (MCC) funded programmes, Orange-Senqu River Commission (ORASECOM) and the protection of the Orange-Senqu Water Sources ('SPONGE') Project. This study focusses on wetlands within the Area of Influence (AoI) of the PRAI project, which forms part of Phase 2 of the LHWP. Wetlands are not only acknowledged to be important for biodiversity support, but also streamflow augmentation, flood attenuation, water purification and erosion control, and therefore for protecting the water resources in the catchments on which the LHWP depends.

Limited wetland data for the Polihali Reservoir AoI (PRAI) existed prior to this study. Wetland information in the CES (2014) baseline report formed a part of the Baseline Botanical Survey but only referred to the presence of degraded Seeps in the reservoir area. Similarly the wetland data provided in the Biophysical supporting report for the Polihali Feasibility study (Rall *et al.*, 2008) provided general desktop habitat mapping of the PRAI area with limited wetland mapping. Therefore this wetland study specifically addresses the wetlands of the PRAI and surrounding area. It involved the use of available aerial imagery in conjunction with the Light Detection and Ranging (LIDAR) data of the dam basin area to identify and delineate wetlands at a desktop level initially.

Target wetlands and possible wetland signatures identified and prioritised for sampling during the desktop wetland mapping exercise were visited and sampled in the field during a summer field survey. A total of 58 sites were surveyed, which included 46 wetlands that were sampled in detail. Field work was undertaken over 12 days from 26 January to 6 February 2017 by a team of wetland specialists. The methodology adopted for the wetland survey included the following tasks:

- Typing of the wetlands;
- Collection of information on attributes such as habitat condition, adjacent land use, alteration of vegetation in the wetland and its local catchment, local hydrology, geomorphology, water quality and levels of disturbance;
- Assessment of Importance and Sensitivity (IS);
- Coring and classification of peat profiles, where applicable;
- A rapid functional assessment of wetland types;
- Identification and assessment of the predicted impacts of the project on wetlands using the impact assessment methodology provided by ERM;
- Identifying and recommending mitigation measures for wetlands; and
- Recommendations for long-term monitoring of selected wetlands that will be relevant to the development of a future Biodiversity Management Plan.

Baseline Assessment – Key Findings

A total of 184.6 ha of wetland habitat were delineated within the local catchment of the PRAI, consisting of six wetland types, classified as follows:

- Seep Wetland
- Sheetrock Wetland
- Valleyhead Seep Wetland
- Valley Bottom Wetland

- Valleyhead Seep (Fen)

No wetlands were found within the direct development footprints of the proposed infrastructure area. Wetlands located in closest proximity to the infrastructure development footprints are located within the reservoir below the Full Supply Level (FSL) and will therefore be lost once the reservoir fills. Only 11 wetlands were identified within the proposed inundation area, covering a combined area of only 3.8 hectares.

Important findings of the summer survey are summarised as follows:

- No Red Data plant species were identified in any of the surveyed wetlands on site.
- Peat was found to occur in eight of the 46 wetlands sampled, though only one of these wetlands, namely Wetland 19 (Phutha Sheep Stud), is located within the local catchment of the PRAI. The remainder of the peat wetlands are generally located at higher altitudes.
- The functional assessment found the wetlands within the local catchment of the PRAI to be important in terms of the following ecosystem services:
  - Biodiversity maintenance;
  - Sediment trapping;
  - Water quality maintenance;
  - Streamflow regulation; and
  - Direct human use benefits including domestic water supply, livestock grazing and livestock watering.
- Although no detailed water quality assessment was undertaken as part of the wetland study and no baseline water quality information is available for the wetlands in the project area, the water quality observed within the wetlands is generally considered to be of a good quality in terms of Total Dissolved Solids (TDS) and pH.
- The bulk of wetland habitat surveyed was considered to be moderately modified (PES category C), though more than 16 % of wetland habitat was rated as largely modified (PES category D). Only three wetlands were considered to remain in a largely natural state (PES category B), most significantly the Valleyhead Fen in the Phutha Sheep Stud (near Mokhotlong) but outside the area of inundation.
- The most important wetland within the PRAI study area is considered to be the Valleyhead Fen located in the Phutha Sheep Stud. This wetland provides an important reference system for wetlands of the area under natural conditions.
- All of the remaining wetlands in the Project Area have been impacted and degraded to some degree, resulting in a moderate importance and sensitivity score. However, the wetlands are considered to be of high importance for the ecosystem services they provide to local communities.

Key Potential Impacts

An impact assessment was undertaken to determine the expected impact to wetlands from the proposed reservoir and associated infrastructure. No direct impacts to wetlands are expected as a consequence of the proposed site clearance and preparation activities for the advanced infrastructure footprints as no wetlands fall within the development footprints.

At least 11 wetlands were identified within the direct footprint of the proposed reservoir inundation area, all of which are moderately to largely modified. These wetlands consist predominantly of small Seep wetlands (9) and Sheetrock wetlands (2) that together cover 3.7 ha which will be flooded by the reservoir.

The primary impact to wetlands from the proposed PRAI project relates to the land use displacement caused by the reservoir inundation. All villages falling within the reservoir FSL will be relocated, presumably to locations within the defined local catchment of the PRAI. Due to the dependence of local communities on subsistence agriculture (cultivation and livestock), it can be assumed that current land use practices within the reservoir FSL will be displaced to surrounding areas. This is predicted to result in increased grazing pressure and increased cultivation in the local catchment surrounding the reservoir in particular, but which is also expected to extend into the upper catchment areas, as has been recorded in the Phase 1 catchments. Wetlands provide prime grazing and are expected to be heavily impacted by an increase in grazing pressures. The consequences for wetlands are expected to result from increased habitat degradation through accelerated erosion, shrub encroachment, trampling and resultant loss of biodiversity. This impact will take place within an environment already significantly degraded and heavily utilised and thus highly vulnerable to increased utilisation pressures.

Of further importance to note is that climate change challenges are predicted to further exacerbate wetland degradation, with predicted changes in temperature and precipitation patterns (Lesotho Meteorological Service (LMS), 2013) resulting in changes to soil moisture, vegetation cover and erosion.

Key potential impacts of the Polihali Reservoir on wetlands were identified and assessed according to the Project Phases, as summarised in the tables below.

Advanced Works and Construction Phases

	Seeps		**Sheetrock Wetland**		**Valley Bottom**	
	Wetland 44 (0.2 ha)		**Wetland 52 (0.2 ha)**			
	Pre-Mitigation Impact	**Residual Impact**	**Pre-Mitigation Impact**	**Residual Impact**	**Pre-Mitigation Impact**	**Residual Impact**
Impact of Site Clearance for Advanced Works (Camps, Offices, Lodge, laydown) on Wetlands						
Type of Impact	Direct		Direct		None	
Magnitude	Small	Negligible	Small	Negligible	NA	NA
Sensitivity	Low	Low	Low	Low	NA	NA
Significance	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**NA**	**NA**
Impact of Site Clearance for Dam and Tunnel Construction on Wetlands						
Type of Impact	Direct		Direct		None	
Magnitude	Small	Negligible	Small	Negligible	NA	NA
Sensitivity	Low	Negligible	Low	Low	NA	NA
Significance	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**NA**	**NA**

Inundation Phase

	Seeps & Sheetrock Wetlands		**Valley Bottom & Valleyhead Seeps**		**Valleyhead Fens**	
	(3.7 ha)		**(0 ha)**		**(0 ha)**	
	Pre-Mitigation Impact	**Residual Impact**	**Pre-Mitigation Impact**	**Residual Impact**	**Pre-Mitigation Impact**	**Residual Impact**
Type of Impact	Direct		None		None	
Magnitude	Medium	Medium	NA	NA	NA	NA
Sensitivity	Low	Low	NA	NA	NA	NA
Significance	**Minor**	**Minor**	**NA**	**NA**	**NA**	**NA**

Operation Phase

	Seeps & Sheetrock Wetlands 151 ha (within AoI)		Valley Bottom & Valleyhead Seeps 27.5 ha (within AoI)		Valleyhead Fens 5.4 ha (within AoI)	
	Pre-Mitigation Impact	**Residual Impact**	**Pre-Mitigation Impact**	**Residual Impact**	**Pre-Mitigation Impact**	**Residual Impact**
Type of Impact	Indirect/ induced		Indirect /induced		Indirect / induced	
Magnitude	Large	Medium	Large	Medium	Large	Low
Sensitivity	Medium	Medium	Medium	Medium	High	High
Significance	**Major**	**Moderate**	**Major**	**Moderate**	**Major**	**Moderate**

Mitigation and Monitoring Measures

The following measures are recommended in mitigation of negative impacts of the Polihali Reservoir on wetlands:

- **Wetland awareness**: Although no wetlands were found within the direct development footprints of the proposed infrastructure area, wetlands may be encountered by contractor staff when working in the Polihali area and it is therefore recommended that induction training and environmental awareness materials for wetlands are developed and discussed at regular training sessions with contractor staff.
- **Vehicle access**: delineate seepage zones in close proximity to works area (e.g. Wetland 44 near tunnel spoil dump) and avoid vehicles traversing through this wetland;
- **Stormwater management**: minimise the channelling of surface runoff from construction sites into seepage wetlands near construction works areas such as the seep zone near the tunnel spoil dump location;
- **Pollution controls**: avoid the location of hydrocarbon or chemical stores, toilets or other polluting activities upslope or near the seepage wetlands close to the tunnel spoil dump.

Wetland Protection and Rehabilitation Strategy

- Identify and prioritise wetlands for protection, and implement rehabilitation and management measures as part of an Integrated Catchment Management (ICM) Strategy and/or Biodiversity Management Plan (BMP) (see Additional Recommendations below);
- Enhance and formalise protection of the Phutha Sheep Stud area and protect it from human or livestock encroachment resulting from displacement of the dam. LHDA should work with relevant government departments to identify an alternative waste land fill site for Mokhotlong to avoid waste vehicles passing through the sheep stud area.

No monitoring of wetlands in the advanced works or inundation zone is required. However, monitoring of catchment wetlands during operation is recommended as part of the proposed ICM Strategy.

Additional Recommendations

Integrated Catchment Management (ICM)

In addition to site specific mitigation measures recommended to minimise and manage impacts related to site preparation and construction, it is recognised that the protection and conservation of wetlands is closely tied to the general condition and management of the wetland catchment. In order to mitigate against the impacts of land use displacement on wetlands in other parts of the catchment, an ICM plan should be developed and implemented for the entire Polihali reservoir catchment. Such an ICM plan should include considerations from a number of integrated perspectives including rangeland management terrestrial biodiversity, wetland and socio-cultural aspects, while taking cognisance of expected climate change impacts. The catchment management plan should include a detailed wetland monitoring plan (based on framework guidelines provided in this report) and should allow for the prioritisation of wetlands for rehabilitation interventions, as well as the implementation of the required rehabilitation activities.

Upper Catchment Protected Area as an Offset

In light of the expected impacts of land use displacement from the reservoir on surrounding rangelands and wetlands, and the need for interventions to arrest the extensive erosion prevalent across much of the catchment, it is strongly recommended that additional protected areas are established in the upper Polihali catchment as a form of broader biodiversity offset for the LHWP Phase 2 development. Such areas will need to adopt alternative rangeland management practices informed by an interdisciplinary approach and involving various specialists and all stakeholders, and should be developed considering the unique challenges associated with rangeland management in the Highlands and the socio-economic consequences of recommended measures. Direct wetland intervention such as rehabilitation of erosion gullies should also be included for priority selected wetlands which will need to be identified during further investigations.

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Section 1 Introduction

1.1 Background

Wetland Consulting Services (Pty) Ltd (WCS) was appointed by Environmental Resources Management Southern Africa (Pty) Ltd (ERM) to undertake the specialist wetland study for the Environmental Impact Assessment (ESIA) study being undertaken for the Polihali Reservoir and Associated Infrastructure (PRAI) project.

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Wetlands are not only acknowledged to be important for biodiversity support, but also streamflow augmentation, flood attenuation, water purification and erosion control, and therefore for protecting the water resources in the catchments on which the LHWP depends.

1.2 Study Team

The WCS study team has a wealth of experience undertaking specialist wetland consulting projects within South Africa and adjacent countries, including extensive experience of the wetlands in Lesotho, with special emphasis on the high-altitude peat wetlands. Team members involved in the project are detailed in Table 1.1.

Table 1.1 Authors and Contributors to this Report

Aspect	Person	Organisation / Company	Qualifications
Wetlands	Dieter Kassier	Wetland Consulting Services (Pty) Ltd	• Bachelor of Science with Honours, Environmental Science (Aquatic Ecosystem Health). • 10 years wetland consulting experience throughout South Africa.
Wetlands	Gary Marneweck	Wetland Consulting Services (Pty) Ltd	• Bachelor of Science with Honours, Botany, Aquatic ecology major. • +20 years' experience in wetland research and consulting across Africa. • Extensive experience in Lesotho wetlands LHWP Phase 1; Orange-Senqu SPONGE Project; wetland rehabilitation as part of the Millennium Challenge Account etc.
Wetlands	Willnerie Janse van Rensburg	Wetland Consulting Services (Pty) Ltd	• M.Sc. Soil Science (In progress). • Bachelor of Science with Honours in Soil Science. • +1 years wetland consulting experience throughout South Africa.
Field Assistant	Motlatsi Phasumane		• Diploma in Agriculture • Bachelor of Agriculture

1.3 Scope of Specialist Study

The wetland study focussed on the proposed PRAI footprint areas, as well as the surrounding local catchment, referred to as the AoI or local catchment. The scope of work for this initial baseline wetland report included the following:

- Review of available information on the wetlands in the AoI or local Polihali catchment;
- Desktop mapping of the wetlands in the AoI local Polihali catchment based on available aerial imagery including the LIDAR data supplied by ERM to identify selected wetlands for the field survey;
- Review of existing data on the wetlands in the broader Polihali catchment and using other available aerial imagery to identify and select additional wetlands for field survey;
- Generation of Geographic Information System (GIS)-based desktop wetland maps of the AoI to provide an indication of the approximate extent and distribution of wetlands within the study area.
- A summer field survey of selected representative/prioritised wetlands identified in the Polihali catchment using a rapid sampling technique similar to that used in previous monitoring surveys for the Lesotho Highlands Development Authority (LHDA) (Mohale and Katse wetland survey 2014). The field survey involved:
    - Typing of the wetlands based on their hydro-geomorphic determinants using a modification of the system in Marneweck and Batchelor (2002), Kotze *et al* (2007) and Ollis *et al* (2013).
    - Collection of information (using a rapid qualitative assessment technique) on attributes such as habitat condition, adjacent land use, alteration of vegetation in the wetland and its local catchment, local hydrology, geomorphology, water quality and levels of disturbance.
    - An Importance and Sensitivity (IS) analysis was also undertaken on those wetlands sampled, using the scoring system applied in the procedure for determination of Resource Directed Measures for Wetland ecosystems (Rountree *et al*., 2013).
    - If peat was present in a system, and if considered of suitable/adequate depth for sampling, then at least one peat profile was cored and classified according to the Von Post humification scale (after von Post and Granlund, 1926) in order to provide a relative comparison of importance and sensitivity of Fens assessed.
    - Where appropriate and based on wetland type, a rapid functional assessment of the wetlands was conducted. For the purpose of this study the Wet-EcoServices tool (Kotze *et al*., 2007) was applied where appropriate.

1.4 Project Description and Location

The Polihali Reservoir is located in the Mokhotlong District of Lesotho (Figure 1.1). The Project comprises a number of components, as described below, and illustrated in Figure 1.2.

Polihali Dam, Saddle Dam and Reservoir: The proposed Polihali Dam is a 164 m high, concrete-faced rockfill dam with a side channel spillway located approximately 2 km downstream of the confluence of Khubelu and Senqu Rivers. The Saddle Dam is a 50 m high, concrete-faced rockfill embankment dam. During construction, the works will be protected by upstream and downstream embankment coffer dams with two diversion tunnels through the left flank, one 7 m and one 9 m in diameter. The Full Supply Level (FSL) for Polihali Reservoir is 2075 metres above sea level (masl). The flood demarcation level is 2080 masl and exceeds the 1:100 year flood level in the upper reaches of Polihali Reservoir. The Reservoir will inundate an area of approximately 5042 ha upstream of the Dam at the 2075 FSL (C4/SEED, 2008).

Quarries and Borrow Pits: material for the rockfill embankments are proposed to be obtained from quarries located on the left and right banks upstream of the Polihali Dam wall, primarily below the FSL. It is also proposed that material suitable for use as concrete aggregate will be obtained from the Tsilantso quarry. Advance geotechnical investigations has been undertaken to: i) confirm the quarry locations, ii) test the suitability of sand sourced from the Senqu and Khubelu Rivers near their confluence for use in concrete; and iii) locate additional quarry sources for use as concrete aggregates near the proposed bridge sites along the A1 Road.

Polihali to Katse Transfer Tunnel (Eastern Side): The Polihali to Katse transfer tunnel comprises the intake works and gate shaft at the western edge of the Polihali Reservoir (just upstream of the confluence with the Khubelu and Senqu Rivers. Associated infrastructure for construction will include site access roads, quarries, plant yards, labour accommodation, spoil areas and other tunnel works areas. Tunnelling activities will be done using both drill-and-blast methods and a Tunnel Boring Machine (TBM).

Major Bridges (Senqu, Khubelu and Mabunyaneng Bridges), and Associated Road Works: Three major bridges will be constructed on the Senqu, Khubelu and Mabunyaneng on the existing A1 national road between Oxbow and Mokhotlong. Portions of the A1 near the bridge locations will be realigned due to inundation by the reservoir, and a number of other existing roads and tracks will require replacement. A new pedestrian bridge (Tlhakola Bridge) is proposed across the reservoir at Tlhakola. Note: the scope of the PRAI ESIA does not include the replacement of existing roads and tracks that will be inundated or the construction of new feeder roads and minor bridges.

Bulk Power Supply and Telecommunications infrastructure to be located at the Polihali Reservoir that is included in this Environmental and Social Impact Statement (ESIS) are:

- A new substation at Masokong near the advanced infrastructure area;
- A new telecommunications mast on the hill; and
- A new 33kV powerline from Tlokoeng across the reservoir to the permanent Polihali Village (for future electrical distribution by the Lesotho Electricity Company (LEC) on the west side of the reservoir).

Note: the construction of a new 132kV powerline from Katse (Matsoku Intake substation) to Polihali (Masokong substation) and a new paved road from Ha Seshote to Polihali falls under a separate ESIS for the Polihali Western Access Corridor (PWAC, LHDA Contract 6004).

Project Housing and Site Establishment: The Phase II works will be built under a number of construction contracts, each of which will require accommodation facilities for staff and the labour force, site offices, workshops, plant yards, quarries, explosives stores and other works areas. In general, all temporary accommodation, offices and buildings needed for a particular construction contract will be provided by the relevant construction contractor and will removed at the end of construction.

Where facilities will have long-term use during the operation of the scheme, these will be designed and built to appropriate standards for permanent works under the advance infrastructure contracts.

The permanent facilities include:

- Staff accommodation at the Polihali Reservoir area, built as a village with all communal services. This will be the accommodation for the Employer, Engineer and Contractor's staff during construction of the Main Works and for operations staff following the completion of dam and tunnel construction;
- A visitors' lodge at the staff village, which will become a tourist facility; and
- The Employer's and Engineer's offices at the dam site, which will become the operations staff offices and visitor centre.

Temporary construction areas include labour camps and works areas for construction of the eastern sections of the Polihali Western Access Road (PWAR); Bulk Power Supply and Telecommunications (BPST) component, and Polihali-Katse Transfer Tunnel, and for the Polihali Dam and Saddle Dam and bridges. The labour camps will be provided with a raw water supply (contractors will provide their own sewage treatment and waste facilities). The Transfer Tunnel and Dam works areas/ sites will be provided with a raw water supply and a power supply.

Figure 1.1 Proposed Location of the Polihali Reservoir and Associated Infrastructure

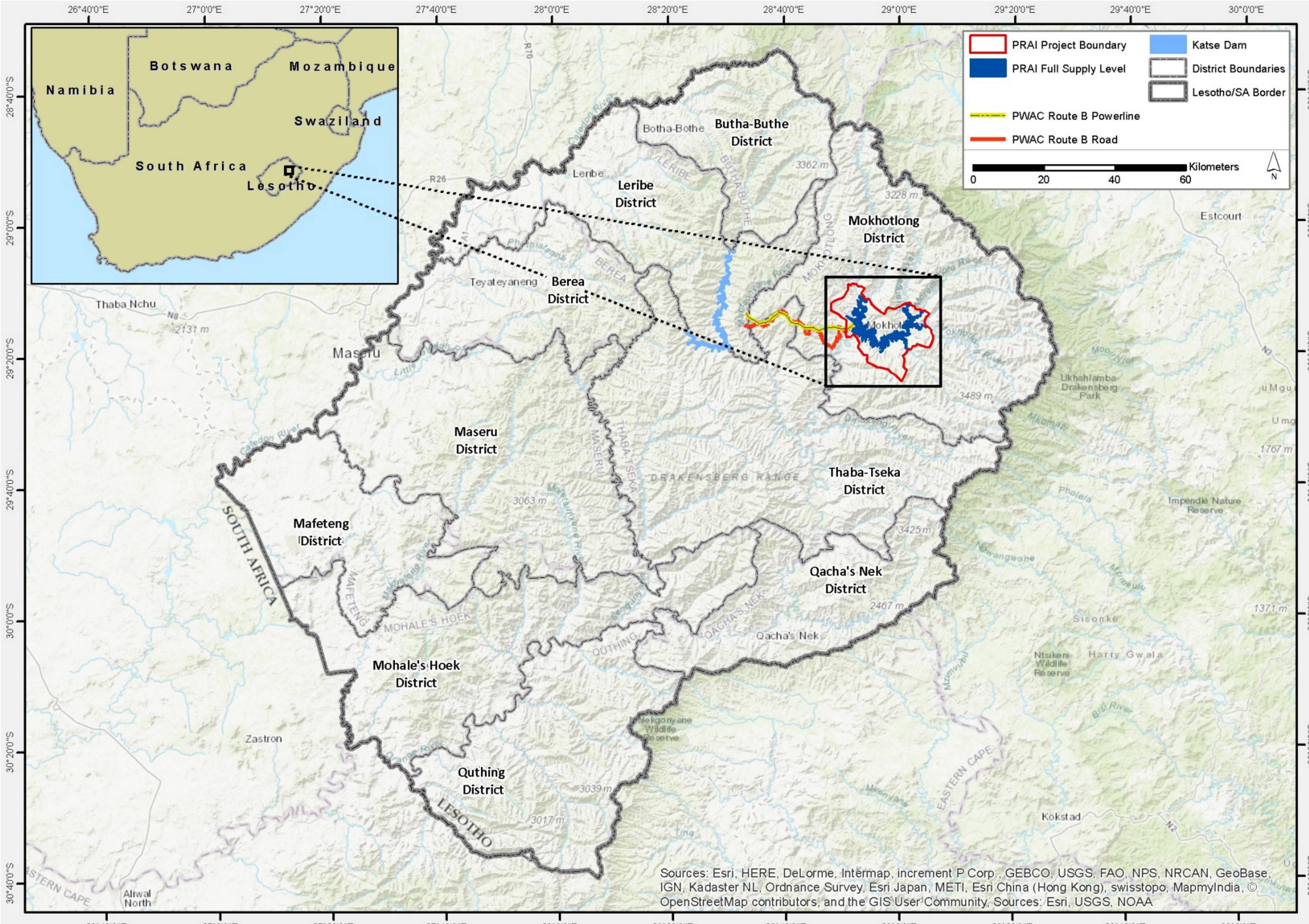
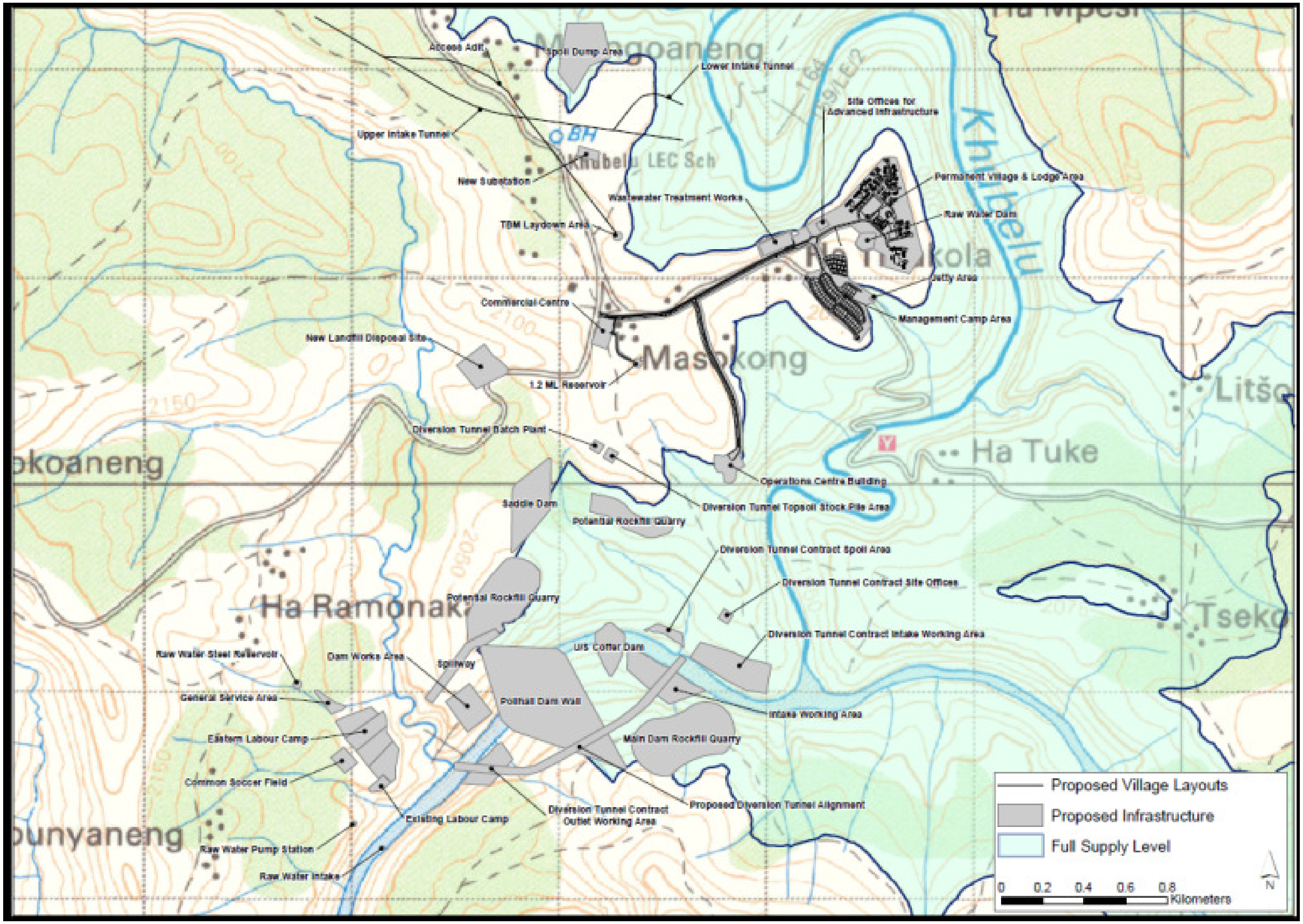


Figure 1.2 Proposed Polihali Dam Infrastructure Layout



Section 2 Institutional and Legal Framework

2.1 Relevant Institutions

The protection and management of Lesotho's wetlands falls within the mandates of a number of institutions:

The **Ministry of Tourism, Environment and Culture** aims to be a 'leading ministry in ensuring a well-managed environment and preserved cultural heritage' (http://www.gov.ls), so as to make Lesotho a quality ecotourism destination. The Department of Environment (DoE) promotes environmentally and culturally sustainable development and co-ordinates, advises, and regulates environmental management at all levels in the nation.

The **Ministry of Water Affairs** gives effect to the Water Act (2008) and promotes the sustainable use of water resources through an integrated water resources management approach.

The **Ministry of Forestry, Range and Soil Conservation** has as its mission the protection and rehabilitation of the physical environment through forestry, the management of rangeland resources and the control of soil erosion and harvesting of water so as to enhance the livelihoods of local communities.

2.2 Legislation and Policies

The mandate on the protection and wise-use of the environment, which includes the protection and wise-use of wetlands, is derived from Section 36 of the Constitution of Lesotho (Kingdom of Lesotho, 1993), which states that: "Lesotho shall adopt policies designed to protect and enhance the natural and cultural environment of Lesotho for the benefit of both present and future generations and shall endeavour to assure to all its citizens a sound and safe environment adequate for their health and well-being".

Lesotho has developed a framework of National Legislation to give effect to their constitutional and international obligations as signatory to a number of environmental conventions, as well as regional obligations as part of the Southern Africa Development Community (SADC), specifically the SADC Policy and Strategy for Environment and Sustainable Development.

2.2.1 Legislation

A summary of the most important environmental legislation applicable to wetlands is provided in Table 2.1 below.

Table 2.1 Legislation Relevant to Wetland Protection

Legislation	Requirements
Lesotho Environment Act No.10 of 2008	The Environment Act, 2008 provides a framework environmental law for the implementation of the National Environmental Policy. It sets out the principles of environmental management in Part II, Section 3(2) of the Act, which include: • To reclaim lost ecosystems where possible and reverse the degradation of natural resources; • To ensure that waste generation is minimised and safely disposed of; • To prevent interference with the climate and adverse disturbances of the atmosphere and take compensatory measures for any unavoidable interference; • To require prior environmental impact assessment of proposed projects or activities

Legislation	Requirements
	which are likely to have adverse effects on the environment or natural resources; and • To ensure that appropriate measures are taken to prevent soil erosion. The Environment Act specifies the need for an environmental licence that must be obtained for certain types of projects and activities prior to construction of the development. A list of these types of developments is provided in Part A of the First Schedule of the Act, and includes projects that affect wetlands. It governs the requirements for the preparation of Project Brief's and Environmental Impact Assessments (EIAs). Sections 61 and 62 of the Environment Act 10 of 2008 deal specifically with the protection of rivers, riverbanks and wetlands and provide specific orders and standards for the management of rivers, riverbanks, lakes, lakeshores and wetlands.
National Environmental Policy	The goal of the National policy on environment is to protect and conserve the environment with a view to achieving sustainable development for Lesotho. The policy includes numerous principles and strategies relevant to wetlands: • Integrating environment and development into decision making • Integrated approach to planning and management of land • Sustainable rangeland and mountain development • Conservation of biological diversity • Combating desertification and drought • Afforestation and revegetation • Water Resources Management • Environmental Impact Assessment, audits and monitoring
Lesotho Water Act 15 of 2008	• No person shall engage in an activity of using or abstracting water without a water use permit. • Where pollution occurs or is likely to occur as a result of activities on land, the person who owns, controls, occupies or uses the land in question shall be responsible for taking measures to prevent such pollution from occurring or continuing. • If there is a discharge of effluent into water courses a permit in accordance with the Environment Act No.10 of 2008, must be obtained. • Regulates the requirement for a construction permit for any water related activities such as storage, water purification, sewage treatment and effluent discharge.
Lesotho Water and Sanitation Policy, 2007	The objectives of the Lesotho Water and Sanitation Policy (LWSP) are to promote: • The proper management of the country's water resources and its sustainable utilisation; • Adequate and sustainable supply of potable water and sanitation services to all of the population of Lesotho; • Co-ordination and coherence in the management and development of water and other related natural resources, in order to maximise the resultant socio-economic benefits without compromising the sustainability of vital ecosystems; and • Harmonisation of processes and procedures followed by different development partners and other stakeholders in order to optimise available internal and external resources as well as ensure timely implementation of sector programmes.
National Range Resources Management Policy, 2014	• Purpose: To provide guidance for the development of effective strategies that combat land and vegetation degradation and motivate for improved legislation and implementation thereof. • Goal: To attain sustainable development and management of rangeland resources for an enhanced biodiversity, optimum productivity and improved livelihoods of the people of Lesotho. One of the Key Policy Areas of the National Range Resources Management Policy, 2014 includes the maintenance and protection of wetland areas. The objectives of the

Legislation	Requirements
	Policy relating to wetlands are: • To produce, maintain, and deliver current and historical geospatial wetland data and information for the Nation, in partnership with others; • To analyse and report on status, trends, threats, and assessments of wetlands and related habitats, with a focus on habitats that have experienced substantial wetland change or that are changing rapidly, and • To promote sound decision making and policy formulation through the development and dissemination of wetlands data and information through a variety of media.

2.2.2 Protected Species

The Lesotho Red Data Plant List (dated 2002) was compiled by Dombo *et al.* (2002). Plant species recorded within the sampled wetlands were compared to this list to determine if any listed protected species occur in wetland areas. The Dombo *et al.* (2002) list was also compared to the IUCN Red List for Lesotho plants (http://www.iucnredlist.org/search/link/598198a5-86804b5b) as available on the IUCN website.

Red Data plant species occurring in wetlands are detailed in Table 2.2.

Table 2.2 List of Wetland Species included in the Lesotho Plant Red Data and IUCN Red List for Lesotho

Dombo *et al.* (2002)				IUCN Website 2017	
Family	**Scientific Name**	**Status**	**Endemism**	**Red List Status**	**Year assessed**
EXTINCT & THREATENED					
APONOGETONACEAE	*Aponogeton ranunculiflorus* Jacot Guill. & Marais	CR B1B2d	Near-endemic	EN	2010
CYPERACEAE	*Carex killickii* Nelmes	VU D2	Near-endemic	-	-
HYACINTHACEAE	*Eucomis autumnalis* subsp. *clavata*	VU A1acdA2cd	-	-	-
LOWER RISK					
HYPOXIDACEAE	*Rhodohypoxis thodiana* (Nel) Hilliard & B.L. Burtt	LC-nt	Near-endemic	-	-
DATA DEFICIENT					
ASTERACEAE	*Helichrysum palustre* Hilliard	DD	Near-endemic	-	-
	Senecio austromontanus Hilliard	DD	Near-endemic?	-	-
CAMPANULACEAE	*Wahlenbergia doleritica* Hilliard & B.L. Burtt	DD	Near-endemic	-	-
CYPERACEAE	*Carex monotropa* Nelmes	DD	Near-endemic	-	-
IRIDACEAE	*Hesperantha crocopsis* Hilliard & B.L. Burtt	DD	Endemic	-	-
MESEMBRYANTHEMACEAE	*Delosperma clavipes* Lavis	DD	Endemic?	-	-
ORCHIDACEAE	*Corycium alticola* Parkman & Schelpe	DD	Endemic	-	-
	Disa basutorum Schltr.	DD	Near-endemic	-	-
	Disa cephalotes Rchb.f. subsp. *frigida* (Schltr.) H.P.Linder	DD	Near-endemic	-	-
	Disa oreophila Bolus subsp. *erecta* H.P.Linder	DD	Near-endemic	-	-
	Satyrium microrrhynchum Schltr.	DD		-	-
POACEAE	*Agrostis subulifolia* Stapf	DD	Near-endemic	LC	2013
	Anthoxanthum brevifolium Stapf	DD	Near-endemic	-	-
	Aristida monticola Hern.	DD	Near-endemic	-	-

Dombo *et al.* (2002)				IUCN Website 2017	
Family	**Scientific Name**	**Status**	**Endemism**	**Red List Status**	**Year assessed**
	Setaria obscura de Wit	DD	Near-endemic	-	-
Wetland species not included by Dombo *et al.* (2002) but listed by the IUCN in categories NT or higher					
AMBLYSTEGIACEAE	*Drepanocladus hallii* Broth. & Dixon	-	-	DD	2010
CYPERACEAE	*Carex subinflata* Nelmes	-	-	VU	2010
GRAMINEAE	*Colpodium drakensbergense* Hedberg & I.Hedberg	-	-	VU	2010
ISOETACEAE	*Isoetes transvaalensis* C. Jermy & Schelpe	-	-	NT	2010

NB. List of Wetland Species included in the Lesotho Plant Red Data List (Dombo *et al.*, 2002) as well as species included on the IUCN Red List for Lesotho. Only species likely to occur in wetland habitat and listed in category NT or higher are included.

2.3 Initiatives

Initiatives in Lesotho that are relevant to wetland conservation with specific reference to the Project Area are summarised in Table 2.3.

Table 2.3 Wetland Initiatives in Lesotho

Initiative	Activities and Relevance to PRAI
Millenium Challenge Corporation Wetlands Project	The Wetlands Project formed part of the Water Sector Project of the MCC which was designed to support Lesotho's vision to provide secure, adequate, sustainable and clean water supply and sanitation services to rural and urban consumers. Of relevance to the PRAI, the MCC project undertook pilot wetland restoration and monitoring in the upper Khubelu catchment.
ORASECOM and Sponge Project as part of the Transboundary Water Management in SADC Programme	The Orange-Senqu River Commission (ORASECOM) promotes the equitable and sustainable development of the resources of the Orange-Senqu River. ORASECOM provides a forum for consultation and coordination between the riparian states to promote integrated water resources management and development within the basin (www.ORASECOM.org). The pilot project of the "Protection of the Orange-Senqu Water Sources" or Sponge Project initiated by ORASECOM on the implementation of a strategy for the protection of the Orange-Senqu sources targeted the protection and conservation of 'sponges' in the Khubelu catchment. The project strove to improve the sustainable use of wetlands in the Khubelu catchment of the Lesotho Highlands. Specific objectives were: • That rangeland management in the Khubelu catchment is improved. • Rehabilitation of degraded wetlands in the Khubelu catchment. • Providing results of monitoring of wetlands in the Khubelu catchment, research and a collection of lessons learned to be available for replication in other catchments. The project is an integral part of RSAP IV, namely of Programme 6.4.5 "Protection of Fragile Ecosystems (Wetland Management). It is implemented by the Lesotho Department for Water Affairs in cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, which is commissioned by the German government with co-financing from the Government of the United Kingdom acting through DFID.
Integrated Catchment Management	The Integrated Catchment Management (ICM) Programme forms part of the LHDA's Environmental Action Plan. It includes the establishment of Catchment Management Authorities, Environmental Awareness and Recycling of Waste Material. The Programme specifically addresses erosion and included various rehabilitation initiatives, including

Initiative	Activities and Relevance to PRAI
(ICM)	wetland rehabilitation at Bokong.

2.4 International Conventions

Lesotho is a signatory to a number of international conventions of relevance to the PRAI project. These are summarised in Table 2.4 below, with reference to the relevant PRAI component:

Table 2.4 Examples of International Conventions and their Relevance to PRAI

Convention	Provisions and Relevance to PRAI
United Nations Convention on Biological Diversity (UNCBD)	Requires signatories to make provision for the conservation of biological diversity, sustainable use of its components; and fair and equitable sharing of benefits arising from genetic resources. Wetlands that will be affected by the PRAI project support unique ecosystems and species, contributing to the overall biodiversity of the area and the country. Wetlands are also known to provide important ecosystem services of value to surrounding and downstream ecosystems.
The Convention on Wetlands also known as the Ramsar Convention	Requires commitments from its member countries to maintain the ecological character of Wetlands of International Importance[1].The mission statement of the Ramsar Convention is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". One of the three pillars of the Convention requires that signatories "work towards the wise use of all of their wetlands". Numerous wetlands will be affected by the PRAI project. A single Ramsar wetland occurs within Lesotho, namely Lets'eng-la-Letsie, located in Quthing in the south of the country. This Ramsar wetland will not be impacted by the PRAI project.
Convention on International Trade in Endangered Species (CITES)	Regulates and enforces controls relating to international trade in specimens of wild animals and plants. Wetlands that will be affected by the PRAI project could potentially support various Red Data listed species that require protection and would be covered by the CITES convention.
Convention to Combat Desertification	The Convention to Combat Desertification aims to reverse and prevent desertification/land degradation. Overutilisation of natural resources by communities' dependent on these natural resources exacerbated by drought conditions has led to extensive land degradation in the PRAI Area of Influence. Land degradation affects the wetlands of the area both directly through erosion and degradation of wetland habitat, and indirectly through changing catchment characteristics, specifically increasing runoff.

