Aquatic Specialist Assessment for a Section 24G and WULA for an Enlarged Dam on Farm Buffelsrivier 42/46 and 34/46, George

Prepared for Ecoroute

by

Dr. Jackie Dabrowski

Confluent Environmental (Pty) Ltd

confluent
aquatic consulting & research

Tel: 083 256 3159
Email: jackie@confluent.co.za

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Jackie Dabrowski (Ph.D., Pr.Sci.Nat. *Aquatic Science*)
SACNASP Registration Number 115166
Co-director: Confluent Environmental (Pty) Ltd

Qualifications: BSc, BSc Honours (Entomology), MSc & PhD (Veterinary Science)

Expertise: > 10 years' experience working on aquatic ecosystems across South Africa, with a focus on the Southern Cape in the last 3 years. Includes research and consulting expertise, having published > 10 water-related research articles and compiled > 80 aquatic specialist reports. Research and consulting have been in a range of sectors including agriculture, urban developments, linear structures, renewable energy, conservation, and mining.

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EXECUTIVE SUMMARY

The owner of Portion 42/46 Farm Buffelsrivier enlarged an instream dam in 2017 from a volume of approximately 4 000 m^3 to 49 861 m^3. The enlargement was also meant to replace storage in a dam downstream of approximately 5 600 m^3 which is no longer being used. No environmental authorisations were obtained in terms of the National Water Act or the National Environmental Management Act.

The enlarged dam is on a network of non-perennial drainage lines with a small unchanneled valley-bottom wetland downstream. The affected watercourse is a tributary of the Kammanassie River in quaternary catchment J34C. The enlarged dam is located in habitat classified as Critical Biodiversity Area according to the Western Cape Biodiversity Spatial Plan.

The Present Ecological State (PES) of the drainage lines dropped one category as a result of the dam enlargement. The Index of Habitat Integrity determined that instream habitat had decreased from a C (Moderately Modified) to a D (Largely Modified). While the riparian habitat decreased from a B/C (Largely Natural to Moderately Modified) to a C/D (Moderately to Largely Modified). The wetland PES pre- and post-enlargement of the dam was B/C Largely Natural to Moderately Modified as impacts related to the dam were minor. The Ecological Importance and Sensitivity (EIS) of the both the drainage lines and downstream wetland were determined to be Moderate.

The impact assessment considered all phases of the dam enlargement as far as possible. Being a retrospective assessment means the dam's construction phase impacts could be assessed with the assumption being that mitigation measures were not applied.

Construction phase impacts included the dam excavation and vegetation removal. In the dam basin, approximately 3 m depth of soil was removed and used for the dam embankment, and approximately 0.9 ha of indigenous riparian vegetation was cleared. This impact was rated as a Moderate Negative. Downstream of the enlarged dam soil and rocks were discarded into small areas of two watercourses. The latter impacts should be rectified regardless of whether the enlarged dam is authorised and are considered a Negligible Negative impact in their mitigated state.

Operational phase impacts consider the impact to hydrology of downstream watercourses. The impacted watercourses have been historically impounded for many decades, just in a different layout with two dams of lower volume. Enlargement of the dam coincided with the landowner decommissioning storage in the downstream dam. This effectively resulted in one less watercourse being impounded. Greater storage was needed to improve security of supply by storing an existing allocation of water from the Klein River approximately 2.2km north of the dam. Enlargement of the dam was not primarily aimed at storing more surface runoff. Mitigation measure should the dam be retained include the need for a Rehabilitation Plan to restore structure and function in the wetland and downstream dam. Without knowledge of the volumes of water from respective water sources it is not possible to fully assess the impacts to hydrology, but in their mitigated state the impacts to hydrology were considered a Minor Positive due to decommissioning of one dam and rehabilitation of one watercourse.

It is recommended that a professional with experience in dam design assess the spillway of the dam to ensure it is adequate and appropriately aligned with the downstream watercourse.

Primarily it must not pose a risk to the downstream watercourse because the receiving system is the one earmarked for rehabilitation.

The decommissioning phase impacts essentially provide a rehabilitation plan should regulating authorities direct the landowner to restore the dam to its original size. Mitigation measures consider the impacts during mass earth-moving, the need for re-vegetation and erosion control.

In conclusion, the network of affected watercourses was already impacted through impoundment by two dams. Enlargement of the upstream dam has resulted in a decrease in the PES of the system by one level due to loss of riparian and aquatic habitat. The increased volume of the enlarged dam is much greater than the sum of storage in the two existing dams. However, it is understood that the intention of the enlarged dam was to store an allocation of water from the Klein River, and not to store additional surface runoff from the catchment. The landowner effectively decommissioned storage in the downstream dam letting most of the water run out of the dam creating the opportunity to rehabilitate one previously impounded reach in the stream network.

It is recommended that the enlarged dam be retained with the following provisions:

- A comprehensive rehabilitation plan for the downstream wetland and decommissioned dam must be compiled and fully implemented.
- Confirmation of the exact volume of water to be abstracted from the Klein River on an annual basis along with proof of the lawfulness of this abstraction must be provided.
- All water abstraction points must be metered to ensure over-abstraction doesn’t occur.
- An assessment of the dam wall and spillway by a suitable professional must be undertaken to ensure the dam poses no risk to the receiving wetland.
- Aquatic habitat that has established vlei-like conditions in standing water in the downstream dam should be maintained with a trickle-flow of water released from the dam as long as this is available. This is achievable using a siphon system with a valve to open / close the pipe.

1. INTRODUCTION

Confluent Environmental was appointed by the owners of Farm Buffelsrivier 42/46 and 34/46, George, to undertake an Aquatic Specialist Impact Assessment for one new offstream dam on 34/46 Buffelsrivier, and an instream dam that was enlarged on 42/46 Buffelsrivier without the necessary environmental authorisations (Figure 1). This report is a requirement of the Section 24G rectification process in terms of the National Environmental Management Act (NEMA), and Water Use License Application (WULA) in terms of the National Water Act (NWA; Act No. 36 of 1998).

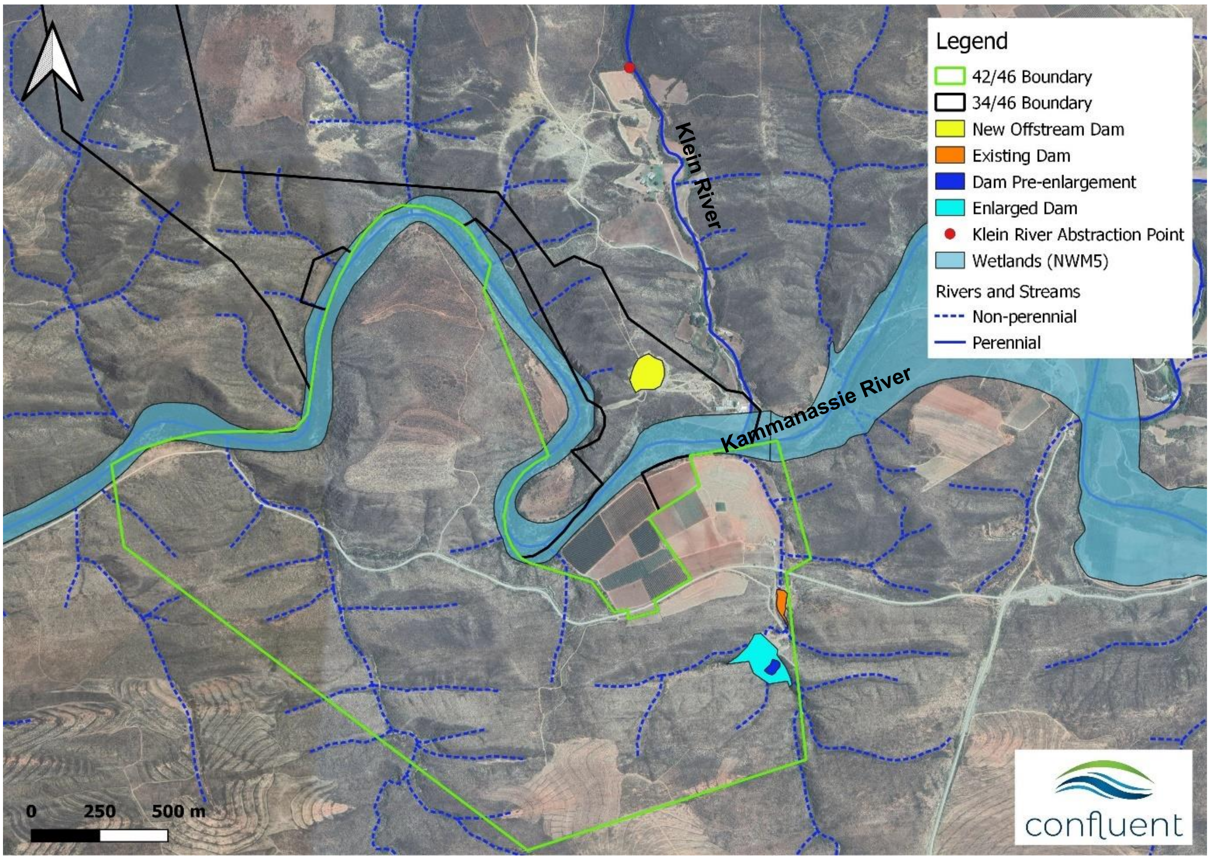


Figure 1. Location of the enlarged dam, and new offstream dam on Buffelsrivier Farm.

The new dam constructed on Portion 34/46 was classified as offstream based on the site visit conducted on 27 July 2022. While the clearance of vegetation and soil required for the construction of the offstream dam form part of the S24G application, they are excluded from this report as they are considered terrestrial impacts with no impact on a watercourse as defined in the NWA. Water supply to the offstream dam is an existing allocation pumped from the Kammanassie River.

The enlarged dam is instream on a network of tributaries of the Kammanassie River. The original dam (pre-enlargement) impounded one tributary while the enlarged dam includes a second tributary. However, the latter was historically impounded by an existing dam a short distance (approximately 200m) downstream. An historical allocation of water from the Klein River is now transferred approximately 2.2km via a gravity-fed pipeline into the enlarged dam for storage. The small dam located downstream of the enlarged dam has an outlet in the wall which is permanently open to ensure no water is being stored in the dam. The enlarged dam was surveyed in August 2022 and the results are presented in Table 1 and Appendix 1. Other dam volumes are roughly estimated based on surface area (m^2) and average depth (2 m).

Table 1. Summarised dam information

Dam Parameter	Enlarged Dam	Dam Pre-enlargement	Existing Dam	Offstream Dam
Surface area	1.90 ha	0.28 ha	0.46 ha	0.68 ha
Water source	Surface runoff & abstraction from the Klein River	Surface runoff	Surface runoff	Pumped from the Kammanassie River
Wall height	9 m	3 m	3 m	-
Volume	49 861 m^3	4 130 m^3	5 646 m^3	-

1.1 Scope of work

The purpose of this assessment is as follows:

- Conduct a desktop assessment of the site characteristics including historical aerial photos, mapped aquatic features and catchment management.
- Compile a report with an assessment of the ecological state and sensitivity of the affected watercourses.
- Compile an impact assessment for all phases of the development along with mitigation measures to minimise disturbance of the aquatic environment through each phase.

1.2 Assumptions and exclusions

One site visit was conducted during July 2022 which is considered Winter. It is possible that sensitive features such as rare or unique biota, plants or habitat were not observed during the site visit, but are influenced by season, time of day or flow level.

