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Memo

To:	Mr Richard Ciza	**Date:**	5 November 2025
Company:	GG&G Consulting Engineers (Pty) Ltd ('GG&G')	**From:**	Mr Brent Cock
Copy to:	Mr Godwyn Smith (GG&G)	**Project #:**	624065
Subject:	**Outeniqua Game Farm Irrigation Dam Wall Geotechnical Desk Study & Site Walkover**		

1. Introduction

SRK Consulting (South Africa) (Pty) Ltd (SRK) were appointed by GG&G Consulting Engineers (Pty) Ltd (GG&G) to undertake a Preliminary Geotechnical Investigation (comprised of a desk study and site walk over) to support GG&G's Water Use Application ('WUA') for a proposed irrigation dam wall located within the Outeniqua Game Farm property.

2. Scope of Report

The following items are addressed in the report:

- Determine the regional geology, with a specific focus on the rock type, based on published geological maps.
- Summarise the general engineering geology conditions associated with soils derived from the identified rock type, as well as the properties of the rock type itself (if available) based on published information.
- Based on the findings from the site assessment, recommendations on the dam foundation and most appropriate location
- Assessment and preliminary recommendations on the potential locations of a quarry for construction material
- In addition to the above, GG&G requested that SRK provide brief comments on the following:
  - 'Some indication of water table based on the vegetation indicators on site'.
  - 'If there is any environmental sensitivity linked to the observed geology'.

3. Regional locality and description

3.1. Site locality and proposed dam site locations

The proposed dam site, within the Outeniqua Garm Farm property, is located approximately 18 km north of the R102/R328 road intersection in Hartenbos, Western Cape (Figure 3-1).

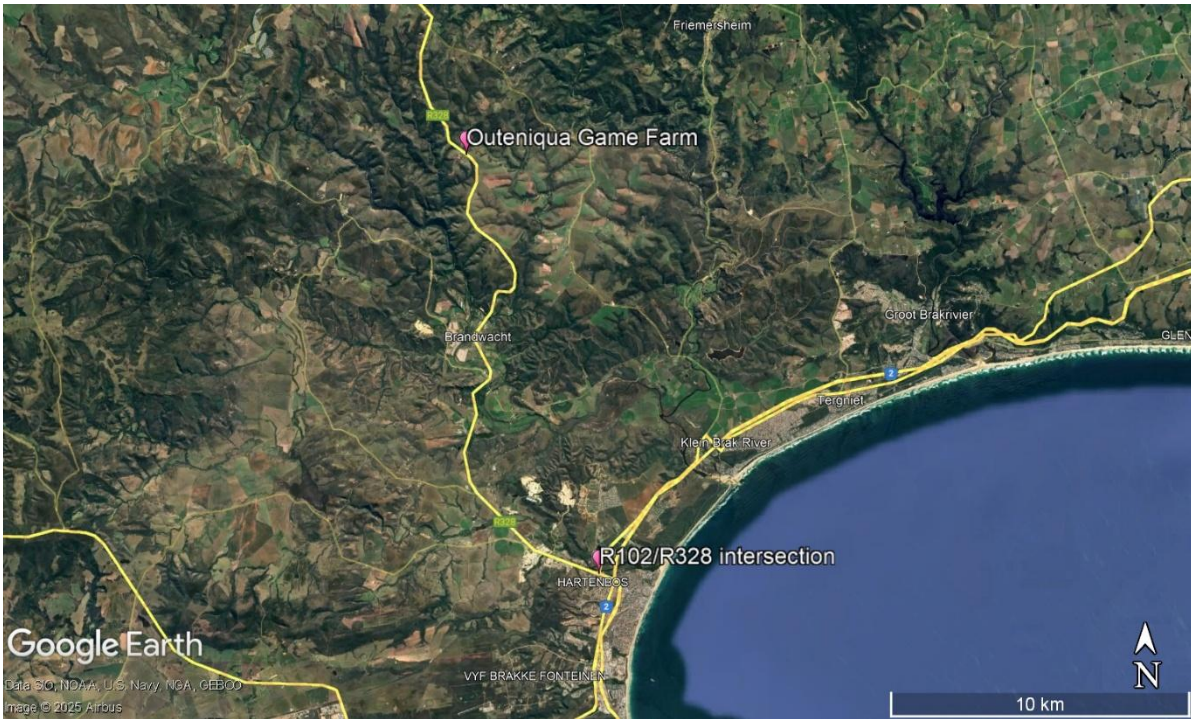

Figure 3-1: Site locality

Three potential dam site locations were identified during the site walk over (Options 1 – 3); these are shown in Figure 3-2.

Figure 3-2: Proposed dam site locations

3.2. Description

The proposed dam wall sites are all located within the north-south aligned Ruiterbosrivier drainage feature characterised by very steep valley slopes. Bedrock is exposed in places, on both sides of the drainage with large (occasionally car to caravan-sized) boulders present within the drainage course in places.