[1] http://www.ramsar.org

Section 3 Approach and Methods

3.1 Introduction

The wetland study includes desktop mapping of the wetlands present in the local catchment, as well as targeted field surveys of a number of selected wetlands to allow for ecological characterisation of these wetlands. Methods utilised are based in large part on methodologies developed and widely applied in wetland assessment studies for EIA purposes in South Africa, but also commonly applied in Lesotho and other southern African countries.

3.1.1 Approach

The existing wetland information for the PRAI as captured in the CES (2014) report formed a part of the Botanical Baseline Survey. Similarly the wetland data provided in the Rall *et al*., (2008) report formed part of more general desktop habitat mapping of the general PRAI area. The primary limitation of the existing wetland data is therefore the lack of a focused wetland study specifically addressing the wetlands of the PRAI.

A focused wetland study was therefore undertaken using available aerial imagery in conjunction with the LIDAR data of the dam basin area to identify and delineate wetlands at a desktop level. Selection and prioritisation of the desktop-mapped wetlands for field investigations was based on consideration of the following:

- Whether or not the wetland is located below the FSL of the reservoir;
- Whether or not the wetland is expected to be affected by dam-related infrastructure;
- Distance from the reservoir, with higher priority systems (from a survey perspective) being those closer to the dam;
- Accessibility, with those that are most accessible assigned greater priority over those that are less accessible (for logistical reasons);
- Whether or not the wetland is representative of a particular type, considered to contribute a particular ecosystem service, or considered to have a particular ecological importance within the catchment; and
- Whether or not the wetland is representative of a certain category of systems impacted by a particular type of land-use.

An initial number of 50 wetlands/areas of possible wetland habitat were identified as targets for a summer field survey, though eventual survey sites were adapted based on access conditions encountered in the field, additional wetlands identified during the field survey, and the discarding of sites found not to support wetland habitat. Further detail on the sampling sites included in the survey is provided in Section 3.3.

3.1.2 Methods

Target wetlands and possible wetland signatures identified and prioritised for sampling during a desktop wetland mapping exercise were visited and sampled in the field. A number of additional wetlands identified on site were also added to the list of target wetlands visited. A total of 58 sites were surveyed, which included 46 wetlands sampled in detail. The bulk of the sampled wetlands (35) were located within the local catchment or AoI. A further 11 wetlands were located higher up the catchments of the Seate, Moremoholo and Bobatsi catchments, but within a 15 km radius of the reservoir FSL. These more distant wetlands were included within the survey to provide a broader perspective of wetlands within the affected catchments and to specifically include some high altitude wetlands in the survey.

Field work was undertaken over 12 days from the 26 January 2017 to the 6 February 2017 by a team of wetland specialists. A full list of wetlands surveyed is provided in Table 3.5 and illustrated in Figure 3.2.

The methodology adopted for the wetland survey is summarised below, with more detail provided in the following sections:

- A summer field survey of selected representative/prioritised wetlands in the Polihali catchment was undertaken using a rapid sampling technique similar to that used in previous monitoring surveys for LHDA Phase 1 areas (i.e. Mohale and Katse wetland monitoring surveys by Anchor, 2014). The field survey involved:
  - Confirming the presence/absence of wetland habitat through observations of wetland indicator plant species and observations of the wetland soil profiles exposed with a hand-held soil auger;
  - Typing of the wetlands based on their hydrogeomorphic (HGM) determinants using a modification of the system described in Kotze, Marneweck, Batchelor, Lindley and Collins (2007) and Ollis, Snaddon, Job and Mbona (2013);
  - Collection of information (using a rapid qualitative assessment technique) on attributes such as habitat condition, adjacent land use, alteration of vegetation in the wetland and its local catchment, local hydrology, geomorphology, water quality and levels of disturbance; Note: The assessment of these attributes were used to establish the health of the wetlands sampled and formed the basis of a Present Ecological State (PES) categorisation (using a modification of the scoring system used by Kleynhans, 1996 and Macfarlane *et al*., 2007) of the systems assessed. As part of this categorisation, the likely trajectory of change from current conditions (assuming a continuation of the status quo) was also determined;
  - An Importance and Sensitivity (IS) analysis was undertaken on the sampled wetlands using the indicators and scoring system as provided in Rountree, Malan and Weston (2013);
  - Where peat was found in a system, and where it was of suitable/adequate depth for sampling, then at least one peat profile was cored and classified according to the Von Post humification scale (after von Post and Granlund, 1926) in order to provide a relative comparison of importance and sensitivity of Fens assessed; and
  - Where appropriate and based on wetland type, a rapid functional assessment of the wetlands was conducted. For the purpose of this study the Wet-EcoServices tool (Kotze *et al*, 2007) was applied to groupings of similar wetlands (based on HGM type). This tool enables one to make relative comparisons of systems based on a logical framework that measures the likelihood that a wetland is able to perform certain functions.

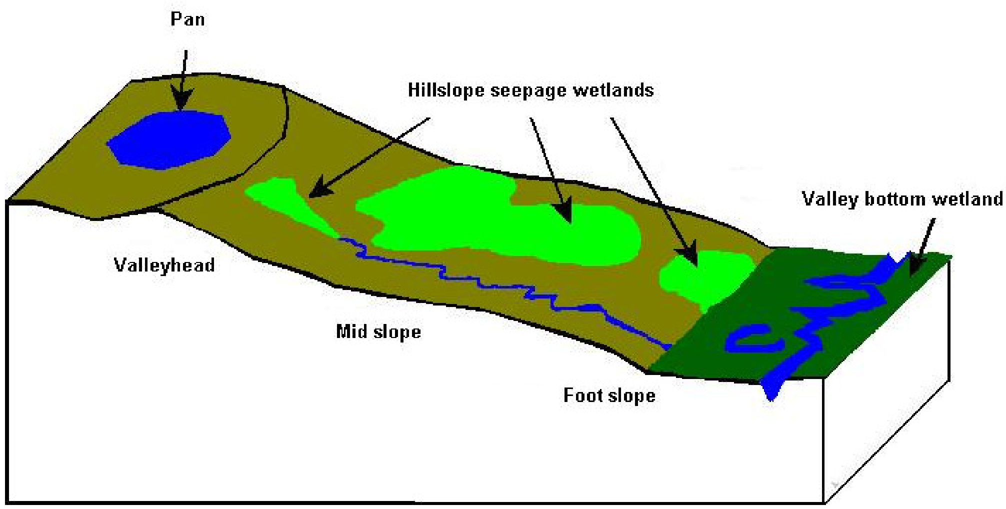
Following on from the baseline assessment, a wetland impact assessment was undertaken that included the following tasks:

- Identification of the likely impacts of the project on wetlands, including direct impacts in the project footprint area, as well as the risks of wetland degradation from indirect impacts (displacement of grazing and settlement from the reservoir area to higher lying areas), induced and cumulative impacts;
- Assessment of the identified impacts to wetlands using the impact assessment methodology provided by ERM; and
- Identifying and recommending mitigation measures for wetlands including direct interventions (such as for example, gabions) through to broader wetland protection measures relating to agricultural practices, livestock and catchment rangeland management. Identified mitigation measures were informed from a review of the results of MCC wetland studies, Phase 1 Wetland Resources Monitoring studies, and the findings and experience of the pilot project of the "Protection of the Orange-Senqu Water Sources" or Sponge Project initiated by ORASECOM; and
- Providing recommendations for long-term monitoring of selected wetlands that will be relevant to the development of a future Biodiversity Management Plan.

3.1.2.1 Wetland Typing

The presence of wetlands in the landscape can be linked to the presence of both surface water and perched groundwater. Wetland types are differentiated based on their hydro-geomorphic (HGM) characteristics; i.e. on the position of the wetland in the landscape, as well as the way in which water moves into, through and out of the wetland systems. A schematic diagram of how these wetland systems are positioned in the landscape is given in Figure 3.1 below.

Figure 3.1 Diagram Illustrating the Position of the Various Wetland Types within the Landscape



Use was made of 1:50,000 topographical maps, 1:10,000 orthophotos, Google Earth Imagery and the LIDAR imagery supplied by ERM to create digital base maps of the study area onto which the wetland boundaries could be delineated using ArcMap 10. The wetlands systems were mapped from available aerial imagery at a scale of 1:5000 wherever possible and where the imagery was of sufficient resolution for this purpose. Due to the extent of the area and the mapping scale used, the actual extent of the boundaries of these systems may be underestimated or overestimated in places. This may range from metres to tens of metres but generally is regarded as being of sufficient accuracy for the purposes of this study. The desktop delineation of wetland areas was undertaken by identifying rivers and wetness signatures on the digital base maps.

The delineated wetlands were then typed using a hydro-geomorphic (HGM) classification system based on the system proposed by Brinson (1993), and most recently modified for use in South African conditions by Ollis *et al*. (2013) and Kotze *et al*. (2007). The HGM classification system differentiates wetlands based on landform setting and the way that water moves into, through and out of the wetland. Wetlands were typed to Level 4A (HGM classification) of the classification system detailed by Ollis *et al*. (2013).

3.1.2.2 Peat Profiling

Where peat was found to be present in a system, and was of suitable/adequate depth for sampling (generally more than 50 cm), then one to three peat profiles were cored and classified according to the Von Post humification scale (after von Post and Granlund, 1926) in order to provide a relative comparison of importance and sensitivity of Fens assessed. Wetlands in which peat was found and cored for peat were generally located outside the Polihali AoI in higher altitude areas. Wetlands 2, 6, 7, 8, 9 and 10 were cored for peat, as well as Wetland 19 located in the Sheep Stud. The Von Post humification scale is provided in Table 3.1.

Table 3.1 Von Post Humification Scale (after von Post and Granlund, 1926)

Symbol	Description
H1	Completely undecomposed peat which, when squeezed, releases almost clear water. Plant remains easily identifiable. No amorphous material present.
H2	Almost entirely undecomposed peat which, when squeezed releases clear or yellowish water. Plant remains still easily identifiable. No amorphous material present.
H3	Very slightly decomposed peat which, when squeezed, releases muddy brown water, but no peat passes between the fingers. Plant remains still easily identifiable and no amorphous material present.
H4	Slightly decomposed peat which, when squeezed, releases very muddy dark water. No peat is passed between the fingers but the plant remains are slightly pasty and have lost some of their identifiable features.
H5	Moderately decomposed peat which, when squeezed, releases very **"muddy" water with a very small** amount of amorphous granular peat escaping between the fingers. The structure of the plant remains is quite indistinct although it is still possible to recognise certain features. The residue is very pasty.
H6	Moderately highly decomposed peat with a very indistinct plant structure. When squeezed, about one-third of the peat escapes between the fingers. The residue is very pasty but shows the plant structure more distinctly than before squeezing.
H7	High decomposed peat. Contains a lot of amorphous material with very faintly recognisable plant structure. When squeezed, about one-half of the peat escapes between the fingers. The water, if any is released, is very dark and almost pasty.
H8	Very highly decomposed peat with a large quantity of amorphous material and very indistinct plant structure. When squeezed, about two-thirds of the peat escapes between the fingers. A small quantity of pasty water may be released. The plant material remaining in the hand consists of residues such as roots and fibres that resist decomposition.
H9	Practically fully decomposed peat in which there is hardly any recognisable plant structure. When squeezed it is a fairly uniform paste.
H10	Completely decomposed peat with no discernible plant structure. When squeezed, all the wet peat escapes between the fingers.
B1	Dry peat
B2	Low moisture content
B3	Moderate moisture content
B4	High moisture content
B5	Very high moisture content

3.1.2.3 Functional Assessment

Numerous functions are typically attributed to wetlands, which include nutrient removal (and more specifically nitrate removal), sediment trapping (and associated with this is the trapping of phosphates bound to iron as a component of the sediment), stream flow augmentation, flood attenuation, trapping of pollutants and erosion control. Many of these functions attributed to wetlands are wetland type specific and can be linked to the position of wetlands in the landscape as well as to the way in which water enters and flows through the wetland. Thus not all wetlands can be expected to perform all functions, or to perform these functions with the same efficiency.

WET-EcoServices is a tool developed to provide an initial, high-level, qualitative assessment of the goods and services that individual wetlands provide so as to aid informed planning and decision making (Kotze *et al.*, 2007). In interpreting the results of the WET-EcoServices assessment, the following must be borne in mind:

- The level of services delivered is based on current as well as future potential benefits (i.e. a wetland might have high ability to perform a service such as trapping pollutants but is currently afforded little opportunity to perform the service due to a lack of pollutants within the wetland catchment, resulting in an intermediate score);

- WET-EcoServices scores make no reference to the size of the wetland (i.e. a 3 ha wetland and a 300 ha wetland might both score 3 for flood attenuation. Given the size of the wetlands in question, the overall importance of flood attenuation performed by the 300 ha wetland is obviously greater than for the 3 ha wetland); and
- Scores between different hydro-geomorphic wetland units (i.e. different wetland types) should not be compared directly.

A functional assessment of the wetlands on site was undertaken using the level 2 assessment as described in "WET-EcoServices" (Kotze *et al.*, 2007). This method provides a scoring system for establishing wetland ecosystem services. It enables one to make relative comparisons of systems based on a logical framework that measures the likelihood that a wetland is able to perform certain functions. Given the large number of wetlands within the Polihali AoI, the wetlands were grouped based on hydro-geomorphic type and a functional assessment was undertaken for each wetland type.

3.1.2.4 Present Ecological State (PES) Assessment

Use was made of the Present Ecological State (PES) assessment methodology described as part of the Resource Directed Measures for the Protection of Water Resources, Volume 4 ((Department of Water Affairs and Forestry (DWAF), 1999)). This method for assessing the PES of wetlands is based on that developed by Kleynhans (1999) for determining the habitat integrity of rivers. It estimates the degree of habitat integrity on the basis of anthropogenic change relative to a reference state. A qualitative assessment is made of the changes to wetland hydrology, water quality, geomorphology, vegetation and fauna using indicators of such change. On the basis of this assessment, the wetland is categorised on a scale from natural/unmodified to critically modified and assigned a PES category, according to that indicated in Table 3.2. PES categories were adjusted as necessary in cases where the specialist was of the opinion that the score or category derived did not take certain factors on site into account that may influence the state score derived.

Table 3.2 Scoring System Used for the PES Assessment (after DWAF, 1999)

Mean*	Category	Explanation
Within generally acceptable range		
>4	A	Unmodified, or approximates natural condition.
>3 and <=4	B	Largely natural with few modifications, but with some loss of natural habitats.
>2.5 and <=3	C	Moderately modified, but with some loss of natural habitats.
<=2.5 and >1.5	D	Largely modified. A large loss of natural habitat and basic ecosystem function has occurred.
Outside generally acceptable range		
>0 and <=1.5	E	Seriously modified. The losses of natural habitat and ecosystem functions are extensive.
0	F	Critically modified. Modification has reached a critical level and the system has been modified completely with almost complete loss of natural habitat.

3.1.2.5 Importance and Sensitivity (IS) Assessment

Use was made of the Importance and Sensitivity (IS) assessment tool developed by Rountree, Malan and Weston (2013). The tool allows the categories to be determined for each of the following criteria:

- Ecological Importance and Sensitivity (EIS) – considers the presence of Red Data species, populations of unique species, importance for migration, breeding and feeding sites for species, the protection status of the wetland and vegetation type/s present, the diversity of habitat types, the regional context of ecological integrity of the wetland, and the sensitivity of the wetland to changes in hydrology and water quality;

- Hydro-functional importance – considers the ecosystem services the wetland provides in terms of flood attenuation, stream-flow regulation water quality enhancement, sediment trapping, phosphate, nitrate and toxicant assimilation, erosion control, and carbon storage; and
- Direct human benefit importance - considers the subsistence uses and cultural benefits of the wetland system.

On the basis of this assessment, each of the criteria above are scored and categorised on a scale from 0 to 4 and assigned a category, according to that indicated in Table 3.3. The overall IS of the wetland is derived from the highest of the three main criteria (EIS, hydro-functional importance or direct human benefit importance).

Table 3.3 Scoring System Used for the IS Assessment (after Rountree *et al.*, 2013)

Ecological Importance and Sensitivity Categories	Range of IS Scores
Very high Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2
Low/marginal Wetlands that are considered not to be ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1

3.1.3 Assumptions and Limitations

The following assumptions and limitations apply to this study:

- Given the large size of the Project area and the nature and inaccessibility of the terrain, it was not possible to sample all wetlands. A total of 58 sites were surveyed, which included 46 representative wetlands. It is likely that smaller wetland systems, specifically small areas of riparian wetland or isolated springs were missed during the desktop wetland delineation;
- This study was focussed on wetland habitats and does not specifically include consideration of floodplain, riparian areas or water courses not displaying typical wetland signatures or characteristics;
- Wetland boundaries reflect the ecological boundary where the interaction between water and plants influences the soils, but more importantly the plant communities. The depth to the water table where this begins to influence plant communities is approximately 50 cm. This boundary, based on plant species composition, can vary depending on antecedent rainfall conditions, and can introduce a degree of variability in the wetland boundary between years and/or sampling period;
- The wetland systems were mapped from the available 2012 LIDAR and Google Earth imagery at a scale of 1:5000 wherever possible and where the imagery was of sufficient resolution for this purpose. Due to the extent of the area and the mapping scale used, the actual extent of the

boundaries of these systems may be underestimated or overestimated in places. This may range from metres to tens of metres but generally is regarded as being of sufficient accuracy for the purposes of this study;

- Plant species lists for wetland plants compiled during field work should not be considered complete, but provide an accurate representation of the key and dominant species recorded within the wetlands; and
- No information is available on the wetlands in the PRAI, specifically the more important Valleyhead Fen wetlands in the upper parts of the catchment, which can inform the baseline (pre-project) rate of change in the wetland health status. It is assumed that these wetlands - as for most such wetlands in Lesotho Highlands - are exhibiting a decline in condition from overgrazing. This limits the ability to infer and compare future rate of change that may be induced by the project and to separate this from 'natural' background change. Future wetland monitoring activities undertaken as part of the future BMP or ICM strategy scope of work should attempt to differentiate PRAI project induced change from existing changes due to natural trends in land use practices and/or climatic changes. However, it is acknowledged that differentiating natural trends in land use pressures on wetlands from increasing pressures caused by displacement of land use from the reservoir will be difficult to distinguish without annual records of livestock numbers and grazing areas. Correlating wetland condition with climatic variables will require monitoring of rainfall (at minimum) in the sub-catchments of monitored wetlands. The approach to this monitoring will need to be developed and confirmed as part of the BMP or ICM initiatives.

3.2 Review of Previous Data

3.2.1 Reservoir Area & Local Catchment

The three main documents that were made available, and which specifically refer to, and deal with wetlands in the Project Area, and which were reviewed for the purpose of identifying gaps in wetland information, and refining/updating the proposed wetland study methodology below, are:

1. Coastal & Environmental Services (CES), July 2014: *Lesotho Highlands Water Project (LHDA Contract No. 6002), Summary Report: Biological and Archaeological (Including Heritage) Baseline and Impact Assessment*, Prepared for LHDA by CES, Grahamstown.
2. Coastal & Environmental Services (CES), August 2014: *Lesotho Highlands Water Project (LHDA Contract No. 6002), Baseline Botanical Survey*, Prepared for LHDA by CES, Grahamstown.
3. Rall JL, Letsela O, Jacobsen N, Mahlelebe T, Brown C, August 2008. *Lesotho Highlands Water Project (LHWC Contract No. 001), Consulting Services for the Feasibility Study for Phase II – Stage 2, Biophysical Impact Assessment Supporting Report, Final Report V2.0*, Prepared by Consult 4 Consortium and SEED Consult for the LHWC, Report No. LHWC 001/217-2007, P RSA D000/00/6307.

A brief summary of the information that can be garnered from the above reports is provided in Table 3.4.

Table 3.4 Summary of Baseline Data Available on Wetlands in the Project Area

Baseline data required	Baseline Report Reference	Methods and Survey Areas	Information Provided in Available Baseline Reports
• Typing / characterisation and mapping of wetlands in the dam basin area as well as broader catchment area. • Determination of extent, type and ecological categorisation of wetlands in the inundation area. • Determination of extent, type and ecological categorisation of prioritised wetlands (those identified / targeted for field survey) in the broader catchment area. • Descriptions of peat profiles in selected wetlands.	Rall *et al*. (2008). Desktop habitat mapping of the Phase 2 area. CES (2014) Baseline Botanical Survey, Annexure A. Table 3.5 gives coordinates for sampled Seeps shown in Figure 4.4.	No specific wetland study has been undertaken. The CES (2014) Baseline Botanical Survey did however identify, partly characterise, and provide a point data map of the Seeps visited/sampled as part of the study. The Rall *et al*. (2008) desktop habitat mapping of the Phase 2 lay out area only mapped wetlands that were visually assessed to be functioning and which had a low level of impact. Extrapolation was used for wetlands below the proposed dam wall to provide an estimate of probable extent of wetland habitats.	The Rall *et al*. (2008) desktop habitat mapping of the Phase 2 lay out area provided some general information of wetland condition in the area and some wetland desktop survey hectare based results in Table 6-2. The study concluded that the wetlands in the area are generally degraded and that a total of 80.32 hectares of wetland will be inundated by the proposed dam, which constitutes 0.3% of the regional occurrence of wetlands. The study concluded that the wetlands are highly degraded within the immediate area of impact and that the impacts on the wetlands are therefore unlikely to be significant. The CES (2014) Baseline Botanical Survey provides a description of 11 Seeps sampled in the project area; the dominant plant species identified and a general description of the status of the Seeps. Two of the Seeps were identified as intact Seeps (dominated by *Carex subinflata* and *Gunnera perpensa*. These occur in an area managed by the Department of Agriculture (Phutha Sheep Stud area). Table 6-1 of the CES (2014) Baseline Botanical Survey indicated Threatened Plant Species and Plant Species of Special Concern that are likely to occur within the study area (some of which are likely to occur in the wetlands). Some mitigation recommendations are provided for those Seeps that will remain within the project site area indicated in the CES (2014) Baseline Botanical Survey report.

3.3 Surveys and Data Analysis

3.3.1 Sampling Sites/ Areas

Field work was undertaken over 12 days from 26 January 2017 to 6 February 2017 by a team of wetland specialists.

A total of 58 sites were surveyed, which included 46 wetlands sampled in detail. A full list of wetlands surveyed is provided in Table 3.5 and illustrated in Figure 3.2.

Figure 3.2 Location of Wetlands and Potential Wetlands Sampled during Fieldwork Undertaken in January/February 2017

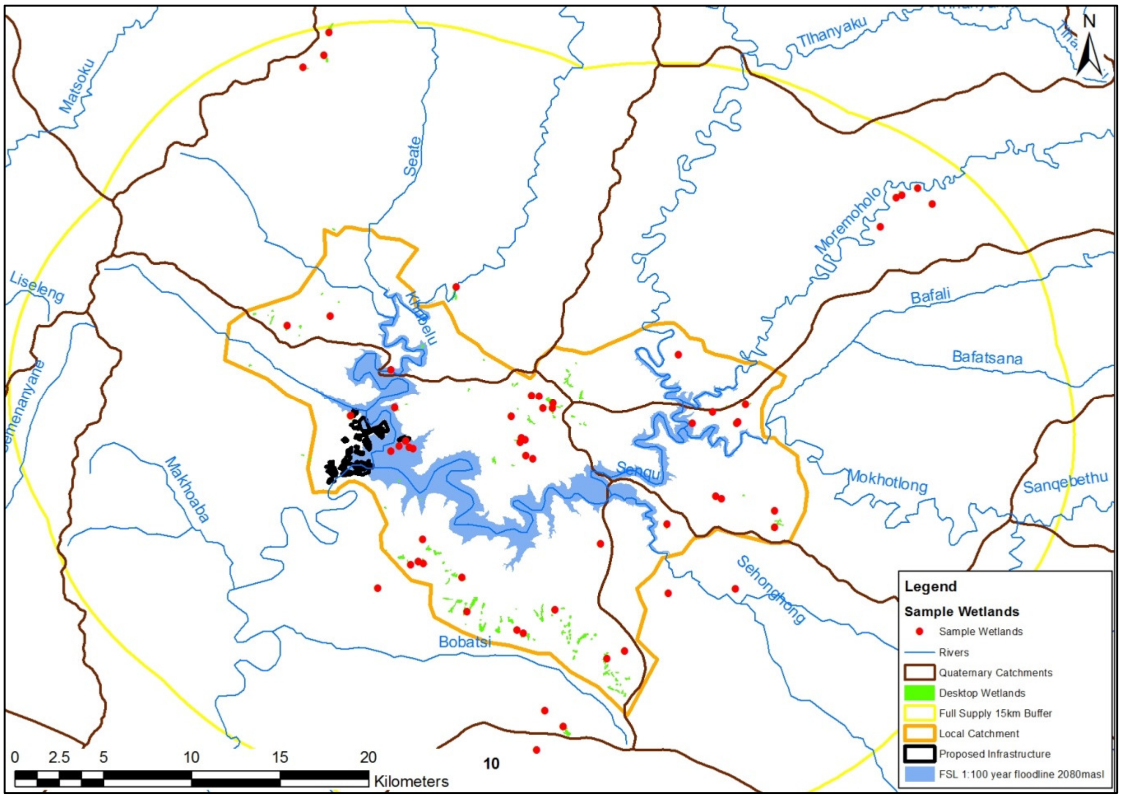


Table 3.5 Wetlands Sampled during Fieldwork Including the Wetland Type, Location, and Catchment

Number	Catchment	Wetland Type	Co-ordinates		Additional Details
1	Moremoholo	Seep Wetland	-29.151	29.143	
2	Moremoholo	Fen (Valleyhead)	-29.150	29.146	Peat sampled
3	Moremoholo	Valleyhead Seep Wetland	-29.146	29.154	
4	Moremoholo	Seep Wetland	-29.154	29.161	
5	Seate	Fen (Valleyhead)	-29.067	28.854	
6	Seate	Fen (Seep)	-29.085	28.841	Peat sampled
7	Seate	Fen (Valleyhead)	-29.079	28.852	Peat sampled
8	Bobatsi	Fen (Seep)	-29.412	28.964	Peat sampled
9	Bobatsi	Fen (Valleyhead)	-29.420	28.974	Peat sampled

Number	Catchment	Wetland Type	Co-ordinates		Additional Details
10	Linaheng Tributary	Fen (Seep)	-29.432	28.960	Peat sampled
11	Senqu	Seep Wetland	-29.386	28.996	
12	Senqu	Seep Wetland	-29.382	29.006	
14	**Khubelu**	**Sheetrock Wetland**	**-29.279**	**28.897**	
16	Khubelu	Seep Wetland	-29.276	28.952	
17	Khubelu	Seep Wetland	-29.273	28.952	
18	Khubelu	Seep Wetland	-29.274	28.954	
19	Mokhotlong	Fen (Valleyhead)	-29.319	29.081	Peat sampled
20	Mokhotlong	Seep Wetland	-29.266	29.062	
21	Mokhotlong	Seep Wetland	-29.265	29.062	
25	Sehonghong	Seep Wetland	-29.317	29.026	
27	Senqu	No Wetland	-29.260	29.050	
28	Senqu	No Wetland	-29.231	29.032	
29	Moremoholo	Sheetrock Wetland	-29.256	29.066	
30	Senqu	No Wetland	-29.266	29.039	
31	Khubelu	Valleyhead Seep Wetland	-29.258	28.968	
32	Khubelu	Sheetrock Wetland	-29.258	28.963	
33	Khubelu	Valleyhead Seep Wetland	-29.262	28.947	
37	Khubelu	Seep Wetland	-29.251	28.959	
38	Senqu	Seep Wetland	-29.338	28.896	
39	Senqu	Seep Wetland	-29.337	28.902	
40	Senqu	Sheetrock Wetland	-29.344	28.922	
41	Senqu	Sheetrock Wetland	-29.373	28.953	
42	Senqu	Sheetrock Wetland	-29.361	28.969	
43	Senqu	Sheetrock Wetland	-29.362	28.925	
44	**Khubelu**	**Seep Wetland**	**-29.261**	**28.866**	
46	Khubelu	Valleyhead Seep Wetland	-29.216	28.833	
47	Khubelu	Seep Wetland	-29.258	28.888	
48	**Khubelu**	**Seep Wetland**	**-29.280**	**28.886**	
49	Khubelu	Floodplain	-29.201	28.918	
50	Khubelu	Valley Bottom Wetland	-29.256	28.968	
51	**Khubelu**	**Seep Wetland**	**-29.277**	**28.890**	
52	**Khubelu**	**Sheetrock Wetland**	**-29.275**	**28.893**	
53	**Khubelu**	**Seep Wetland**	**-29.278**	**28.895**	
54	Sehonghong	Seep Wetland	-29.352	29.027	
55	Senqu	Seep Wetland	-29.336	28.900	
56	Senqu (Downstream)	Sheetrock Wetland	-29.350	28.879	
57	Senqu	Valleyhead Seep Wetland	-29.327	28.993	
58	Senqu	Sheetrock Wetland	-29.371	28.950	

Note: Table entries in bold and highlighted light blue denote wetlands within the inundation basin. Co-ordinates provided in geographic co-ordinate system WGS 1984.

3.3.2 Impact Assessment

Following on from the baseline assessment, a wetland impact assessment was undertaken. This involved:

- The identification of the likely impacts of the project on wetlands, including direct impacts, as well as the risks of wetland degradation from indirect impacts (mainly as a result of likely changes in the hydrology), induced and cumulative impacts;
- Assessment of the identified impacts to wetlands using the impact assessment methodology provided by ERM;
- Identifying and recommending mitigation measures for wetlands including direct interventions (such as for example, where along the road route specific stormwater management measures will be required) through to broader wetland protection measures relating to, for example, general avoidance and protection requirements during the phases of infrastructure development and operation; and
- Providing recommendations for long-term monitoring of selected wetlands that will be relevant to the development of a future Biodiversity Management Plan.

Impacts were assessed in accordance with the standard impact assessment methodology provided by ERM and the ratings provided in Table 3.6. However, the impact significance table for biodiversity impacts has been modified slightly to allow for a Critical rating for biodiversity impacts of large magnitude on biodiversity receptors of High or Very High sensitivity (e.g. endangered/critically endangered species). This is to align with critical habitat triggers used by IFC PS6 (IFC 2012a, b). A category of Very High sensitivity has been added to enable better differentiation of different portions of the route for ecological risks.

Table 3.6 Impact Significance Rating Table

Evaluation of Significance		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	Medium	High / Very High
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Critical
	Positive Impacts			
	Positive	Minor	Moderate	Major

Magnitude ratings are derived from a combination of the assessed extent and duration of an impact, and scale and frequency, where impacts can be quantitatively calculated or modelled, e.g. where a percentage of a habitat or species loss can be determined. Where major unplanned events (i.e. ones which cannot be reasonably foreseen to occur (e.g. an oil spill or dam tailings break), the likelihood of the event occurring is also factored into the assignment of magnitude.

Sensitivity ratings were assigned based on the biodiversity importance of the vegetation or faunal receptors (i.e. threatened status or other values such as ecological condition or functional value) and taking into consideration their vulnerability and resilience to the particular impact assessed.

Significance ratings are assigned for impacts before mitigation is applied ('pre-mitigation') and after mitigation has been applied ('residual')[2].

A more detailed description of the methodology is provided in the Environmental Impact Statement report.

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[2] Residual impact ratings are often referred to as post-mitigation ratings elsewhere but are considered the same in this report.

Section 4 Baseline Environment

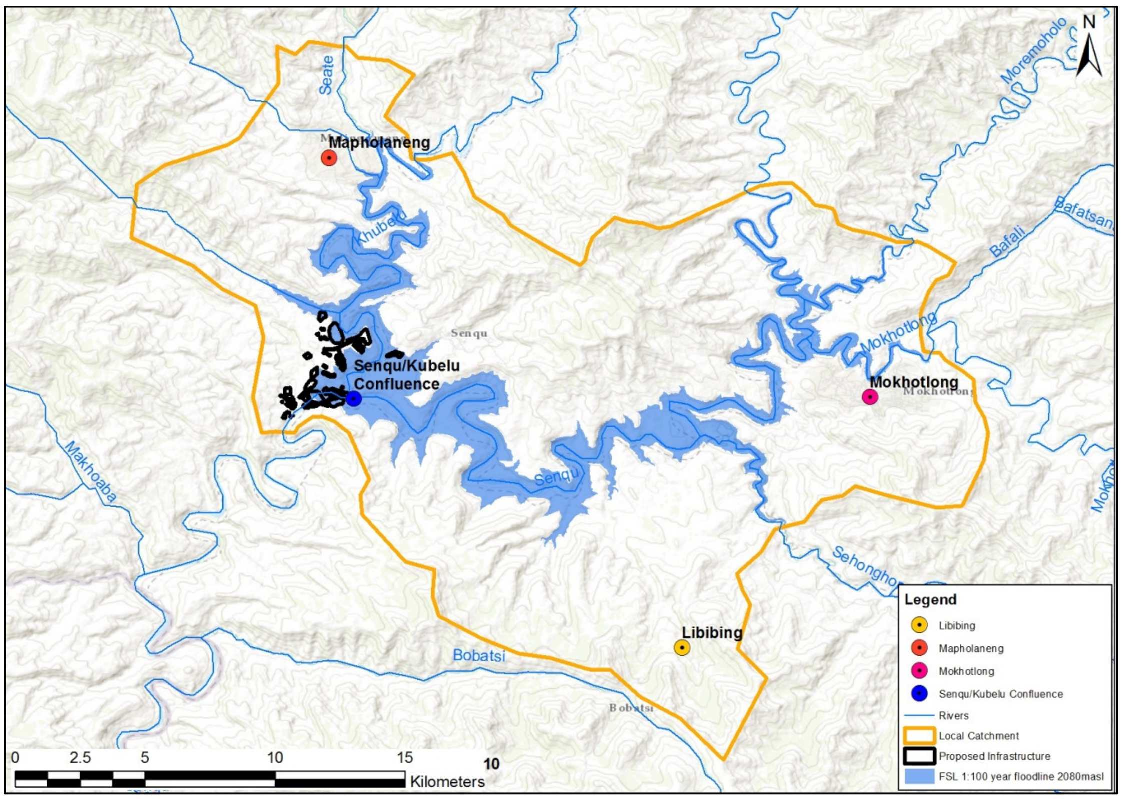
4.1 Area of Influence

The direct development footprint of the proposed PRAI activities is limited to the inundation area of the proposed Polihali Reservoir as well as the footprint of associated permanent and temporary infrastructure located in close proximity to the proposed dam wall (see Figure 4.1).

However, impacts to wetlands and the environment will extend far beyond the directly impacted footprint as people, infrastructure, cultivated fields and livestock are displaced from the affected areas and relocated and re-established elsewhere. For the purpose of this ESIA, the AoI has therefore been defined as including the directly affected areas as well as the surrounding local catchment, as indicated in Figure 4.1 below.

The Area of Influence extends from roughly the town of Mokhotlong in the east to just west of the Senqu/Khubelu confluence. It extends past Mapholaneng in the north and reaches Libibing near its southern extremity.

Figure 4.1 Polihali Reservoir Area, Associated Infrastructure Footprint and the Local Catchment Defined as the Area of Influence



4.1.1 Catchment and River Systems

The proposed dam wall for the Polihali Reservoir will be located just downstream of the Senqu/Khubelu confluence in quaternary catchment D16M, with the bulk of the inundation basin falling within this catchment as well. The inundation does however extend into catchment D16C (drained by the Khubelu and Seate rivers), catchment D16E (drained by the Senqu and

Moremoholo rivers), catchment D16H drained by the Mokhotlong, Bafatsana and Bafali rivers) and catchment D16J (drained by the Sehonghong and Sakeng rivers). A map of affected catchments is provided in Figure 4.2.

Further detail on the affected quaternary catchments is provided in Table 4.1.

Figure 4.2 PRAI and AoI in Relation to Quaternary Catchment Boundaries

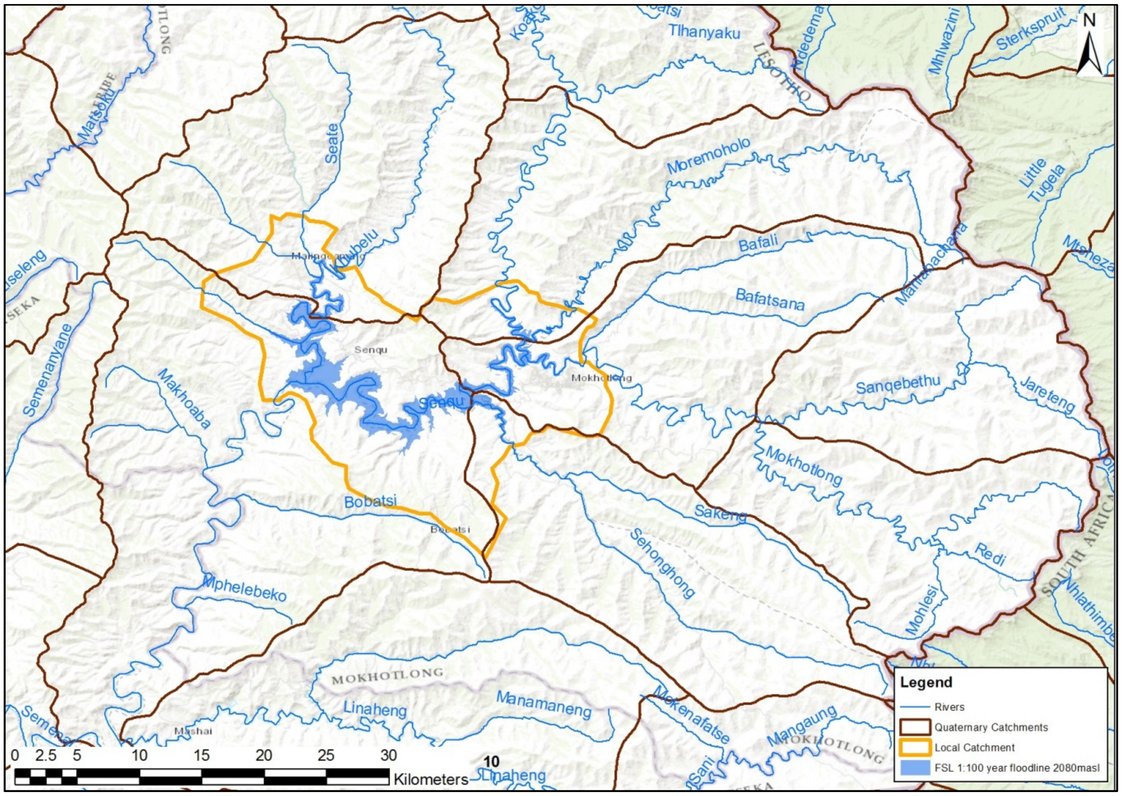


Table 4.1 Area, Mean Annual Precipitation (MAP) and Run-off (MAR) per Quaternary Catchment (Midgley *et al.*, 1994)

Quaternary Catchment	Catchment Surface Area (ha)	Mean Annual Precipitation (MAP) in mm	Mean Annual Run-off (MAR) in mm	MAR as percentage of MAP
D16M	69 946	669.41	85	12.70%
D16C	40 533	652.44	113.7	17.40%
D16E	40 201	637.42	176	27.60%
D16H	31 951	603.5	142	23.50%
D16J	34 730	617.77	195.7	31.70%

Based on the wetland component of the Desktop Ecoclassification Assessment undertaken by ORASECOM (2010), all of the affected quaternary catchments are classified as having a High Integrated Environmental Importance (IEI). This rating was based in large part on a high Socio-Cultural Importance (SCI) rating for all of the wetlands in the affected catchments (ORASECOM, 2010).