The abstraction point from the Klein River was not inspected as part of this assessment as the landowner has recently had a Validation and Verification of this water use confirmed.

The retrospective nature of this assessment considering the impacts of activities that have already occurred is an inherent challenge. Every effort was made to gather representative lines of evidence to provide the most accurate assessment of the site's pre-condition possible.

2. CATCHMENT CONTEXT

2.1 Catchment features

The instream dam that was enlarged is on a network of unnamed streams indicated as non-perennial drainage lines which historically flowed into the Kammanassie River (NGI, 1:50 000 drainage lines). The enlarged dam is in quaternary catchment J34C (Table 2). The project area is located within the Southern Folded Mountains (Ecoregion Level 2:19.01). The terrain is described as parallel hills and low mountains with moderate and high relief. Altitude ranges between 100 – 1 300 m.a.m.s.l. The Mean Annual Precipitation (MAP) is 674 mm. Rainfall in the catchment can occur year-round, although there are bimodal seasonal peaks in autumn and spring.

Table 2. Summarised features of the catchment and site.

Catchment Feature	
Quaternary catchment	J34C
Ecoregion Level 2	19.01 Southern Folded Mountains
Mean Annual Precipitation (mm)	674.0
Mean Annual Runoff (mm)	67.0
Vegetation type (SANBI Vegmap, 2018)	Eastern Little Karoo (Least Concern)
Conservation category (WCBSP, 2016)	Critical Biodiversity Area1

2.2 Vegetation

The mapped vegetation type at the site is Eastern Little Karoo (SKv11) which has a conservation status of Least Concern (SANBI NVM, 2018). Plants listed for the vegetation type were consulted to determine whether any important taxa associated with wetlands or watercourses could be present at the site. No important wetland taxa were listed.

2.3 Conservation and Catchment Management

The Western Cape Biodiversity Spatial Plan (WCBSP; 2016) indicates that all three dams are located in Critical Biodiversity Area 1 (Terrestrial) with areas downstream of the existing dam classified as Ecological Support Area 2 (Figure 2). The lower conservation status of the watercourse downstream of the dam indicates that it has already been degraded due to historical impoundment by the two dams. The WCBSP defines systems in this category as follows:

Critical Biodiversity Area: "*Areas in a natural condition that are required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure*."

The management objective for systems in this category is to:

"Maintain in a natural or near-natural state with no further loss of natural habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity-sensitive land-uses are appropriate."

Ecological Support Area: *"Areas that are not essential for meeting biodiversity targets, but that play an important role in supporting the functioning of PAs or CBAs and are often vital for delivering ecosystem services."*

The remaining stream section is not identified in any category in the WCBSP.

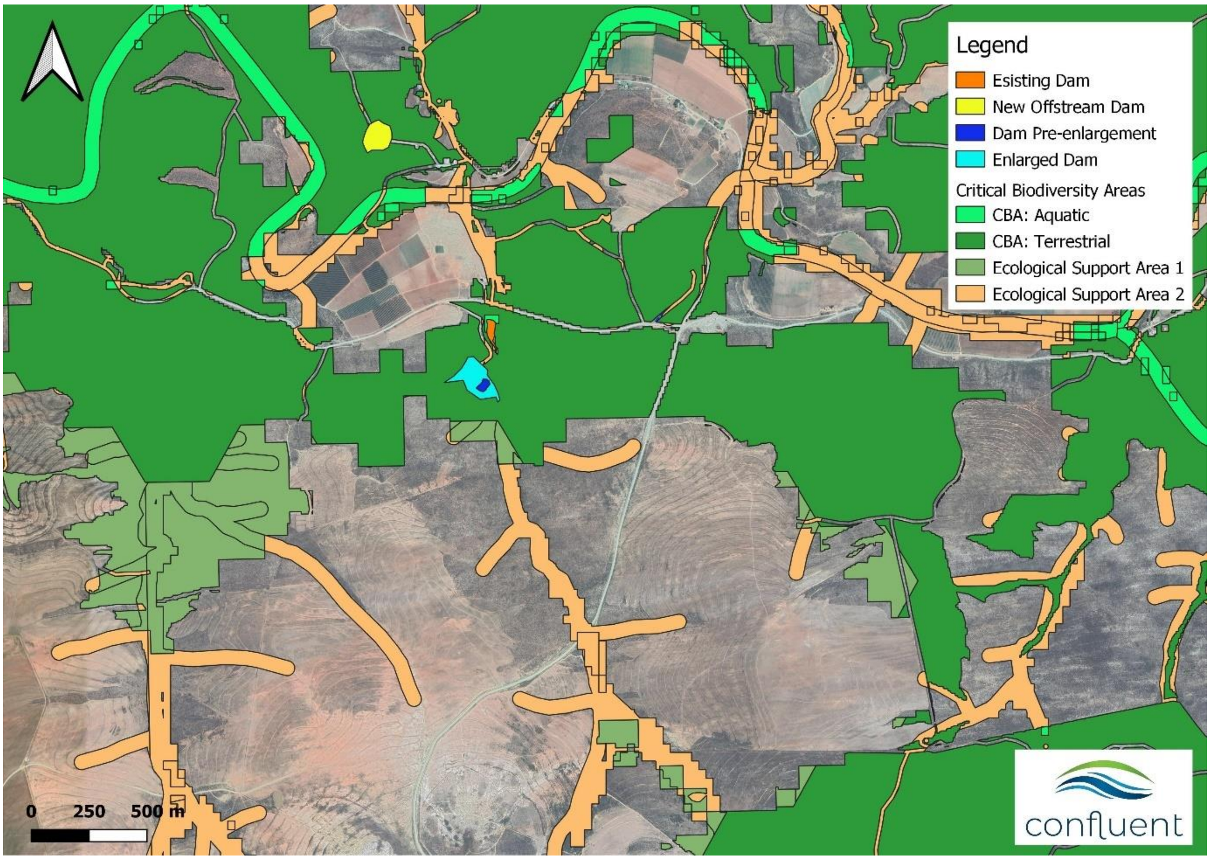


Figure 2. Mapped conservation categies according to the Western Cape Biodiversity Spatial Plan (WCBSP, 2016).

2.4 Historical assessment

The historical assessment relied upon satellite imagery obtained from Google Earth. The original two dams were clearly evident in the 2004 image (Figure 3). The two dams collectively impound the network of streams arising in the hills forming the extent of their catchment to the south. The image from 2014 indicates when the upstream of the two dams was enlarged, with an overlay of the approximate size of the original dam (Figure 3). The enlarged dam subsequently intercepts water from all the streams except a small inflow immediately upstream of the lower dam. While the upstream dam in its enlarged state has largely replaced the lower dam in terms of storage, a small volume of water is still retained in the lower of the two dams.

Figure 3. Historical aerial photos of the project area pre- and post-enlargement.

In 1992 the two dams are evident, but the historical photographic record doesn't provide confirmation of when exactly they were constructed. In 1942 neither of the dams was present, but the original road route was very distinct, and a heritage type river crossing is still present at the location indicated by the arrow in Figure 4.

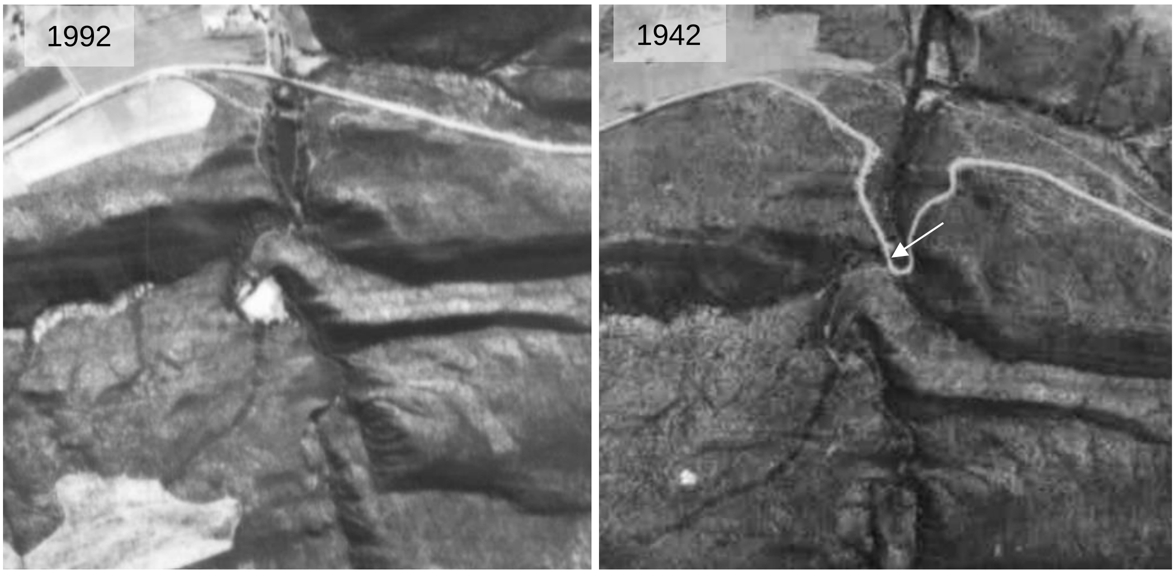


Figure 4. Historical aerial images. White arrow on 1942 image indicates historical road bridge.

2.5 Resource Quality Objectives

Resource Quality Objectives (RQOs) are defined as clear goals (numerical or descriptive statements) relating to the quality of a water resource and are set in accordance to the management class for the resource to ensure the water resource is protected. The purpose of RQOs is to set clear objectives for the resource against which WULs and the related impacts can be evaluated and managed to achieve a balance between the need to protect and utilise the resource.

The Breede-Gouritz Catchment Management Agency recently concluded an assessment of major rivers in the Water Management Area (DWS, 2018).

In quaternary catchment J34C, the Kammanassie River was assessed. The Present Ecological State (PES) was determined to be C/D, Moderately to Largely Modified. The Target Ecological Categorty (TEC) and Recommended Ecological Category (REC) are to maintain the PES at its current level. Management guidelines relevant to the enlarged dam on Buffelsrivier Farm specified to achieve the TEC are listed as follows:

- Maintenance of low and high flows as per the Hydrology RQOs (Appendix 3).
- No introduction of *Micropterus salmoides* (Largemouth Bass) as the Kammanassie River has two sensitive indigenous species (*Sandelia capensis* and *Pseudobarbus asper*) which are susceptible to extirpation by Bass.

3. SITE ASSESSMENT

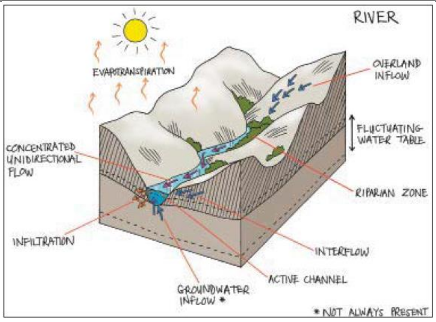
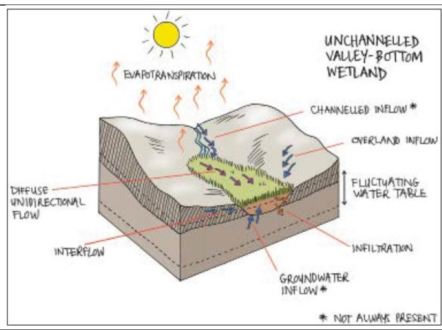
3.1 Site visit

The site was visited on 26 July 2022 which is considered winter. Conditions on the day were clear and sunny, and no significant rainfall had been recently recorded in the area.