4. Geology

4.1. Regional

The published geological map (Figure 4-1) indicates that the dam site is underlain by granite plutons[1] (Cape Granite Suite), specifically the Rooiklip Granite[2], which intruded into the older, pre-Cape Supergroup Kaaimans Group.

The Kaaimans Group typically consists of quartzites, phyllites and schists. The Kaaimans Group rock types, specifically the schist mapped north of the pluton, were not observed in the outcrop at the proposed dam sites, only the granite which will be discussed in more detail under Section 4.2 below.

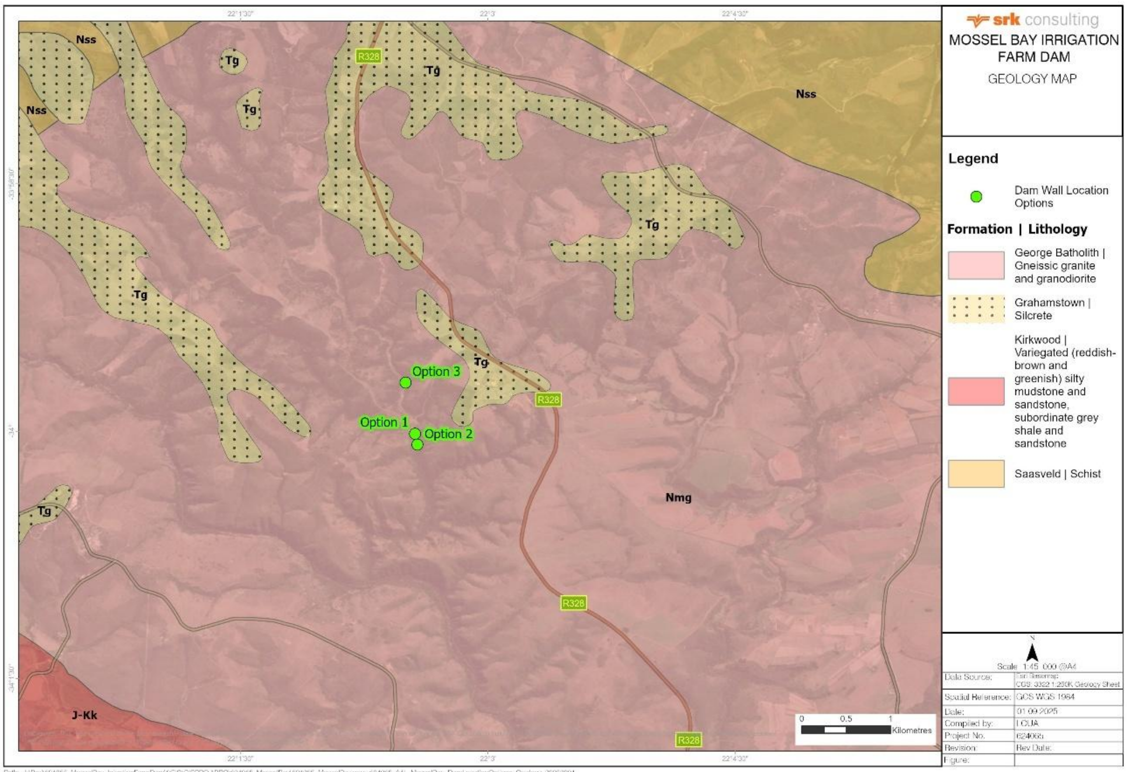

Figure 4-1: Regional geological map

[1] A pluton is a body of igneous rock that forms from the slow cooling and crystallization of magma deep beneath the Earth's surface. These intrusive igneous formations are exposed at the surface through erosion and uplift and are characterized by large mineral crystals, which form because of the slow cooling process. Common examples of plutonic rocks include granite and gabbro.

[2] Browning, C. & Macey, P.H., 2015, *Lithostratigraphy of the George Pluton Units (Cape Granite Suite), South Africa*, South African Journal of Geology, Volume 118.3, Page 323-330

4.2. Local/dam site specific

Where exposed, the granite is typically slightly weathered, coarse-grained with gneissic banding (Figure 4-2) with an estimated unconfined compressive strength of at least *hard rock* based on industry-accepted field estimation techniques.

The orientation of the banding dips towards the southwest at a steep angle; based on a dip and dip direction measurement (45°/201°) collected at Option 2. This is like the orientation provided in Brink (1981)[3] for a case study for a large road cutting located 1.0 km east of the Great Brak River, or ~18.9 km southeast of the proposed dam sites, which potentially indicates a degree of 'regional uniformity'.

Figure 4-2: Gneissic banding (darker band below the centre cross)

The discontinuity spacing observed in the outcrop varies from wide to very wide, with the rock mass considered to be massive in places. The macro condition of the discontinuity surfaces was noted be rough planar to undulating and iron stained, with no infill visible. This does not mean that infill is completely absent in the rock mass rather, it may have been eroded away at these exposures.