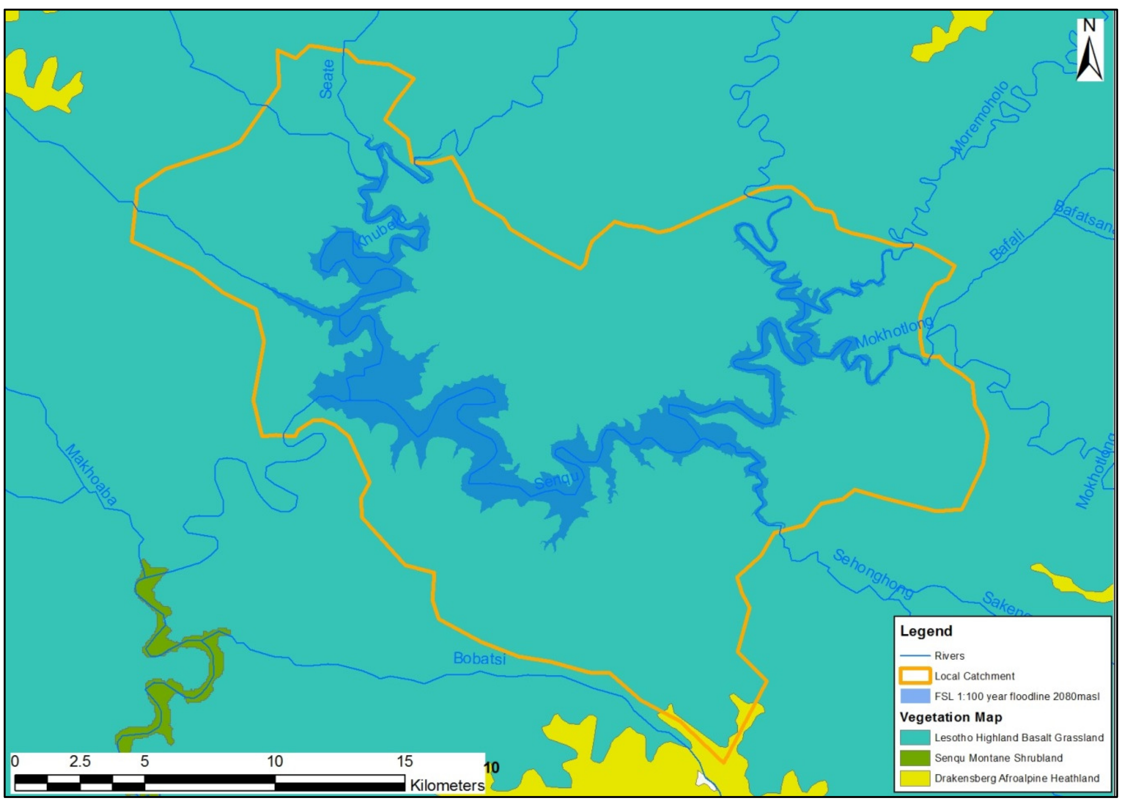
4.1.2 Vegetation Type

According to the Vegetation Map of South Africa, Lesotho and Swaziland (Mucina and Rutherford, 2006), the study area falls within the Grassland Biome and Drakensberg Grassland Bioregion. The dominant vegetation type found within the AoI, and which covers the entire inundation basin, is **Lesotho Highland Basalt Grassland (Gd 8)**. A small patch of Drakensberg Afroalpine Heathland (Gd 10) extends marginally into the extreme south of the AoI. However, this grassland is a broadly defined category within which various different grassland communities occur which are described in more detail in the Terrestrial Ecology Report (P2W-6014-DFR-0002, 2017).

Lesotho Highland Basalt Grassland occurs on most of the high basalt plateau of Lesotho at an altitude between 1900 and 2900 masl, with areas of Drakensberg Afroalpine Heathland embedded within this vegetation type. The landscape consists of numerous high-lying plateaus and high mountain ridges separated by deep and often steep valleys. Natural vegetation of this unit is short, closed grassland with areas dominated by shrubland. The area is mostly underlain by basaltic lava flows of the Drakensberg Group. This vegetation type was considered by Mucina and Rutherford (2006) to be Least Threatened, though it is pointed out that the vegetation type has experienced transformation due to cultivation and is heavily utilised for grazing.

Senqu Montane Shrubland occurs along the Senqu River downstream of the proposed Polihali Reservoir and will as such not be directly impacted by proposed project activities.

Figure 4.3 Vegetation Types of the PRAI AoI (Mucina and Rutherford 2006)



4.2 Regional Context of Wetlands

The wetlands occurring in the Lesotho highlands can largely be found in the headwaters of the Senqu River (Orange River in South Africa), which is an international watercourse (Olaleye Nkheolane, and Mating, 2012). In general mountain systems and the ecosystems and habitats occurring in mountainous areas should be considered amongst the world's most important conservation areas as they are often watercourses that contain important biological diversity (Messerli and Ives, 1997). In addition, the mires/peatlands occurring in the Lesotho Highlands are found nowhere else in the world, although marshes and bogs and other peat containing wetlands can be found over vast areas of the Northern Hemisphere.

Lesotho's wetlands are a critical grazing resource for local livestock (Olaleye *et al*., 2012). These wetland systems are reported to support over 300 000 households in Lesotho through agricultural practices (Olaleye *et al*., 2012). Concern, around accelerated soil erosion due to overgrazing and subsequent degradation of the soils, is growing. Essentially the continued degradation of wetland systems not only threatens the livelihoods of those directly dependent upon them, but also the flow regimes of the rivers and other dependent ecosystems and users of the water downstream.

Previous studies have not only shown highly degraded wetlands based on soil organic matter (Olaleye *et al.,* 2012) and condition/state (MCC Wetlands Project, the pilot ORASECOM Sponge Project, and various monitoring assessments undertaken as part of the Phase 1 monitoring of the LHWP Catchments). Climate change may also be playing a role in the degradation of wetlands in the Highlands through its impact on rainfall variability. Understanding how this may be affecting the wetlands in the Highlands is a topic requiring further research. Concern around accelerated soil erosion and loss of peat due to overgrazing and trampling and subsequent degradation of the wetlands and associated soils was raised in previous survey and monitoring reports to LHDA, some of the more recent of which include the Biological Resources Monitoring within Phase 1 of the LHWP Catchments (2013-14) reports (Anchor, 2014).

The wetlands of this region provide a number of important functions namely: water storage, water discharge and recharge, flood/flow attenuation, sediment retention and organic matter production and export (Grobbelaar and Stegmann, 1987). In terms of the importance of the area as a watershed, the integrity of the wetlands in the upper catchment areas is vital as they support perennial runoff with low sediment loads (Nuesser and Grab, 2002), an aspect particularly beneficial for downstream dams such as Katse and the proposed new Polihali Dam. Accelerated soil erosion leads to higher sediment loads in the rivers. This increased rate of erosion is thought to be due to a number of factors including overgrazing, livestock trampling and possibly also over burning to mention some of the most common. The number of livestock together with the timing and duration that they utilise the wetlands and the catchments of the wetlands, are thought to be important factors contributing to the accelerated overgrazing and resulting increased runoff and soil erosion taking place in the wetlands.

Drying out and degradation of the Fens in particular is a cause for concern. By becoming drier these wetlands are slowly providing favourable conditions for terrestrial plants such as *Chrysocoma* and animal species such as Ice Rats to successfully colonise areas within the wetland boundaries. These areas would previously have been permanently saturated and therefore have prevented the aforementioned species from being able to colonise these areas successfully. The drying out and decomposition or oxidising of the peat also makes these systems more susceptible to erosion.

This background and context is important when considering the findings and recommendations of this report.

4.3 Wetland Delineation and Typing

A total of 184.6 ha of wetland habitat were delineated within the local catchment of the PRAI.

The three main wetland types identified are Seep Wetlands, Sheetrock Wetlands and Valley Bottom Wetlands, with Seep Wetlands further classified into a number of subcategories based on landform setting (e.g. valleyhead) and presence of peat (fens):

- Seep Wetlands;
  - Seep Wetlands (Fen)
  - Valleyhead Seep Wetlands
  - Valleyhead Seep Wetlands (Fen)
- Sheetrock Wetlands;
- Valley Bottom Wetlands.

The most abundant and extensive wetlands were the Seeps and Sheetrock wetlands, which are predominantly concentrated in two large clusters within the local catchment, one cluster being located along a mid-slope bench in the south of the Project Area, and the second cluster located in the central northern section of the Project Area. Both these clusters fall outside the proposed reservoir FSL. See Figure 4.4 and Table 4.2 for more detail regarding the delineated wetland habitats.

Table 4.2 Summary of the Wetland Types and Extent Delineated within the PRAI Area

Wetland Type	Area (ha)	Percentage of Wetland Area	Percentage of Local Catchment
Seep	78.1	42.33%	0.21%
Sheetrock Wetland	73.4	39.79%	0.20%
Valley Bottom	7.5	4.05%	0.02%
Valleyhead Seep	20.1	10.91%	0.05%
Valleyhead Seep (Fen)	5.4	2.91%	0.01%
Total	**184.6**	**100.00%**	**0.49%**

Figure 4.4 Map of the Delineated Wetlands within the PRAI Area

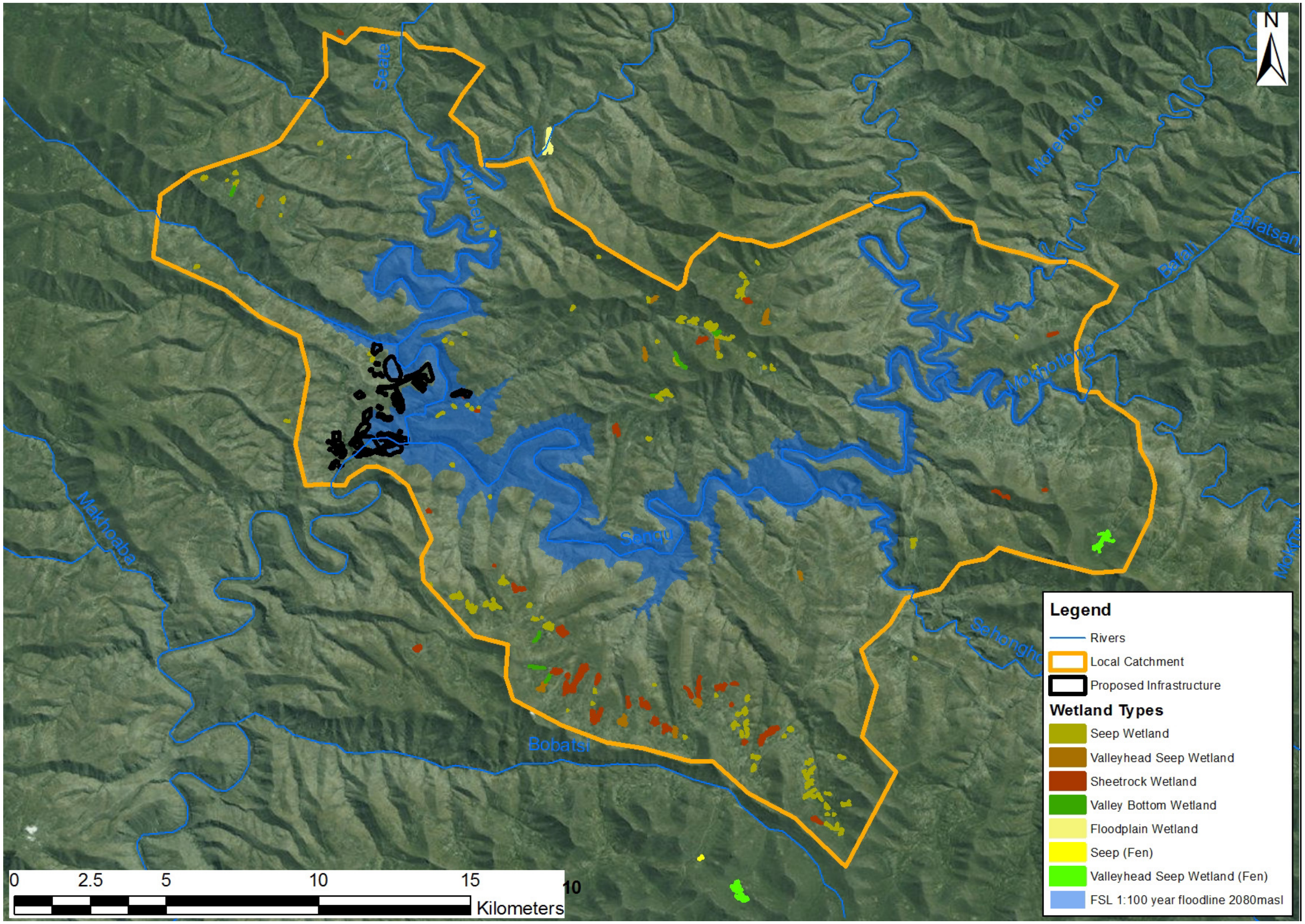


Figure 4.5 Photo Examples of the Different Wetland Types Observed within the PRAI Area

Photo 1. View across Wetland 19, a Valleyhead Seep (Fen) in the Sheep Stud.

Photo 2. View across Wetland 9, a Valleyhead Seep (Fen).

Photo 3. Phragmites reed bed along Khubelu river bank in Wetland 49 (floodplain)

Photo 4. View across Wetland 42 – Sheetrock wetland

Photo 5. View across a Seep wetland – Wetland 48

Photo 6. Sheetrock wetland – Wetland 58

Source: Photo 1 (R Palmer); Photo 2-6 (WCS)

Seep wetlands are the most abundant wetland type recorded, covering 78 ha and making up 42% of the wetland area identified. The key driver of the Seep wetlands is interflow – the movement of water through the soil profile leading to saturation of the soil profile within the Seep wetland. Interflow is derived from rainfall infiltrating the soils in the wetland catchment and moving laterally through the soil profile, typically along an aquitard, and expressing in the Seep wetlands where the shallow water table supports the wetland habitat. The diffuse, subsurface nature of flows results in fairly low energy environments with limited alluvial sediment movement. Outflows from the Seeps is mostly channelled and into adjacent streams.

Activities altering this process of rainfall infiltration and subsequent diffuse, subsurface flow will impact on the seep wetlands and lead to habitat degradation. Agricultural activities, such as cultivation and heavy livestock grazing and trampling, lead to increased surface runoff and decreased infiltration. Water inputs to Seep wetlands change as a result, with increased surface flow input volumes and velocities, leading to increased erosive energy of flows, increased flood peaks and reduced hydro-period.

Virtually all of the Seep wetlands observed on site are located in an agricultural setting and are fringed by cultivated fields, with cultivation often extending into Seep wetlands. All wetlands are grazed and show signs of overutilisation. A further impact observed in many Seep wetlands is the collection of water for domestic use. In some cases this results in decreased flows in the wetland as flows are diverted via pipes for use outside the wetland area, while in other cases the leakage of such water infrastructure has led to increased flows in some sections of wetlands.

Sheetrock wetlands, a sub-set of Seep wetlands, were the next most common and extensive wetland type, covering 73 ha and making up 40% of the wetland area. Driving processes for Sheetrock wetlands are much the same as for Seep wetlands. The key difference between Sheetrock wetlands and other Seeps is the shallow nature of the soil profile in these wetlands and the presence of extensive exposed bedrock within the wetlands. The shallow nature of the soil profile in the Sheetrock wetlands leads to these systems being somewhat more ephemeral in nature as they dry out and re-wet quickly. These extremes can result in a specialised assemblage of plant species adapted to these conditions. Most Sheetrock wetlands were also observed to support springs, resulting in sections of these wetlands being considered permanently saturated. As is the case with the Seeps described above, the Sheetrock wetlands were also generally located in an agricultural setting and are also heavily grazed. The shallow nature of the soil profile in these systems makes them extremely susceptible to erosion.

Valleyhead Seeps form a further sub-set of Seep wetlands, and are differentiated on their location within the drainage network, typically at the head of small streams. They cover 25 ha and make up 14% of the wetland area. The key driver of these systems is once again interflow derived from rainfall infiltrating within the wetland catchment. Activities reducing infiltration within the wetland catchment or encouraging surface runoff therefore impact on these wetlands. Outflow from Valleyhead Seeps is invariably channelled. Given the location of these wetlands at the head of streams, they tend to be important from a streamflow regulation perspective, especially where these Valleyhead Seeps contain peat.

Valleyhead Seeps containing peat belong to the group of wetlands referred to as Fens. The presence of peat indicates permanent saturation of the soil profile. Permanent saturation results in limited decomposition of plant material and the accumulation of an organic soil horizon made up of partially decomposed plant matter, referred to as peat. Peat has high water holding capacity and these wetlands act as sponges, storing large volumes of water that is slowly released to the downstream environment. These wetlands are therefore very important from a streamflow regulation perspective, being a key source of baseline in the streams. The only Valleyhead Fen observed within the PRAI area was found within the Phutha Sheep Stud.

Very few **Valley Bottom wetlands** were delineated within the study area, with these wetlands only making up 4% of the wetland habitat identified. The steep slopes and erosive, high-energy nature of most of the streams in the area are not conducive to wetland formation. Those Valley Bottom wetlands recorded were typically fairly small and narrow in nature, located immediately downstream of Seep wetlands. All of the Valley Bottom wetlands visited were incised and channelled, though it is possible that some of these would have been unchannelled under undisturbed conditions.

4.3.1 Reservoir and Infrastructure Area

Wetlands delineated within and in close proximity to the footprint of the proposed infrastructure associated with the PRAI are illustrated in Figure 4.6. No wetlands, not even Seeps, were found within the direct development footprints of the infrastructure. The Upper Intake Tunnel, which is shown as crossing a Seep wetland in Figure 4.6, will in fact be located underground and pass underneath the wetland. Wetlands located in closest proximity to the infrastructure development footprints are located within the reservoir below the FSL and will therefore be lost once the reservoir fills.

Figure 4.6 Map of Delineated Wetlands within the Vicinity of the Proposed Infrastructure. Refer to Table 4.3 for infrastructure footprint labels.

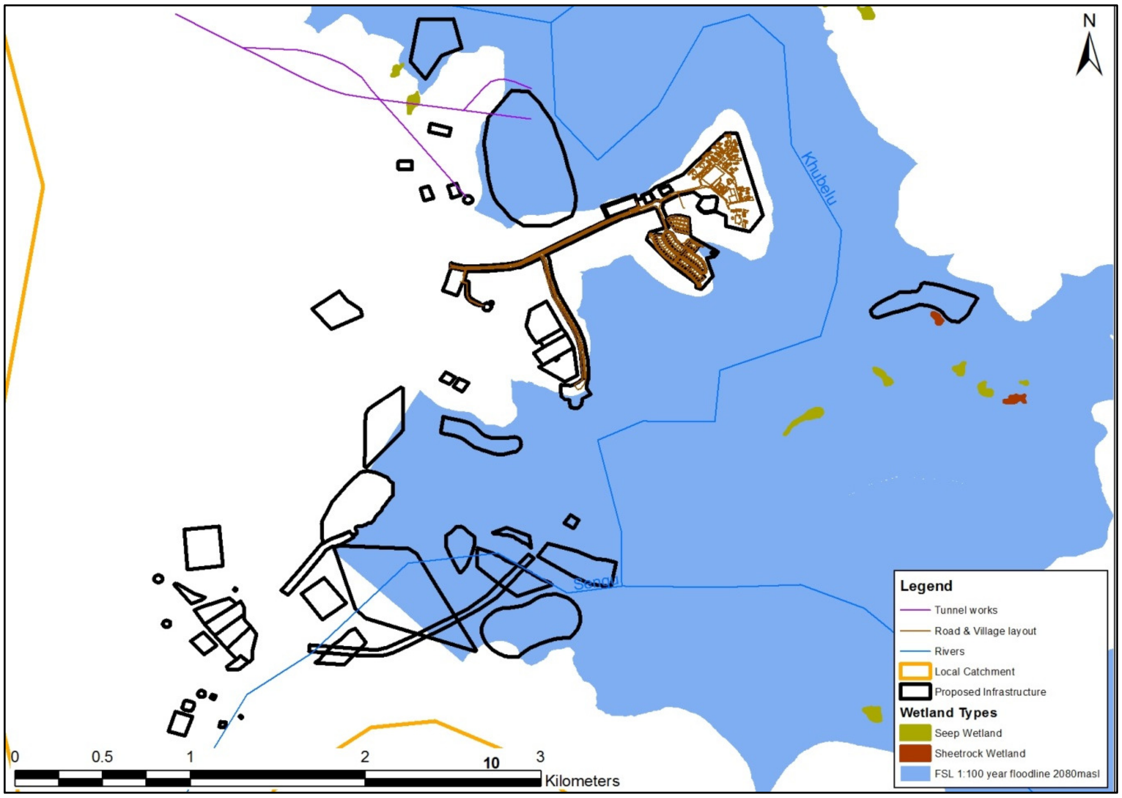


Table 4.3 Labels for infrastructure footprints illustrated and numbered in Figure 4.6.

ID	Description	Area (Ha)
1	1.2 ML Reservoir	0.1
2	Access Road to Reservoir	0.3
3	Advance Infrastructure Management Camp	0
4	Broadly Defined Tunnel Adit Works Area	0
5	Bulk Power & Telecommunications Management Camp	0
6	Commercial Centre	1.2
7	Common Soccer Field	0.8
8	Dam Works Area	2.7
9	Dam Workshops & Site Offices	4
10	Diversion Tunnel Batch Plant	0.3
11	Diversion Tunnel Contract Intake Working Area	4.9
12	Diversion Tunnel Contract Outlet Working Area	2.5
13	Diversion Tunnel Contract Site Offices	0.3
14	Diversion Tunnel Contract Spoil Area	0.7
15	Diversion Tunnel Management Camp	0
16	Diversion Tunnel Topsoil Stock Pile Area	0.3
17	Eastern Labour Camp - Site F	1.4
18	Eastern Labour Camp - Site G	1.6
19	Eastern Labour Camp - Site H	1.5
20	Eastern Labour Camp - Site I	1.6
21	Existing Labour Camp	0.4
22	General Service Area	0.6
23	Indicative Telecomms Tower Location	0

ID	Description	Area (Ha)
24	Indicative Temporary Wastewater Treatment Works	0
25	Intake Working Area	4.5
26	Jetty Area	0
27	Main Dam Rockfill Quarry	11.6
28	Management Camp Area	7.2
29	New Landfill Disposal Site	2.9
30	New Substation	0.5
31	Operations Centre Access Road	2.2
32	Operations Centre Building	1.5
33	Other Roads	5.6
34	Permanent Village & Lodge Area	14.7
35	Polihali Dam Wall	22.1
36	Potential Concrete Aggregate Quarry	6
37	Potential Rockfill Quarry	8.3
38	Potential Rockfill Quarry	3.7
39	Proposed Diversion Tunnel Alignment	5
40	Proposed Magazine Location	0.1
41	PWAR Management Camp	0
42	Raw Water Dam	0.3
43	Raw Water Dam	0.7
44	Raw Water Intake	0
45	Raw Water Pump Station	0
46	Raw Water Steel Reservoir	0.1
47	Saddle Dam	5.5
48	Site A	0.3
49	Site A	0.7
50	Site B	0.4
51	Site C	0.5
52	Site D	0.5
53	Site E	0.8
54	Site E	0.2
55	Site Offices for Advanced Infrastructure	0.2
56	Site Offices for Advanced Infrastructure	0.2
57	Spillway	2
58	Spoil Dump Area	5.4
59	Substation Option1	0
60	Substation Option3	0.3
61	Substation Option4	0
62	TBM Laydown Area	0.2
63	Temporary Water Treatment Plant	0
64	Treated Water Reservoir	0.1
65	U/S Coffer Dam	2.5
66	Wastewater Treatment Works	1
67	Wastewater Treatment Works	1
68	Water Treatment Works	0.1
	TOTAL	**144.1**

Only 11 wetlands were identified within the proposed inundation area, covering a combined area of only 3.8 hectares Table 4.4. Although this is greater than the wetland area mapped within the FSL level by the MDTP in 2006, this is significantly less than the wetland area estimated to occur within the inundation area by Rall *et al.* (2008). The difference is ascribed to the large number of riparian wetlands (wetland habitat along the channel banks of larger rivers) that were expected to occur based on the Rall *et al.* (2008) study, but which were not observed during the current study and which could not be readily identified on aerial imagery.

Table 4.4 Summary of Wetland Types and Extent Recorded within the Polihali Inundation Area

Wetland Type	Area (ha)	Percentage of Wetland Area
Seep	3.2	85.28%
Sheetrock Wetland	0.6	14.72%
Total	**3.8**	**100.00%**

4.4 Wetland Vegetation

Two wetland vegetation types are indicated by Mucina and Rutherford (2006) to occur within the PRAI, namely Drakensberg Wetlands (AZf 4) and Lesotho Mires (AZf 5). Both of these vegetation types are considered Azonal Vegetation types that occur as small patches embedded within other vegetation types; in the case of the study area the wetland vegetation types occur embedded within Lesotho highland Basalt Grassland Vegetation.

Lesotho Mires vegetation generally occurs at higher altitudes, ranging from around 2500 to 3400 masl and is largely confined to Lesotho, with only small areas recorded within South Africa. These wetlands are characterised by peat soils and are permanently saturated. This vegetation type consists of short grass-sedge meadows that appear lawn-like from a distance, though areas of tussock grasses and herblands also occur.

Drakensberg Wetlands vegetation occurs at somewhat lower altitudes, occupying the range of 1800 – 2500 masl. The wetlands typically occupy positions along broad ridges and along the footslopes adjacent to small streams. Although soil organic matter remains high in these wetlands, they seldom support peat. Vegetation is generally fairly dense and of medium height under natural conditions, including grasses, herbs, and shrubs.

The only wetland sampled that displayed largely intact vegetation was the Valleyhead Seep located within the Phutha Sheep Stud, Wetland 19. The strict control of grazing within this wetland and its catchment, as well as the complete exclusion of cultivation from the wetland and its catchment, have resulted in the wetland and the vegetation it supports remaining largely intact. This wetland is considered a suitable reference site for similar wetland types in the area. The wetland is characterised by dense vegetation of medium height dominated by the species *Carex subinflata* and *Gunnera perpensa*. This area lies above the reservoir FSL.

Within the Project Area, the bulk of the wetlands are located within landscapes heavily utilised for subsistence agriculture, including cultivation and livestock grazing, as well as a scattering of informal villages and dwellings. In many cases cultivation extends into the marginal wetland habitat along the wetland perimeter, resulting in the loss of natural wetland vegetation and an increased prevalence in weeds and alien species (Table 4.5). This is exacerbated by heavy livestock grazing and trampling within the wetlands that lead to and accelerate erosion of the wetland systems.

Table 4.5 List of the Common and Widespread Weeds and Alien Species Observed within the Wetlands of the PRAI Area

Species name
Amaranthus hybridus
Berula erecta
Bidens bipinnata
Bidens formosa
Bidens pilosa
Bromus catharticus
Cirsium vulgare
Datura ferox
Nasturtium officinale
Plantago lanceolata
Populus canescens

Species name
Salix fragilis
Tagetes minuta
Verbena bonariensis

Springs within the wetlands were typically dominated by species such as Haplocarpha nervosa, Cotula paludosa, Isolepis sp. Ranunculus multifidus, Senecio polyodon, Juncus exertus and Limosella maior, with species such as Kyllinga pulchella and Cyperus congestus occurring along the edges of these zones. Where shallow excavations or pools of water occurred within the wetlands, these were typically lined by Nasturtium officinale, Persicaria sp. and Veronica anagallis-aquatica.

The drier margins of the wetlands supported grass species such as Agrostis lachnantha, Fingerhuthia sesleriiformis, Pennisetum sp. and Helicotrichon galpinii, as well as forbs such as Senecio inornatus and Conyza podocephala.

Figure 4.7 Photos Showing Examples of Wetland Vegetation Observed within the PRAI Area

Photo 1. Intact wetland habitat and vegetation observed in Wetland 19, a Valleyhead Seep in the Sheep Stud

Photo 2. View across Wetland 4, showing conversion to agriculture and numerous livestock paths

4.4.1 Species of Conservation Importance

A number of species included on the Lesotho Red Data List (Dombo *et al*., 2002) are wetland species, some of which could potentially occur within the wetlands on site. However, the only species included on the Lesotho Red Data List (2002) observed during the current survey are *Eucomis autumnalis* (Vulnerable) and *Hypoxis hemerocallidea* (Data Deficient). Both these species were located in terrestrial habitat immediately adjacent to wetland habitat located outside the reservoir area but within the local catchment (Project Area boundary):

- *Eucomis autumnalis* - observed within the Sheep Stud; and
- *Hypoxis hemerocallidea* – observed in close proximity to Wetland 29.

As a result of the heavy utilisation and resultant degradation of the wetlands, few species of conservation concern were recorded within the surveyed wetlands, though species such as *Gladiolus saundersii, G. permeabilis, Kniphofia caulescens* and *Corycium nigrescens* were recorded in some of the wetlands.

Figure 4.8 Photos Showing the Vulnerable *Eucomis autumnalis* and an Orchid, *Corycium nigrescens*, Observed in and near the Wetlands on Site.

	
Photo 1. *Eucomis autumnalis* observed near Wetland 19	Photo 2. *Corycium nigrescens* observed in numerous locations on site, including this specimen in Wetland 31

4.5 Peat Wetlands

Peat was found to occur in eight of the 46 wetlands sampled, though only one of these wetlands, namely Wetland 19 (Phutha Sheep Stud), is located within the local catchment of the PRAI. The remainder of the peat wetlands are generally located at higher altitudes and included Wetlands 2, 6, 7, 8, 9 and 10 (Figure 4.9).

A summary of the peat profiles augered within Wetland 19 is illustrated in Figure 4.10 and Figure 4.11. Wetland 19 is located at an altitude of approximately 2550 masl, which is within the lower limit of the altitudinal range of the Lesotho Mires indicated by Mucina and Rutherford (2006) as occurring from 2500 to 3400 masl. Two peat samples were augered, revealing a fairly shallow peat depth of 0.6 and 1.05 m. Peat varied from slightly decomposed (H4 on the Von Post humification scale) to highly decomposed (H9 on the Von Post humification scale). The general absence of coarse sand/gravel in the upper peat profile is indicative of a fairly intact catchment with limited erosion and sediment deposition within the wetland under the current hydrological regime. The wetland and peat profile was found to be somewhat drier than expected, especially lower down the peat profile, which could be related to water abstraction from the wetland for potable use, or could be related to the drought conditions prevailing at the time of sampling.

Figure 4.9 Map Showing the Location and Numbering of Peat Wetlands Surveyed

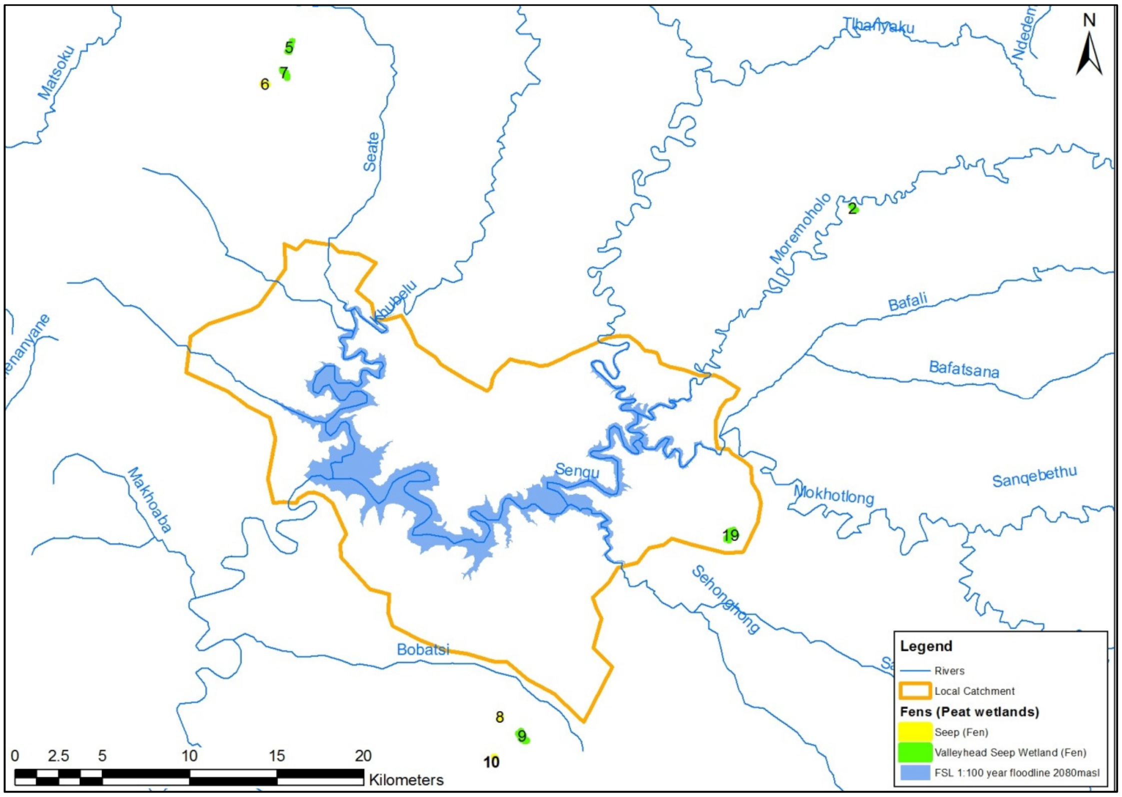
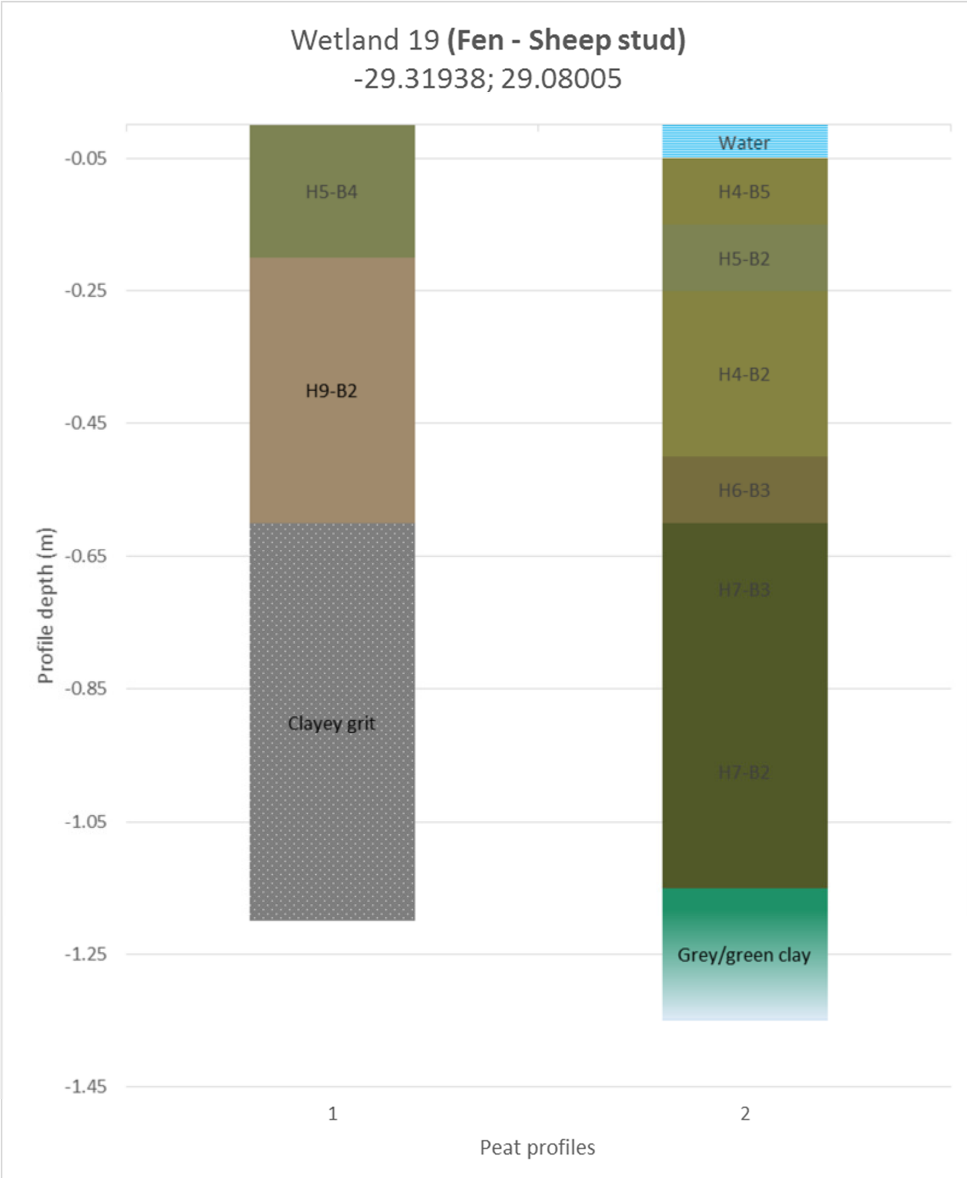


Figure 4.10 Photos of the Peat Profile Augered in Wetland 19 (Phutha Sheep Stud)

The deepest peat found during the current survey was observed in Wetland 7 with a depth of 1.40 m recorded, while Wetland 10 had very shallow peat (0.5 m) overlying bedrock. Summaries of the peat profiles augered in Wetlands 2, 6, 7, 8, 9 and 10 are included as Appendix C to this report.

Figure 4.11 Summary of the Peat Profiles Augered in Wetland 19 (Sheep Stud)



4.6 Functional Assessment

The summarised results of the WET-EcoServices (Kotze *et al.,* 2007) assessment are shown in Table 4.6. Wetlands were grouped according to wetland type for the purpose of this assessment – similar wetlands in similar setting are expected to perform similar functions.

A number of important ecosystem services are highlighted by the results:

Biodiversity maintenance – all of the wetlands play an important role in biodiversity maintenance. They provide a range of habitats and micro-habitats that support species not occurring in adjacent terrestrial habitat. They also provide feeding areas and surface water to species occurring in the surrounding landscape. Large numbers of the Southern Bald Ibis were observed feeding within the wetland areas on site, as well as migratory species such as the White Stork.