3.2 Watercourse classification.

The enlarged dam was completely circumnavigated, and each inflow was inspected upstream of the dam. Watercourses downstream of the dam were also assessed. Classification of watercourses at the site followed the methods developed by Ollis *et al*. (2013) up to Level 4 categorisation (Table 3). The three drainage lines that flow into the enlarged dam were all categorised as non-perennial with intermittent flows (Figure 5). The eastern watercourse immediately downstream of the dam was classified as unchanneled valley-bottom wetlands (Table 3).

Table 3. Classification of different hydrogeomorphic units of the watercourse using methods described by Ollis *et al*. (2013).

Level 1	Level 2		Level 3	Level 4	Graphic
System	**DWS Ecoregion**	**Vegetation**	**Landscape Unit**	**4A**	**From Ollis *et al.* (2013)**
Inland	19.01 Southern Folded Mountains	Eastern Little Karoo	Valley Bottom	Non-perennial stream with intermittent flow	
Inland	19.01 Southern Folded Mountains	Eastern Little Karoo	Valley Bottom	Unchanneled Wetland	

The inflowing drainage line to the western arm of the dam is approximately 500m from the source of a small catchment. The eastern arm of the dam is downstream of the confluence of two drainage lines. The southern of these two watercourses is the most significant in terms of the catchment size, and during the site visit had isolated pools of water. There was very minor, but perceptible flow into the dam from the eastern arm (Figure 5).

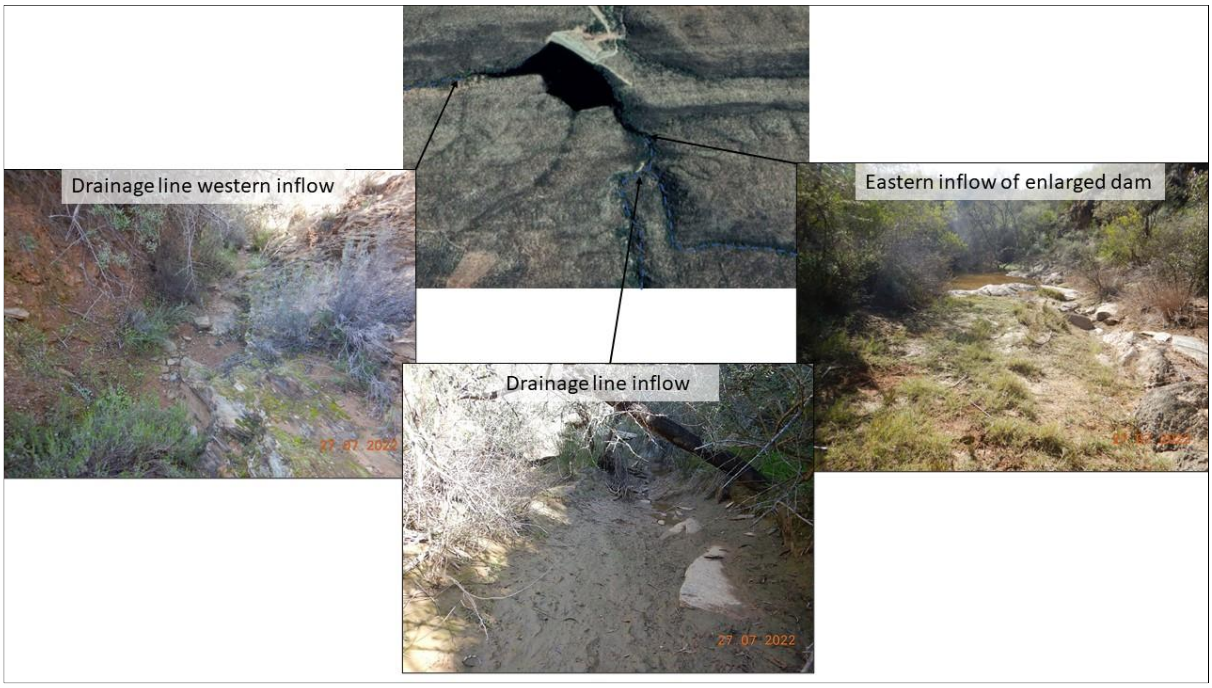


Figure 5. Aerial image of the enlarged dam indicating the three inflows classified as drainage lines with intermittent flows.

Below the enlarged dam, the western watercourse was classified as a drainage line, although small sections of instream wetland vegetation were present. While the eastern watercourse was classified as an unchanneled valley-bottom wetland. The existing dam downstream contained a small volume of standing water, and was full of *Phragmites australis* reeds, as well as birdlife and audible amphibians (Figure 6).

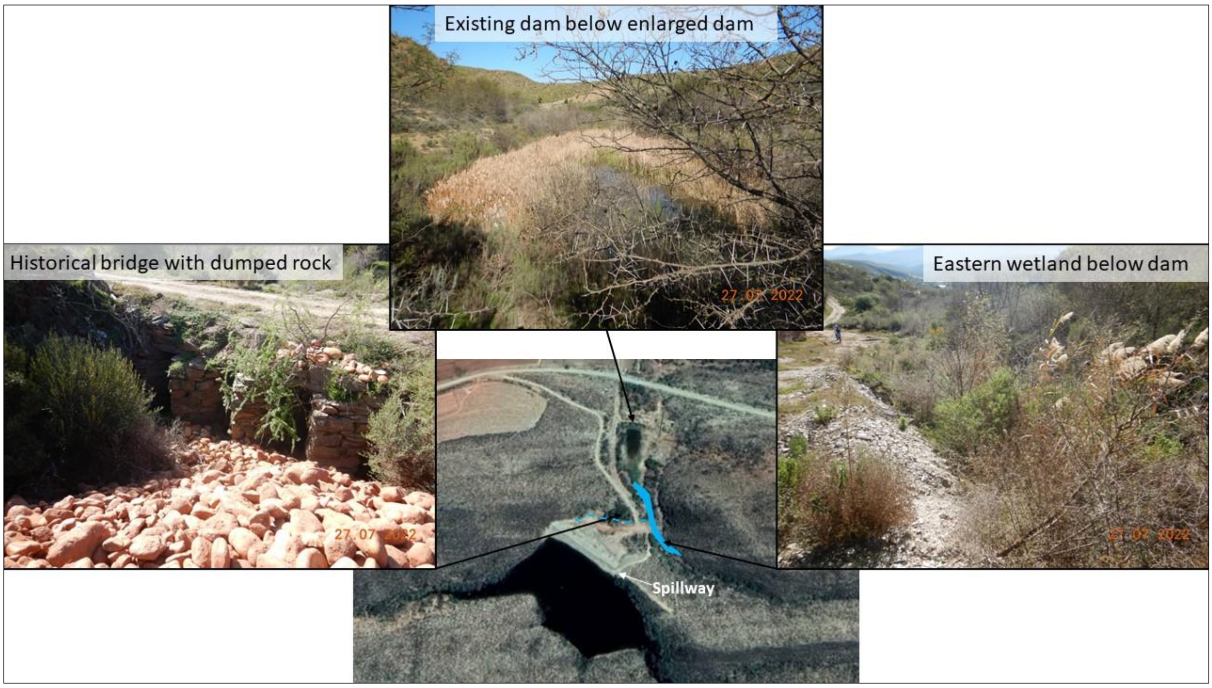


Figure 6. Aerial image of the enlarged dam indicating valley-bottom wetlands and the existing dam.

3.3 Watercourse Assessment

3.3.1 Present Ecological State: Drainage Lines

Methods used to determine the Present Ecological State (PES) of inflowing watercourses and how they have been impacted by the dam's enlargement are provided in Appendix 3. The Index of Habitat Integrity (IHI) was used to determine the PES.

The river reach considered in this assessment incorporates the enlarged dam's catchment and the remaining area downstream up to the confluence with the Kammanassie River. All drainage lines in this system have similar impacts and adjacent land uses.

A dam's primary impacts are usually associated with altered hydrology and flows. In this situation, the same streams were impounded both pre- and post-enlargement of the dam. While the dam was primarily enlarged to store water from the Klein River allocation, when water levels draw down this creates more potential storage volume than was present pre-enlargement, which could lead to reduced flows reaching downstream. However, the lower dam's outlet has since been opened allowing water from its small catchment to permanently drain downstream, which did not happen historically. The enlarged dam is therefore believed to increase the impact in terms of abstraction and flow to a minor degree.

The riparian vegetation lost by inundation post-enlargement measures approximately 0.5 ha in extent. This excludes vegetation loss due to the pre-enlargement dam. However, much of the catchment above the dam remains in a largely natural condition with only two small dams further upstream (on neighbouring properties). Riparian zones upstream of the dam consist primarily of indigenous vegetation and have little to no disturbance. Downstream of the existing dam towards the Kammanassie River, the riparian zone is minimal and agricultural fields have historically replaced areas of riparian vegetation.

Downstream of the dam, the impoundment has blocked any flows from reaching the western watercourse. Rocks cleared from agricultural fields have been dumped into this watercourse, smothering some riparian and instream habitat (Figure 7).

The combined scores for the IHI indicate that the watercourse PES has deteriorated from a Category C (Moderately Modified) to a Category D (Largely Modified) as a result of the dam enlargement.

Table 4. Summarised Index of Habitat Integrity (IHI) scores for drainage lines in the river reach impacted by the dam's enlargement.

Habitat Modification	Pre-enlargement score	Post-enlargement score	Notes
INSTREAM HABITAT			
Water abstraction	15	15	No significant difference to volumes for abstraction.
Flow	10	15	Likely increase in flow alteration due to enlarged dam.
Bed	5	10	Transformed additional 0.5 ha of streambed for dam enlargement.
Channel	5	10	Transformed additional 0.75 ha of channel for dam enlargement.
Physico-chemistry	5	10	Minor alteration due to transfer from Klein River which is a different catchment.
Inundation	5	10	Additional 1.7 ha inundated for dam enlargement.
Alien macrophytes	0	0	None observed.
Introduced aquatic fauna	5	5	Likely to already have bass / carp.
Rubbish dumping	0	5	Stones dumped in watercourse downstream.
	C, Moderately Modified	**D, Largely Modified**	
RIPARIAN HABITAT			
Vegetation removal	5	5	Minor vegetation removal
Exotic vegetation	5	5	Minor levels of invasion.
Bank erosion	5	5	Minor bank erosion downstream of dam.
Channel modification	10	12	Dumping of rock into downstream drainage line.
Water abstraction	5	5	Minor impact on riparian vegetation.
Inundation	5	12	Riparian vegetation loss due to enlargement.
Flow modification	5	5	Reduced flows but minor impact on riparian vegetation.
Physico-chemistry	0	0	Unlikely to be any impact.
	B/C Largely Natural to Moderately Modified	**C/D Moderately to Largely Modified**	

Figure 7. Photos of various aspects of watercourses considered in the IHI PES assessment.

3.3.2 Present Ecological State: Wetland

Methods used to determine the Present Ecological State of the small unchanneled valley-bottom wetland are provided in Appendix 3. The WET-Health method developed by Macfarlane (2008) was used to assess the integrity of the wetland and results are presented in Table 5.

The wetland is a distinct hydrogeomorphic unit (HGM) but it must be noted that it is a very small section of the eastern tributary between the enlarged and existing dams. It measures approximately 0.1 ha in extent. On the day of the site visit, a shallow (approx. 2 cm deep) film of water was moving through the wetland, and abundant instream wetland vegetation was present. Species include *Phragmites australis, Typha capensis, Cyperus textilis, Cliffortia strobilifera* and at least two *Juncus* spp. (Figure 8).

The historical road was placed across the wetland > 80 years ago (Figure 4), and the existing dam has been at this location for several decades. These two barriers represent the main impacts affecting the PES of the wetland prior to the upper dam's enlargement. The main impact of the latter was an area of the wetland where sand from the spillway was dumped into the watercourse. This is having a very localised impact on hydrology, geomorphology and vegetation, but did not result in the PES downgrading from the dam's pre-enlargement state (Table 5).

The wetland PES pre- and post-enlargement of the dam is **B/C which is classified as Largely Natural to Moderately Modified.**

Table 5. Present Ecological State determined using WET-Health for the unchanneled valley-bottom wetland below the enlarged dam.

Wetland PES Pre-Dam Enlargement	Wetland PES Post-Dam Enlargement
HYDROLOGY	**HYDROLOGY**
No abstraction or changes in flood peaks	No abstraction or changes in flood peaks
Channel modified by existing road crossing	Channel modified by existing road crossing
Existing road crossing and dam an impeding feature	Existing road crossing and dam an impeding feature
-	Sand from enlarged dam's spillway dumped instream
Hydrology PES Category: B/C, Largely Natural to Moderately Modified	**Hydrology PES Category: B/C, Largely Natural to Moderately Modified**
GEOMORPHOLOGY	**GEOMORPHOLOGY**
No diversions or shortening	No diversions or shortening
Infilling due to existing road crossing	Infilling due to existing road crossing
-	Sand from enlarged dam's spillway dumped instream
Geomorphology PES Category: B, Largely Natural	**Geomorphology PES Category: B, Largely Natural**
VEGETATION	**VEGETATION**
Existing dam and road crossing	Existing dam and road crossing
Shallow flooding by dam	Shallow flooding by dam
-	Area of infilling due to excavated spillway
Vegetation PES Category: B/C, Largely Natural to Moderately Modified	**Vegetation PES Category: B/C, Largely Natural to Moderately Modified**
OVERALL PES: **B/C, Largely Natural to Moderately Modified**	**OVERALL PES:** **B/C, Largely Natural to Moderately Modified**

Figure 8. Wetland vegetation and instream flowing water (left) and an area of dumped soil upstream of the wetland.

3.3.3 Ecological Importance and Sensitivity: Drainage Lines

Methods used to determine the EIS of drainage lines are in Appendix 5. Results of the EIS are presented in Table 6. The EIS of the network of drainage lines upstream and downstream of the dam was determined to be **Moderate**. As non-perennial systems with intermittent flow, they are not very sensitive to periods of reduced flow or water quality changes related to low flows.

Table 6. Ecological Importance and Sensitivity of the drainage lines on Buffelsrivier Farm.

Determinant	Drainage lines assessed collectively
Presence of Rare & Endangered Species	**0** – No species/taxon judged as rare or endangered at a local scale.
Populations of Unique Species	**1 -** Taxa judged to be unique at a local scale as they are associated with the riparian habitat and exhibit a different growth form and density.
Intolerant Biota	**1** - A very low proportion of the biota is expected to be only temporarily dependent on flowing water for the completion of their life cycle. Sporadic and seasonal flow events expected to be sufficient.
Species/Taxon Richness	2 – Rated on a local scale
Diversity of Habitat Types or Features	**2 –** Significant at the local scale due to standing pools of water between periods of flowing water.
Refuge value of habitat types	**2** – Rated on a local scale as DLs provides a corridor of more dense vegetation allowing movement for wildlife through a fragmented landscape.
Sensitivity of habitat to flow changes	1 – As a non-perennial DL with intermittent flows and a history of impoundment, the system is already adapted to reduced periods of flowing water.

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Determinant	Drainage lines assessed collectively
Sensitivity to flow related water quality changes	**1** – Given the intermittent flow regime, aquatic fauna would already be exposed to periods of low oxygen or higher salinity due to low flows.
Migration route for instream and riparian biota	**2** – The network of DLs is a moderately important link in terms of connectivity for the survival of biota upstream and downstream and is moderately sensitive to modification.
Protection Status	1 – The network of drainage lines is on private, agricultural land.
EIS Score	**1 - MODERATE**

3.3.4 Ecological Importance and Sensitivity: Wetland

The Ecological Importance and Sensitivity (EIS) score was determined using methods developed by Rountree *et al.* (2013). Ecological Importance provides a measure of a wetland's importance to the maintenance of ecological diversity and functioning at local and broader spatial scales. Ecological Sensitivity describes the wetland's ability to tolerate disturbance and recover from these events.

The wetland's EIS was classified as **Moderate** (Table 7). No Red Data or unique aquatic species are expected to occur in the wetland. The importance of the wetland as a migration route and for feeding and breeding of biota relates to presence of water in a semi-arid landscape, and the relatively undisturbed catchment area. This provides space for feeding, breeding and movement of aquatic and semi-aquatic biota.

As an unchanneled valley-bottom wetland which is relatively small, the presence of high velocity channelled flows (ie. From the spillway during flooding) can potentially degrade the wetland due to erosion and channel incision.

Table 7. Summarised assessment of the Ecological Importance and Sensitivity of the wetland downstream of the enlarged dam.

Ecological importance and sensitivity	Score 0-4	Confidence 1-5	Motivation
Biodiversity support	**1.0**		
Presence of Red Data species	0	3	None observed, but not impossible.
Populations of unique species	0	3	None observed, but unlikely given the mapped vegetation type.
Migration/feeding/breeding sites	3	4	Good habitat for amphibians, reptiles, small mammals, birds etc.
Landscape scale	**1.8**		
Protection status of wetland	3	4	Partially mapped CBA in the WCBSP. No formal protection.
Protection status of vegetation type	1	4	Listed as Least Concern
Regional context of the ecological integrity	2	4	Seasonal wetlands with low agricultural impacts rare in area
Size and rarity of the wetland types present	1	3	Small and relatively common
Diversity of habitat types	2	4	Moderate diversity but may have been higher prior to modifications.
Sensitivity of the wetland	**1.6**		
Sensitivity to changes in floods	3	3	Excessive floods likely to cause erosion and channel incision.
Sensitivity to changes in low flows	1	3	Seasonal wetland with periodic saturation of soils.
Sensitivity to changes in water quality	2	3	Moderate sensitivity. Evaporation would lincrease salinity and reduce oxygen. Biota adapted.
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**2.0**	**MODERATE**	

4. IMPACT ASSESSMENT

Methods for the Impact Assessment are explained in Appendix 6.

4.1 Design Phase Impact Assessment

If environmental authorisations had been undertaken prior to enlargement of the dam, a necessary step would have been to consider alternative water storage options from the perspective of environmental sensitivity. The primary purpose of enlarging the dam was to increase capacity to store water from the existing Klein River allocation of water. The dams on Portion 42/46 are lower in altitude than the abstraction point in the Klein River, which presented an opportunity to transfer the water via gravity feed to the dam that was subsequently enlarged. The registered volume for abstraction from the Klein River is 37 500 m^3. From the abstraction point in the Klein River to the confluence with the Kammanassie River is a neighbouring property, which is not owned by JVR Farming. Therefore, constructing a dam either instream or offstream on the Klein River would not have been an option. The original size of both dams on Portion 42/46 was too small to accommodate the volume of storage required for the Klein River allocation, necessitating enlargement of one of the dams.

The location of the road and confined space of the lower dam meant the upper of the two dams was selected for enlargement. One benefit from an ecological perspective is that the constant release of water from the lower dam effectively decommissions that dam, impounding one less catchment, that of the small wetland assessed in this report.

While the above-mentioned reasons provide a logical thought process justifying enlargement of the dam, the option to construct an offstream dam in an agricultural field closer to the Kammanassie River would have required consideration as part of the authorisation process. Despite the loss of agriculturally productive land, this is considered a viable option when surface water resources are under significant pressure, as in this catchment.

4.2 Construction Phase Impact Assessment

As the construction phase for the dam's enlargement has already concluded, the impacts associated with this phase are considered retrospectively. Mitigation measures cannot be provided in this case as the actions have already been taken. These impacts are considered in retrospect.

4.2.1 Dam excavation and vegetation removal

Earthmoving vehicles were required to excavate sediment from the enlarged dam's basin, clear vegetation, and extend the dam wall. Approximately 0.9 ha of riparian vegetation was cleared during the excavation, and soil up to 3 m deep was excavated from the dam basin for use in the dam wall. The impacts were considered a **Moderate Negative** (Table 8).

Figure 9. Enlarged dam shown pre- and post-construction with impacted aquatic habitat overlaid. Green = riparian vegetation, yellow = enlarged dam footprint, Orange = sand discard in wetland, and Red = rock discard in drainage line.

Table 8. Retrospective construction phase impact: Dam excavation and vegetation removal.

Project phase	**Construction**			
Impact	**Dam excavation and removal of 0.9 ha of riparian vegetation.**			
Description of impact	**Loss of riparian and aquatic habitat.**			
Mitigatability	Low	Mitigation does not exist; or mitigation will slightly reduce the significance of impacts		
Potential mitigation	• **Had the dam been proposed through an environmental authorisation process considering viable alternatives, the minimum footprint of disturbance would have been proposed, taking environmental sensitivity into account, possibly reducing the impact to instream and riparian habitat.** • **Vegetation clearing is usually specified out of major breeding seasons in Spring and Summer to minimise disturbance and injury to biota.** • **The erosion risk due to excavation of the dam basin would have been managed through the installation of silt fences, sand-bag barriers and hay-bale check dams.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Permanent	Impact may be permanent, or in excess of 20 years	Permanent	Impact may be permanent, or in excess of 20 years
Extent	Limited	Limited to the site and its immediate surroundings	Limited	Limited to the site and its immediate surroundings
Intensity	Very high	Natural and/ or social functions and/ or processes are majorly altered	Very high	Natural and/ or social functions and/ or processes are majorly altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Almost certain / Highly probable	It is most likely that the impact will occur
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Moderate - negative**		**Moderate - negative**	
Comment on significance	The significance is a "moderate negative" with and without mitigation because the impact cannot be mitigated in retrospect.			
Cumulative impacts	Not applicable.			

4.2.2 Discarding soil and rocks into watercourses

A pile of soil (3-4 m^3) was discarded along the banks and partially into the wetland downstream of the enlarged dam next to the spillway. Rocks removed from nearby agricultural fields were discarded into the drainage line downstream of the dam. In both cases, this discard is causing localised smothering of vegetation and aquatic habitat. These impacts should be mitigated regardless of the outcome of any environmental authorisations related to enlargement of the dam (Table 9).

Table 9. Construction phase impact: Soil and rock discard in watercourses.

Project phase	**Construction**			
Impact	**Disposal of excess soil and rocks**			
Description of impact	**Sediment discarded in wetland downstream and rocks in drainage line**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**• Soil discarded into the wetland must be carefully removed and indigenous vegetation rehabilitated. • Rocks discarded in the drainage line below the dam must be carefully moved out of the drainage line and any bare soil must be revegetated with indigenous vegetation. • The above work should be done by hand without the use of heavy machinery.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	On-going	Impact will last between 15 and 20 years	Short term	Impact will last between 1 and 5 years
Extent	Limited	Limited to the site and its immediate surroundings	Very limited	Limited to specific isolated parts of the site
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Unlikely	Has not happened yet but could happen once in the lifetime of the project, therefore there is a
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	High	The affected environment will be able to recover from the impact	High	The affected environment will be able to recover from the impact
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	Not applicable			

4.3 Operational Phase Impact Assessment

Impacts considered for the operational phase are those affecting the site currently as the dam has already been enlarged.