Sediment trapping – the high erosion rates observed within the area imply that significant volumes of sediment enter the wetlands on site. The increased vegetation cover of the wetlands and the generally lower energy environments allow these systems to trap sediments. However, the degradation of wetland habitat and changes to the supporting hydrology has also resulted in many wetlands on site becoming sources of sediment.

Water quality maintenance – Seep wetlands are ideally placed to play a role in water quality maintenance. The diffuse, subsurface nature of flows through the system allows for extended contact time between incoming flows and wetland sediments and plants, providing ample opportunity for the trapping and breakdown of a range of contaminants, including nitrates and phosphates, contaminants potentially associated with villages, livestock kraals and cultivated fields that often occur in close proximity to wetlands.

Streamflow regulation – this function is specifically attributed to the peat wetlands surveyed (refer to Figure 4.9 above), and more specifically also to the numerous further peat wetlands located higher up the affected quaternary catchments outside the PRAI.

Direct human use benefits of wetlands include provision of natural resources, specifically grass for mats, hats and brooms; grazing for livestock, cultivation of foods and water supply for human use. All of the wetlands are located within an area heavily utilised by local residents for subsistence livestock grazing and cultivation mainly, both of which also take place within the wetlands on site. Local residents are also directly dependent on the wetlands for domestic water supply and watering of livestock. Wetlands play a very important role in forage for livestock especially during winter when grassland biomass has been depleted (Lewis *et al*., 2015), an importance likely to increase as impacts associated with global warming become more apparent (Lewis *et al*., 2015). The wetland component of the Desktop Ecoclassification Assessment undertaken by ORASECOM (2010), found the SCI for wetlands in the affected catchments (ORASECOM, 2010) to be High.

Table 4.6 Summarised Results of the WET-EcoServices Assessment for the Various Wetland Types Recorded during the Study

Ecosystem Service	Wetland Type						Average Score
	Valleyhead Fen	Seep (Fen)	Seep	Sheetrock Wetland	Valley Bottom	Flood-plain	
Biodiversity maintenance	3.8	3.8	3.3	3.5	3.3	3.5	3.5
Natural resources	3.4	3.2	3.0	3.2	2.8	3.8	3.2
Sediment trapping	3.3	3.2	2.6	2.5	3.0	3.1	2.9
Cultivated foods	2.7	2.7	3.4	2.7	3.4	2.7	2.9
Nitrate removal	3.2	3.3	2.8	2.4	2.7	2.6	2.8
Toxicant removal	3.0	3.1	2.6	2.2	2.7	2.9	2.7
Phosphate trapping	2.8	2.9	2.6	2.2	2.6	2.4	2.6
Carbon storage	3.7	3.3	1.7	1.3	1.7	2.3	2.3
Streamflow regulation	3.2	3.2	2.0	1.5	2.0	2.0	2.3
Water supply human use	2.4	2.2	2.8	2.6	1.8	1.3	2.2
Flood attenuation	2.1	2.1	2.1	2.2	2.1	2.2	2.1
Erosion control	1.7	1.8	2.0	2.0	2.3	2.3	2.0
Education and research	2.3	2.0	1.0	1.0	1.3	1.3	1.5
Tourism and recreation	1.6	1.3	0.9	1.0	1.3	2.7	1.5
Cultural significance	1.0	1.0	1.0	1.0	1.0	1.0	1.0

NB. The table indicates the score obtained by each wetland type for the various ecosystem services assessed. Scores are based on a scale of 0 to 4, with 4 being the highest level of ecosystem service provision.

4.7 Water Quality

No detailed water quality assessment was undertaken as part of the wetland study. However, a handheld pH and TDS (Total Dissolved Solids) metre was used to provide an approximate indication of water quality. Water quality results for the wetlands sampled (where surface water was readily available) are displayed in Figure 4.12 and Figure 4.13.

The South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) indicate that the Target Water Quality Range for pH should be within 0.5 pH unit or 5 % (whichever is more conservative) of the background pH value. The average pH value recorded across the 31 wetlands sampled was 8.01, varying from 7.47 to 8.71. The SANS 241 Drinking Water Standards indicate a target pH range of 5.0 – 9.5.

The South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) indicate in the Target Water Quality Range for TDS that TDS concentrations should not differ by more than 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year. The average TDS concentrations recorded across the 31 wetlands sampled was 140 ppm (parts per million), varying from 42 to 256 ppm. The SANS 241 Drinking Water Standards indicate a target TDS range of <1000 ppm.

Although no baseline water quality information is available for the wetlands in the project area, based on the above results, the water quality observed within the wetlands is generally considered to be of a good quality.

Figure 4.12 Graph Showing a Summary of the TDS Results for Wetlands Sampled

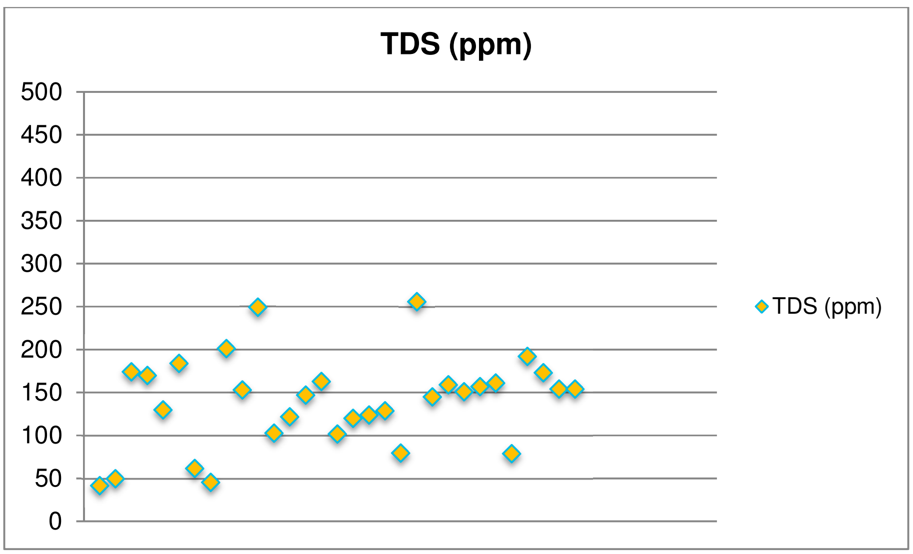
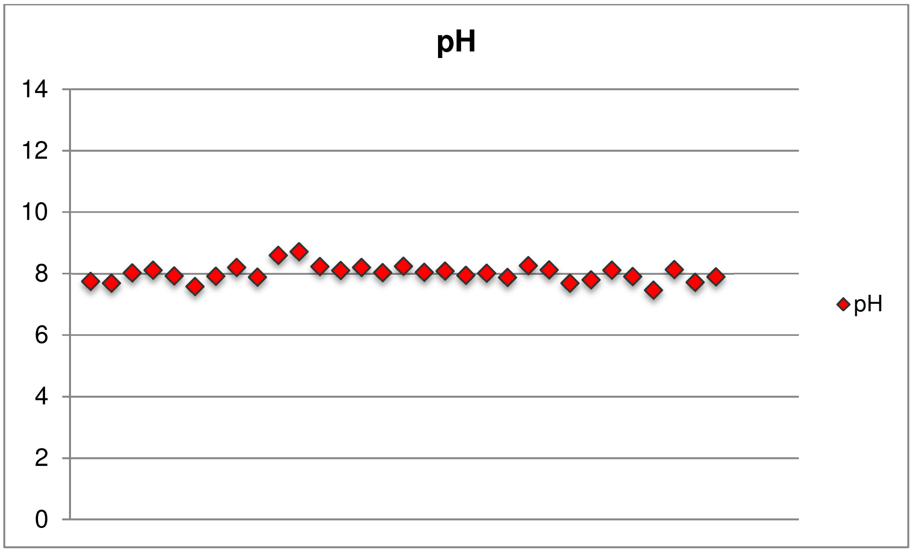


Figure 4.13 Graph Showing a Summary of the pH Results for Wetlands Sampled



4.8 Present Ecological State Assessment

The present ecological state assessment was undertaken for each of the wetlands visited in the field to provide an indication of the general state of wetlands within the PRAI. Results are summarised in Table 4.7 and detailed for each wetland in Annexure C.

The bulk of wetland habitat was considered to be moderately modified (PES category C), though more than 16 % of wetland habitat was rated as largely modified (PES category D). Only three wetlands were considered to remain in a largely natural state (PES category B), most significantly the Valleyhead Fen in the Phutha Sheep Stud, just outside the town of Mokhotlong.

Existing degradation of wetlands in the PRAI is typical of other areas in the Highlands, and is related mainly to habitat transformation both within the wetland through direct disturbance (such as livestock grazing and trampling, and cropping), as well as to land degradation in the wetland catchment which has led to changes in the supporting wetland hydrology.

Excessive grazing of rangelands within the catchments of wetlands leads to increased surface runoff volumes and velocities, resulting in accelerated erosion and resulting transport of sediments into wetlands, as well as accelerated erosion of the wetlands directly. A secondary consequence is the decreased infiltration of rainwater into the catchment soils, reducing recharge of the shallow aquifer supporting the Seep wetlands. All of the wetlands surveyed, with the exception of Wetland 19 located in the Sheep Stud, have been affected by such change in catchment hydrology.

Within wetland habitat transformation is predominantly associated with conversion of wetland habitat to cultivated fields, as well as the trampling and heavy grazing of livestock leading to erosion. Erosion in the wetlands takes the form of channel incision and gully erosion which lowers the local water table within the wetland. This leads to partial desiccation of adjacent wetland habitat which facilitates encroachment of woody shrubs such as *Chrysocoma* and spread of ice rat burrows, causing further desiccation. Erosion reduces the duration of water residence within the wetland, affecting hydroperiod (duration of soil saturation), while sheet erosion resulting in loss of soils and organic matter across the wetland, reducing the water holding capacity of the wetland.

Linear infrastructure crossings of wetlands, particularly roads, have also in some instances contributed to degradation of wetland habitat. Two of the surveyed peat wetlands, Wetland 6 and Wetland 7 have been impacted by road infrastructure. In the case of Wetland 6, excavations associated with road construction have extended into the peat wetland and result in desiccation and oxidation of the peat along the excavated edge, though the impact appears to be limited in extent. Wetland 10 has a road crossing immediately above the upslope wetland edge. The road is a considerable sediment source to the wetland (Figure 4.5), and also concentrates surface runoff along the road margin with discharge as a point source into the wetland. The high velocity surface flows have resulted in the formation of a shallow channel across this wetland.

Besides the direct effects on wetlands, land degradation within the catchment associated with overutilisation of natural resources also increases surface runoff resulting in decreased infiltration of rainfall. Increased surface runoff volumes and velocities entering wetlands exacerbate and accelerate erosion. Decreased infiltration and recharge of interflow and shallow groundwater reduces these inputs to the wetlands, reducing hydroperiod and soil saturation within the wetlands. Associated with increased surface runoff is the increased transport of sediment into wetlands causing smothering of wetland vegetation and an increase in pioneer and weedy species, including alien species, colonising these areas.

Table 4.7 Summarised Results of the Present Ecological State Assessment for Surveyed Wetlands

Wetland Type	PES B (ha)	PES C (ha)	PES D (ha)
Seep Wetland		11.9	12.5
Seep Wetland (Fen)		2.1	1.3
Sheetrock Wetland	0.8	33.3	
Valley Bottom Wetland		1.2	
Valleyhead Seep Wetland		3.4	3.7
Valleyhead Seep wetland (Fen)	5.4	22.6	
Floodplain Wetland	7.2		
Total	**13.4**	**74.4**	**17.5**
Percentage of wetland area	12.70%	70.70%	16.60%

NB. Figures provided are in hectares (ha).

Figure 4.14 Photo Examples of Various Impacts to Wetlands Observed within the Surveyed Wetlands

Photo 1. Virtual complete loss of topsoil cover evident in Wetland 42.

Photo 2. Erosion and habitat transformation resulting from cultivation in Wetland 3.

Photo 3. Severe channel incision observed in Wetland 57, leading to complete desiccation of the wetland habitat.

Photo 4. Increased sedimentation in wetlands due to runoff from roads (Wetland 10).

Photo 5. Overflowing water infrastructure located within a wetland, leading to increased flow and concentrated flow.

Photo 6. Severe erosion and sparse vegetation cover within the catchment of Wetland 49 leading to increased surface runoff and sedimentation.

4.9 Importance and Sensitivity (IS)

The most important wetland within the PRAI study area is considered to be the Valleyhead Seep located in the Phutha Sheep Stud. This is a Fen (peat wetland) and is the only remaining largely natural wetland in the area, and which provides an important reference system for wetlands of the area under natural conditions. The healthy state of the sub-catchment for this wetland also suggests that the trajectory of change for this wetland is stable and the wetland is not currently under threat.

All of the remaining wetlands in the project area have been impacted and degraded to some degree, resulting in a moderate importance and sensitivity score. However, the wetlands are considered to be of high importance for the ecosystem services they provide to local communities. Many of the local residents are directly dependent on subsistence agricultural activities and livestock grazing for their livelihoods, and the wetlands of the area play an important role in supporting these activities.

In addition, within a heavily degraded and ecologically impoverished landscape, the wetlands provide a different habitat within a mosaic of grassland communities that contribute to overall biodiversity. The heavy utilisation and degradation of the wetlands surveyed has likely led to a loss of many sensitive and conservation significant species. No Red Data species were observed within the wetlands during the current survey. Given the habitat degradation observed in many of the sampled wetlands, the likely occurrence of Red Data species within most of these wetlands is considered low.

Table 4.8 Summarised Results of the Importance and Sensitivity (IS) Assessment for Surveyed Wetlands

Wetland Type	Very High	High	Moderate	Low/Marginal
Seep Wetland			23.3	1.2
Seep Wetland (Fen)		3.4		
Sheetrock Wetland			33.5	0.6
Valley Bottom Wetland			8.2	
Valleyhead Seep Wetland				
Valleyhead Seep Wetland (Fen)	15.7	12.3		
Floodplain Wetland		7.2		
TOTAL	**15.7**	**22.9**	**65**	**1.7**
Percentage of wetland area	14.90%	21.70%	61.80%	1.60%

Section 5 Assessment of Impacts and Mitigation

The impact assessment was undertaken as per the impact categories and impact assessment methodology provided by ERM. Identification of impacts was based predominantly on experience gained from previous large infrastructure and mining projects.

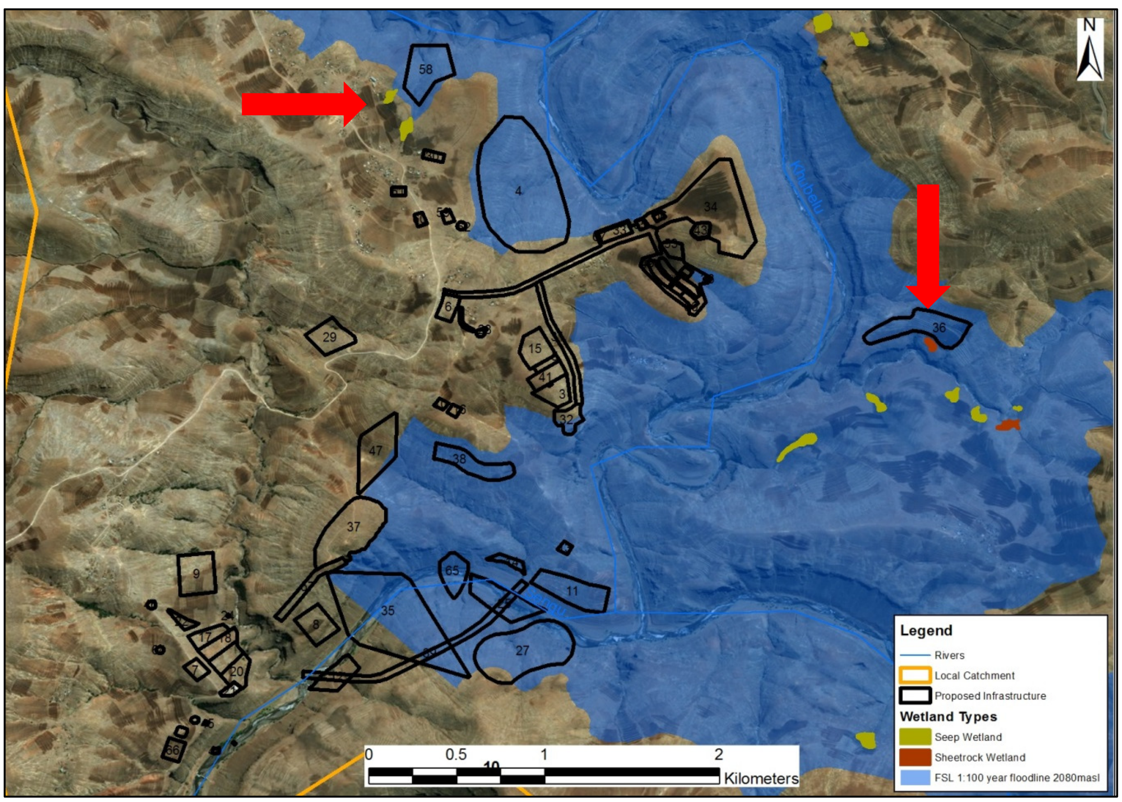
5.1 Advanced Works and Construction Phase

5.1.1 Impacts of Site Clearance and Preparation for Infrastructure Development on Wetlands

5.1.1.1 Description of Impact

No wetlands were identified within the immediate footprint of the proposed infrastructure areas, as indicated in Figure 5.1. Only three wetlands, two Seep wetlands, and one Sheetrock wetland, were found to occur within 50 m of the proposed infrastructure development footprints. All three of the wetlands are also located within or at least partially within the FSL of the reservoir. The affected wetlands included two wetlands sampled as part of the summer field survey, namely Wetland 44 and Wetland 52. No wetlands were found in proximity to the dam wall locations.

Figure 5.1 Map showing the proposed infrastructure footprints in relation to delineated wetland habitat. (Note: Wetlands most likely to be impacted have been highlighted by red arrows)



Wetland 44 and an adjacent Seep wetland to the south east (Figure 5.1) are located upslope of a proposed spoil dump area (Number 58 in Figure 5.1), while Wetland 52 is located roughly 20 m downslope of the footprint area associated with a potential concrete aggregate quarry (Number 36 in Figure 5.1).

Figure 5.2 Photos Showing Wetland Habitat Associated with Wetland 52

	
Sheetrock wetland – Wetland 52.	Sheetrock wetland – Wetland 52.

Direct impacts to wetlands are limited to the potential damage that can be expected on the two Seep wetlands and the Sheetrock wetland resulting from activities associated with the proposed spoil dump area and the potential concrete aggregate quarry, including activities such as access roads to these areas.

Wetland 44 and an adjacent Seep wetland to the south east are likely to be impacted by activities associated with the proposed spoil dump area. Although located outside the direct proposed footprint of the spoil dump area, movement of vehicles and machinery through the area and incorrect alignment of haul roads could impact directly on these wetlands. Dust deposition within the wetlands is a further likely impact.

Indirect impacts associated with the site clearance and preparation activities would be expected to mostly affect wetlands located downslope of the infrastructure footprints though some indirect impacts could also affect upslope wetlands in close proximity to the development footprints (e.g. through dust deposition). The only wetland located in close proximity downslope of the construction footprints is Wetland 52, which is located within the inundation area and will therefore be lost once the reservoir fills. This wetland is likely to be affected by construction and excavation of the potential aggregate quarry immediately upslope which would intercept water feeding the wetland, leading to desiccation of this wetland.

5.1.1.2 Sensitivity of Receptors

The wetlands near the infrastructure footprint comprise small Seep wetlands and Sheetrock wetlands that are considered moderately modified (PES category C) and of *Low*/Marginal ecological importance and sensitivity. None had threatened plants.

5.1.1.3 Assessment of Impacts

Impacts on wetlands may only impact on a Seep and two Sheetrock wetlands. No impacts are expected on Valleyhead Fens. The identified impacts on Sheetrock wetlands are expected to be limited to the local area, be short-term (for the duration of the construction phase), and are therefore assigned a Magnitude of *Small*. Given the *Low* sensitivity of the potentially affected Seeps, the impact of site clearance on wetlands from all advanced works and construction activities based on available design and layout plans (as illustrated in Figure 5.1) are considered **Negligible** before mitigation.

5.1.1.4 Mitigation Measures

Although only three wetlands were found to be located in close proximity to the development footprints and these are close to the FSL of the dam, mitigation is required to limit construction disturbance during advanced works and dam/tunnel construction to as small an area as possible to retain the hydrological function of these seeps. These include:

- Demarcate/fence the seepage zones and restrict construction activities and vehicular use or tracks in proximity of Seep 44, upslope of the tunnel spoil dump;
- Suppress dust along access tracks in the vicinity of Seep 44, and if feasible, suppress dust generation from spoil dump trucks during windy conditions by covering vehicle loads;
- Restrict stormwater runoff from construction works areas draining across or into Seep 44 to avoid sedimentation or contamination;
- Avoid storage of potential contaminants (e.g. hydrocarbons, cement, waste or toilets upslope of seepage zones);
- Undertake wetland and environmental awareness training of staff during environmental induction and toolbox talks. Staff training and awareness is considered an important mitigation measure, as even though no wetlands fall within the direct proposed development footprints, it is likely that staff may encounter wetlands within the general project area and need to be familiar with identifying them and understanding their importance. Wetland training and awareness could be incorporated into general Biodiversity Awareness and Training of Contractor staff.

5.1.1.5 Residual Impact

The significance of residual impacts on Seeps in the infrastructure areas will remain **Negligible**.

Table 5.1 Impacts of Site Clearance for Advanced Infrastructure and Dam and Tunnel Construction on Wetlands

	Seeps		Sheetrock Wetland		Valley Bottom	
	Wetland 44 (0.2 ha)		Wetland 52 (0.2 ha)			
	Pre-Mitigation Impact	Residual Impact	Pre-Mitigation Impact	Residual Impact	Pre-Mitigation Impact	Residual Impact
Impact of Site Clearance for Advanced Works (Camps, Offices, Lodge, laydown) on Wetlands						
Type of Impact	Direct		Direct		None	
Magnitude	Small	Negligible	Small	Negligible	NA	NA
Sensitivity	Low	Low	Low	Low	NA	NA
Significance	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**NA**	**NA**
Impact of Site Clearance for Dam and Tunnel Construction on Wetlands						
Type of Impact	Direct		Direct		None	
Magnitude	Small	Negligible	Small	Negligible	NA	NA
Sensitivity	Low	Negligible	Low	Low	NA	NA
Significance	**Negligible**	**Negligible**	**Negligible**	**Negligible**	**NA**	**NA**

5.2 Inundation Phase

5.2.1 Impacts of Reservoir Inundation on Wetlands

5.2.1.1 Description of Impact

At least 11 wetlands were identified within the direct footprint of the proposed reservoir inundation area, as indicated in Figure 5.3. These wetlands consist predominantly of Seep wetlands (9) and Sheetrock wetlands (2) that together cover 3.7 ha. The affected wetlands included six wetlands sampled as part of the summer field survey, namely Wetlands 14, 44, 48, 51, 52 and 53. Given the size of the proposed reservoir inundation area (5600 ha) it is likely that some additional smaller wetland habitats and possibly some valley bottom wetlands were missed during the desktop wetland identification and field delineation. However, any such wetlands which do occur are likely to be of similar status to those surveyed. No Fens were identified within the reservoir FSL or are expected to occur within the reservoir FSL as Fens are generally associated with higher altitudes, 2500 – 3400 masl (Mucina and Rutherford, 2006).

The proposed inundation of the wetlands within the reservoir FSL will lead to the total loss of these wetland habitats as well as the ecosystem services they provide. The impact can be summarised as follows:

- Loss of wetland habitat and species supported by the wetland habitat. No Red Data species were found to occur within the affected wetlands. The wetlands do however provide a different habitat within a mosaic of grassland communities that contribute to overall biodiversity.
- Loss of regulating and supporting services provided by wetlands such as sediment trapping, nutrient assimilation and water quality maintenance.
- Loss of provisional services such as grazing and water supply. Wetlands in the Highlands play a key role in livestock production by providing high quality grazing (Lewis *et al.*, 2015). Livestock watering, which to some extent is currently supplied by wetlands, could presumably be substituted in part by direct watering of livestock from the reservoir, in areas where the reservoir is accessible to livestock.

Figure 5.3 Map Showing Delineated Wetlands in the PRAI. Note: Red arrows highlight wetlands to be impacted.

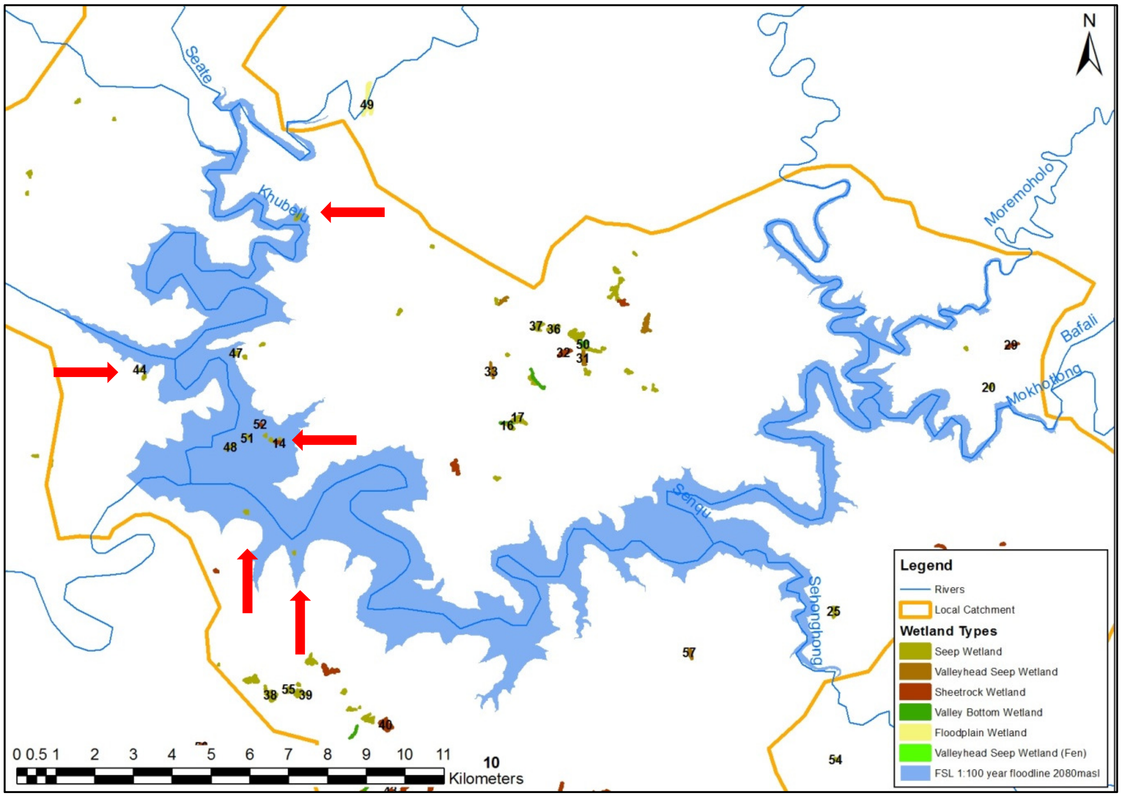


Figure 5.4 Photos of Wetland Habitat to be Inundated

Wetland 14

Wetland 51

	
	
Wetland 48	Wetland 53

5.2.1.2 Sensitivity of Receptors

The affected wetlands included in the summer field survey (Wetlands 14, 44, 48, 51, 52 and 53) were found to be moderately to largely modified (PES categories C and D) and mostly of *Low*/Marginal importance and sensitivity. Only Wetlands 48 and 51 were found to be of Moderate importance and sensitivity.

5.2.1.3 Assessment of Impacts

Inundation is only expected to impact on ~3.7 ha of degraded Seeps and Sheetrock wetlands in the ~5600 ha reservoir area, but given that loss of these wetlands is considered to be permanent, it is assigned a Magnitude of *Medium*. Given the *Low* sensitivity of the affected Seeps, the impact of reservoir inundation on wetlands is considered **Minor** before mitigation.

5.2.1.4 Mitigation Measures

The entire proposed reservoir FSL will be inundated and the wetland habitat within the inundated area will be lost. There is no opportunity to mitigate this impact within the wetlands in question or within the reservoir FSL footprint. Given the importance of wetlands in the upper catchment of the Polihali Reservoir for streamflow regulation, water quality maintenance and erosion protection, recommendations relating to increased protection and restoration of wetlands in the catchment are outlined in Section 5.3.1.4 and Section 6.3 as part of a wider integrated catchment management / biodiversity management plan initiative.

5.2.1.5 Residual Impact

Given the lack of on-site mitigation potential for inundated wetlands, the significance of the residual impacts on Seeps in the reservoir FSL areas will remain **Minor**.

Table 5.2 Impacts of Dam Inundation on Wetlands

	Seeps & Sheetrock Wetlands (3.7 ha)		Valley Bottom Wetlands & Valleyhead Seeps (0 ha)		Valleyhead Fens (0 ha)	
	Pre-Mitigation Impact	Residual Impact	Pre-Mitigation Impact	Residual Impact	Pre-Mitigation Impact	Residual Impact
Type of Impact	Direct		None		None	
Magnitude	Medium	Medium	NA	NA	NA	NA
Sensitivity	Low	Low	NA	NA	NA	NA
Significance	**Minor**	**Minor**	**NA**	**NA**	**NA**	**NA**

5.3 Operation Phase

5.3.1 Impacts of Land Use Displacement on Wetlands

5.3.1.1 Description of Impact

The Polihali reservoir will cover an area of roughly ~5600 ha. Currently this land is utilised predominantly as livestock grazing land, but also includes substantial areas of cultivated land and several villages. All villages falling within the reservoir FSL will be relocated, presumably to locations within the defined AoI of the project, though the exact areas are still to be finalised. Since affected communities are highly dependent on subsistence agriculture it can be expected that land use practices (e.g. grazing and cultivation) within the reservoir FSL will be displaced to surrounding areas in the higher lying portions of the basin. This is expected to result in increased grazing pressure in the AoI as current livestock numbers are restricted to less grazing land.

The grazing land being displaced is predominantly located at an altitude of around 2000 – 2080 masl and is located in relatively close proximity to various villages. Land use displacement is expected to extend across the AoI at the lower altitudes typically utilised for cultivation and winter grazing, and to extend into the higher lying summer grazing areas where grazing condition is expected to deteriorate over time.

A total of 184 ha of wetlands were delineated in the PRAI Project Area (Table 4.2) of which almost 180 ha comprises types of Seep wetlands. Only 5.4 ha of Valleyhead Fens were delineated mostly occurring outside the AoI to the north (along the A1 road to Letseng) and to the south (along the A3 road to Mohlanapeng). The most intact wetland system was found in the Phutha Sheep Stud. Additional wetland systems occur outside of this PRAI Project Area in the higher catchment that have not been assessed but which may be subject to increased grazing pressures.

Wetlands, in particular, provide prime grazing and are expected to be heavily impacted by an increase in grazing pressure, leading to an increased rate of degradation. Overgrazing leads to decreased vegetation cover, a shift from grassland to shrubland (*Chrysocoma* dominated) with decreased basal cover, and increased surface runoff from the catchment. This causes increased surface water flow inputs with higher erosive energy and reduced subsurface (interflow) inputs resulting in wetland desiccation, and increased sediment inputs (causing smothering of wetland vegetation) and increased erosion. All wetland types, particularly the Valleyhead Fens in the upper parts of the catchment can be expected to experience increased grazing pressures.

Expansion of cultivation in surrounding areas is also expected as inundated arable land and fields are substituted with new cultivation areas around the reservoir. It appears that almost all potential arable land in the reservoir and surrounding area is already cultivated, and communities will be forced to cultivate more marginal land on steeper slopes, and will likely target wetland seep zones.

The impacts described above will take place within an environment already significantly degraded and heavily utilised and thus highly vulnerable to further utilisation pressures. In addition, predicted climate change challenges can be expected to further exacerbate wetland degradation. The Lesotho Meteorological Service (LMS) have indicated (LMS, 2013, pg109) that over the coming 90 years an increase in temperature is likely over both the northern and southern parts of Lesotho, with increased temperatures (especially extreme temperatures) and associated changes in rainfall having implications for vegetation growth and consequently soil cover. Although models have also indicated the occurrence of above normal precipitation events, the general indication is of below normal rainfall and a high probability of drought. Decreased soil moisture within wetlands will result in shifts in species composition and possibly loss of certain species, as well as changes in vegetation cover. Changes in vegetation cover within the wetland catchment will lead to increased surface runoff, resulting in increased erosion within wetlands. Decreased water inputs to wetlands could also result in increased oxidation and loss of peat sediments in wetlands.

From the wetland monitoring activities undertaken in the Phase I catchments (Anchor, 2014a & 2014b) it is clear that substantial degradation of wetland habitat occurred during the period between initial surveys in 1996 (Mohale catchment) 1999/2000 (Katse catchment and the follow-up surveys in 2014. The type of impacts and wetland degradation point to the general drying out of wetlands as a result of changes to wetland and catchment hydrology, with subsurface flow being reduced and surface runoff increased: "*Changes in the systems are due in most part to the intense and continuous grazing pressure that these wetlands are exposed to combined with hydrological changes emanating from the surrounding catchments*" (Anchor, 2014a). The consequences for wetlands were observed to include:

- Drying out of wetlands;
- Oxidation of peat;
- Complete loss of peat profiles in some wetlands;
- Accelerated erosion and loss of wetland sediments;
- Invasion by terrestrial species such as *Chrysocoma*; and
- Invasion by species such as the Ice Rat that further accelerate peat oxidation.

Despite the wetland degradation observed, the Anchor (2014a) report states that it is difficult to conclude whether any of the observed changes in wetland integrity are due indirectly to the Phase I dams. Rather, concerns around current rangeland management practices within the catchments are highlighted.

It is therefore difficult to predict the likely impact of the proposed Polihali Reservoir on wetlands within the AoI and the greater catchment. What is, however, clear is that the wetlands within the Lesotho Highlands are currently undergoing negative change due to existing landuse practices, and that the displacement of communities and land use practices due to reservoir inundation will increase utilisation pressure on remaining land area. An exacerbation of existing wetland degradation trends can therefore be expected, even though the relative contribution of the PRAI project to this impact will be difficult to isolate from background trends.

5.3.1.2 Sensitivity of Receptors

Wetlands in the areas around the Polihali Reservoir include Seeps, Sheetrock wetlands and Valley Bottom and Valleyhead Seeps are typically assigned a Class C or D PES and are evaluated as being of *Medium* sensitivity to land use displacement, while Valleyhead Fens are assigned a Class B PES and evaluated as being of *High* sensitivity to grazing displacement from the reservoir area.

5.3.1.3 Assessment of Impacts

The extent of the likely impact to wetlands associated with land use displacement is hard to predict, but for the purpose of this assessment is considered to be most severe within the defined AoI, although impacts may extend beyond this area into the upper catchment areas of the rivers feeding the Polihali reservoir. Given the large extent of the area that is expected to be impacted by land use displacement (catchment wide) and the duration of the impact over the long-term it is assigned a magnitude of *Large*. This, combined with the *Medium* sensitivity for Seep wetlands and *High* sensitivity for Valleyhead Fens, results in an overall impact significance rating of **Major** for all wetland types.

5.3.1.4 Mitigation Measures

Mitigation of wetland impacts associated with the operational phase within the wider catchment should focus on improved rangeland management in the upper catchment and rehabilitation of selected target wetlands.

The protection and conservation of wetlands is closely tied to the general condition and management of the catchment. This was also found to apply within the Khubelu catchment during studies undertaken as part of the SPONGE project (ORASECOM, 2008): "*proper management of wetlands rests on effective rotational grazing that allows the wetlands to rest. The previous/traditional range management procedures are no longer effective and a concerted effort by Government of Lesotho is needed to establish effective range management*". Wetland monitoring within the Phase I catchments recorded extensive wetland degradation over the last two decades and found that ascribing observed wetland degradation to indirect impacts from the Phase I dams is difficult to conclude, but rather that the biggest concerns relate to rangeland management within the catchments (Anchor, 2014a and 2014b).

The key driver of wetland degradation within the AoI is considered to be the change in catchment and wetland hydrology, which is driven by the overutilisation of rangeland resources and the cultivation of the immediate wetland catchments, resulting in decreased infiltration and interflow, increased surface runoff volumes and velocities, and concentration of flows, leading to erosion and loss of wetland functionality. Unless the driver of these changes is addressed, any wetland protection and rehabilitation initiatives are likely to fail. The development and implementation of an ICM that includes detailed recommendations around rangeland management is therefore the critical mitigation measure from a wetland perspective. Active wetland protection and rehabilitation measures, including structural interventions and fencing of wetland areas, will add to this, but cannot successfully be pursued in the absence of a robust rangeland management plan.

In order to mitigate the impacts of land use displacement, an ICM plan should be developed and implemented for the entire Polihali reservoir catchment. This should include considerations from multiple interlinked perspectives including rangeland management, terrestrial biodiversity, wetland and socio-cultural aspects, as well as allow for expected impacts related to future altered climatic patterns.

Effective implementation of a multi-disciplinary catchment management plan will provide benefits not only to the communities impacted by the PRAI and dependent on wetlands for various ecosystem services, but also for the Polihali reservoir through enhancing important hydrological and sediment management functions. These include the supply of clean water, the maintenance of baseflows in streams, flood attenuation, soil stabilisation, sediment and toxin retention, and nutrient assimilation (Lewis *et al.*, 2015).

To guide the ICM, a wetland monitoring strategy should be developed to provide information on wetlands within the Polihali reservoir catchment and to track changes that occur, including potential impacts on wetlands that can be linked to the proposed Polihali reservoir. It is recommended that initially a minimum of 25 wetlands are targeted for monitoring purposes. This would roughly match the wetland monitoring activities being undertaken within the Mohale and Katse catchments in terms of target wetlands. An initial 13 wetlands from within the AoI that could be included within such a monitoring strategy are detailed in Appendix A. These selected wetlands should be supplemented with the selection of at least a further 12 wetlands located within the wider Polihali Reservoir catchment. It is suggested that additional wetlands selected focus on high altitude Fens, though the selection of wetlands must be informed by a prioritisation process similar to the process detailed below. Further details on the proposed wetland monitoring activities are provided in Section 6.4.

In addition to the wetland monitoring strategy, a wetland rehabilitation and management strategy should be developed for the Polihali reservoir catchment. To identify suitable target wetlands for such a management and rehabilitation strategy, a wetland prioritisation exercise should be undertaken which includes consideration of wetlands within the entire Polihali reservoir catchment, i.e. beyond just the AoI, but could also include some of the wetlands selected for monitoring purposes. Considerations that should inform the prioritisation of wetlands for rehabilitation and protection must include consideration of:

- Wetland type, size, present ecological state and importance and sensitivity;
- Presence of peat;
- Wetland functionality, such as prioritising those in the catchment most important for maintaining water supply;
- Presence of Red Data species;
- Opportunities for successfully implementing a rangeland management plan;
- Opportunities for securing long-term stewardship and/or protection of the wetlands;
- Ease of access, especially where rehabilitation structures are required, as materials will need to be transported to site;
- Accessibility of required materials, i.e. availability of rock for gabions/rock packing etc.; and
- Likelihood of rehabilitation success/risk of rehabilitation failure.