4.3.1 Hydrological impacts to downstream watercourses

The assessment took account of the fact that historically (pre-enlargement) the two dams effectively impounded all the affected watercourses, and that the enlarged dam aims to store the Klein River allocation as well as replace the two dams with one. The classification of the watercourses as non-perennial drainage lines reduces their sensitivity to alterations in flow.

The layout of inflowing watercourses in relation to the two dams pre- and post-enlargement is shown in Figure 10. The post-enlargement state (if authorised) presents the opportunity to rehabilitate the inflowing wetland area and lower dam to further enhance this habitat, prevent any significant storage of water, and slightly improve hydrological connectivity with the downstream habitat (Table 10). Without such mitigation measures the impact is considered **Moderate Negative.** If the wetland and decommissioned dam can be rehabilitated to a more hydrological connected state with the downstream watercourse, that will be considered a **Minor Positive** impact (Table 10).

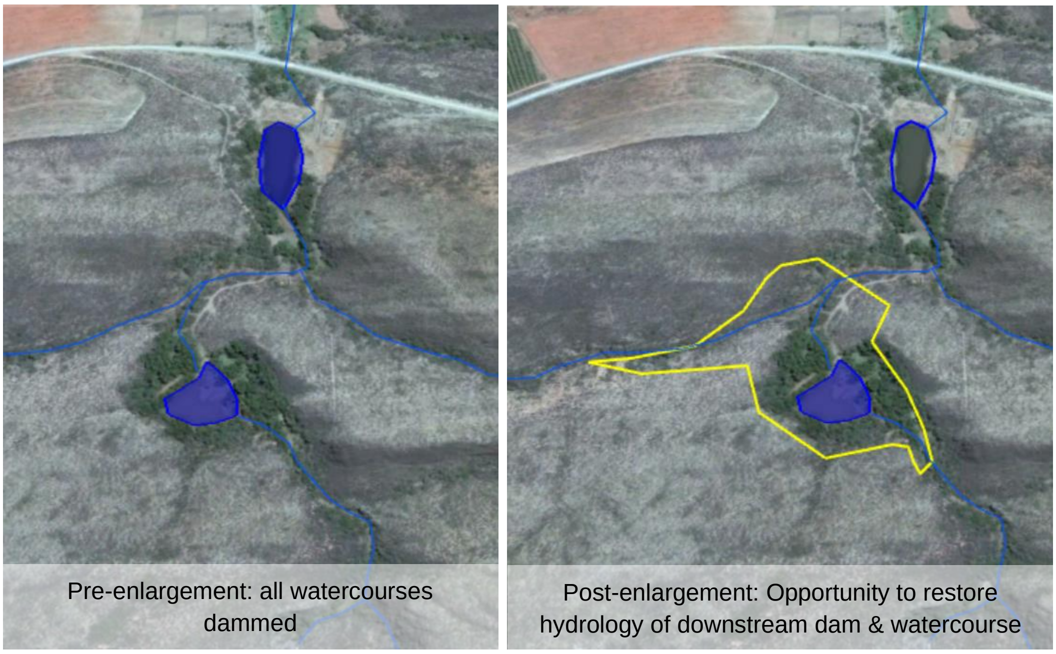


Figure 10. Annotated satellite image showing impounded watercourses pre- and post-enlargement of the dam. Blue lines = watercourses, Blue polygons = dams; Yellow line = enlarged dam.

Table 10. Operational phase impact: Hydrological impacts to downstream watercourses

Project phase	Operation			
Impact	Hydrological impacts to downstream watercourses			
Description of impact	Reduced base flow and flood flows reaching downstream watercourses			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Compile a rehabilitation plan to improve hydrological connectivity for the wetland area and dam downstream of the enlarged dam. This must included detailed methods to remove any infilling from the historical road (which is no longer needed), reduction / removal of the lower dam's embankment, and revegetation of disturbed areas. Existing 'vlei' habitat in the dam should be retained. • Ensure the Section 21a water use from the Klein River has been validated and verified and confirm the volumes abstractable from this source. • Seek advice from someone suitably qulified in dam design to determine whether the spillway is well located and adequate for the dam. One alternative may be to move the spillway to the other side of the dam wall, as there is also a watercourse at this point which is already channelled. Wetland vegetation below the existing spillway could be washed away and the channel incised should the dam spill over into it.**			
Assessment	Without mitigation		With mitigation	
Nature	Negative		Positive	
Duration	Permanent	Impact may be permanent, or in excess of 20 years	Permanent	Impact may be permanent, or in excess of 20 years
Extent	Limited	Limited to the site and its immediate surroundings	Limited	Limited to the site and its immediate surroundings
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Moderate	Natural and/ or social functions and/ or processes are moderately altered
Probability	Certain / definite	There are sound scientific reasons to expect that the impact will definitely occur	Likely	The impact may occur
Confidence	High	Substantive supportive data exists to verify the assessment	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Low	The resource is not damaged irreparably or is not scarce
Significance	Moderate - negative		Minor - positive	
Comment on significance	Mitigation measures will result in an improvement compared to the current and historical hydrology of the watercourse(s) downstream of the enlarged dam.			
Cumulative impacts	No applicable			

4.3.2 Dam maintenance

Possible maintenance actions for the dam were considered a Negligible Negative impact in their mitigated state. Maintenance actions to remove / dredge accumulated silt, repair flood damage, and control trees on the dam embankment were considered (Table 11).

Table 11. Operational phase impact: Dam maintenance

Project phase	**Operation**			
Impact	**Dam Maintenance**			
Description of impact	**Silt removal, flood repairs, dam wall vegetation control**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Heavy machinery for dredging the dam of periodic siltation may only gain access to the basin from the spillway 'road' and the dam wall. Earth-moving vehicles may not drive over anyshoreline vegetation to access the dam. • To minimise the impact of dredging on instream biota (plants and animals) dredging must be conducted in mid-winter to avoid the breeding season. • If aquatic vegetation has established over large areas, only 60% of vegetation that has established (reeds etc.) can be removed, working from the central basin outwards. • Make an effort to rescue any obvious wildlife from disturbance such as frogs. • Work should be conducted when the water level is as drawn down as low as possible to minimise increasing suspended sediments in the dam, as this can harm aquatic biota. • The dam's capacity must not be increased in volume, and records of the cubic metres of sediment removed must be maintained. • No trees or large shrubs must be allowed to grow on the dam embankment (wall) as these can lead to piping erosion and dam wall failure. Existing trees must be removed carefully, roots and all. Guidance in this respect must be obtained from a person experienced in dam design and maintenance. • In the event of flood damage, soil from any eroded areas must be replaced as before and revegetated with indigenous plants. Heavy vehicles may not enter the bed or banks of inflowing or outflowing watercourses unless in agreement through consultation with the BGCMA.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Short term	Impact will last between 1 and 5 years	Brief	Impact will not last longer than 1 year
Extent	Limited	Limited to the site and its immediate surroundings	Very limited	Limited to specific isolated parts of the site
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Probable	The impact has occurred here or elsewhere and could therefore occur	Rare / improbable	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has
Confidence	Medium	Determination is based on common sense and general knowledge	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	Not applicable			

4.4 Decommissioning Phase Impact Assessment

This component of the assessment essentially considers the impacts if the landowner is instructed to rehabilitate the enlarged dam to its previous level of storage. This section can also be considered a rehabilitation plan as it provides the steps required to rehabilitate the dam to its pre-enlarged state. This plan should be reviewed by a person experienced in dam design to ensure that no aspects will compromise dam safety during the decommissioning phase.

4.4.1 Earthworks to remove soil from the dam embankment

The first step in the decommissioning phase would be to remove soil from the dam embankment to the level stipulated by regulators. An alternative may be to simply lower the spillway, but this option must be determined in consultation with a dam engineer. This impact can be mitigated from a Minor to a Negligible Negative impact if all mitigation measures are followed (Table 12).

Table 12. Decommissioning Phase Impact: Earthworks to remove soil from the dam embankment

Project phase	**Decommissioning**			
Impact	**Earthworks to remove soil from the dam embankment**			
Description of impact	**Erosion, sedimentation, and vegetation disturbance in dam footprint and downstream.**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Demarcate the area to be cleared and ensure all workers know this is the limit of disturbance and vehicle access. • Construction vehicle parking and equipment stores must be located at least 100 m from the demarcated area to prevent fuel and material spills from entering the watercourse. • Fence off the watercourse and wetland area downstream of the dam for the duration of decommissioning. These must be demarcated 'No-go Areas' for people and vehicles. • Draw down the water level of the dam if necessary to ensure earthorks are undertaken under dry conditions. Water can be released downstream using a siphon system, but the flow velocity existing the pipe must not cause erosion. • Replace and reshape disturbed soils to natural contours in the order in which they were removed. ie. rock layer followed by subsoils (usually yellowish colour). Topsoil must be placed over the subsoil, but the latter must not be compacted. • Topsoil must be at a depth greater than or equal to 50 cm to facilitate revegetation. • Attempt to reshape and slope the valley to the natural site contours, avoiding the creation of ditches and cuts which channel water flow and cause erosion. • Work must not be conducted during periods of rainfall to avoid further disturbance. • A large silt fence along the disturbed area must be established and maintained free of silt for the duration of the rehabilitation work. • The depth of topsoil and final landform must be independently assessed by an Environmental Control Officer / Aquatic Ecologist using an auger prior to revegetation to ensure a uniform distribution of topsoil has been achieved.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Medium term	Impact will last between 5 and 10 years	Short term	Impact will last between 1 and 5 years
Extent	Local	Extending across the site and to nearby settlements	Limited	Limited to the site and its immediate surroundings
Intensity	High	Natural and/ or social functions and/ or processes are notably altered	High	Natural and/ or social functions and/ or processes are notably altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Unlikely	Has not happened yet but could happen once in the lifetime of the project, therefore there is a
Confidence	High	Substantive supportive data exists to verify the assessment	High	Substantive supportive data exists to verify the assessment
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	Not applicable			

4.4.2 Restoration of the watercourse channel

With renewed rainfall and flows once the dam level has adjusted lower, the watercourse will begin reforming along the low point near its historical path. This area will likely have minimal soil and vegetation cover. It is necessary to aid the watercourse in reforming a channel without resulting in excessive erosion and sedimentation. Measures to mitigate this impact are provided in Table 13. Detailed methods for the installation of hay-bale check dams is provided below.

Table 13. Decommissioning Phase Impact: Restoration of the Stream Bed.