The development and implementation of wetland management and rehabilitation measures should be informed by the following considerations (these measures have been extensively informed by the recommendations from the wetland monitoring activities undertaken in the Phase I catchments by WCS (Anchor, 2014a and 2014b):

- Urgent interventions are required in the catchment to prevent the further wetland degradation and loss;
- The driver of wetland degradation appears to be the change in catchment and wetland hydrology being brought about by continuous grazing within wetlands and their catchments at levels above carrying capacity. Altered rainfall patterns potentially exacerbates these impacts;
- The resilience of wetland systems is dependent on their ability to sustain nutrient cycles and the storage of water (Du Preez & Brown, 2011). Within the Phase I catchments, an apparent reduction in the resilience of wetland systems was observed due to the high intensity of grazing and lack of resting of the wetland areas from grazing pressure, with extensive and sometimes dramatic wetland degradation being the result (Anchor, 2014a & 2014b);
- Any proposed wetland protection and rehabilitation initiative will need to include both a rangeland management as well as wetland rehabilitation strategy. Any wetland restoration or rehabilitation effort will depend on addressing the rangeland management issue. A key finding of wetland monitoring in the Katse and Mohale catchments (Anchor, 2014a & 2014b) was that “any recommendations for rehabilitation or restoration of these systems will have to include addressing the issue of rangeland management in general, and not just in regard to the utilisation of the wetlands”;
- Active rehabilitation of wetlands should be undertaken in specific selected wetlands to increase resilience to change in the targeted wetlands. This could in part be achieved through structural interventions that stabilise wetland sediments by providing a key point to limit erosion and increasing water retention within eroded/eroding systems;
- A wetland prioritisation exercise should be undertaken to priorities wetlands for active, structural rehabilitation (see above);
- Adaptive management of any interventions implemented in the catchment, whether it is an alternative rangeland management system, or physical or other interventions in the wetlands, which should be guided by monitoring;
- A detailed wetland monitoring strategy should be implemented. Monitoring should be up-scaled from what has been undertaken within the Phase I catchments and should include a specific hydrological monitoring programme for at least some of the targeted wetlands (refer to Sections 6.3.2.1 and 6.4.2).

A number of previous wetland rehabilitation and monitoring projects undertaken in the Lesotho Highlands have provided important insights and lessons that should inform the wetland components of the proposed ICM strategy and the BMP. Ignoring these considerations is likely to lead to reduced success of wetland protection and rehabilitation initiatives and possibly to failure of rehabilitation interventions. A number of such considerations informed by experience gained on previous wetland rehabilitation projects, including amongst others through the wetland rehabilitation project undertaken for GIZ in part of the catchment of the Khubelu River by Wetland Consulting Services (Pty) Ltd in association with GOPA Worldwide Consultants (Gesellschaft für Organisation, Plannung und Ausbildung) and GWC Consulting Engineers (Pty) Ltd as part of the Transboundary Water Management in SADC Programme Protection of the Orange-Senqu Water Sources (Sponge) Project, are summarised below:

- A key challenge of implementing structural rehabilitation interventions in wetlands in the Highlands are the practical and logistical challenges associated with working in remote locations and a harsh climate. Challenges generally encountered include issues around site access, weather, availability of construction materials, construction mitigation to minimise the impacts on wetland habitats, training of construction staff and labourers, environmental compliance, occupational health and safety, site management, design revision during implementation due to specific site constraints, revegetation of disturbed footprints, livestock management and control, maintenance of the rehabilitation measures implemented, and monitoring. These challenges need to be considered already during the wetland identification and prioritisation phase of rehabilitation projects;
- Structural wetland rehabilitation interventions must be accompanied by a grazing/rangeland management strategy. Livestock grazing must be managed, and if possible, excluded from the site during, and for a certain period after, the implementation of the structural rehabilitation interventions to allow for vegetation recovery;
- Selection of methods and structures suitable to the types of wetlands targeted, specifically where Fens are targeted and peat occurs in the wetlands;
- Provision must be made to secure some form of long-term stewardship of the rehabilitation structures, including but not limited to structural maintenance, livestock/rangeland management and monitoring strategy, and financial provision should be secured for this;
- To improve the success of structural interventions, planning must allow for the generation of all require information to inform engineering designs, including potentially detailed contour surveys and geotechnical surveys; and
- A monitoring programme supporting wetland rehabilitation interventions should be initiated well before the start of the implementation of rehabilitation interventions so that baseline data can be collected. Monitoring should include hydrological aspects wherever practical.

5.3.1.5 Residual Impact

A well-resourced, effective and coordinated ICM strategy focussed on altered grazing patterns in and around wetlands, and rehabilitation of priority wetlands, could reduce the significance of the residual impacts on wetlands to **Moderate**. In the absence of a strong and integrated multi-sectoral commitment to implementation of the ICM strategy across the broader Polihali catchment, with a focus of significantly reducing livestock grazing intensity in Valleyhead Fens, in particular, it is likely that the residual impact significance could remain **Major**. Despite attempts to implement ICM approaches in Phase I catchments over the last two decades, wetland condition has continued to decline in these areas.

Table 5.3 Impacts of Land Use Displacement on Wetlands

	Seeps & Sheetrock Wetlands		Valley Bottom & Valleyhead Seeps		Valleyhead Fens	
	151 ha		27.5 ha		5.4 ha	
	Pre-Mitigation Impact	Residual Impact	Pre-Mitigation Impact	Residual Impact	Pre-Mitigation Impact	Residual Impact
Type of Impact	Indirect/ induced		Indirect /induced		Indirect / induced	
Magnitude	Large	Moderate	Large	Medium	Large	Low
Sensitivity	Medium	Medium	Medium	Medium	High	High
Significance	**Major**	**Moderate***	**Major**	**Moderate***	**Major**	**Moderate***

Note: achieving a residual impact of Moderate significance depends on full commitment to early and ongoing implementation of a catchment wide ICM strategy.

Section 6 Mitigation and Monitoring

6.1 Introduction

The purpose of mitigation is to identify measures to protect the environment from impacts associated with a proposed development and is therefore a critical component of the ESIA process. Mitigation is generally undertaken according to the mitigation hierarchy which seeks to avoid, minimise and then remedy expected impacts. In the case of residual impacts that cannot be addressed through avoidance, minimisation and remedial activities, compensation activities are sometimes required. To ensure the effectiveness of mitigation, and to allow for an adaptive management approach, it is important that monitoring plans are implemented.

In relation to wetland impacts associated with the PRAI, the infrastructure footprints largely avoid wetlands, but there is little opportunity to avoid direct impacts associated with reservoir inundation. Mitigation for indirect impacts of landuse changes in the catchment are the biggest challenge for the project and will require a multi-disciplinary approach and effective coordination by many stakeholders if it is to arrest the high levels of catchment degradation and loss of wetlands and their ecological functionality. Mitigation measures therefore focus on activities and measures that can minimise and remedy expected impacts, while some compensation activities are also considered.

Mitigation measures are detailed under Section 5: Assessment of Impacts and Mitigation, specifically under Sections 5.1.1.4; 5.2.1.4 and 5.3.1.4. A brief summary of mitigation measures per project phase is provided below, as well as some additional recommendations around the proposed ICM and BMP.

6.2 Mitigation

6.2.1 Advanced Works / Construction Phase

No wetlands are located within the direct development footprints and only three small wetlands are situated close to the construction works area; notably two Seep wetlands near the tunnel rock spoil dump, and a Sheetrock wetland downslope of the aggregate quarry which will be inundated by the reservoir). . To prevent construction disturbance of these seepage zones it is recommended that the Seep wetlands near the tunnel spoil dump are demarcated and construction works and vehicular access near or across this area is limited, and that surface runoff into these Seeps is controlled.

6.2.2 Inundation and Operation Phase

There is no opportunity to mitigate the direct impacts of inundation on the 11 affected wetlands (occupying a total of 3.6 ha) within the reservoir FSL. The impact of displacement of land use from the reservoir on other wetlands in the catchment will require an integrated approach to catchment management which involves the control of grazing and agricultural pressures on wetlands as well as rehabilitation of selected priority wetlands. This will serve to enhance the delivery of clean water, reduce sedimentation and regulate stream flows that supply the dam. Enhanced protection of portions of the upper catchment can serve as a form of biodiversity offset for the broader impacts of LHWP Phase II (refer to Section 5.3.1.4 and Section 6.3).

These wetland initiatives should be complemented by a wetland monitoring strategy (Section 6.4) and a wetland management and rehabilitation strategy that can be incorporated into the proposed ICM and BMP plans (refer to Section 5.3.1.4 and Section 6.3).

6.3 Other Recommendations

In addition to the mitigation measures outlined above recommendations related to the need for broader catchment management initiatives that are expected to be implemented under a future ICM Strategy and/or BMP for the Polihali sub-basin are outlined below.

The key driver of wetland degradation within the AoI is considered to be the change in catchment and wetland hydrology, which is driven by the overutilisation of rangeland resources and the cultivation of the immediate wetland catchments, resulting in decreased infiltration and interflow, increased surface runoff volumes and velocities, and concentration of flows, leading to erosion. Unless this is addressed any wetland protection and rehabilitation initiatives are likely to fail. Implementation of an ICM strategy is the most critical mitigation measure from a wetland perspective. Active wetland protection and rehabilitation measures, including structural interventions and fencing of wetland areas, will support ICM, but cannot successfully be pursued in the absence of a thorough rangeland management plan.

6.3.1 Integrated Catchment Management Strategy

It is recognised that sustainable rangeland management is critical to enhanced biodiversity and wetland condition in Lesotho. Therefore, measures that lead to successful moderation of grazing intensity, soil conservation and restrictions on cultivation in sensitive areas of the catchment can be expected to maintain and potentially improve wetland condition and associated biodiversity and ecological functioning. The ICM strategy for the Polihali catchment is expected to address issues related to overall catchment condition with a view to reducing the rate of soil loss and dam sedimentation, and optimising rangeland condition to support the prevailing livestock-based economy. This strategy will need to incorporate direct rehabilitation measures for identified wetlands and which may include some form of structural interventions in certain targeted wetlands.

The ICM strategy must include considerations from various perspectives including rangeland management, water quality management, terrestrial biodiversity and wetland protection, and socio-cultural aspects, as well as make provision for expected consequences of future altered rainfall and temperature patterns. In particular, wetland protection is closely tied to management of livestock grazing practices and cropping in and around wetlands and therefore requires coordination by all relevant stakeholders including those working in the Department of Water Affairs, Department of Livestock, Department of Environment, Department of Range Management, and Department of Soil Conservation. The requirements of such an ICM plan should be determined through interdisciplinary workshops between the various national and district stakeholders.

In particular, the Phutha Sheep Stud and associated wetland represents an excellent example of what is possible under strict grazing management and represents a good reference for natural or largely natural wetlands of the area. Enhanced protection and management of the Phutha Sheep Stud and its wetland is therefore considered a priority. More formal protection should be extended to this area to prevent increased human encroachment and livestock pressures as a result of land use displacement from the reservoir.

In addition, the catchment management plan should prioritise wetlands for formal rehabilitation interventions, and should include a detailed wetland monitoring plan (see guidelines in Table 6.2).

6.3.2 Protection of Upper Catchment Area

Wetlands of highest priority for conservation are those in the subalpine and alpine zones of the Lesotho Highlands, generally located above 2800 m. These wetlands are typically the high altitude Valleyhead Fens or mires that occur in the inter-fluvial valleys and which are under significant summer grazing pressures, but increasingly subject to grazing during winter as well. These Fens are generally considered to have high conservation, related to the presence of peat, their role in the hydrological functioning of the catchment through purifying and attenuating flow and reducing sedimentation of rivers and streams, as well as their uniqueness, being restricted to the Highlands of Lesotho.

However, high altitude Fens are poorly protected in Lesotho with only the Bokong Nature Reserve a statutory reserve that protects high altitude wetlands of the Bokong River system which feeds the Katse Reservoir. The MDTP has recognised the importance of conserving these high lying areas of the country and has prioritised the Mokhotlong – Sanquebethu and Sani Top areas for enhanced protection (MDTP 2009); although no rangeland protection has yet been implemented due to lack of funding. As many as possible of these high altitude Fens should be formally protected, an objective that could be pursued through including the alpine and subalpine reaches of the Polihali reservoir catchment into the Maloti Drakensberg Transfrontier Park.

In light of the expected impacts of land use displacement from the reservoir on surrounding rangelands and wetlands, and the need for interventions to arrest the extensive erosion prevalent across much of the catchment, it is strongly recommended that additional protected areas are established in the upper Polihali catchment. Such areas would comprise a form of compensation or offset for the wider biodiversity impacts of the LHWP Phase 2 development. Such areas will need to adopt alternative rangeland management practices informed by an interdisciplinary approach and involving various specialists and all stakeholders. The approach will need to be developed considering the unique challenges associated with rangeland management in the Highlands and the socio-economic consequences of recommended measures.

Management measures will need to focus on strategies to reduce livestock grazing pressures on wetlands (e.g. by implementing rotational grazing of wetlands, curtailing livestock grazing in high altitude areas during winter, and possibly excluding grazing from certain wetlands entirely until they can recover, with or without direct rehabilitation interventions such as gabions).

Du Preez and Brown (2011) highlight that conservation areas should be multi-usage and that there can be zones/areas within the larger conservation areas that allows grazing at different times of the year or via an alternative rangeland management strategy/system. The complete exclusion of grazing is unlikely to be achieved across a wide area and probably would only displace the impact of grazing elsewhere. The key is however that a rangeland management plan is developed, implemented and carefully monitored to ensure grazing is undertaken within the carrying capacity of the rangeland and does not contribute to further degradation of wetland habitats and their catchments. Given the dependence of local communities on livestock grazing and other subsistence land uses, the key factor in the success of a management plan would be obtaining the buy in of the local communities. All key stakeholders should be involved in the decision-making processes regarding rangeland management plans and grazing restrictions. No strategy will be successful without the support, buy in and even ownership/stewardship of the strategy by key stakeholders, including the Department of Range Resources Management, the Grazing Associations and the Principal Chiefs.

Direct wetland intervention such as rehabilitation of erosion gullies in selected wetlands, particularly Valleyhead Fens, should also be included under a Wetland Rehabilitation and Management Plan as part of the broader integrated approach to catchment protection (as outlined in Section 5.3.1.4).

6.4 Monitoring Requirements for Wetlands

6.4.1 Scope and Rational

Wetland monitoring requirements are proposed to focus on wetland condition monitoring post-inundation due to displacement effects of the dam. Monitoring is required in the defined AoI due to the socio-cultural importance of these wetlands and the dependence of communities on services such as grazing and water supply provided by these wetlands.

Further monitoring is however also required beyond the AoI across the entire catchments feeding the Polihali reservoir, with specific reference to the high altitude wetlands located at the top of the catchments. These wetlands, which include extensive peat wetlands, are unique to Lesotho and are considered important from a water supply perspective, feeding into the Polihali reservoir and playing an important role in maintaining baseflow within headwater streams. The contribution of wetlands and ecosystems to water security has been recognised by the Lesotho Government and the rehabilitation of degraded wetlands has become a priority for the Lesotho government, specifically also in adapting to projected changes in the climate (LMS, 2013), which are likely to exacerbate impacts to wetlands.

Monitoring activities should focus on the key drivers of wetlands and should include consideration of changes to wetland hydrology (within wetland and within wetland catchments), geomorphological changes, and vegetation composition and structure. Water quality components are also included at a basic level.

Table 6.1 Mitigation Measures for Wetlands

Ref	Activity	Requirements / specifications	Responsibility	Scheduling / Timing/ Frequency	Phase	Performance Indicator(s)	Training Requirements
1	**Wetland Awareness and Training**						

1.1	Develop induction and training and awareness materials for wetlands and hold regular training sessions.	Implement education and awareness training of staff on identifying wetlands and minimising their disturbance and prohibition of collection / harvesting of wetland resources (e.g. posters, toolbox talks, etc.). Specific measures include:
		• Design and put up posters representing wetland types and importance in the project area;
		• Develop wetland education and awareness materials to enable staff to identify sensitive wetland features;
		• Hold regular tool box talks with staff informing them of the following restrictions:
		  • Prevention of fires, digging, trampling or driving across wetlands;
		  • Harvesting of wetland resources and picking of flowers;
			Contractors	Regular training	Prior to and throughout advanced works and construction phases	• Induction and awareness materials prepared and approved prior to on-site construction activities.
						• Posters on wetlands developed and put up in central locations e.g. labour camp central areas; contractor offices.
						• Induction materials set out restrictions on causing harm to wetlands.
						• Tool box talks on general wetland habitat and species protection provided at regular intervals
						• All staff signed proof of attendance of induction and tool box talks.
						• No evidence of damage to wetlands from contractors
							All staff to undergo Induction.
							
							Regular tool box talks.

2	**Stormwater Management** ***Objective:** minimise impacts of uncontrolled drainage and polluted water on wetlands*						
2.1	Uncontrolled stormwater drainage, erosion / sediment and pollution controls	A construction stormwater management plan must be developed and implemented prior to the commencement of any large scale vegetation clearing activities or construction activities and must be maintained until the end of the construction phase. The plan must minimise the transport of sediment off site as well as prevent the discharge of high velocity flows into downslope wetlands. The plan must make provision for : • Installation of sediment traps and sediment barriers	Contractor: EM and ECO.	Throughout construction	Construction	• Stormwater management plan in place • On – site evidence of specified sediment, erosion and pollution controls. • Incidence reporting of spills and clean ups	Staff to undergo training to deal with spills and clean-ups.

Ref	Activity	Requirements / specifications	Responsibility	Scheduling / Timing/ Frequency	Phase	Performance Indicator(s)	Training Requirements
		• Protection of stormwater discharge points against erosion and incorporation of energy dissipaters. • Limiting the area of disturbance and vegetation clearing to minimum area; • Optimise construction during the dry season; • Phase vegetation clearing activities and limit the time that bare soil is exposed to erosion; • Control stormwater flowing onto and through the site. Divert stormwater from upslope around the construction site; • Promptly stabilise and re-vegetate soils after disturbance and construction activities are completed in any given area; and • Protection of slopes: stabilise steeper slopes using geotextiles or any other suitable product designed for the purpose. • Installation of sediment controls around the perimeter of the site through sediment fences along downslope verges of the construction site. Where channelled or concentrated flow occurs, reinforced sediment fences or other sediment barriers such as sediment basins should be used; • Discharge stormwater from the construction site into adjacent grassland rather than directly into wetland habitats. Discharged flows must be slow and diffuse. • Regular inspection and maintenance of sediment controls. • Control of contaminated runoff from the construction sites should include: • Use and storage of potential contaminants in bunded areas and on impermeable surfaces to contain spills and leaks. • Retain sufficient spill clean-up material on site at all times to deal with minor spills. • Report all spills to the Environmental Control Officer and report incidence of large spills to					

Ref	Activity	Requirements / specifications	Responsibility	Scheduling / Timing/ Frequency	Phase	Performance Indicator(s)	Training Requirements
		the relevant authorities, and appoint specialists to oversee the clean-up operations.					
3	**Protection of Phutha Sheep Stud** ***Objective:*** *Protect sheep study as intact example of natural wetland habitat and as refuge for wetland biodiversity.*						
3.1	Protection of Phutha Sheep Stud	• Appoint range management offices to patrol and enforce grazing restrictions in Phutha Sheep Stud. • Erect signage on entrance roads to and through the sheep stud to highlight its protection status and avoidance of fires, harvesting, grazing pressures. • Prioritise additional grazing restrictions in a buffer area around the sheep stud and work with district stakeholders to consider increasing size of the sheep stud area with aim of designating it as a nature reserve.	LHDA and Livestock Department, Range Management Division	Initiated during Advance Works Phase	During construction and inundation and operation	• Range management staff appointed and patrols implemented. • Signage erected. • Stakeholders engaged. • Defined buffer area with grazing restrictions implemented. • Declaration as a nature reserve.	Training of range staff to implement grazing controls
3.2	Mokhotlong waste management site	• Work with District officials in Waste Management departments to avoid creation of a new waste management site near Phutha Sheep Stud in order to minimise throughflow of traffic and risk of dumping and littering en route in the sheep stud. • Provide assistance to identify a suitable waste landfill site for Mokhotlong town.	LHDA and Waste Management Authorities of Mokhotlong	Initiated during Advance Works Phase	Starting during site preparation phase	• Waste management / landfill site relocated to suitable site near Mokhotlong (away from sheep stud).	NA

6.4.2 Monitoring Plan

6.4.2.1 Advanced Works / Construction Phase

No specific wetland monitoring requirements are proposed for the advanced works and construction phase. The appointment of an on-site ECO is however recommended to ensure compliance with proposed mitigation measures and to ensure that project activities are limited to the development footprints indicated.

Wetland monitoring initiatives for the PRAI will focus on the catchment and will be incorporated into the ICM and BMP.

6.4.2.2 Operation Phase

The proposed wetland monitoring measures are detailed in Table 6.2.

Baseline assessment descriptions, wetland delineation and photographic records for a number of wetlands recommended for future monitoring purposes are provided in Appendix A. These monitoring wetlands should be supplemented with further wetlands, specifically Fens, located higher up the catchments and outside the AoI defined for this assessment (refer to Section 5.3.1.4).

Table 6.2 Monitoring Plan for Protection of Wetlands

No.	Aspect	Objectives	Method	Frequency and months	Sampling locations	Detection limit / Performance Target	Responsibility	Reporting
Wetland Monitoring Requirements								
1	Wetland health	Provide an overall indication of wetland health and trajectory of change	• WET-Health Level 2 (Macfarlane *et al.,* 2009) or other suitable published method.	Every 5 years	Selected target wetlands within the Polihali AoI as well as wetlands within the upper catchments feeding the reservoir	n/a	LHDA	A summary wetland monitoring report should be compiled by an appointed specialist for submission to the relevant authorities.
2	Wetland vegetation	Determine changes in vegetation composition and structure	• Fixed vegetation transects to map extent of vegetation zones • Record dominant species per zone • Compile basic species lists for entire target wetland • Map extent/count individuals of any Red Data species recorded	Every 5 years	Selected target wetlands within the Polihali AoI as well as wetlands within the upper catchments feeding the reservoir	n/a	LHDA	A summary wetland monitoring report should be compiled by an appointed specialist for submission to the relevant authorities.
3	Peat	Sample peat depth and humification to determine drying out or oxidation of peat	• Undertake peat sampling using a handheld peat auger along a fixed transect through the wetland • Record peat depth and humification using Von Post humification scale	Every 5 years	Selected target wetlands within the Polihali AoI as well as wetlands within the upper catchments feeding the reservoir	n/a	LHDA	A summary wetland monitoring report should be compiled by an appointed specialist for submission to the relevant authorities.
4	Erosion	Determine impact and rates of erosion in wetlands	• Visual inspections of erosion features in wetlands • Record locations of headcuts with GPS • Measurement of gully width and depth	Every 5 years	Selected target wetlands within the Polihali AoI as well as wetlands within the upper catchments feeding the reservoir	Gully erosion does not increase	LHDA	A summary wetland monitoring report should be compiled by an appointed specialist for submission to the relevant authorities.
5	Flow monitoring	Collect detailed data on flow and saturation within a sample of wetlands	• Install piezometers and data loggers to record flow and soil saturation in wetland • Install rain gauges in	Data to be collected at regular intervals	Select 5 target wetlands within the upper catchments of the reservoir, ideally Fens	n/a	LHDA	A summary wetland monitoring report should be compiled by an appointed

No.	Aspect	Objectives	Method	Frequency and months	Sampling locations	Detection limit / Performance Target	Responsibility	Reporting
			wetland/wetland catchment if possible (consideration of theft of equipment will be an important factor). Otherwise a suitable nearby location should be selected.	depending on technology and equipment installed				specialist for submission to the relevant authorities.
6	Fixed point photography	Provide a visual record of wetland changes	• Fixed point photography • Photography of key impacts/locations within the wetland	Every 5 years	Selected target wetlands within the Polihali AoI as well as wetlands within the upper catchments feeding the reservoir	n/a	LHDA	A summary wetland monitoring report should be compiled by an appointed specialist for submission to the relevant authorities.
7	Livestock numbers and grazing	Collect detailed data on livestock numbers and grazing areas and practices	• To be defined under ICM strategy	To be determined in ICM strategy			LHDA	To be determined in ICM strategy

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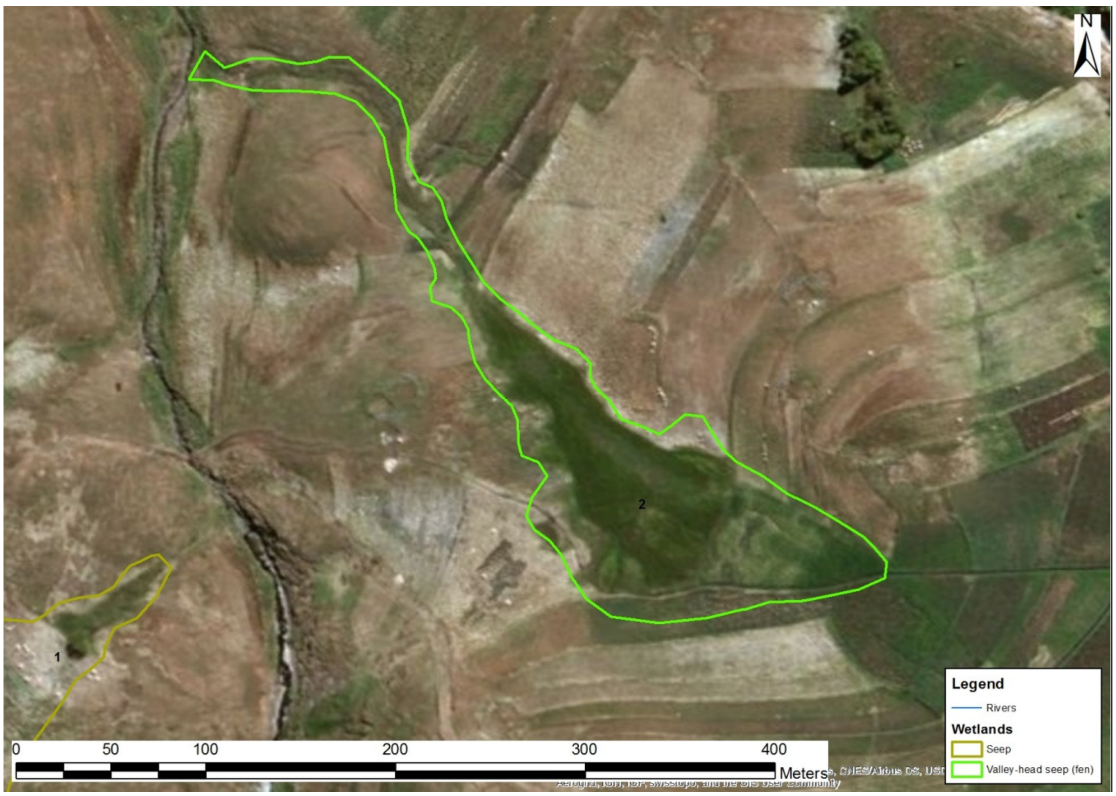
Appendix A. Wetland Descriptions – Baseline Assessment

This section details descriptions and photographic summaries of several of the sampled wetlands earmarked for future monitoring purposes. These descriptions, together with the contents of this report, provide the baseline against which future change can be assessed.

Wetland 02

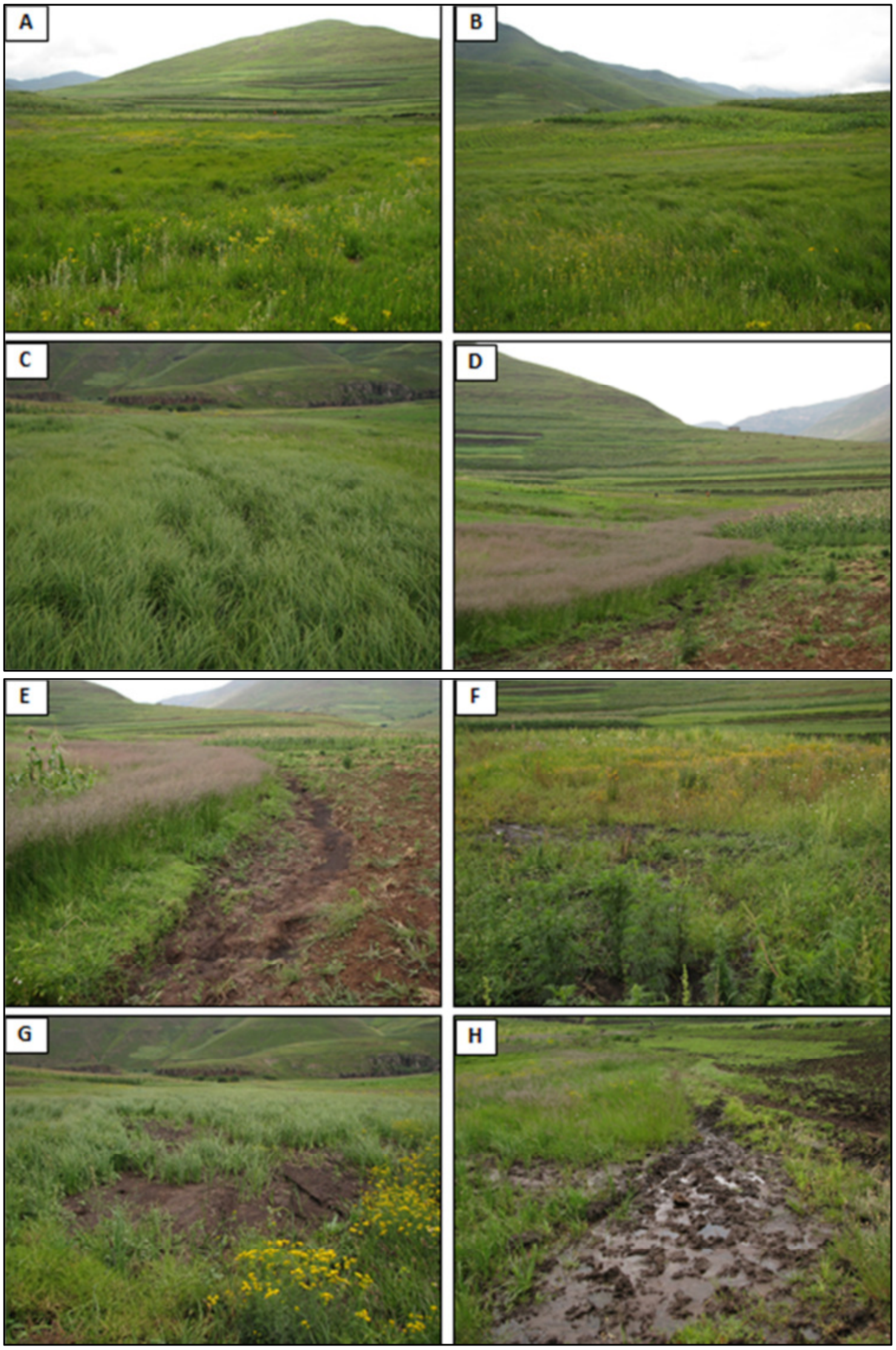
Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 02	Valleyhead Seep (Fen)	1.8	-29.149	29.146	2 396	15.8	C	High

Figure A.0.1 Map of Wetland 02



Wetland 02 is a NW facing Valleyhead Seep containing approximately 0.5m of highly decomposed peat in the main body of the wetland. The middle portions of the wetland were dominated by dense stands of tall *Carex* sp., being replaced by tall *Eragrostis heteromera* along the more confined lower reaches of the wetland. The upper reaches of the wetland as well as the immediate catchment of the wetland are mostly cultivated, with numerous erosion scars in the cultivated fields. This has resulted in significant sediment deposition in the upper reaches of the wetland, with some smothering of *Carex* vegetation evident. The more confined lower reaches of the wetland show signs of erosion and channel incision along the cultivated edge of the wetland; this is likely to continue due to increased surface runoff derived from the upslope cultivated fields. Minimal livestock grazing was observed at the time of the site visit, though some trampling by livestock did indicate recent utilisation. The wetland drains into an incised stream.

Figure A.0.2 Photos of Wetland 02.

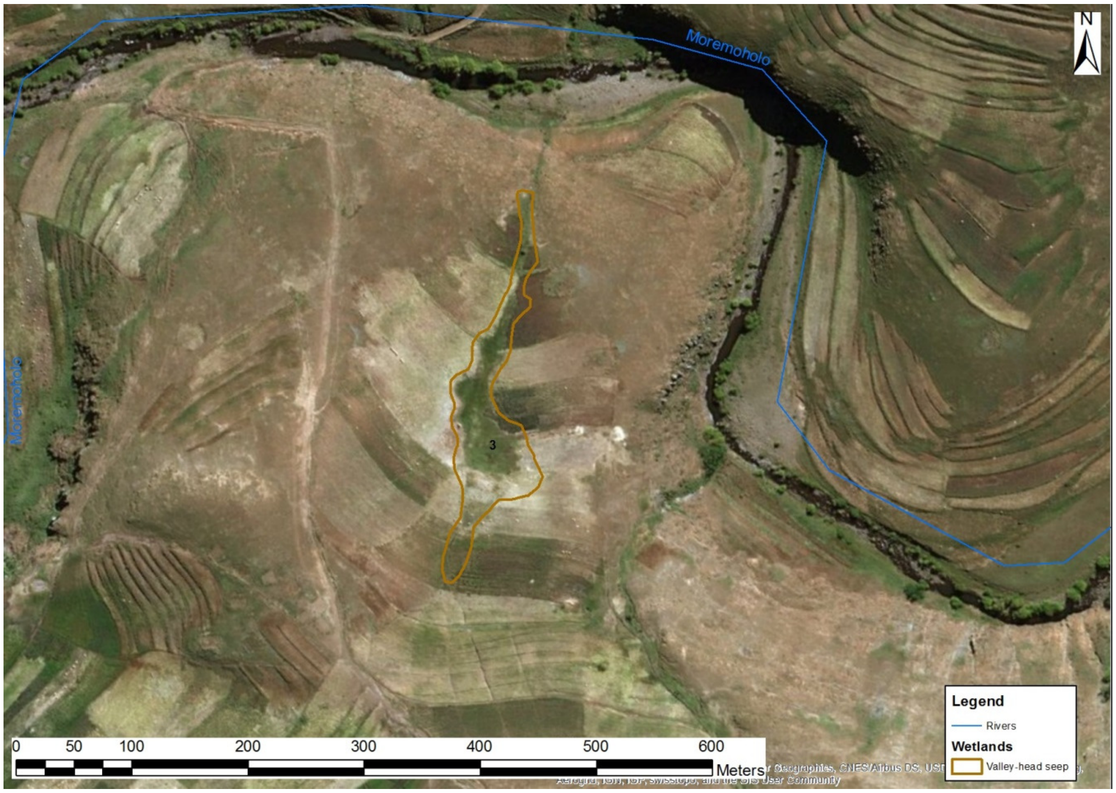


A: View across wetland into upslope catchment; **B**: Tall sedge meadow in main body of wetland; **C**: Tall sedge meadow in main body of wetland with weakly defined flow path; **D**: Tall Eragrostis meadow towards lower end of wetland; **E**: Erosion along edge of cultivated field in wetland; **F**: Secondary vegetation in previously cultivated section of wetland; **G**: Sediment deposition in wetland; **H**: Livestock trampling in wetland.

Wetland 03

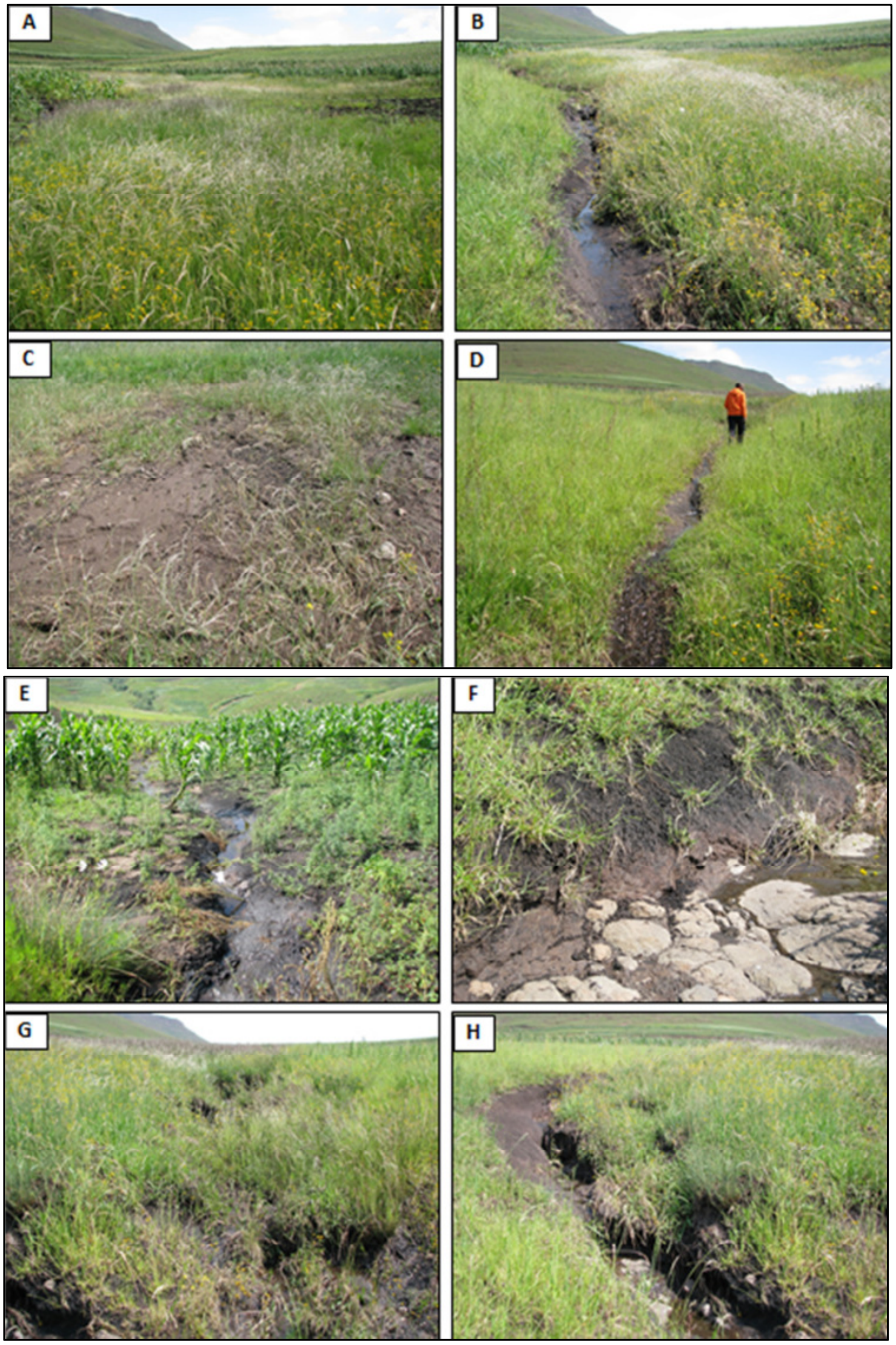
Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 03	Valleyhead Seep	1.0	-29.146	29.154	2 427	24	D	Moderate

Figure A.0.3 Map of Wetland 03



Wetland 03 is a roughly N facing Valleyhead Seep that is considered seasonal in nature. The immediate catchment of the wetland is entirely cultivated with numerous erosion scars. Sediment from these erosion scars is partially being deposited within the wetland. Cultivation has resulted in increased surface runoff, leading to increased flow velocities, as well as decreased interflow. As a consequence the wetland is undergoing erosion in the form of channel incision, with channel incision exploiting preferential flow paths created by footpaths and livestock paths, as well as edges of cultivated fields. In some instances erosion has reached bedrock. The wetland is dominated by a mixed grass sedge community with *Agrostis lachnantha* being prominent. Significant portions of the wetland margins were cultivated. It is likely that the wetland will continue to erode, which will result in portions of the wetland drying out.

Figure A.0.4 Photos of Wetland 03.

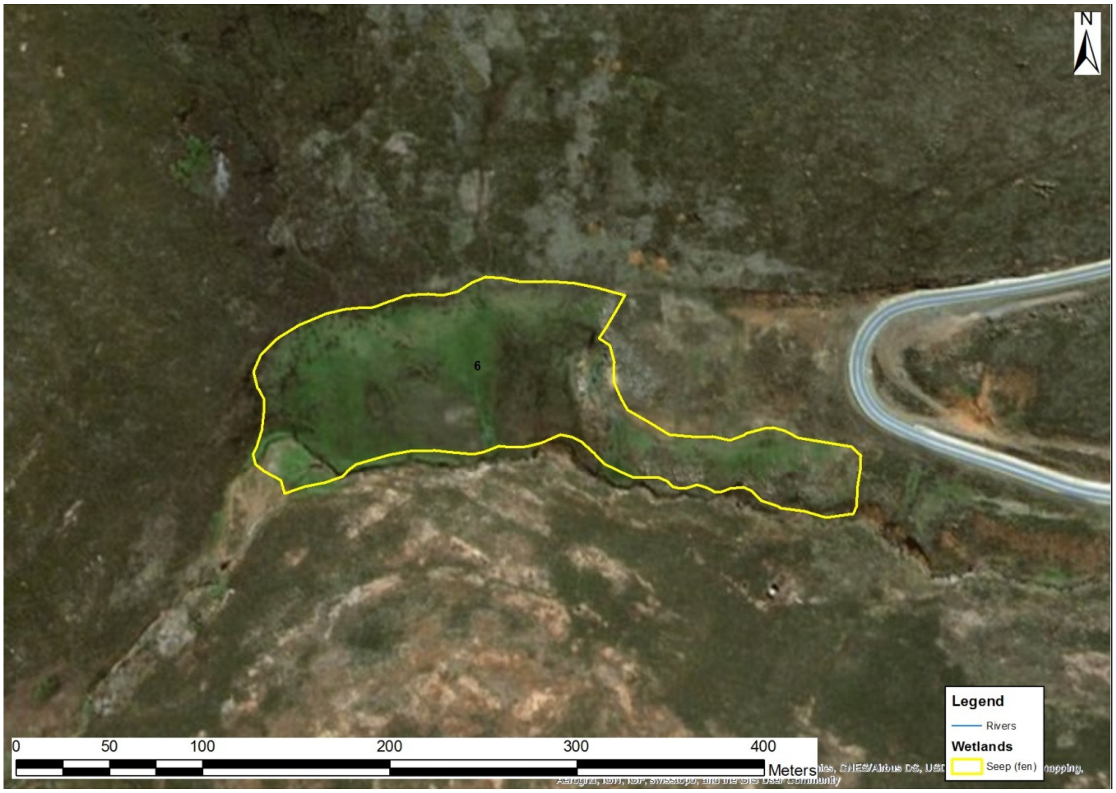


A: Mixed grass sedge meadow; **B**: Channel incision along edge of wetland; **C**: Sediment deposition in wetland; **D**: Erosion along footpath/livestock path; **E**: Erosion within adjacent cultivated fields increasing sediment inputs to wetland; **F**: Erosion to bedrock; **G**: Headcut within wetland; **H**: Channel incision.

Wetland 06

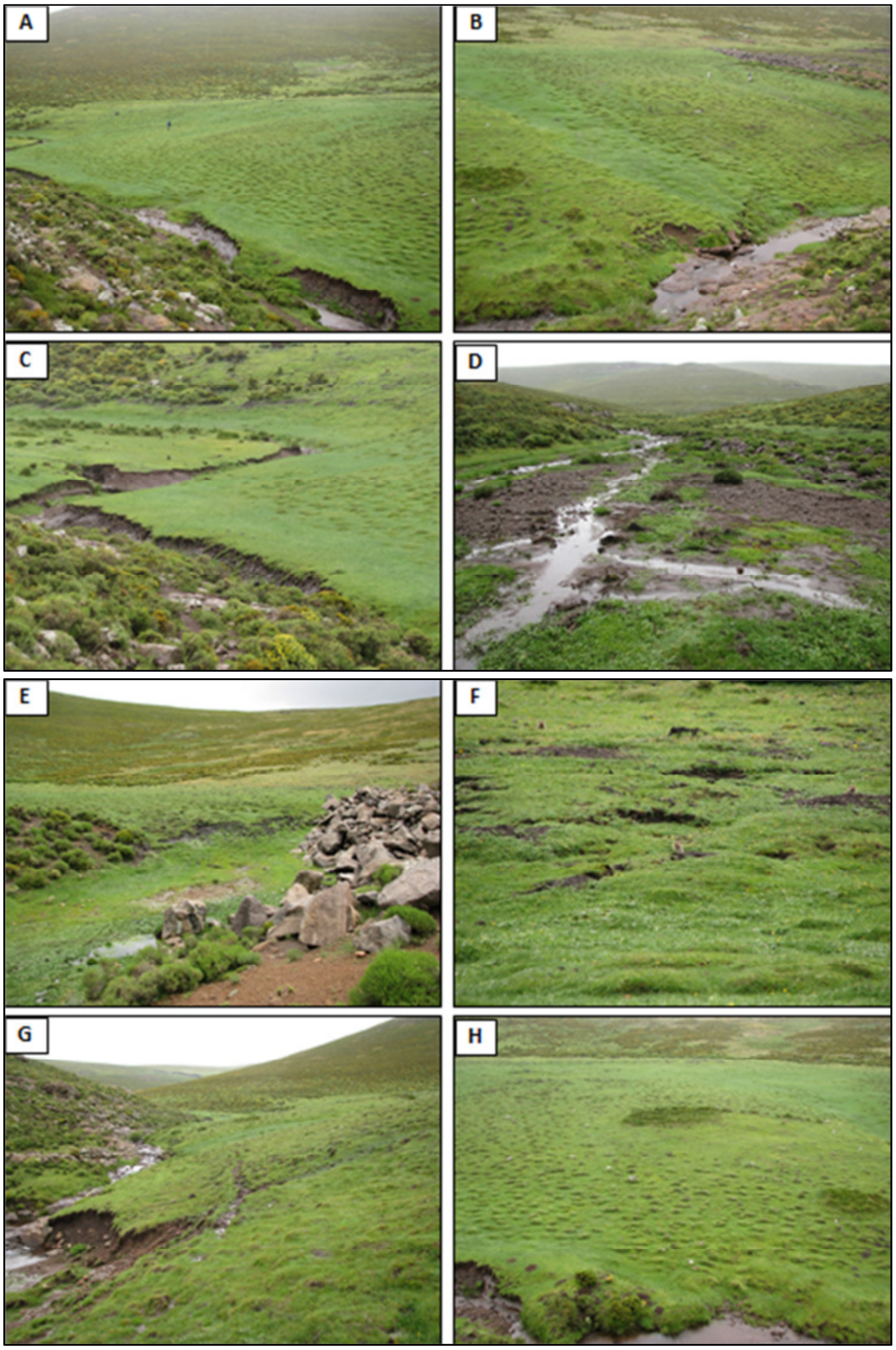
Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 06	Seep (Fen)	2.1	-29.084	28.842	2 919	15	C	High

Figure A.0.5 Map of Wetland 06



Wetland 06 is a south facing Seep (Fen) located on the moist south-facing footslope adjacent to an incised stream channel. The A1 road from Letseng pass just to the east of the wetland, with the wetland being clearly visible from the road. Road construction activity (presumably from when the road was tarred) infringed on the wetland with some excavations and rock infill extending into the wetland. It is likely that some wetland habitat was lost at the time. The catchment of the wetland is characterised by fairly steep natural grassland with numerous shrubs. As a consequence, the hydrology of the wetland appears largely intact. The wetland drains into an incised stream channel that is eroded to bedrock, but appeared largely stable. Extensive sediment deposition immediately upstream of the wetland indicates erosion within the stream's catchment. The wetland is dominated by the typical short sedge meadow that characterises the high-altitude Lesotho Mires. Approximately 0.8 m of peat was sampled, including virtually undecomposed peat (H2) at the bottom of one peat profile. An Ice Rat colony was observed along the upper margin of the Fen.

Figure A.0.6 Photos of Wetland 06.

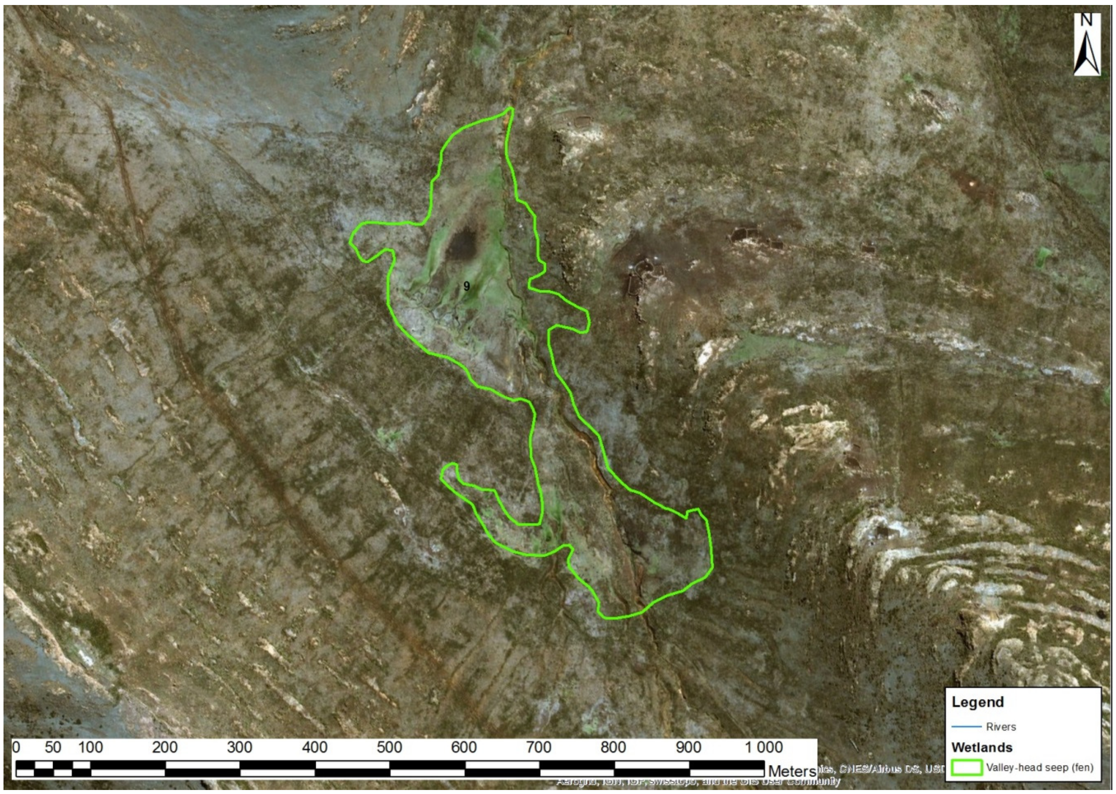


A: View across the Fen looking NW; **B**: View across the Fen looking NE; **C**: Incised stream channel along lower edge of Fen; **D**: Sedimentation in stream channel just upstream of Fen; **E**: Excavation and rock infill associated with road construction along eastern edge of Fen; **F**: Ice Rats along upper edge of Fen; **G**: Limited livestock trampling; **H**: Short sedge meadow vegetation dominates the Fen.

Wetland 09

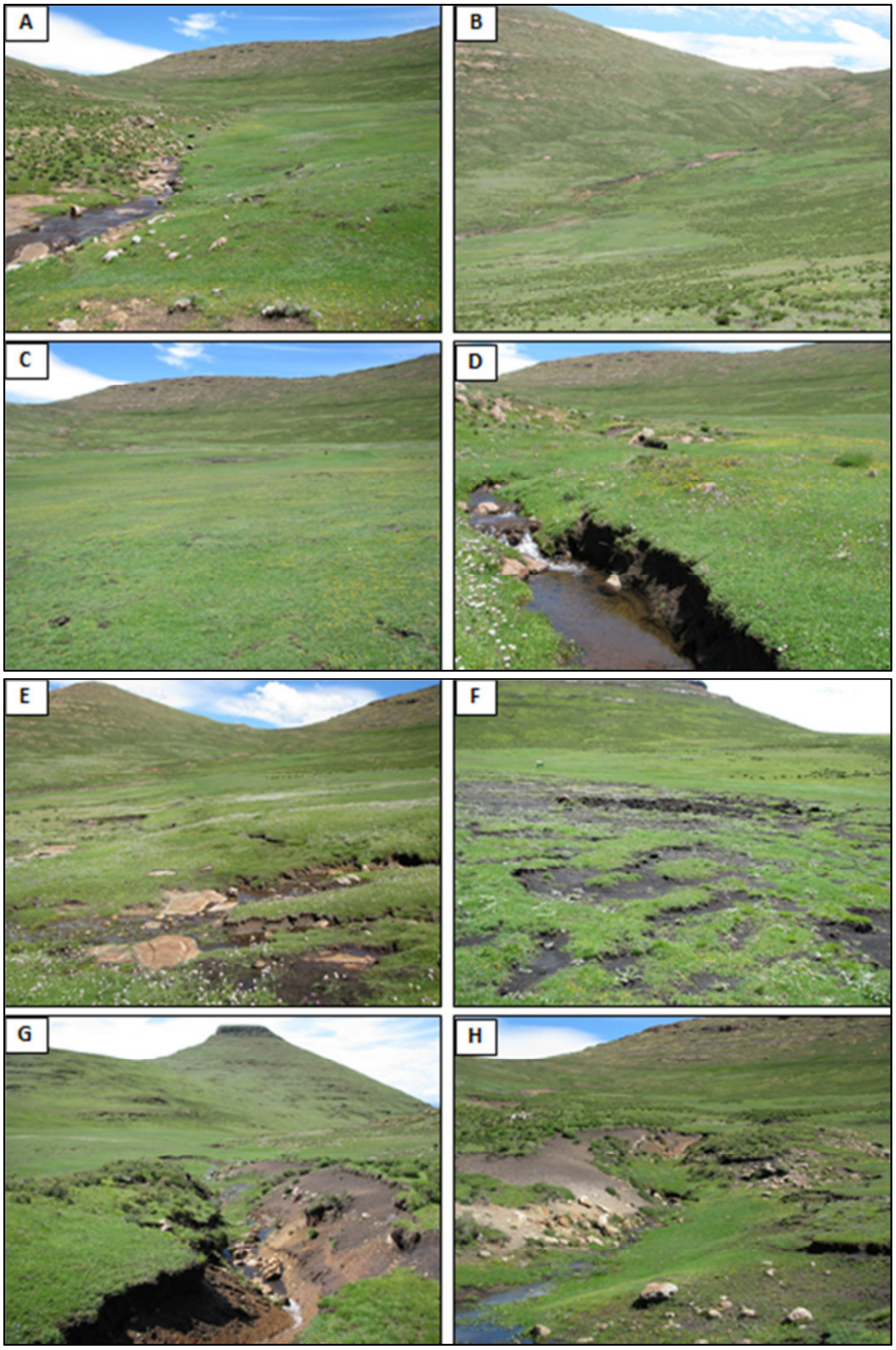
Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 09	Valleyhead Seep (Fen)	10.3	-29.421	28.975	2 997	12	C	Very High

Figure A.0.7 Map of Wetland 09



Wetland 09 is a NNW facing Valleyhead Seep that was the largest Fen surveyed as part of the PRAI Project. The Fen exists as two parts, and upper and lower part, with the upper part being somewhat drier and more heavily eroded, while the lower part is more intact. The Fen drains into a small stream that originates as an erosion gully in the upper part of the Seep and its upslope catchment, becoming a small stream that skirts the eastern edge of the lower part of the Fen; along the edge of the lower part of the Fen the stream is only weakly incised and controlled by bedrock. The upper part of the Fen is heavily eroded with numerous headcuts and gully incisions apparent. This has led to the partial drying out of the wetland and encroachment of shrubs. An excavation presumably associated with diamond prospecting (anecdotal evidence) was also observed within the wetland. The lower portion of the Fen is more intact and wetter. Three peat cores were sampled with a maximum depth of 0.85 m recorded. A large bare patch of soil was observed within the centre of the wetland – it appeared as though a vehicle had gotten stuck in the wetland, though the bare patch of soil has consistently been visible on aerial imagery (black smudge in centre of wetland Figure A-28 above). Parallel to the upper edge (SW) of the lower portion of the Fen there appears to be some form of slumping/erosion taking place. This could be associated with oxidation of the peat, though the wetland was fully saturated at the time of the site visit.

Figure A.0.8 Photos of Wetland 09.



A: Fen drains into a small stream; **B**: View across the upper portion of Fen and upslope catchment; **C**: The mostly intact lower portion of Fen with typical short sedge meadow vegetation; **D**: channel along eastern margin of Fen; **E**: Slumping and erosion along SW edge of lower portion of Fen; **F**: Large bare soil area in central portion of Fen; **G**: Erosion in upper portion of Fen; **H**: Erosion in upper portion of Fen.

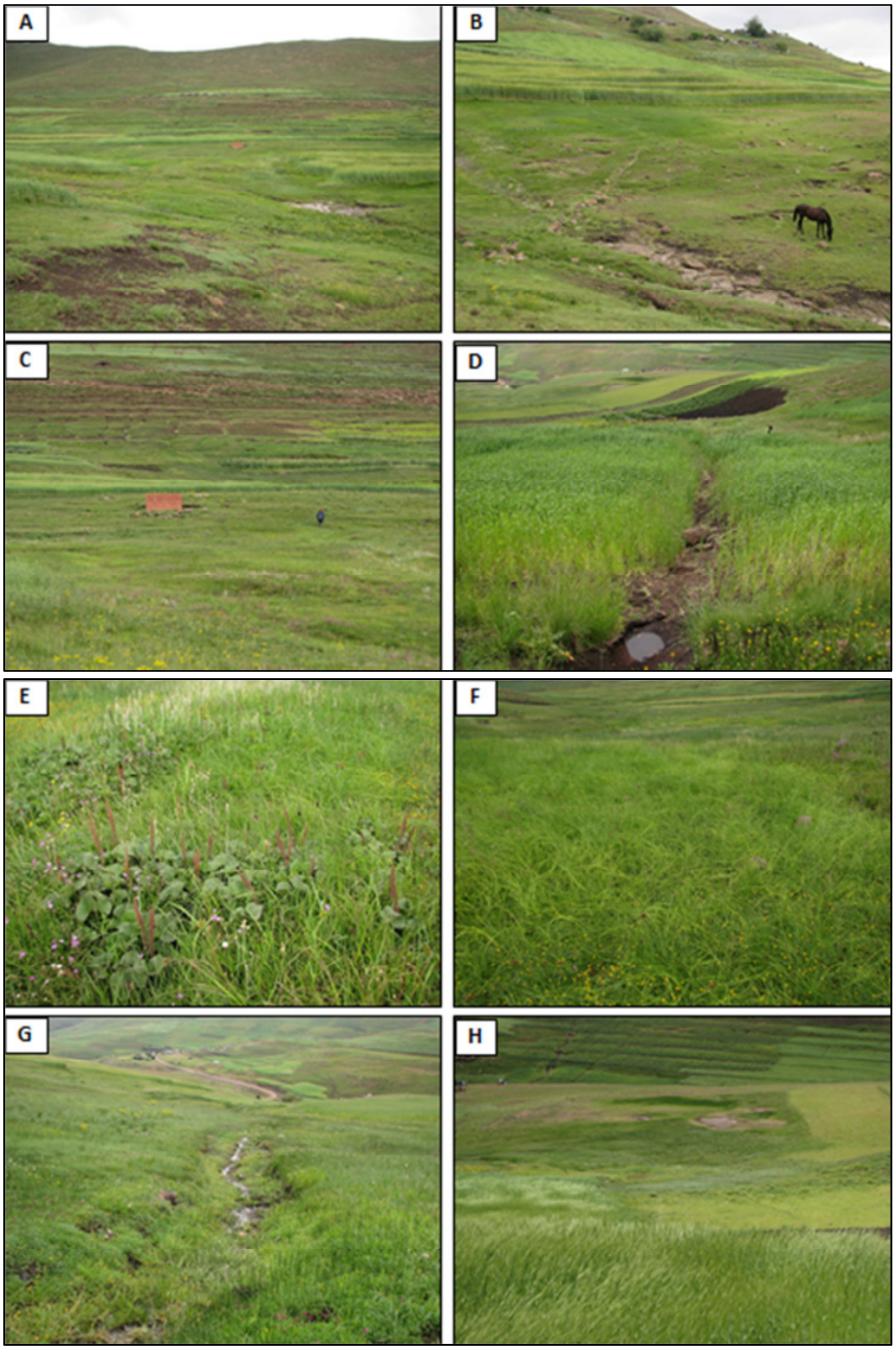
Wetland 11

Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 11	Seep	2.2	-29.385	28.996	2 547	20	C	Moderate

Figure A.0.9 Map of Wetland 11

Wetland 11 is one of several Seep wetlands located along a NE facing slope upslope of the A3 road. Numerous small villages and homesteads are scattered along the slope and the entire slope and wetland perimeter is extensively cultivated. Wetland 11 consists of the large (1.4 ha) main wetland body as well as three smaller Seep wetland areas located upslope of the main body. The wetland has become fragmented by cultivation. Extensive erosion scars occur within the cultivated fields and extend into the wetland. Increased surface runoff from the wetland catchment due to cultivation and livestock grazing has resulted in these erosion scars. Resulting sediments are partially deposited within the wetland, though most sediment is likely transported right across the wetland. Increased flows within the wetland have also resulted in channel incision within the wetland. Loss of topsoil has exposed bedrock in various places in the wetland, with Sheetrock wetland habitat also occurring. The main flow driver maintaining wetland habitat and saturation is however interflow. Numerous springs occur within the wetland, some of which are used for water collection. Formal water infrastructure was also observed within the wetland. The wetland is at risk of further erosion and channel incision, which would lead to loss of soil and partial drying out of the wetland. Towards the downstream end of the wetland the system becomes naturally more confined and a channel forms which drains into a small stream at the A3 road crossing.

Figure A.0.10 Photos of Wetland 11.

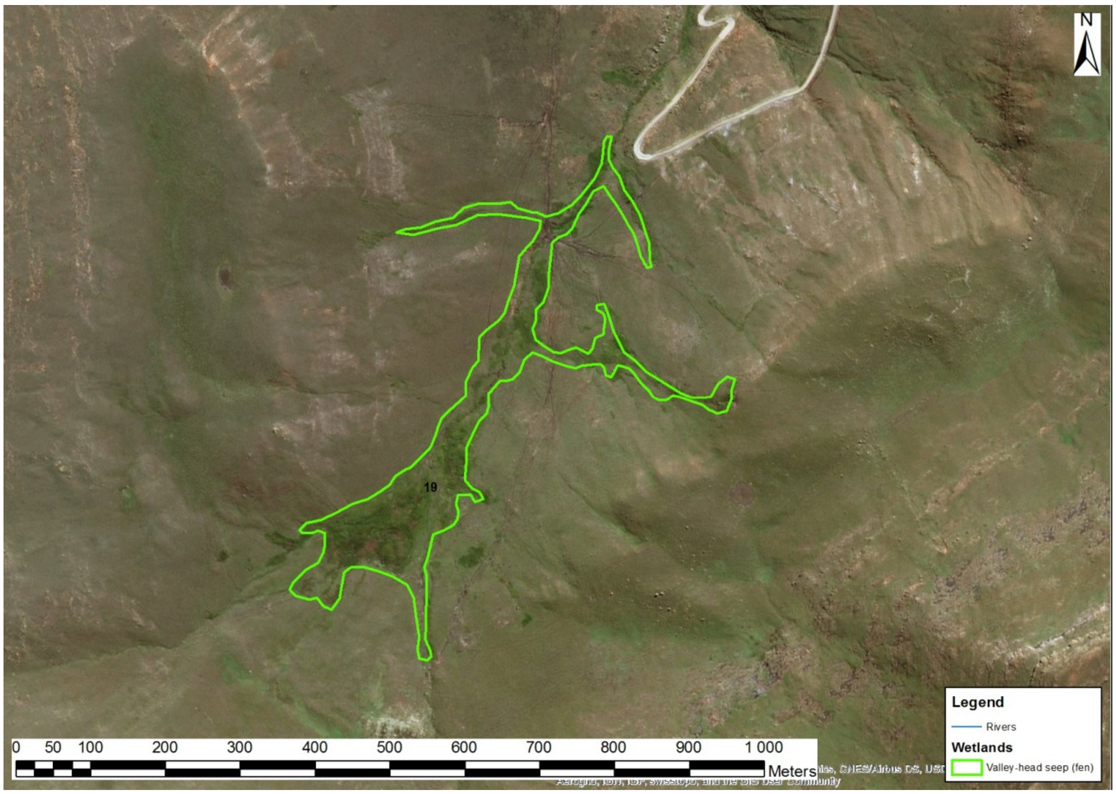


A: View across wetland; **B**: Bare rock and sheetrock habitat within the wetland; **C**: Water infrastructure; **D**: Erosion in cultivated fields extending into wetland margins; **E**: Mixed grass/sedge meadow with *Gunnera perpensa*; **F**: Sedge meadow; **G**: Channel incision within wetland; **H**: View across wetland, sheetrock habitat in background.

Wetland 19

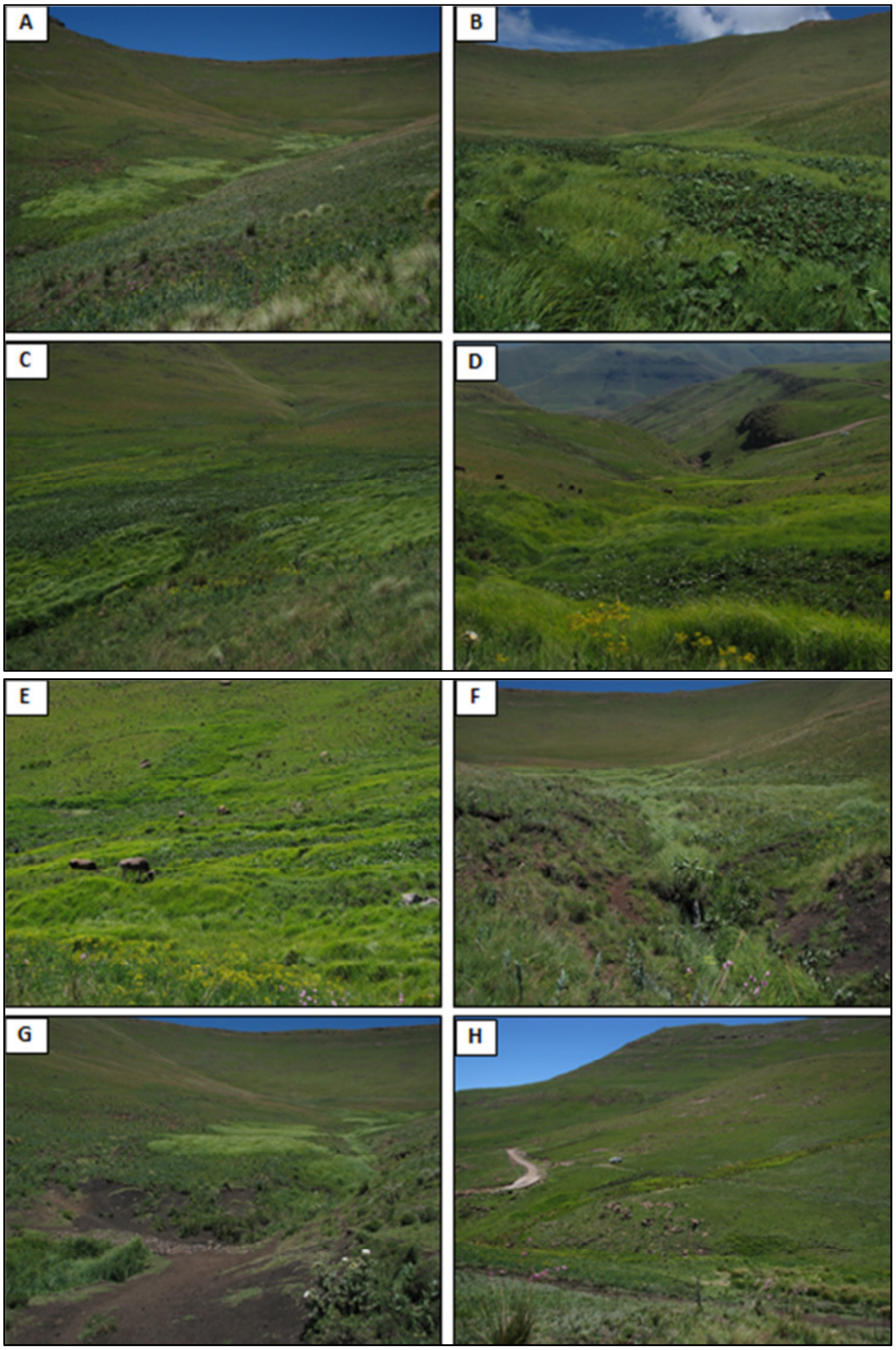
Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 19	Valleyhead Seep (Fen)	5.4	-29.317	29.082	2 542	17	B	Very High

Figure A.0.11 Map of Wetland 19



Wetland 19 is located within the Phutha Sheep Stud and is a NNE facing Valleyhead Seep supporting up to 1 m of peat. This wetland is considered as possibly the most important wetland surveyed, and represents a reference system for wetlands of the area. Careful management of grazing within the wetland and its catchment has resulted in the wetland and its supporting hydrology remaining intact. A striking feature of the wetland was the immediate sense of "life" upon arrival. Insects and birds where immediately audible – something that was noticeably absent from other wetlands surveyed. Large numbers of widows, bishops, weavers and cisticolas were seen utilising and nesting within the wetland. The main body of the wetland is dominated by tall *Carex* and *Gunnera*, changing to virtually monospecific *Carex* in the somewhat drier lower regions. The margins supported tall grass meadow. The wetland is mostly unchannelled in its upper reaches, but becomes clearly channelled in the more confined lower reaches, exiting the wetland as a stream near the public road. Numerous narrow side arms drain into the wetland. Within the upper reaches of the wetland some water collection infrastructure was observed. A well-defined track and livestock pathway traverse the wetland near its lower end and have resulted in severe trampling of vegetation in this area. A risk of erosion exists. The wetland catchment was grass dominated with very low occurrence of shrubs and a high number of flowering herbs.

Figure A.0.12 Photos of Wetland 19.



A: View across the wetland and its catchment; **B**: Tall Carex and Gunnera dominate the system; **C**: Main body of the wetland; **D**: View down the wetland towards the road; **E**: Livestock grazing within the wetland; **F**: Headcut erosion along a confined section of the wetland; **G** Livestock trampling at wetland crossing point near lower end of wetland; **H**: Side arm of wetland near public road crossing.

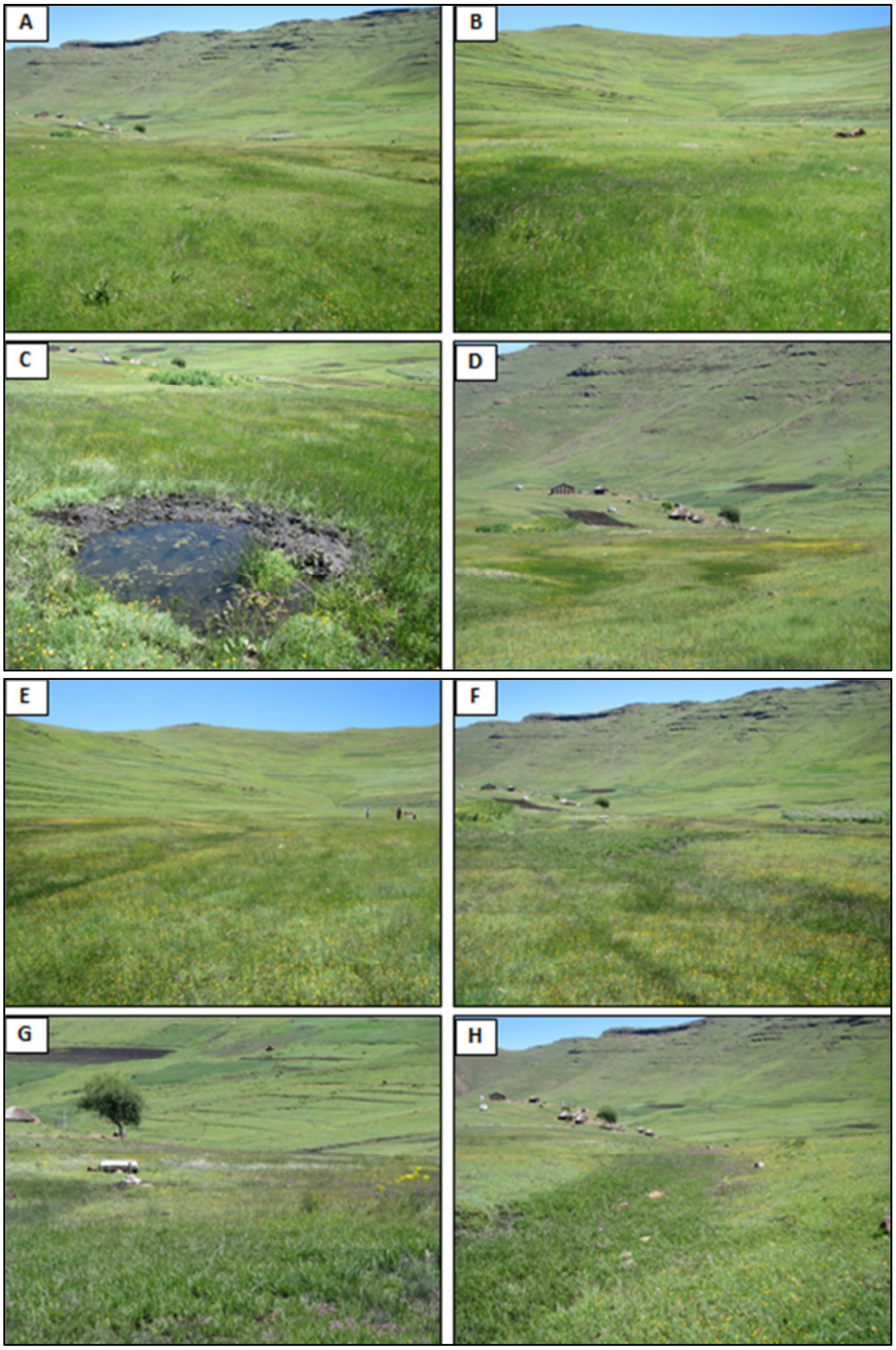
Wetland 31

Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 31	Valleyhead Seep	2.1	-29.259	28.968	2 631	10	C	Moderate

Figure A.0.13 Map of Wetland 31

Wetland 31 is a north facing Valleyhead Seep. The immediate catchment is cultivated along the entire wetland perimeter, with the upper catchment characterised by steeper grass covered slopes. A village occurs near the lower end of the wetland. The upper third of the wetland shows no signs of channelisation; the middle third of the wetland is characterised by numerous shallow, well-vegetated preferential flow paths indicating historical erosion; the lower third of the wetland becomes progressively more confined and incised, draining into a stream. Water collection infrastructure for the nearby village was observed within the central portion of the wetland. The wetland is heavily grazed, maintaining the vegetation as a fairly short grass/sedge meadow. Numerous shallow excavations were observed, presumably to expose water for livestock watering. The orchid species *Corycium nigrescens* was observed along the wetland margins.

Figure A.0.14 Photos of Wetland 31.



A: View across the wetland looking upstream; **B**: View across the wetland looking downstream; **C**: Numerous shallow excavations for livestock watering; **D**: Shallow flow paths from historical erosion; **E**: Mixed grass/sedge meadow kept short by heavy grazing; **F:** Minor preferential flow path; **G**: Water collection infrastructure for downslope village; **H**: Minor preferential flow path.

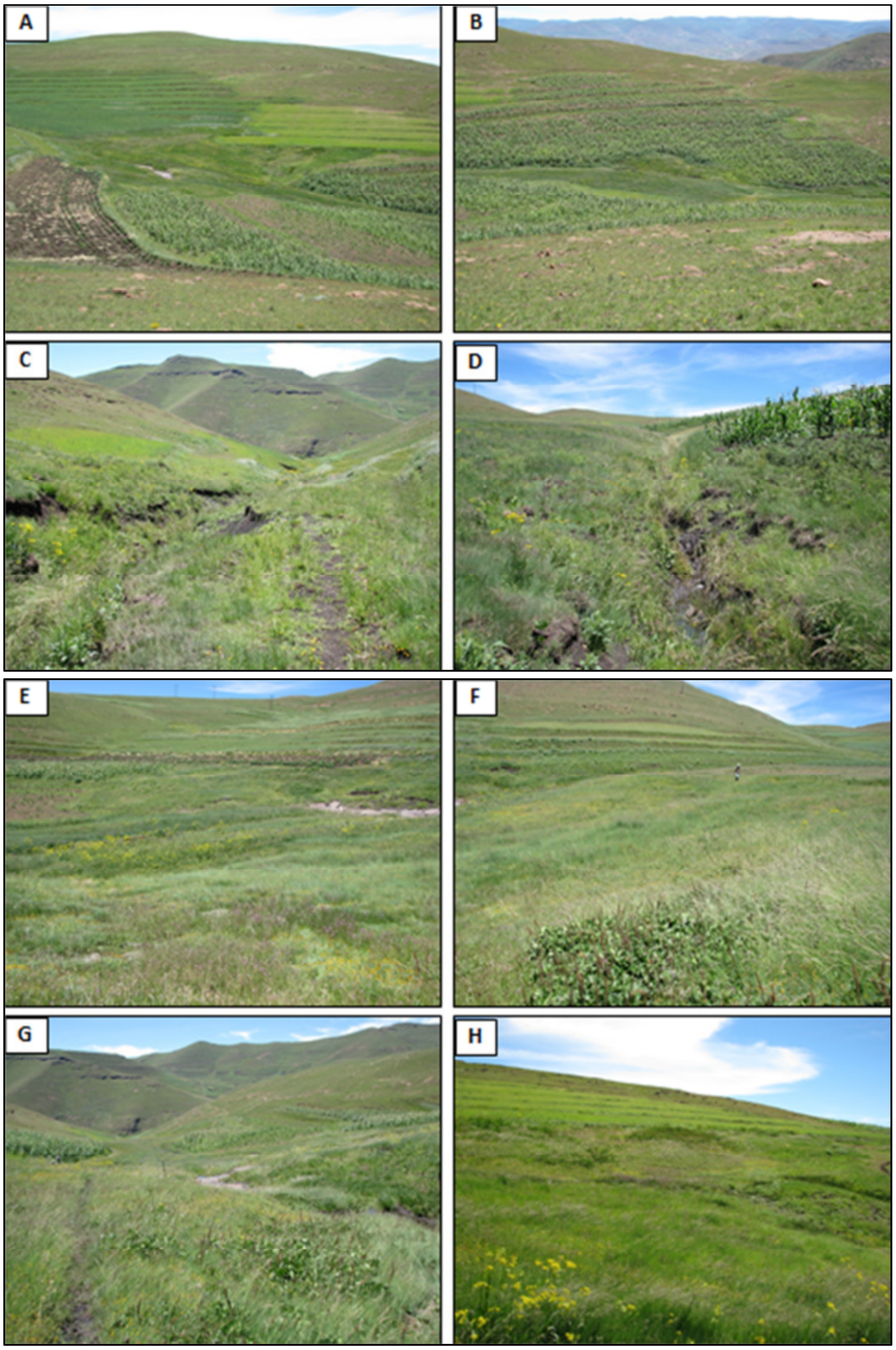
Wetland 33

Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 33	Valleyhead Seep	1.3	-29.262	28.947	2 500	10	C	Moderate

Figure A.0.15 Map of Wetland 33

Wetland 33 is an N facing Valleyhead Seep that has an incised channel of various depths along its full length. The immediate wetland catchment and wetland margins are mostly cultivated, extending marginally into the delineated wetland habitat. Gully erosion within the wetland catchment has resulted in extensive sediment deposits within the wetland, though most sediment is likely transported through the wetland. Surface runoff from the catchment is expected to have increased due to decreased vegetation cover from cultivation and livestock grazing. As a consequence an incised channel extends across the full length of the wetland. Active erosion in the form of headcut erosion and lateral bank collapse was observed. Within the wetland an area of exposed bedrock occurs along the channel and its banks. This area appears to be used for clothes washing purposes. A spring supporting an area of permanent saturation occurs along the western edge of the wetland. At the time of the field survey the wetland had not been recently grazed and was characterised predominantly by a tall grass meadow, with wetter patches supporting mixed sedge/grass meadow. The dominant grass species observed was *Eragrostis planiculmis*. The tall grass habitat supported numerous widowbirds.