Project phase	**Decommissioning**			
Impact	**Restoration of the stream bed**			
Description of impact	**Erosion, channel incision and sedimentation downstream**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Install 4 - 5 small (1 layer high) hay-bale check dams perpendicular to the water flow, equally spaced at intervals along the stream channel. The purpose is to slow and filter flows, and encourage settling of sediment upstream of each check dam. • Hay-bale check dams must be correctly installed wrapped in a biodegradable material such as hessian to hold them together. They should be 'dug in' to the stream bed and keyed into the banks. • Cover approximately 40% of the stream bed with cobbles and small rocks (Approx. 30 cm width) placed randomly along the length of the stream bed. Rocks removed from agricultural fields would be acceptable for this purpose but must be placed in a single layer, not as a pile.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Medium term	Impact will last between 5 and 10 years	Short term	Impact will last between 1 and 5 years
Extent	Local	Extending across the site and to nearby settlements	Limited	Limited to the site and its immediate surroundings
Intensity	Moderate	Natural and/ or social functions and/ or processes are moderately altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Likely	The impact may occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	Medium	Determination is based on common sense and general knowledge	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Minor - negative**		**Negligible - negative**	
Comment on significance				
Cumulative impacts	No applicable.			

Methods: Hay-bale check dams

- Bales should be bound with wire or nylon string. Twine bound bales are less durable.
- The check dams should cross the stream bed and extend slightly up the slope on both sides of the valley (**Error! Reference source not found.**).

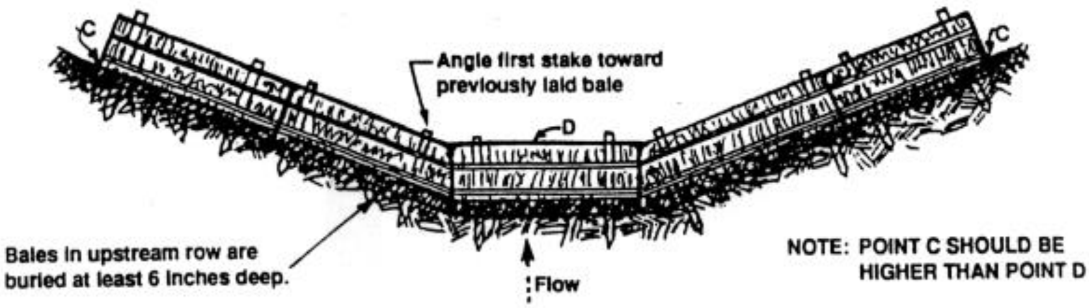


Figure 11. Cross-section of a hay bale check dam.

- Hay bales should be dug into a shallow trench approximately 15 cm deep.
- Soil must then be replaced and compacted around the base of the bales.
- The row of bales must be orientated perpendicular to the flow of water to capture water from the slope above.
- Bales must then be secured using wooden stakes hammered in the soil angled towards each neighbouring bale to ensure a seamless barrier (Figure 11).

No gaps must be present at the base of the bales as this will create preferential flow paths resulting in erosion. The purpose of this intervention is to capture high velocity runoff in a check dam and allow it to slowly filter through the bales.

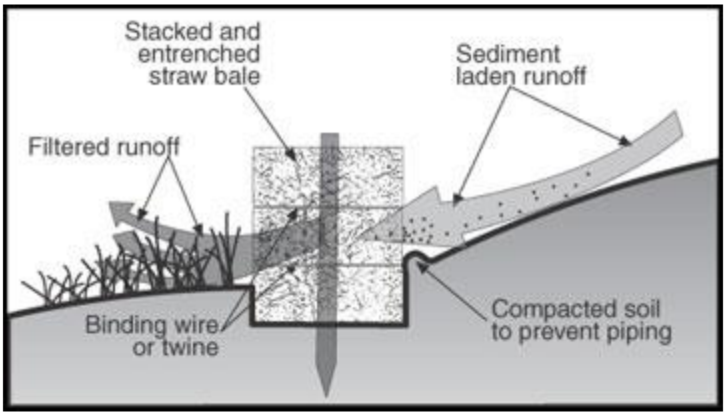


Figure 12. Cross-section of installed hay bale check dam indicating staking and excavation of bales into the soil.

- The lowest check dam at the outflow must include an additional row of hay bales downstream placed on their side in case the dam fills with water and overflows. This measure is to prevent erosion of a plunge pool below the bales (Figure 13).

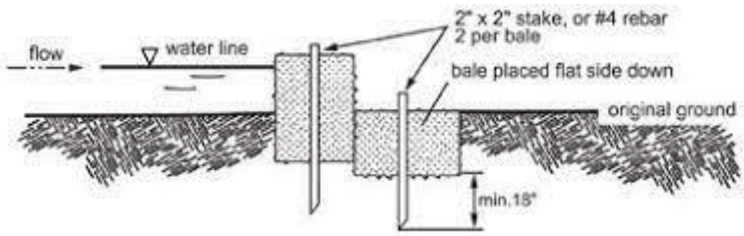


Figure 13. Cross section of the lowest check dam showing the second row of bales on their side.

4.4.3 Erosion of recently disturbed soil

Excavation of soil from the dam's embankment, and drawdown of the water level will result in areas of exposed soil being prone to erosion. To avoid deposition of this soil in the watercourse, these areas should be revegetated and stabilised using mitigation measures provided in Table 14 with detailed methods provided in the sections following.

Table 14. Decommissioning Phase Impact: Erosion of recently disturbed soil

Project phase	**Decommissioning**			
Impact	**Erosion of recently disturbed soil**			
Description of impact	**Without revegetation, exposed soil will erode causing sedimentation downstream**			
Mitigatability	Medium	Mitigation exists and will notably reduce significance of impacts		
Potential mitigation	**• Lightly seed the slopes and stream bed with the grass Cynodon dactylon (kweek). Seed into topsoil, and cover with a thin layer of mulch. • On slopes greater than 1:3, nail in overlapping soil saver matting to protect the soil. • On steep slopes silt fences must be installed perpendicular to the slopes and parallel to each other approximately 8 - 10 m apart (Methods provided). • Revegetated slopes must be actively monitored to ensure a dense cover of > 80% of grass. Gaps should be actively reseeded. • The indigenous seed bank may have been destroyed through inundation by dam water, or lost through earth-moving. Passive establishment of indigenous plants must be monitored. If after one full growing season following decommissioning of the dam there is still < 50% cover with indigenous seedlings, active planting may be necessary (see plant list). This must be monitored and overseen by an Aquatic Ecologist. • Alien vegetation must be actively removed before it becomes established when it can either be hand-pulled or removed with a tree popper. NO heavy machinery can be used within the recovering watercourse or previously disturbed area for the purpose of alien plant removal. • Revegetation of the riparian area and previously excavated area must be monitored 6-monthly for 3 years by an Aquatic Ecologist. • Monitoring should also take place by the land-owner following heavy rainfall to identify and proactively address erosion before it can progress too severely. • Eroded areas of the steep banks must be refilled with topsoil, reseeded with grass, covered with a light mulch and protected with soil saver mats. Silt fencing must be used in problem areas to provide further protection against erosion.**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	On-going	Impact will last between 15 and 20 years	Short term	Impact will last between 1 and 5 years
Extent	Local	Extending across the site and to nearby settlements	Limited	Limited to the site and its immediate surroundings
Intensity	High	Natural and/ or social functions and/ or processes are notably altered	Moderate	Natural and/ or social functions and/ or processes are moderately altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	Medium	Determination is based on common sense and general knowledge	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Moderate - negative**		**Minor - negative**	
Comment on significance				
Cumulative impacts	Not applicable			

Placement of soil protection matting

Exposed soil on slopes or within the watercourse will be vulnerable to erosion and must be stabilised with vegetation. A combination of temporary vegetation cover and soil matting is recommended (Table 14). The following steps must be taken.

- Lightly rake over the soil to create a uniform surface.
- Seed the areas with *Cynodon dactylon* and *Digitaria eriantha* purchased from a registered supplier (e.g. Agricol). These grasses will rapidly provide cover and stabilise

the soil. The seeding rate should be 20 -30 kg / ha. Seed should be scattered as uniformly as possible to prevent clumping.

- The seeded area must be covered in a **light mulch (1-2cm deep**). This can consist of shredded woody material but must not be wood chips. Chipped alien vegetation is not suitable as it will contain seeds of alien vegetation.

Cover the seeded and mulched slops with a rolled erosion control product (such as jute, coir or straw matting). Preferably a natural (vs. man-made), bio-degradable product should be used. The use of a jute geotextile called *Soilsaver* is recommended. It is available from Kaytech in Port Elizabeth and in Cape Town. The role of the erosion control matting is not to provide long-term protection for slopes from erosion, but to protect the soil surface until vegetation can establish and become the permanent stabilising feature. The slope should be seeded and mulched, and then covered with erosion control matting which will remain in place until the vegetation has established. Matting should be overlapped by about 10cm and secured using wooden stakes along the edges. Terminal ends of the matting can also be staked or buried in an anchor trench (Figure 14).

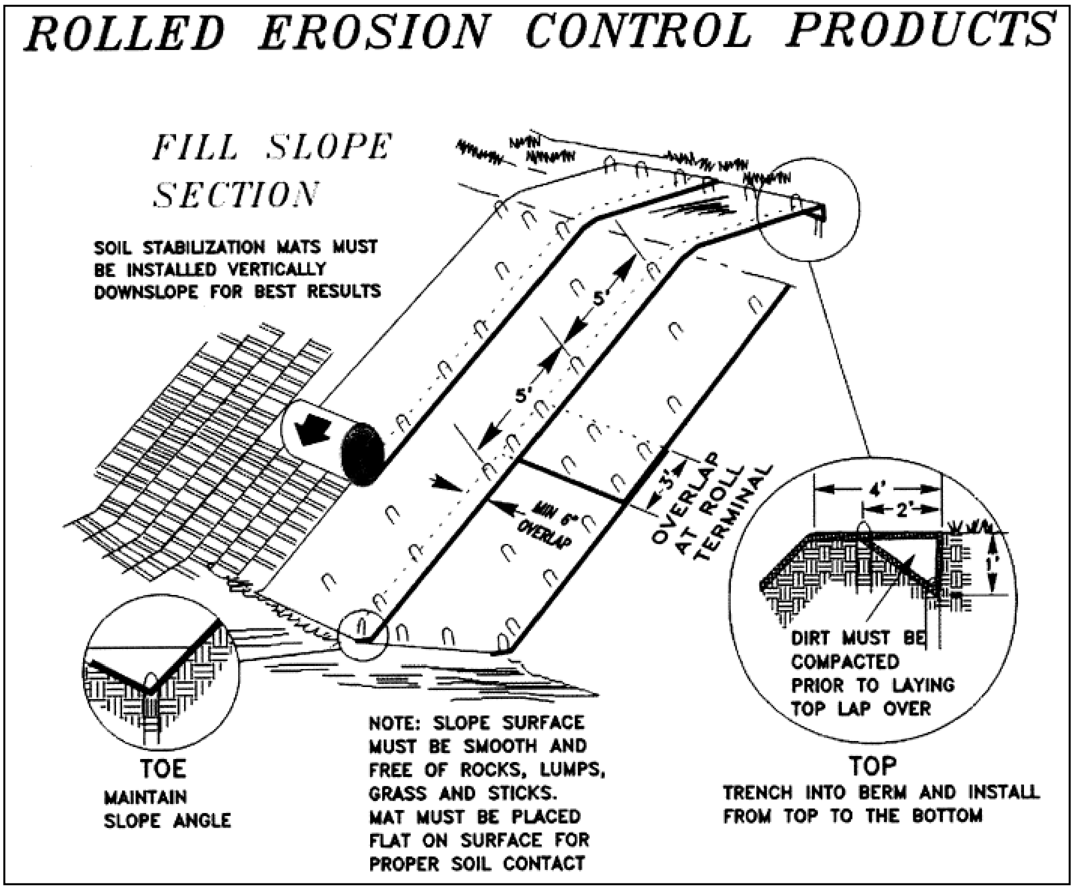


Figure 14. Example of methods recommended to install erosion control matting on sloping areas that require revegetation (Source: Department of Environmental Protection, West Virginia)