Figure A.0.16 Photos of Wetland 33.

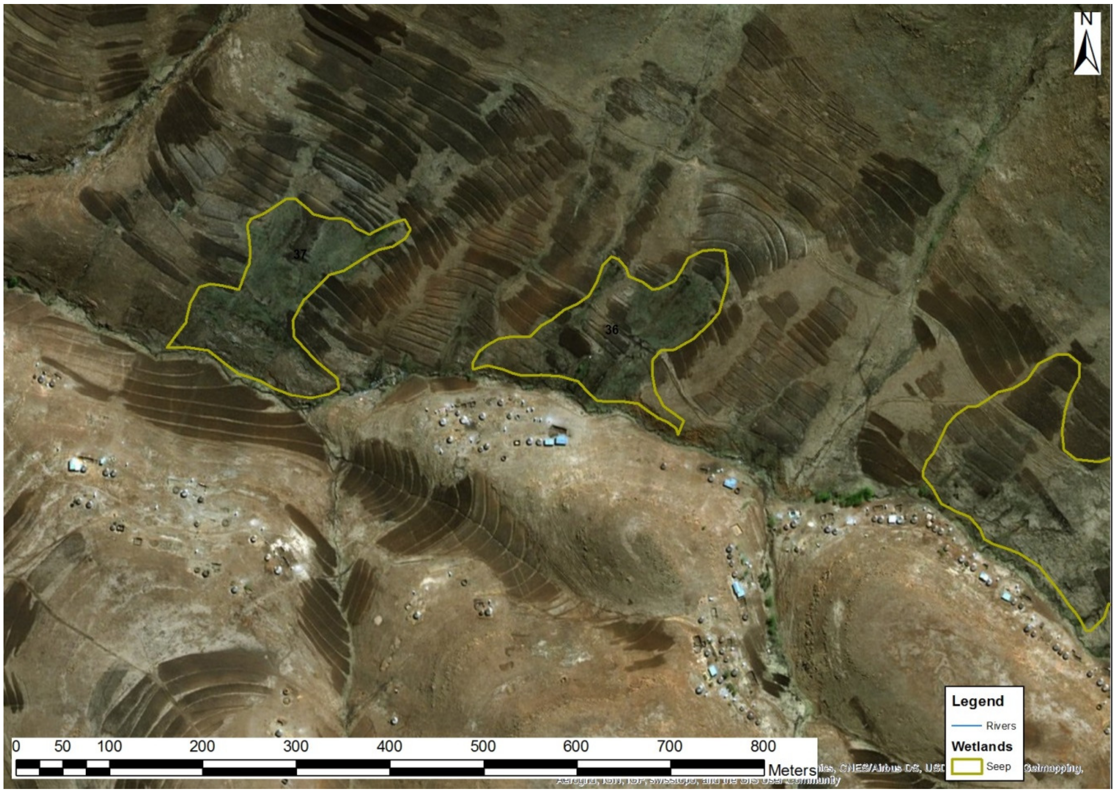


A: View across upper portion of wetland; **B**: View across middle portion of wetland; **C**: View along incised channel draining from wetland; **D**: Channel incision extending up into wetland; **E**: Note exposed bed rock in wetland used as a place for washing; **F**: Tall grass/sedge vegetation; **G**: Footpath through wetland; **H**: View towards a spring located along the western wetland margin.

Wetland 37

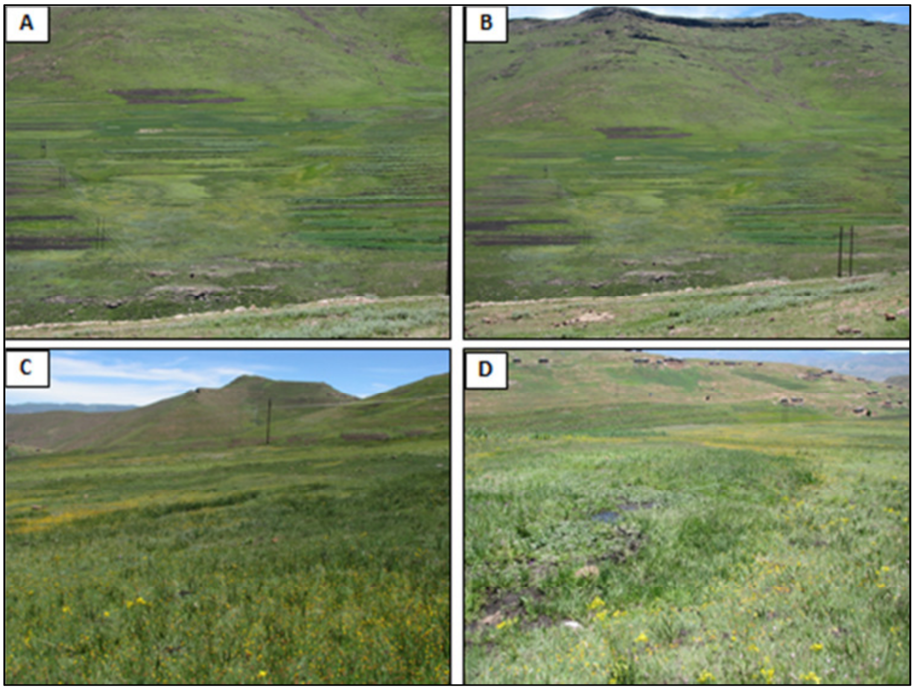
Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 37	Seep	2.3	-29.252	28.958	2 530	21	D	Moderate

Figure A.0.17 Map of Wetland 37 (western most wetland)



Wetland 37 is one of several Seeps located along the slopes adjacent to a west draining stream. The Seep is located on a fairly steep (20%), moist south facing slope that is extensively cultivated. The entire wetland perimeter was cultivated at the time of the site visit. The upper catchment of the wetland consists of steep mostly grass-covered slopes. Cultivation of the immediate catchment appears to have resulted in an increase in surface runoff and surface flow through the wetland. The wetland is characterised by a fairly short grass/sedge meadow with a high occurrence of ruderal species, maintained short by heavy grazing. A number of shallow, well-vegetated preferential flow paths exist within the wetland, but little active erosion was observed. A spring occurs near the NE corner of the wetland. A powerline runs along the western boundary of the wetland.

Figure A.0.18 Photos of Wetland 37.

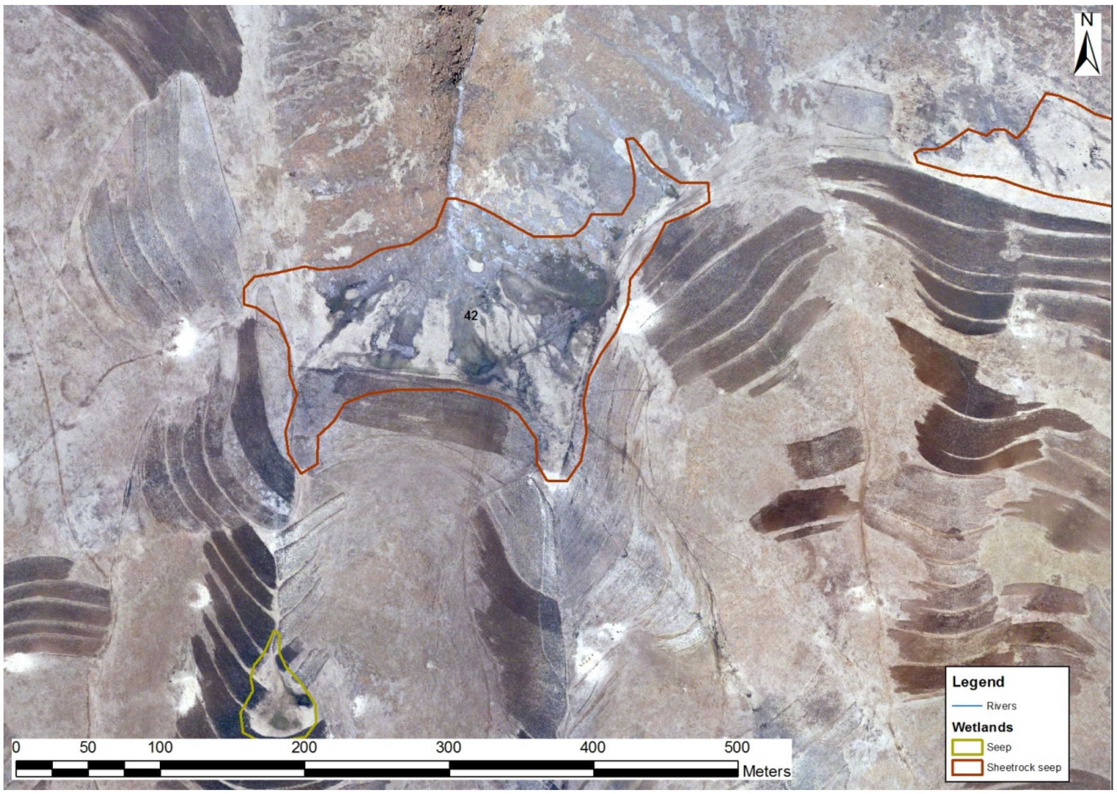


A & **B**: View across the wetland and its upslope catchment; **C**: Short grass meadow vegetation, heavily grazed. Note powerline in background; **D**: Spring in NE corner of wetland.

Wetland 42

Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 42	Sheetrock Wetland	3.2	-29.360	28.969	2 463	9	C	Moderate

Figure A.0.19 Map of Wetland 42



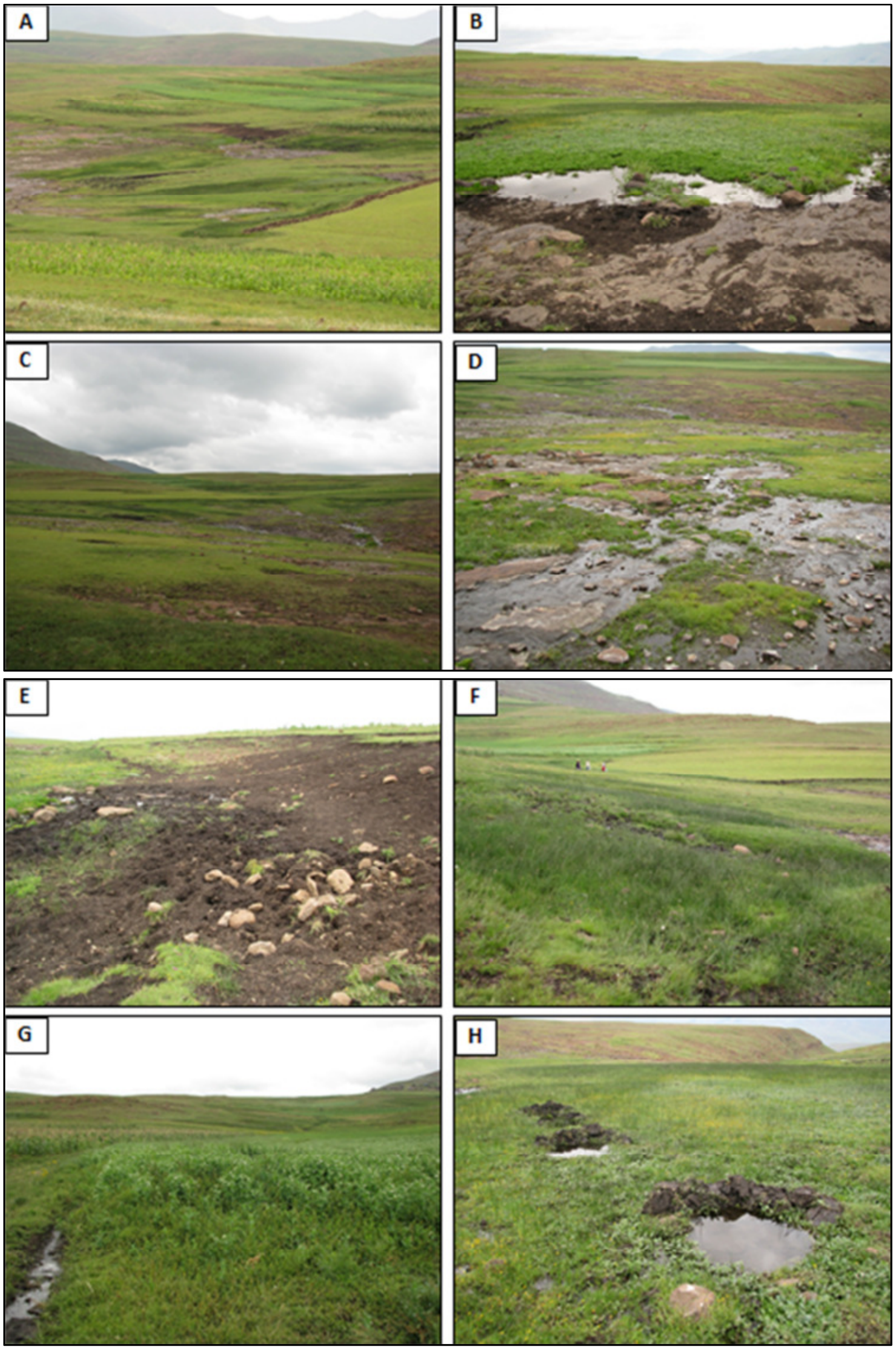
Wetland 42, a north facing Sheetrock wetland, forms part of the largest cluster of wetlands identified as part of the PRAI studies; the cluster is located to the south of the proposed Polihali Reservoir along an east-west running band located along a bench[3] at an altitude of approximately 2 450masl. The immediate adjacent catchment of the wetland is cultivated, with cultivation extending marginally into the upper wetland edge. The higher catchment is characterised by a combination of grazing land, cultivated fields and homesteads along the public road.

The seep front is located along the lower edge of the cultivated fields, which forms the upper edge of the wetland. A number of springs were identified along this edge. Soil cover within the wetland is generally shallow, with extensive bare rock exposed, estimated on site to be in the region of 30-40% of the wetland by area. Associated with the springs is some permanent wetland habitat, though the bulk of the wetland habitat was considered seasonal in nature. Bare soil exposed by livestock trampling was observed along the upper edge in the vicinity of one of the springs. The wetland is therefore considered important from a livestock watering perspective. A rock wall/terrace was observed along the edge of some of the cultivated fields, indicating an attempt to arrest soil erosion. Erosion within the wetland and its immediate catchment is widespread, with limited soil cover

[3] A **bench** is a long, relatively narrow strip of relatively level or gently inclined land that is bounded by distinctly steeper slopes above and below it.

remaining within the wetland. Flows drain from the wetland via a defined, bedrock controlled drainage line.

Figure A.0.20 Photos of Wetland 42.

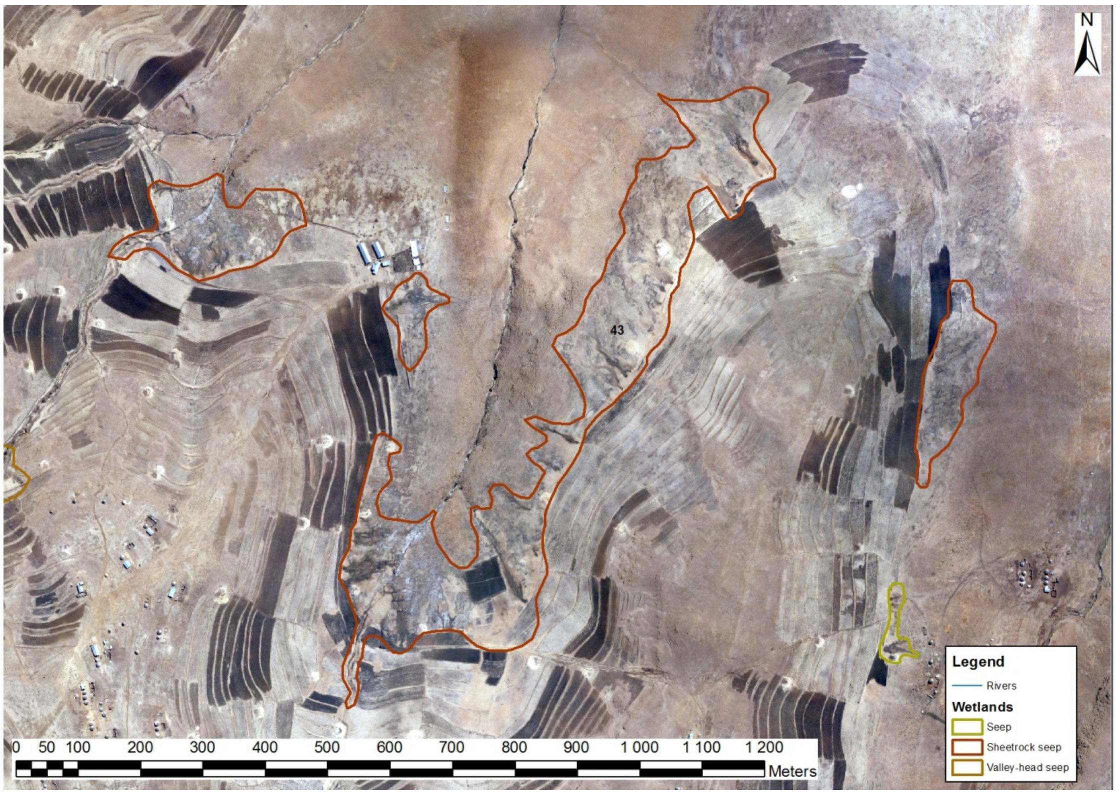


A: View across the wetland; **B**: Spring area along upper edge of wetland; **C**: View across wetland looking upslope; **D**: Extensive exposed rock and sheetrock habitat; **E**: Livestock trampling and erosion of upper edge of wetland; **F**: Seep front with numerous springs along edge of cultivated fields; **G**: Channelled flow from cultivated fields extending into wetland; **H**: Small holes excavated to expose water for livestock watering.

Wetland 43

Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 43	Sheetrock Wetland	14.3	-29.358	28.927	2 463	10	C	Moderate

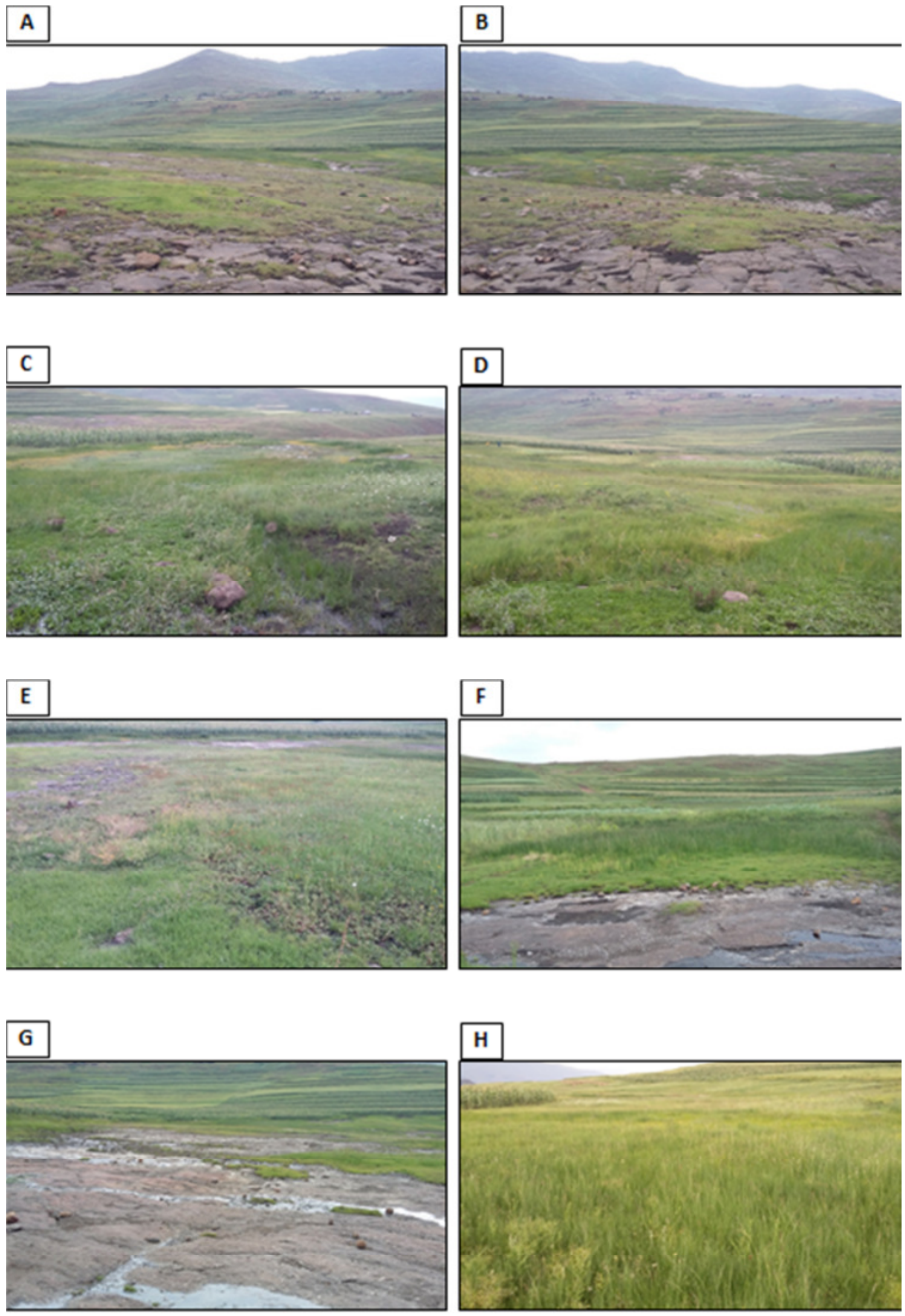
Figure A.0.21 Map of Wetland 43



Wetland 43 consists of an extensive Sheetrock wetland system that forms part of the same wetland cluster as Wetland 42 and occurs along the same bench. The wetland occurs on a predominantly northwest facing slope, though parts of the wetland are also north and northeast facing. This wetland forms the largest single wetland system surveyed during the PRAI studies, at just over 14 ha in extent.

As with most of the Sheetrock wetlands located along this bench, the seep front is located along the lower edge of cultivated fields, which form the upper edge of the wetland. A number of springs occur along this edge. Soil cover within the wetland is generally shallow, with extensive bare rock exposed, estimated on site to be in the region of 25-35% of the wetland by area. The bulk of the wetland habitat was considered seasonal in nature. Erosion within the wetland and its immediate catchment is widespread, with limited soil cover remaining within the wetland. Flows drain from the southern portions of the wetland via a defined, bedrock controlled drainage line, while the north-eastern section drains diffusely into adjacent terrestrial grassland.

Figure A.0.22 Photos of Wetland 43.

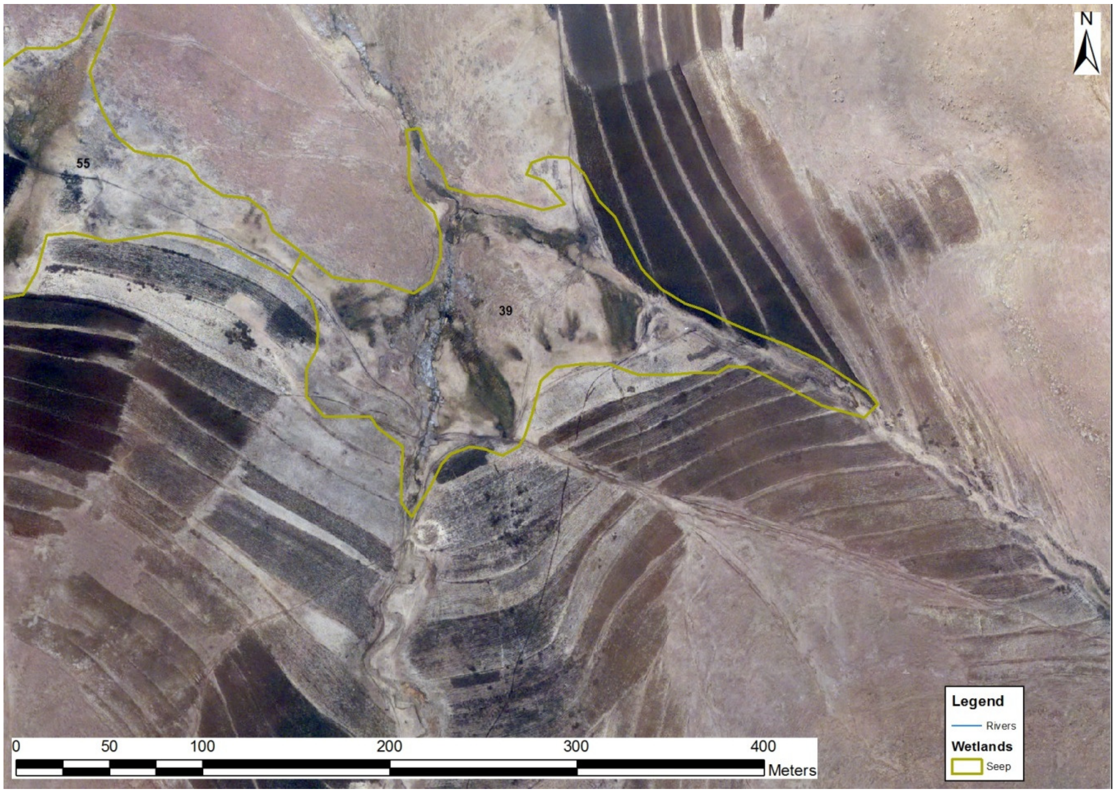


A & B: View across the wetland showing extensive exposed sheetrock and cultivation in immediate catchment; **C** Spring draining towards a cultivated field within the wetland; **D**: Typical vegetation cover observed within the wetland; **E**: Large proportion of weeds and pioneer species point to overgrazing; **F**: View from wetland upslope showing deeper soils along upper wetland edge and exposed rock in wetland centre; **G**: Extensive exposed sheetrock; **H**: Grass/sedge meadow on deeper soils along upper edge of wetland.

Wetland 39

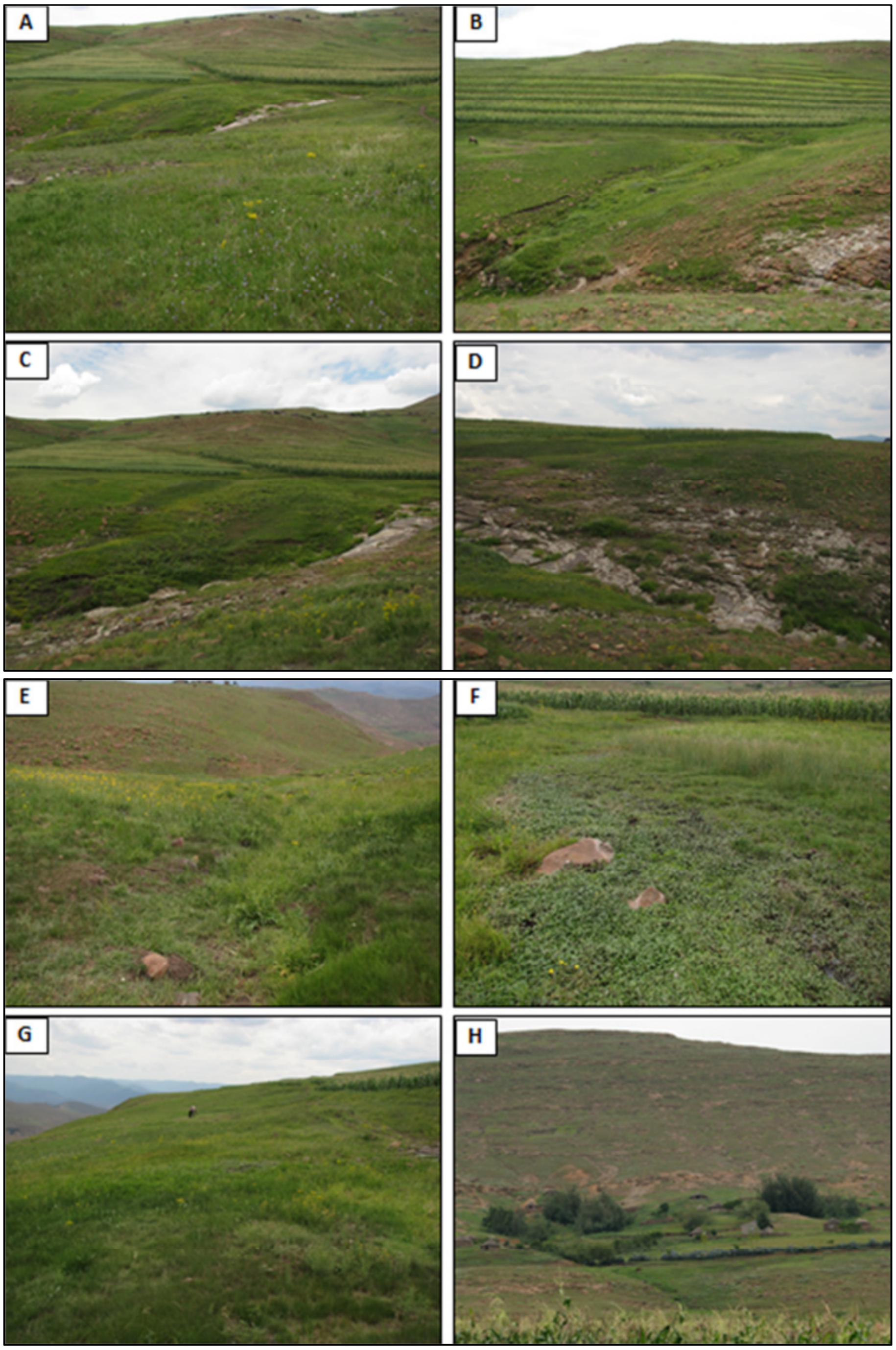
Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 39	Seep	2.2	-29.337	28.903	2 420	12	D	Moderate

Figure A.0.23 Map of Wetland 39



Wetland 39, a Seep wetland, is also located along the same bench as Wetlands 42 and 43. The wetland is mostly north-west facing and consists of two incised watercourses draining in a northerly direction with Seep wetland habitat along the margins of the watercourses, specifically in the peninsula of land between the two watercourses. Once again the immediate catchment of the wetlands is cultivated, with the upper catchment characterised by mixed landuse including cultivation, grazing land and villages. Severe gully erosion within the watercourses upslope of the wetland channels flows through the wetland, though the presence of bedrock limits the incision of channels through the wetland. A number of springs located along the Seep front around the upper edge of the Seep wetland continue to provide diffuse flow inputs to the wetland, maintaining soil moisture. The Seep habitat is therefore mostly unimpacted by the channelled flow through the wetland. Soils are generally deeper than most of the wetlands within the cluster, resulting in the wetland being typed as a Seep rather than a Sheetrock wetland. Wetland vegetation is dominated by grass meadow (50 %) and grass/sedge meadow (25 %) habitat, with exposed rock concentrated around the channels and limited to in the region of 10 % cover.

Figure A.0.24 Photos of Wetland 39.

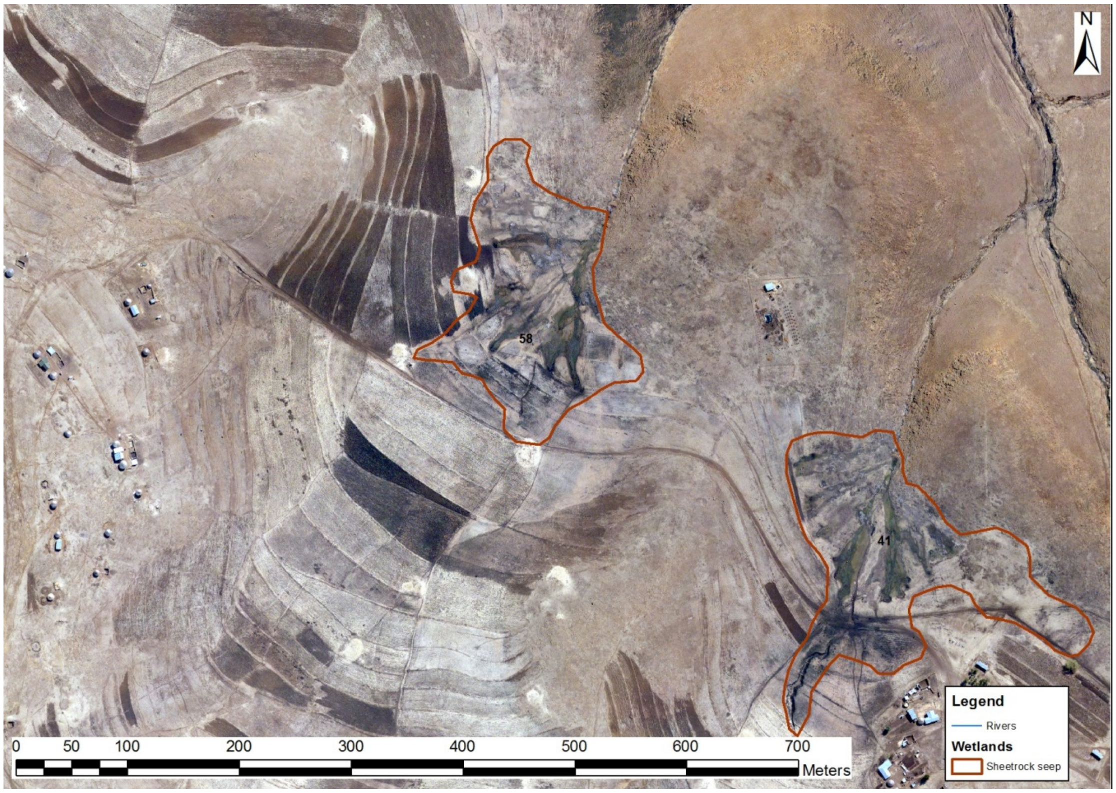


A: View across the wetland; **B**: View showing one of the watercourses draining through the wetland; **C**: The lower edge of the Seep drops steeply into a watercourse draining northwards; **D**: Extensive exposed rock towards the lower edge of the Seep and along the watercourses; **E**: Well vegetated preferential flow path; **F**: Spring habitat; **G**: Temporary habitat along the wetland margins; **H**: View into the upper catchment showing steep slopes with limited soil and vegetation cover.

Wetland 58

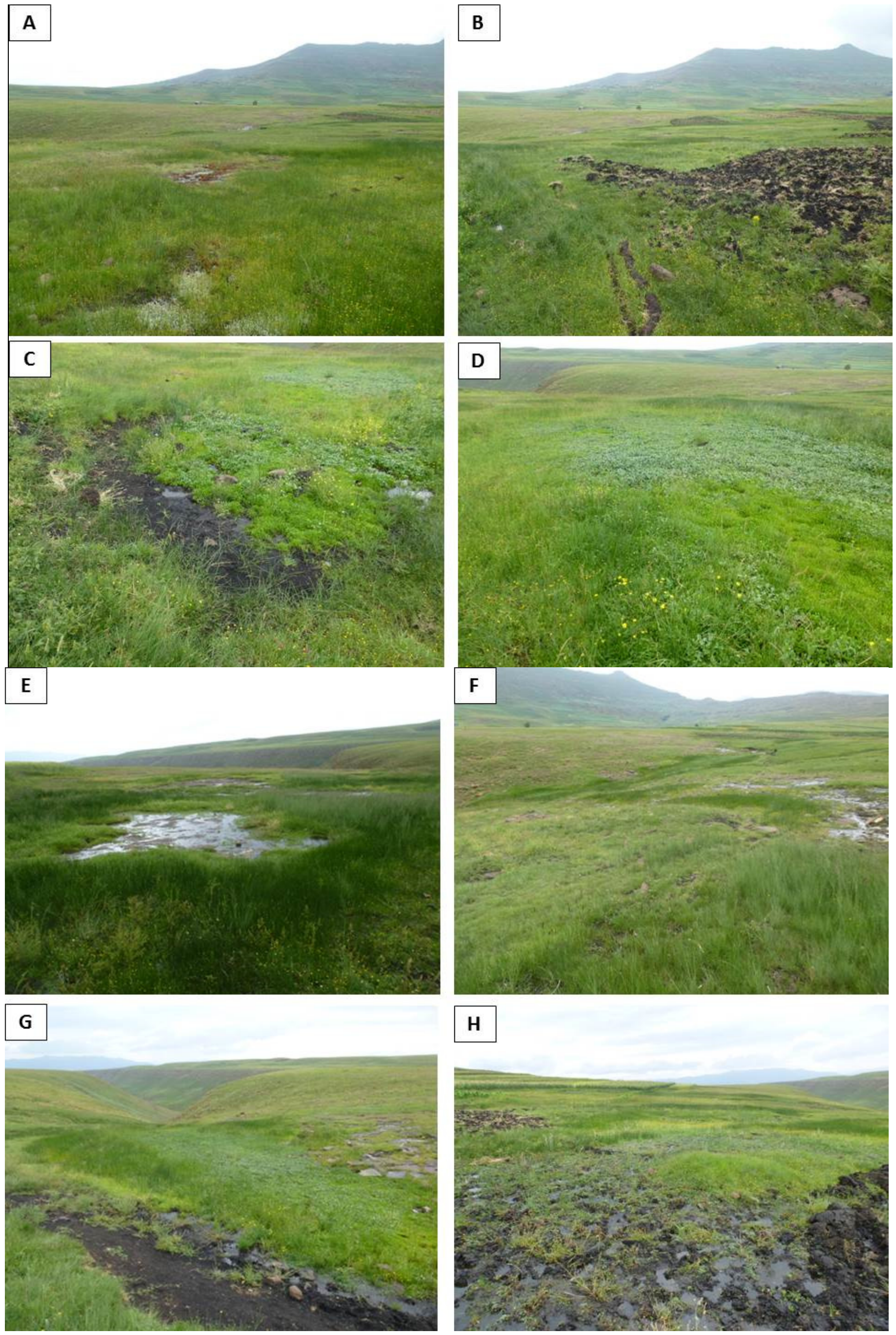
Name	Wetland Type	Area (hectares)	South Coordinate	East Coordinate	Average Altitude (mamsl)	Slope (%)	PES	IS
Wetland 58	Sheetrock Wetland	2.7	-29.371	28.950	2 477	10	C	Moderate

Figure A.0.25 Map of Wetland 58



Wetland 58 consists of another Sheetrock wetland located along the bench south of the proposed Polihali reservoir. The immediate catchment is cultivated, with the entire upper perimeter of the wetland cultivated. The higher catchment is characterised by mixed landuse including cultivation, grazing land and villages. Cultivation in the catchment encourages surface runoff and channels flows along footpaths/plough furrows/around contour berms resulting in higher erosive energy of flows. Clear signs of sediment deposition, including coarse gravel, indicate erosion within the wetland catchment. Bare soil and incised channels indicated erosion within the wetland. Numerous springs occur along the lower edge of the cultivated fields and within the cultivated fields. Some utilisation of springs for livestock watering/collection of water was observed. A single bedrock watercourse drains from the wetland in a northerly direction. Wetland vegetation is dominated by mixed grass/sedge meadow (70 %) and sheetrock habitat (15 %).

Figure A.0.26 Photos of Wetland 58.



A: View across the wetland showing typical habitat; **B**: cultivation extending into wetland habitat **C**: Spring; **D**: Typical near-permanently wet habitat below spring; **E**: Sheetrock habitat; **F**: View across wetland; **G**: Outflow from wetland. Note change in slope along edge of bench; **H**: Livestock trampling.

Appendix B. Plant Species List for Surveyed Wetlands

Appendix Table B-1. Plant species list for surveyed wetlands

(Note: missing wetland numbers relate to initial survey points not supporting wetland habitat and some wetlands where no vegetation lists were compiled).

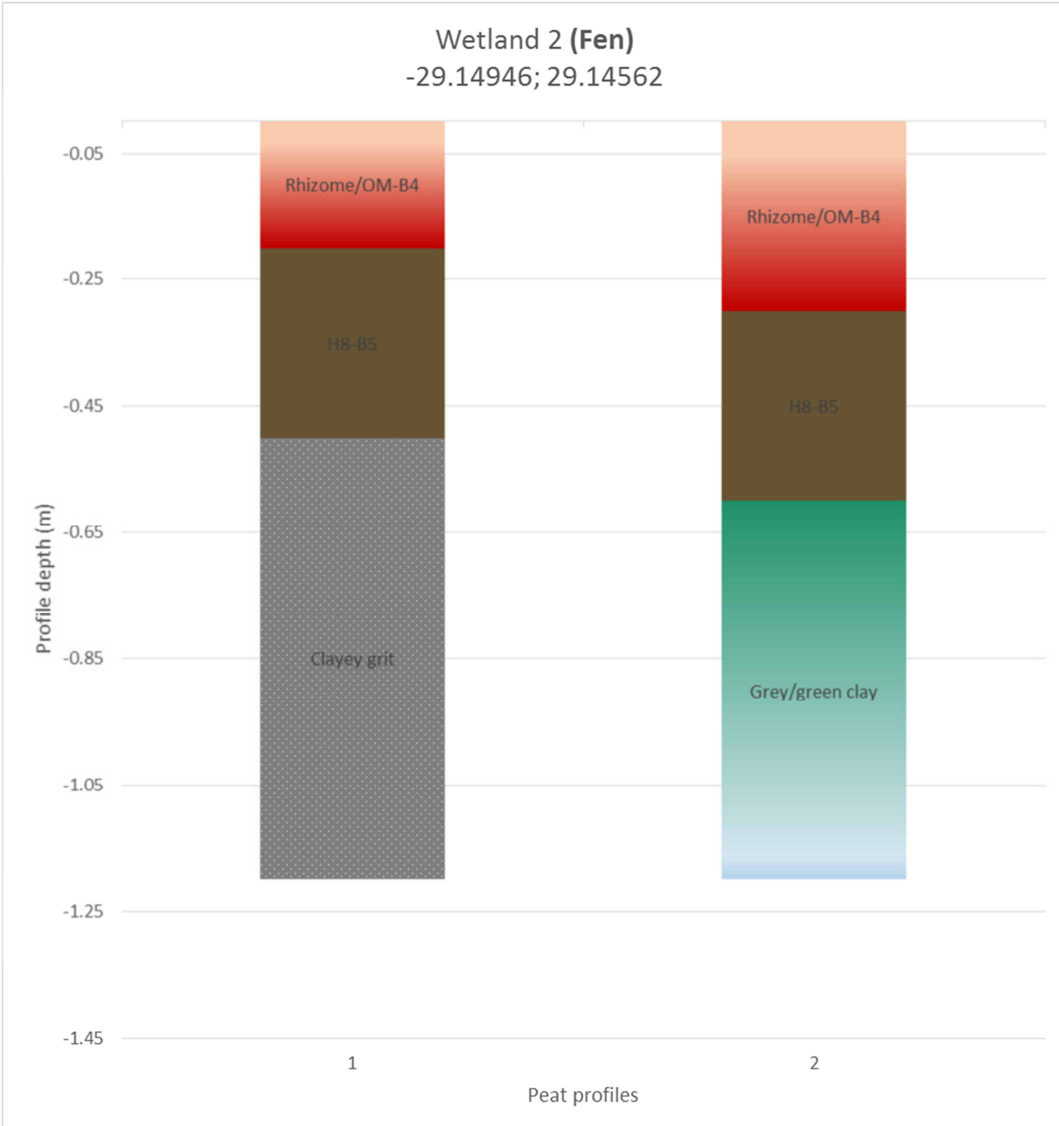
Species Name	WETLAND NUMBER																																				
	1	2	3	4	7	8	9	10	11	14	17	18	19	21	25	31	32	33	36	38	39	40	41	42	43	44	46	47	48	49	50	51	52	54	55	56	57	58
Agrostis lachnantha	1	1	1	1					1						1			1		1	1	1			1	1	1	1				1	1	1	1			
Agrostis subulifolia								1																														
Amaranthus hybridus		1		1																	1		1												1			
Androcymbium striatum						1										1														1			1					
Aponogeton junceus								1																														
Arctotheca calendula					1																																	
Arctotis sp.								1																														
Aristea angolensis													1																									
Athrixia fontana								1																														
Berkheya cirsiifolia													1																									
Berula erecta									1	1			1								1		1							1			1					
Bidens bipinnata																		1														1						
Bidens formosa			1												1			1								1						1		1			1	
Bidens pilosa																		1								1												
Brachiaria eruciformis		1																																				
Brachiaria serrata															1			1																1				
Brachiaria sp.			1																			1																
Bromus catharticus		1	1	1					1																													1
Bryum sp.													1										1		1											1		
Bulbostylis humilis					1				1													1	1	1												1		1
Cannabis sativa	1	1	1																																			
Carex glomerabilis		1																																				
Carex sp.		1																																				
Carex subinflata													1																									
Centella asiatica												1							1																			
Cerastium arabidis					1																																	
Chenopodium album																					1					1												
Chironia sp.								1																														
Chrysocoma cilliata								1																														
Cirsium vulgare																										1	1	1	1			1		1				
Convolvulus natalensis																								1								1						
Conyza pinnata	1	1	1										1														1											
Conyza podocephala																				1	1	1	1		1				1							1	1	1
Corycium nigrescens																1			1																			
Cotula paludosa							1	1	1		1	1				1	1	1	1		1	1	1	1	1						1				1	1		1
Crassula dependens										1														1									1					1
Cymbopogon dieterlenii														1																								
Cynodon dactylon																														1								
Cynodon hirsutus		1									1		1		1												1	1									1	
Cyperus congestus		1	1						1	1	1	1		1	1			1			1	1			1	1	1	1				1	1	1	1	1		1
Cyperus esculentus																																					1	
Cyperus rupestris																				1		1			1				1	1			1	1		1	1	
Datura ferox				1																	1											1			1			

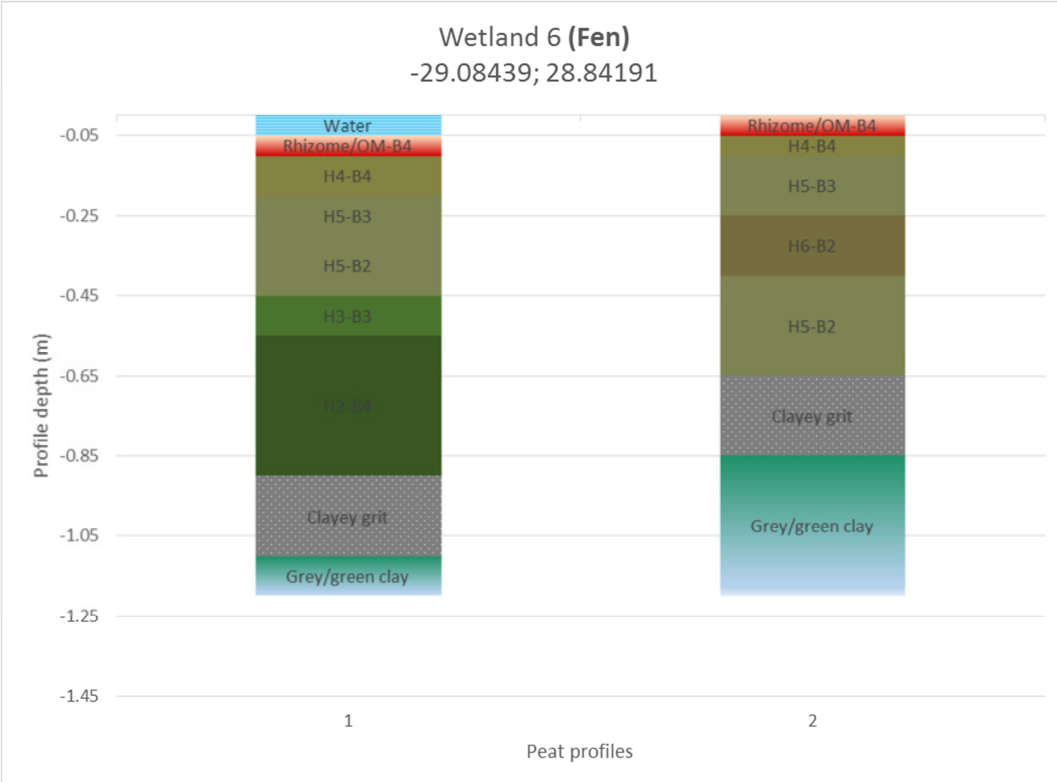
Species Name	WETLAND NUMBER																																				
	1	2	3	4	7	8	9	10	11	14	17	18	19	21	25	31	32	33	36	38	39	40	41	42	43	44	46	47	48	49	50	51	52	54	55	56	57	58
Diascia barberae					1																																	
Dierama robustum													1																									
Dinebra retroflexa																																	1					
Echinochloa crus-galli																					1																	
Eleocharis dregeana															1										1													
Eragrostis capensis			1																				1															
Eragrostis curvula																																			1			
Eragrostis heteromera	1	1	1	1																																		
Eragrostis plana										1											1					1		1	1	1		1	1				1	
Eragrostis planiculmis			1						1		1					1		1							1		1											1
Eriocaulon dregei							1																															
Felicia quinquenervia															1																							
Festuca caprina																			1																			
Fingerhuthia sesleriiformis										1	1	1	1	1		1	1		1	1	1			1							1	1			1	1		1
Fuirena pubescens		1	1						1						1										1													
Gazania krebsiana										1																												
Geranium wakkerstroomianum													1																									
Gladiolus permeabilis		1																																				
Gladiolus saundersii		1	1											1															1								1	
Gunnera perpensa									1				1		1			1	1		1									1					1			
Haplocarpha nervosa		1				1	1													1	1	1	1	1	1										1	1		1
Haplocarpha scaposa														1	1						1	1						1						1	1	1		1
Helichrysum sp.																				1				1								1	1			1		
Helichrysum appendiculatum													1																									
Helichrysum subglomeratum								1																														
Helichrysum trilineatum																																		1				
Helictotrichon galpinii		1	1						1		1	1		1	1	1		1	1		1	1					1						1					
Hermannia coccocarpa																																	1					
Hibiscus trionum		1		1					1											1			1	1	1													1
Hypoxis costata																																		1				
Isolepis costata									1																			1										
Isolepis sp.		1				1	1																									1				1		
Juncus dregeanus														1					1		1	1	1									1	1					
Juncus effusus	1		1												1												1											
Juncus exertus		1							1						1						1	1	1		1									1	1	1		1
Juncus oxycarpus																																				1		
Kniphofia caulescens					1			1					1																									
Koeleria capensis																1																						
Kyllinga pulchella		1	1	1					1	1		1							1		1	1	1	1	1	1							1	1				1
Ledebouria sp.																									1													1
Limosella maior		1			1				1	1		1	1		1				1	1		1	1	1	1									1	1	1		1
Limosella vesiculosa					1		1															1		1												1		
Lobelia flaccida										1																		1				1		1		1		
Lobelia galpinii						1	1	1															1															
Lobelia laxa																				1	1		1		1										1			1

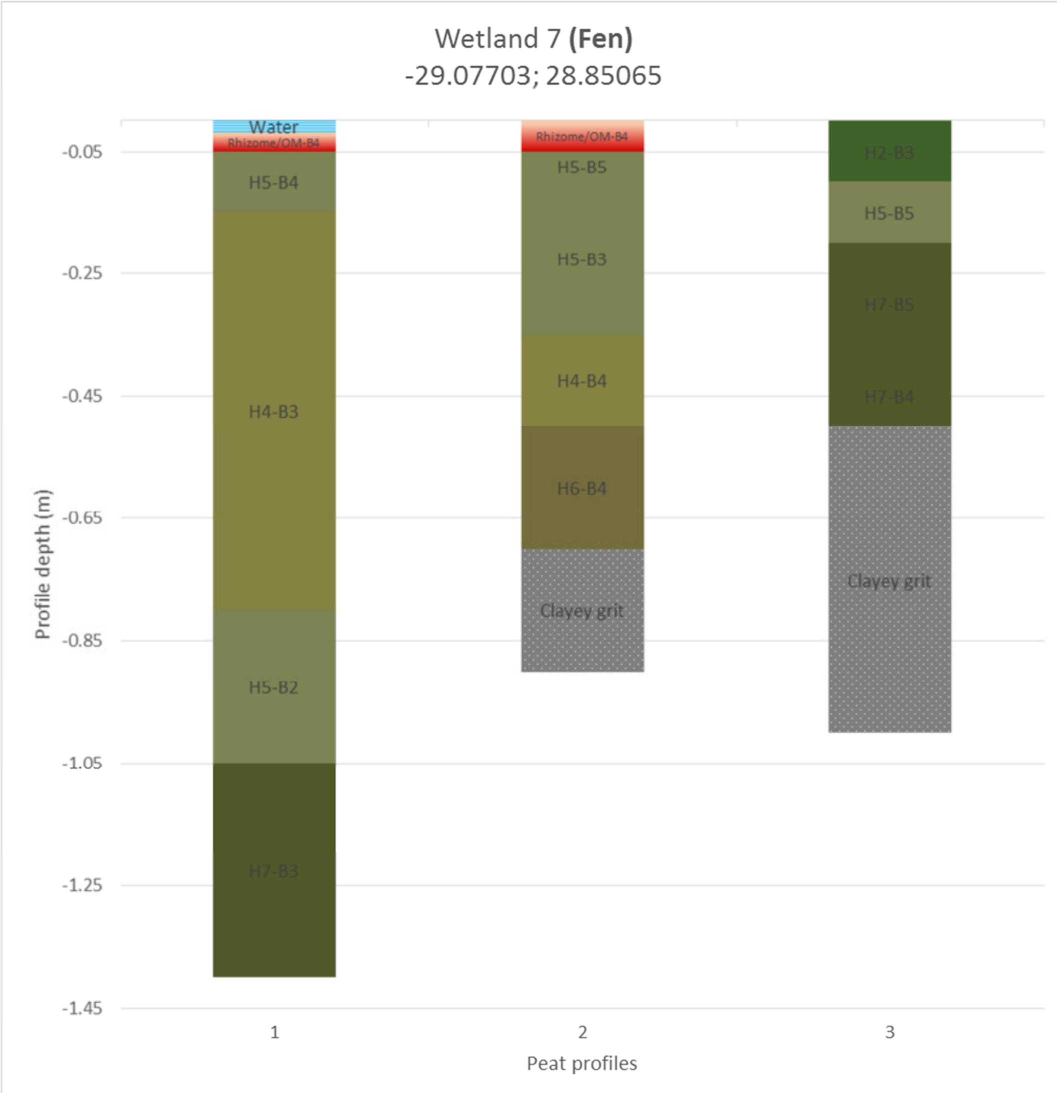
	WETLAND NUMBER																																					
Species Name	**1**	**2**	**3**	**4**	**7**	**8**	**9**	**10**	**11**	**14**	**17**	**18**	**19**	**21**	**25**	**31**	**32**	**33**	**36**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**54**	**55**	**56**	**57**	**58**
Mentha aquatica		1											1		1			1	1															1				
Mentha longifolia	1		1							1			1							1	1					1	1	1	1			1	1		1			
Merxmuellera macowanii						1		1																														
Myosotis semiamplexicaulis					1													1																				
Nasturtium officinale	1	1										1											1			1	1	1				1			1	1		1
Oenothera rosea										1																1												
Oxalis obliquifolia		1			1			1						1				1			1													1				
Panicum schinzii		1																						1														1
Papaver aculeatum													1																		1							
Paspalum distichum																										1		1										
Pennisetum sphacelatum		1	1						1		1	1								1	1	1	1		1									1	1	1	1	1
Pennisetum thunbergii																			1																			
Persicaria lapathifolia	1	1	1	1											1						1	1				1	1							1				
Persicaria sp.																					1																	
Phragmites australis																											1											
Plantago lanceolata			1																																			
Poa annua							1																1															
Poa binata		1																																				
Populus canescens												1															1		1	1								
Pseudognaphalium luteo-album			1						1	1	1	1	1	1		1	1	1					1	1	1	1		1		1		1	1	1	1			1
Pycreus sp.																														1			1					
Ranunculus meyeri		1			1	1	1	1														1														1		
Ranunculus multifidus	1	1	1	1					1	1	1	1	1		1			1		1	1	1	1	1	1		1	1				1	1		1	1		1
Rhodohypoxis rubella								1																														
Rumex crispus	1	1	1						1			1	1		1	1			1				1		1	1				1				1				
Salix babylonica																																						
Salix fragilis									1						1													1		1				1			1	
Salvia runcinata																																	1					
Scabiosa columbaria		1																	1		1	1	1		1									1				1
Schoenoplectus corymbosus																												1										
Schoenoplectus decipiens		1							1		1	1				1	1		1	1			1	1	1						1	1	1	1	1			1
Scirpus ficinoides																					1	1																
Senecio harveianus																																		1				
Senecio inornatus	1	1	1	1					1		1	1				1	1	1	1	1	1		1		1		1		1					1	1		1	1
Senecio othonniflorus																	1																					
Senecio paucicalyculatus															1							1									1							
Senecio polyodon						1	1	1	1		1	1				1	1	1	1												1							
Senecio sp.													1		1																							
Tagetes minuta		1		1														1								1	1					1		1			1	
Themeda triandra														1																								
Trifolium burchellianum		1	1			1	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1						1	1	1		1
Typha capensis																														1								
Verbena bonariensis										1																												
Veronica anagallis-aquatica	1	1		1					1				1		1			1	1		1	1	1	1	1	1	1	1						1	1	1		
Wahlenbergia cuspidata												1		1																								

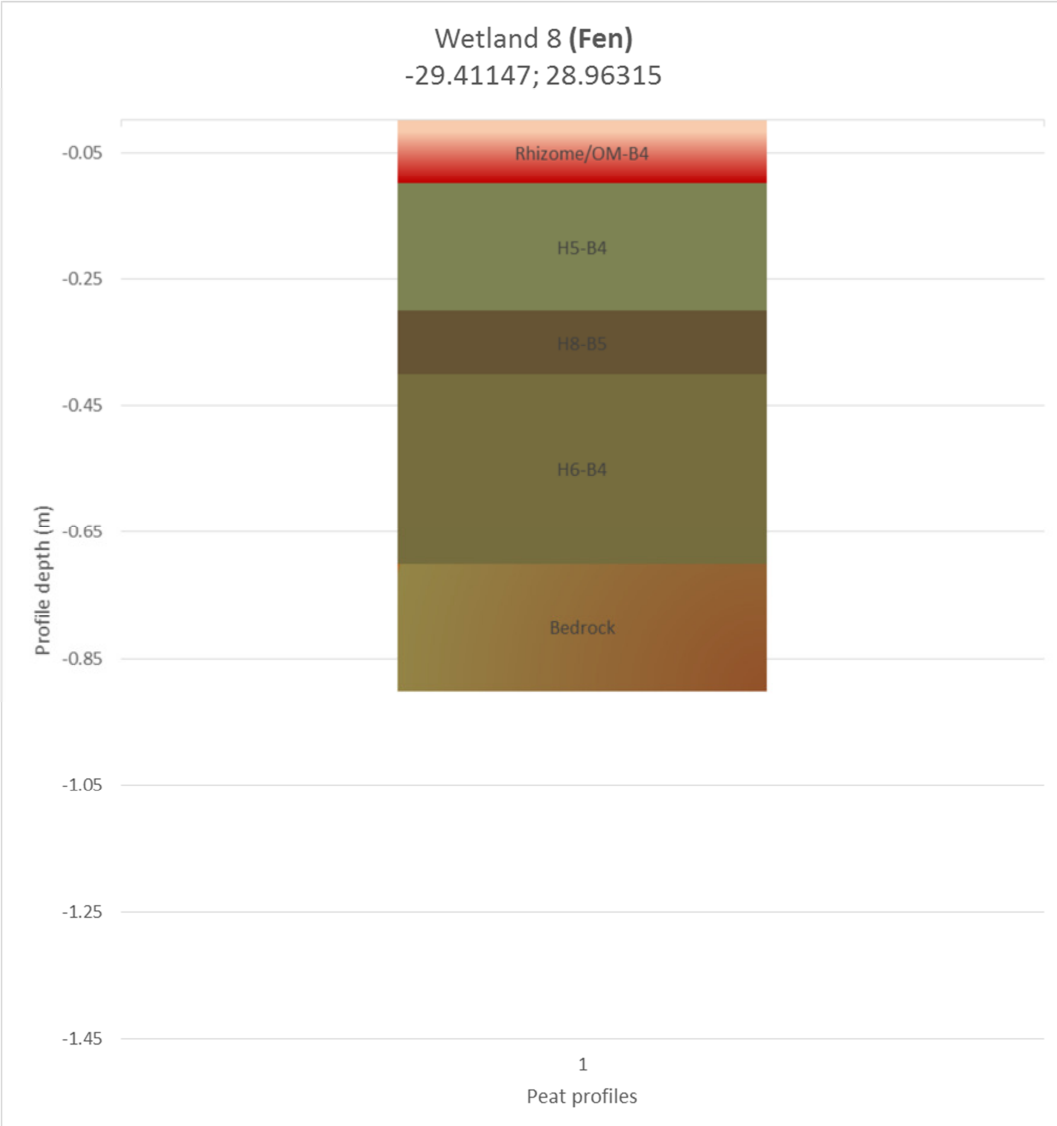
Species Name	WETLAND NUMBER																																				
	1	2	3	4	7	8	9	10	11	14	17	18	19	21	25	31	32	33	36	38	39	40	41	42	43	44	46	47	48	49	50	51	52	54	55	56	57	58
Wahlenbergia krebsii																																		1				
Xanthium strumarium																																1						

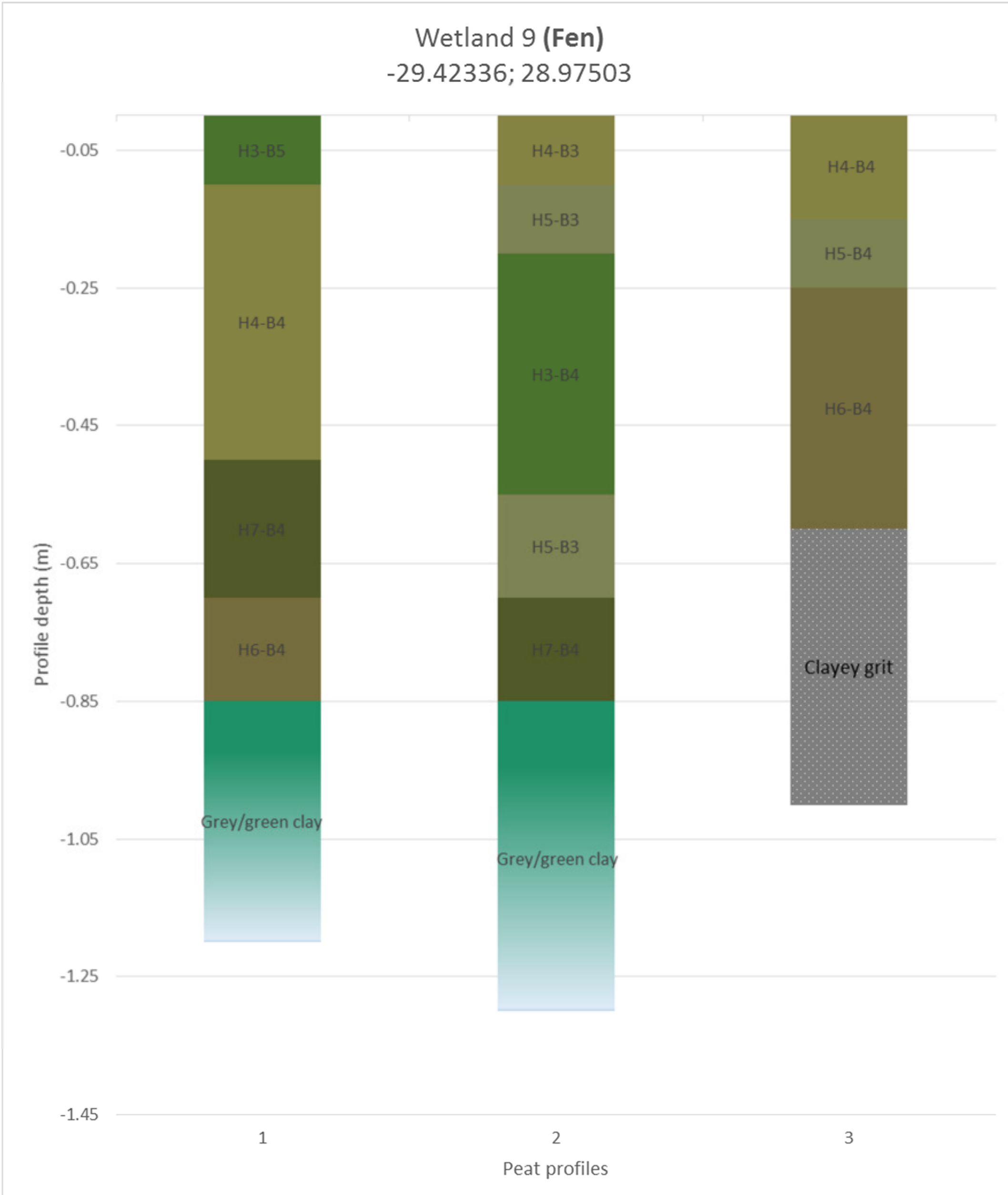
Appendix C. Peat Profiles of Surveyed Wetlands

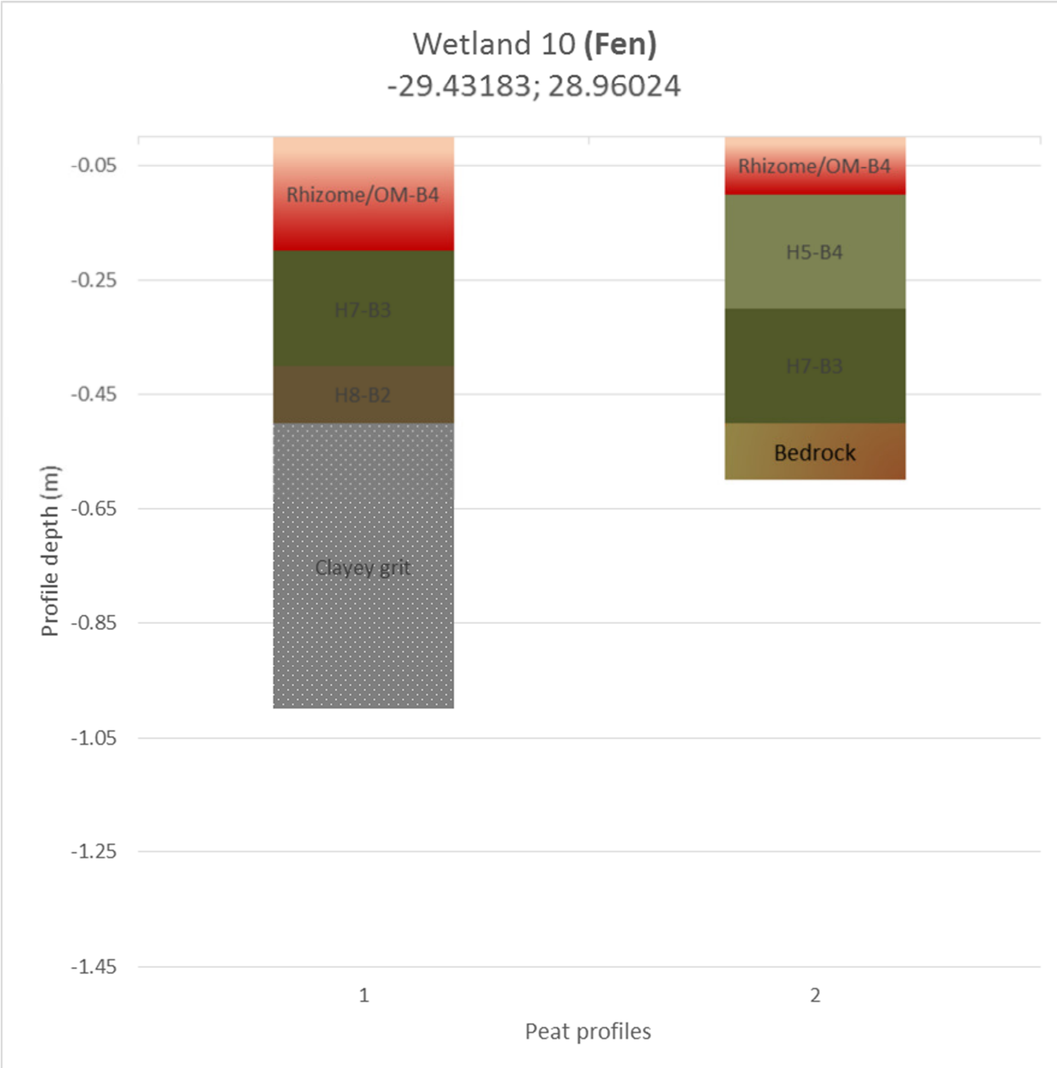

Wetland 2 (Fen)
-29.14946; 29.14562
Profile depth (m)
-0.05
-0.25
-0.45
-0.65
-0.85
-1.05
-1.25
-1.45
Rhizome/OM-B4
H8-B5
Clayey grit
Rhizome/OM-B4
H8-B5
Grey/green clay
1
2
Peat profiles


Wetland 6 (Fen)
-29.08439; 28.84191
Profile depth (m)
-0.05
-0.25
-0.45
-0.65
-0.85
-1.05
-1.25
-1.45
Water
Rhizome/OM-B4
H4-B4
H5-B3
H5-B2
H3-B3
H2-B4
Clayey grit
Grey/green clay
Rhizome/OM-B4
H4-B4
H5-B3
H6-B2
H5-B2
Clayey grit
Grey/green clay
1
2
Peat profiles


Wetland 7 (Fen)
-29.07703; 28.85065
Profile depth (m)
-0.05
-0.25
-0.45
-0.65
-0.85
-1.05
-1.25
-1.45
Water
Rhizome/OM-B4
H5-B4
H4-B3
H5-B2
H7-B3
Rhizome/OM-B4
H5-B5
H5-B3
H4-B4
H6-B4
Clayey grit
H2-B3
H5-B5
H7-B5
H7-B4
Clayey grit
1
2
3
Peat profiles


Wetland 8 (Fen)
-29.41147; 28.96315
-0.05
-0.25
-0.45
-0.65
-0.85
-1.05
-1.25
-1.45
Profile depth (m)
Rhizome/OM-B4
H5-B4
H8-B5
H6-B4
Bedrock
1
Peat profiles


Wetland 9 **(Fen)**
-29.42336; 28.97503
-0.05
-0.25
-0.45
-0.65
-0.85
-1.05
-1.25
-1.45
Profile depth (m)
H3-B5
H4-B4
H7-B4
H6-B4
Grey/green clay
H4-B3
H5-B3
H3-B4
H5-B3
H7-B4
Grey/green clay
H4-B4
H5-B4
H6-B4
Clayey grit
1
2
3
Peat profiles


Wetland 10 (Fen)
-29.43183; 28.96024
-0.05
-0.25
-0.45
-0.65
-0.85
-1.05
-1.25
-1.45
Profile depth (m)
Rhizome/OM-B4
H7-B3
H8-B2
Clayey grit
Rhizome/OM-B4
H5-B4
H7-B3
Bedrock
1
2
Peat profiles

Appendix D. PES Assessment Tables

Criteria and attributes	POLIHALI 1	2	3	4	5	6	7	8	9	10	11	12	14	16	17	18	19	20
HYDROLOGIC																		
Flow modification	2	2	2	2	3	2	2	2	2	2	3	3	2	2	2	2	4	2
WATER QUALITY																		
Water quality modification	3	3	3	2	4	4	4	4	4	4	4	3	4	4	4	4	5	4
Sediment load modification	2	2	2	2	3	3	2	3	2	2	1	1	2	2	2	2	4	2
HYDRAULIC / GEOMORPHIC/PHYSICAL																		
Cananlisation	3	4	3	3	2	3	3	2	3	2	2	4	4	2	2	2	3	2
Topographic alteration	3	4	3	2	3	2	3	2	3	2	3	3	2	2	2	2	3	2
Modification of key driver or keypoint	2	2	2	2	3	3	2	2	2	2	3	3	2	2	2	2	4	2
BIOTA																		
Change in species composition and richness	1	2	1	1	3	3	3	2	2	2	2	1	2	3	3	3	4	3
Invasive plant encroachment	1	2	1	1	3	3	3	2	3	2	3	2	3	3	3	3	4	3
Over utilization of biota (including over-grazing)	1	3	1	1	2	2	2	2	2	2	2	1	2	3	3	3	4	2
Land-use modification (including conversion to pasture or crops)	1	2	1	1	4	4	3	2	3	2	4	1	4	3	3	3	4	3
TOTAL	19	26	19	17	30	29	27	23	26	22	27	22	27	26	26	26	39	25
MEAN	**1.9**	**2.6**	**1.9**	**1.7**	**3.0**	**2.9**	**2.7**	**2.3**	**2.6**	**2.2**	**2.7**	**2.2**	**2.7**	**2.6**	**2.6**	**2.6**	**3.9**	**2.5**
PES	D	C	D	D	C	C	C	D	C	D	C	D	C	C	C	C	B	D

Criteria and attributes	POLIHALI													
	21	**25**	**29**	**31**	**32**	**33**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**
HYDROLOGIC														
Flow modification	2	2	3	3	3	3	2	2	3	2	3	2	3	3
WATER QUALITY														
Water quality modification	4	3	5	4	4	4	4	4	4	3	4	3	4	4
Sediment load modification	2	2	3	2	2	2	2	2	3	1	2	2	2	2
HYDRAULIC / GEOMORPHIC/PHYSICAL														
Cananlisation	2	3	4	3	3	3	3	2	4	2	3	2	3	3
Topographic alteration	2	2	3	3	3	2	3	3	3	2	2	3	2	2
Modification of key driver or keypoint	2	2	3	3	3	3	2	2	3	2	3	3	3	3
BIOTA														
Change in species composition and richness	3	2	3	3	2	3	3	3	2	2	2	3	2	2
Invasive plant encroachment	3	3	3	3	2	3	3	3	2	3	3	3	3	3
Over utilization of biota (including over-grazing)	2	2	3	3	2	3	2	2	2	2	2	2	2	2
Land-use modification (including conversion to pasture or crops)	3	2	4	3	2	3	2	2	2	2	2	3	2	2
TOTAL	25	23	34	30	26	29	26	25	28	21	26	26	26	26
MEAN	**2.5**	**2.3**	**3.4**	**3.0**	**2.6**	**2.9**	**2.6**	**2.5**	**2.8**	**2.1**	**2.6**	**2.6**	**2.6**	**2.6**
PES	**D**	**D**	**B**	**C**	**C**	**C**	**C**	**D**	**C**	**D**	**C**	**C**	**C**	**C**

Criteria and attributes	POLIHALI													
	44	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**
HYDROLOGIC														
Flow modification	1	2	2	3	3	3	2	2	2	3	3	3	2	3
WATER QUALITY														
Water quality modification	3	4	4	4	4	4	4	4	4	4	4	4	3	3
Sediment load modification	3	2	2	3	2	2	2	2	2	3	3	2	1	2
HYDRAULIC / GEOMORPHIC/PHYSICAL														
Cananlisation	3	2	4	3	4	3	2	4	4	3	4	2	2	3
Topographic alteration	3	2	3	3	2	3	2	2	2	2	3	2	2	3
Modification of key driver or keypoint	1	2	2	3	3	3	2	2	2	3	3	3	2	3
BIOTA														
Change in species composition and richness	2	2	2	2	4	2	2	2	2	3	2	2	2	3
Invasive plant encroachment	2	2	3	2	3	2	2	3	3	3	2	3	3	3
Over utilization of biota (including over-grazing)	2	2	2	2	3	2	2	2	2	2	2	2	2	2
Land-use modification (including conversion to pasture or crops)	2	2	2	2	4	2	2	4	4	3	2	2	2	3
TOTAL	22	22	26	27	32	26	22	27	27	29	28	25	21	28
MEAN	**2.2**	**2.2**	**2.6**	**2.7**	**3.2**	**2.6**	**2.2**	**2.7**	**2.7**	**2.9**	**2.8**	**2.8**	**2.1**	**2.8**
PES	**D**	**D**	**C**	**C**	**B**	**C**	**D**	**C**	**C**	**C**	**C**	**C**	**D**	**C**