Silt fencing methods

Proper installation of soil erosion control fences is necessary for them to be effective. Silt fences will only be necessary where the slope exceeds 1:3 increasing the risk of erosion. These guidelines must be followed:

- Geotextile fences must be installed perpendicular to the direction of water flow and along a line of uniform elevation or contour. In other words they should not waiver up and down the slope, but should be in a straight line across the slope. If this guideline is not followed, water will flow along the fence to the lowest point creating stress and potential collapse at this point;
- Use synthetic UV resistant geotextile fabric able to withstand at least 6 months of sun exposure. The product *Grassfence* (available from Kaytech) is specifically made for this application and is available in rolls 500mm and 700mm wide. The material must be able to allow water to move through it, so materials like bidim are not suitable, but 70-80% shadecloth can be used if necessary;
- Silt fences can be staked using wooden stakes. Metal droppers are preferable but could be stolen. The stakes should be arranged in straight lines across the area to be rehabilitated, at most 3m apart and firmly driven into the ground. A steel wire along the top of the stakes and also along the ground must then be secured and to which the geotextile is fastened, top and bottom;
- A 250 to 350 cm wide and 10 cm deep trench must be dug upslope of the location of the fence and the bottom half of the geotextile then laid into the trench;
- The trench must be backfilled and the soil compacted over the geotextile;
- The height of the silt fence should be between 20 and 30 cm;
- The distance between silt fences should be 8-10m. This results in 4 silt fences at the site, with the lowest one following the line of the lowest uncleared vegetation;
- Geotextile should be in a continuous roll to avoid joins which weaken the structure. Where joins are unavoidable both fabric ends should be wound around stakes to prevent it from unravelling (See Figure 16);
- Terminal ends of the silt fence should run slightly uphill to prevent runoff from going around the ends of the fences.
- Silt fences will be removed once vegetation has established on exposed areas.

Figure 15. Installation of the soil erosion control fence. A: Installing the standards and wires and preparing the trench. B: Fitting the geotextile, tying it on with wire. C: Filling in the trench over the geotextile. D: Applying a mulch against the completed fence (Photos courtesy Ken Coetzee).

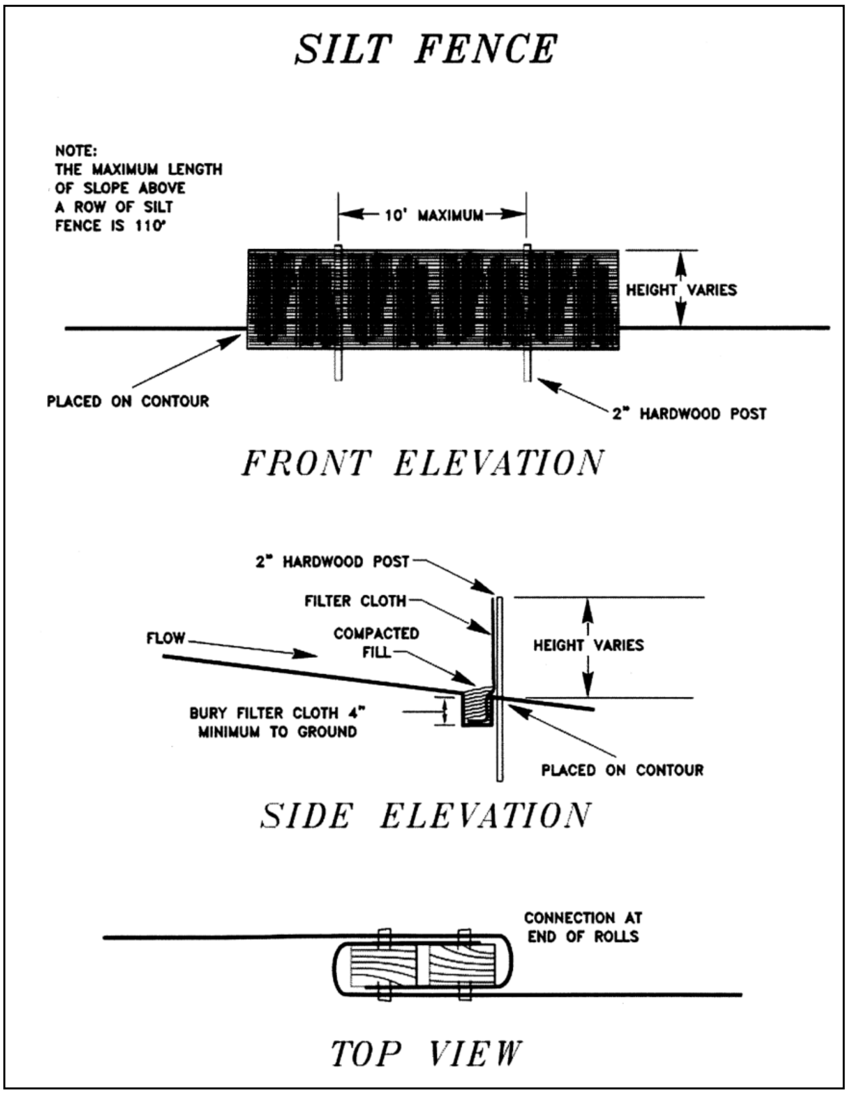


Figure 16. Example of methods recommended to install silt fencing (Measurements in inches; Source: Department of Environmental Protection, West Virginia)

If more active revegetation is required following a full growing season, the plants listed in Table 15 can be used to revegetate the riparian zone.

Table 15. Selected indigenous plant species for active replanting in riparian and wetland areas.

Species Name	Common Name
Riparian Plants	
Vachellia karroo	Sweet thorn
Aloe ferox	Cape aloe
Searsia lucida	Blinktaaibos
Euclea undulata	Common guarri
Carissa bispinosa	Numnum
Osteospermum moniliferum	Bitou
Themeda triandra	Red grass
Cynodon dactylon	Kweek / Bermuda
Carprobrotus sp.	Creeping sour fig
Wetland Plants	
Cyperus textilis	Mat sedge
Typha capensis	Bulrush
Phragmites australis	Fluitjiesriet
Cliffortia strobilifera	Cone river caperose

5. CONCLUSIONS

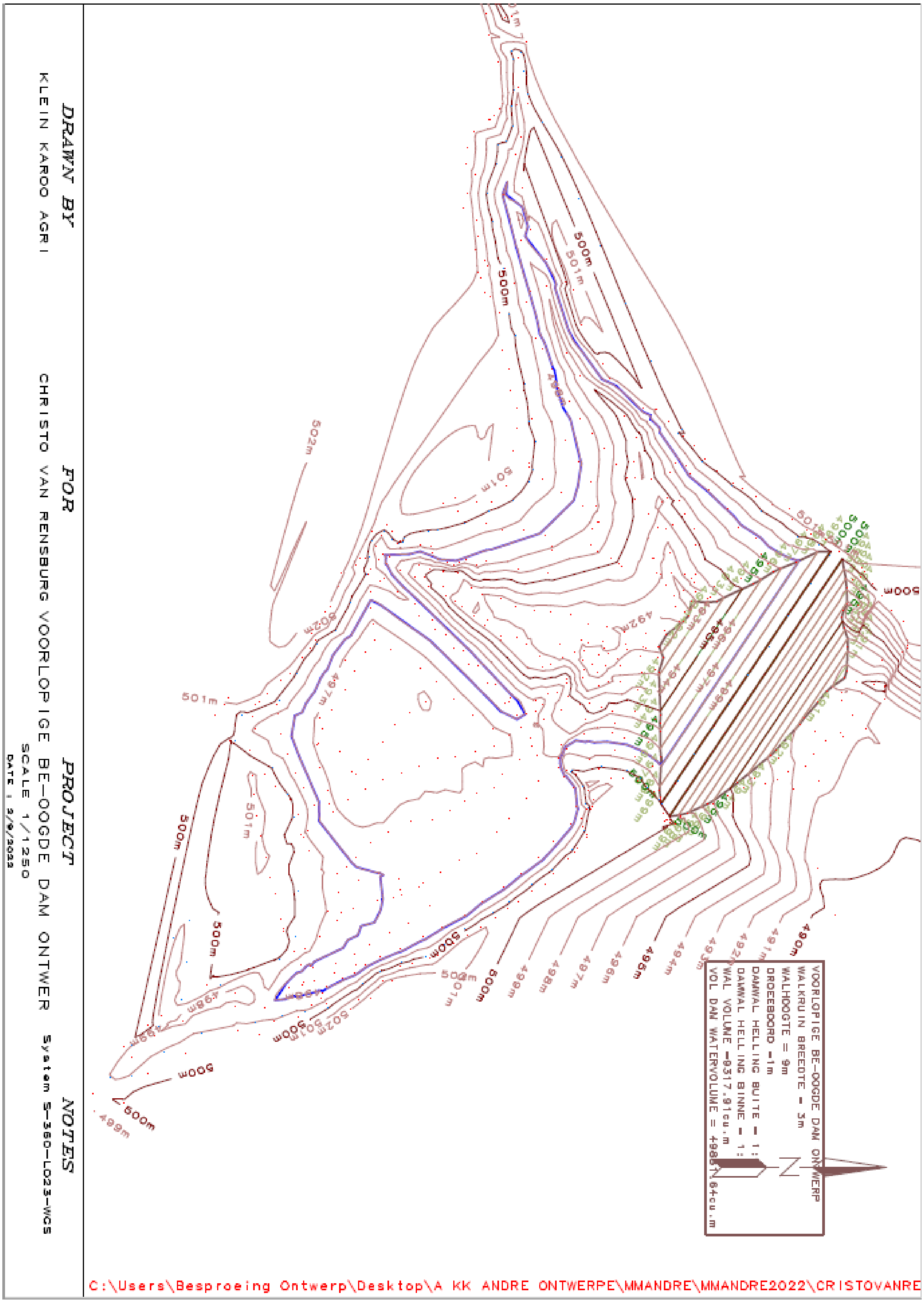
In conclusion, the network of affected watercourses was already impacted through impoundment by two dams. Enlargement of the upstream dam has resulted in a decrease in the PES of the system by one level due to loss of riparian and aquatic habitat. The increased volume of the enlarged dam is much greater than the sum of storage in the two existing dams. However, it is understood that the intention of the enlarged dam was to store an allocation of water from the Klein River, and not to store additional surface runoff from the catchment. The landowner effectively decommissioned storage in the downstream dam letting most of the water run out of the dam creating the opportunity to rehabilitate one previously impounded reach in the stream network.

It is recommended that the enlarged dam be retained with the following provisions:

- A comprehensive rehabilitation plan for the downstream wetland and decommissioned dam must be compiled and fully implemented.
- Confirmation of the exact volume of water to be abstracted from the Klein River on an annual basis along with proof of the lawfulness of this abstraction must be provided.
- All water abstraction points must be metered to ensure over-abstraction doesn’t occur.
- An assessment of the dam wall and spillway by a suitable professional must be undertaken to ensure the dam poses no risk to the receiving wetland.
- Aquatic habitat that has established vlei-like conditions in standing water in the downstream dam should be maintained with a trickle-flow of water released from the dam provided this is available. This is achievable using a siphon system with a valve to open / close the pipe.

6. APPENDICES

6.1 Survey of the enlarged dam



6.2 Historical photos of the dam enlargement

Figure 17. Photos taken during the construction phase of the dam enlargement by the landowner (J.C. Jansevanrensburg; September, 2017).

6.3 Hydrology Resource Quality Objectives for the Kammanassie River

Desktop Version 2, Generated on 09/03/2017
Summary of Desktop (Version 2) estimate for Quaternary Catchment Area:
Total Runoff : gv36

Annual Flows (Mill. cu. m or index values):

MAR	=	41.216
S.Dev.	=	48.110
CV	=	1.167
Q75	=	0.500
Q75/MMF	=	0.146
BFI Index	=	0.249
CV(JJA+JFM) Index	=	5.452

Ecological Category = C/D

Total IFR	=	6.324 (15.34 %MAR)
Maint. Lowflow	=	3.488 (8.46 %MAR)
Drought Lowflow	=	0.398 (0.97 %MAR)
Maint. Highflow	=	2.836 (6.88 %MAR)

Monthly Distributions (Mill. cu. m.)
Distribution Type : S.Karoo

Month	Natural Flows			Modified Flows (IFR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	3.177	5.086	1.601	0.435	0.048	0.218	0.653
Nov	4.269	10.513	2.463	0.431	0.047	0.218	0.649
Dec	3.188	8.794	2.758	0.327	0.070	0.000	0.327
Jan	1.479	3.502	2.368	0.252	0.016	1.091	1.343
Feb	1.657	6.797	4.101	0.179	0.000	0.218	0.397
Mar	2.575	8.056	3.129	0.182	0.011	0.000	0.182
Apr	3.511	10.572	3.011	0.182	0.000	0.000	0.182
May	4.238	9.687	2.286	0.215	0.011	0.000	0.215
Jun	2.659	5.079	1.910	0.239	0.016	0.000	0.239
Jul	2.783	4.810	1.728	0.311	0.038	1.091	1.402
Aug	6.832	21.300	3.118	0.381	0.064	0.000	0.381
Sep	4.849	10.520	2.169	0.353	0.078	0.000	0.353

6.4 Present Ecological State Methods

6.4.1 Drainage lines

Drainage lines are natural channels in which water flows intermittently following rainfall. These are assessed using the Index of Habitat Integrity (IHI; Kleynhans, 1996) which measures the impact of human disturbance on riparian and instream habitats. The IHI is a rapid assessment of the severity of impacts affecting habitat integrity within a defined segment of a watercourse. The method can be applied to both perennial and non-perennial watercourses. The instream impacts considered both before and after the dam enlargement were: water abstraction; flow modification; bed modification; channel modification; physico-chemical modification; inundation; alien macrophytes; and rubbish dumping. The riparian impacts assessed were: vegetation removal; exotic vegetation; bank erosion; channel modification; water abstraction; inundation; flow modification; physico-chemistry. Each of the impacts were given a score based on their degree of modification (1-25;Table 16), along with a confidence rating based on the level of confidence in the score.

Table 16. Descriptive classes for assessment of habitat modifications (Kleynhans, 1996)

Impact Class	Description	Score
None	No discernible impact or the modification is located in a way that has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not affected.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

An IHI class is then determined based on the resulting score which is shown in Table 17. These results provide an indication of the site-specific PES.

Table 17. Index of habitat integrity (IHI) classes and descriptions

Integrity Class	Description	IHI Score (%)
A	Natural	> 90
B	Largely Natural	80 – 90
C	Moderately Modified	60 – 79
D	Largely Modified	40 – 59
E	Seriously Modified	20 – 39
F	Critically Modified	0 – 19

6.4.2 Wetland

The unchanneled valley-bottom wetland was assessed using the WET-Health model developed by Macfarlane (2008). The tool aims to assess the integrity of a wetland which is defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. The method combines an assessment of hydrological, geomorphological and vegetation health in three modules.

Data collection involved a desktop review of the extent and intensity of catchment land use impacts and was undertaken using historical and recent aerial imagery of the site (Chief Directorate: National Geo-spatial Information). Fieldwork onsite involved the identification and recording of observable impacts to the wetland at the site of relevant impacts as well as at reference points upstream and downstream. The magnitude of observed impacts to the hydrological, geomorphological and vegetation components of the wetland were calculated and combined as per the tool to provide a measure of the overall condition of the wetland. The condition ranges in scale from 1-10 and resultant scores were then used to assign the wetland one of six PES categories as shown in Table 18.

Table 18. Wetland Present Ecological State (PES) categories and impact descriptions.

Ecological Category	Description	Impact Score
A	Unmodified, natural.	0 – 0.9
B	Largely natural with few modifications / in good health. A small change in natural habitats and biota may have taken place but the ecosystem functions are still predominantly unchanged.	1 – 1.9
C	Moderately modified / fair condition. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	2 – 3.9
D	Largely modified / poor condition. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	4 – 5.9
E	Seriously modified / very poor condition. The loss of natural habitat, biota and basic ecosystem functions is extensive.	6 – 7.9
F	Critically modified / totally transformed. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota.	8 - 10

6.4.3 Ecological Importance and Sensitivity Methods: Drainage Lines

The Ecological Importance and Sensitivity (EIS) for drainage lines was derived using the methods developed by Department of Water Affairs and Forestry (DWAF; 1999). Ecological Importance of a system is defined as the expression of its importance to the maintenance of ecological diversity and functioning on local as well as broader scales. Ecological sensitivity relates to the system's resilience to disturbance, or its ability to recover from disturbance that has occurred. The EIS rating does not incorporate the PES and therefore indicates the potential importance or sensitivity of a system as could be expected under unimpaired conditions (ie. Pre-enlargement). For the assessment both biotic and abiotic factors are considered as follows:

- The presence of rare, endangered or unique aquatic species. This includes species of conservation concern, endemic or isolated species populations, intolerant species and overall species richness;
- Diversity and refuge value of habitat types;
- Sensitivity of the system to changes in flow and related water quality changes;
- Importance of providing functional connectivity between related systems;
- Biological connectivity in the form of migration routes / corridors instream and along riparian zones;
- Protection level of the area where the system is located (e.g. National Park).

These parameters are scored individually and the median score of all variables is calculated to derive an EI and ES category as defined in (Table 19).

Table 19. Ecological Importance and Sensitivity Categories

Ecological Importance and Sensitivity Categories	General Description
Very High	Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use
High	Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.
Moderate	Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
Low/Marginal	Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.

6.4.4 Ecological Importance and Sensitivity Methods: Wetland

The revised method for the determination of the EIS of a wetland considers the three following ecological aspects (Rountree *et al*., 2013):

- **Ecological importance and sensitivity**
  - Biodiversity support including rare species and feeding/breeding/migration;
  - Protection status, size and rarity in the landscape context;
  - Sensitivity of the wetland to floods, droughts and water quality fluctuations.
- **Hydro-functional importance**
  - Flood attenuation;
  - Streamflow regulation;
  - Water quality enhancement through sediment trapping and nutrient assimilation;
  - Carbon storage
- **Direct human benefits**
  - Water for human use and harvestable resources;
  - Cultivated foods;
  - Cultural heritage;
  - Tourism, recreation, education and research.

Each criterion is scored between 0 and 4, and the average of each subset of scores is used to derive a score for each of the three components listed above. The highest score is used to determine the overall Importance and Sensitivity category of the wetland system (Table 20).

Table 20.Ecological importance and sensitivity categories for wetlands. Interpretation of average scores for biotic and habitat determinants.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high: Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains 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	A
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these floodplains 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	B
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains 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	C
Low/marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains 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	D

6.5 Impact Assessment Methods

Criteria are ascribed for each predicted impact. These include the intensity (size or degree scale), which also includes the type of impact, being either a positive or negative impact; the duration (temporal scale); and the extent (spatial scale), as well as the probability (likelihood). The methodology is quantitative, whereby professional judgement is used to identify a rating for each criterion based on a seven-point scale (Table 21) and the significance is auto-generated using a spreadsheet through application of the calculations.

For each predicted impact, certain criteria are applied to establish the likely **significance** of the impact, firstly in the case of no mitigation being applied and then with the most effective mitigation measure(s) in place.

These criteria include the **intensity** *(*size or degree scale), which also includes the **nature** of impact, being either a positive or negative impact; the **duration** (temporal scale); and the **extent** (spatial scale). These numerical ratings are used in an equation whereby the **consequence** of the impact can be calculated. Consequence is calculated as follows:

Consequence = type x (intensity + duration + extent)

To calculate the significance of an impact, the **probability** (or likelihood) of that impact occurring is applied to the consequence.

Significance = consequence x probability

Depending on the numerical result, the impact would fall into a significance category as negligible, minor, moderate or major, and the type would be either positive or negative.

Table 21. Assessment criteria for the evaluation of impacts

Criteria	Numeric Rating	Category	Description
Duration	1	**Immediate**	Impact will self-remedy immediately
	2	**Brief**	Impact will not last longer than 1 year
	3	**Short term**	Impact will last between 1 and 5 years
	4	**Medium term**	Impact will last between 5 and 10 years
	5	**Long term**	Impact will last between 10 and 15 years
	6	**On-going**	Impact will last between 15 and 20 years
	7	**Permanent**	Impact may be permanent, or in excess of 20 years
Extent	1	**Very limited**	Limited to specific isolated parts of the site
	2	**Limited**	Limited to the site and its immediate surroundings
	3	**Local**	Extending across the site and to nearby settlements
	4	**Municipal area**	Impacts felt at a municipal level
	5	**Regional**	Impacts felt at a regional level
	6	**National**	Impacts felt at a national level
	7	**International**	Impacts felt at an international level
Intensity	1	**Negligible**	Natural and/ or social functions and/ or processes are negligibly altered
	2	**Very low**	Natural and/ or social functions and/ or processes are slightly altered
	3	**Low**	Natural and/ or social functions and/ or processes are somewhat altered
	4	**Moderate**	Natural and/ or social functions and/ or processes are moderately altered
	5	**High**	Natural and/ or social functions and/ or processes are notably altered
	6	**Very high**	Natural and/ or social functions and/ or processes are majorly altered
	7	**Extremely high**	Natural and/ or social functions and/ or processes are severely altered
Probability	1	**Highly unlikely / None**	Expected never to happen
	2	**Rare / improbable**	Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere
	3	**Unlikely**	Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur
	4	**Probable**	Has occurred here or elsewhere and could therefore occur
	5	**Likely**	The impact may occur
	6	**Almost certain / Highly probable**	It is most likely that the impact will occur
	7	**Certain / Definite**	There are sound scientific reasons to expect that the impact will definitely occur

When assessing impacts, broader considerations are also considered. These include the level of confidence in the assessment rating; the reversibility of the impact; and the irreplaceability of the resource as set out in (Table 22, Table 23, & Table 24), respectively.

Table 22. Definition of confidence ratings.

Category	Description
Low	Judgement is based on intuition
Medium	Determination is based on common sense and general knowledge
High	Substantive supportive data exists to verify the assessment

Table 23. Definition of reversibility ratings.

Category	Description
Low	The affected environment will not be able to recover from the impact - permanently modified
Medium	The affected environment will only recover from the impact with significant intervention
High	The affected environmental will be able to recover from the impact

Table 24. Definition of irreplaceability ratings.

Category	Description
Low	The resource is not damaged irreparably or is not scarce
Medium	The resource is damaged irreparably but is represented elsewhere

7. REFERENCES

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