Most of the plutons have been intruded by younger dykes and veinlets of microgranite, aplite and quartz porphyry, often containing abundant concentrations of the mineral tourmaline. The rock type observed at Option 2 and Option 3 (appeared to be in a slightly more weathered state compared to Option 2) resembles 'aplite' which is described as *a uniformly fine-grained (with crystals that are generally not visible to the naked eye [aphanitic]), pale-coloured intrusive igneous rock, often found as small, often thin, bodies, sometimes called 'lenses', that intrude into or are contained within larger igneous intrusions like those of the Cape Granite Suite. The intrusion has a near-vertical to vertical orientation and moderately jointed (*Figure 4-3*). The image is captured looking south of southeast*

[3] Brink, A.B.A., 1981, Engineering Geology of Southern Africa, Volume 2: Rocks of 2000 to 300 million years in age, Building Publications, Pretoria

indicating that the dyke dips towards the north of northwest. The estimated hardness is the same as the granite i.e. at least hard rock.

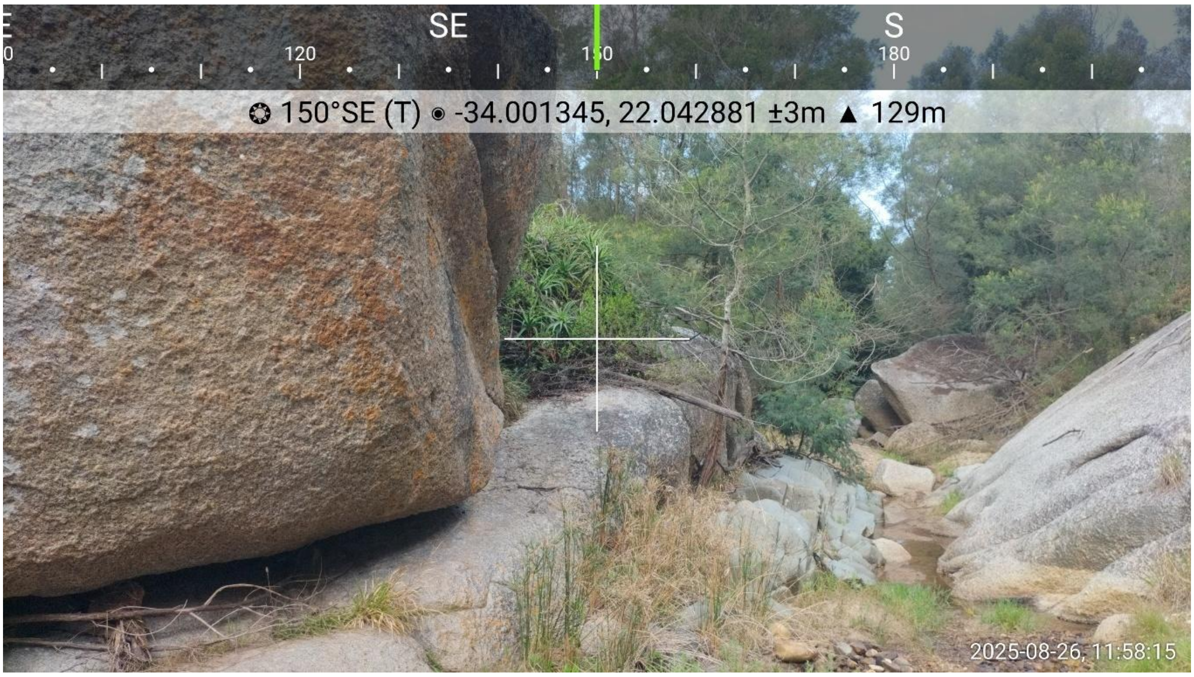

Figure 4-3: Near-vertically dipping, light bluish grey 'aplite' dyke within granite gneiss (bottom right quadrant).

5. General engineering properties of the Cape Granite Suite

5.1. Residual soils

No residual soils were observed at the three dam site options, though the following characteristics are noted for residual soils in the published literature referenced:

- Shear strength > 30.
- Fair degree of variation in compressibility.
- Non-expansive to slightly expansive.
- Generally stable when dry, pose stability problems when saturated and prevailing stress conditions change i.e. additional loading.
- There is a general absence of soils with a significant collapse potential in the Mossel Bay to George area which may be related to the relatively limited development of residual soils, the Plio-Pleistocene era dissection having been responsible for their removal.
  - The 'Plio-Pleistocene dissection in South Africa' refers to significant river incision and gorge formation driven by a complex interplay of limited tectonic uplift and pronounced climatic fluctuations. These climatic shifts led to *intensified precipitation* and glacial-interglacial cycles, *enhancing fluvial erosion* and *shaping the landscape by carving deep gorges into older erosion surfaces. The topography along the Ruiterbosrivier resembles this description.*
- Presence of core stones. These are not considered to prove problematic in the Mossel Bay area due to the 'relatively limited development of residual soils' stated above.

5.2. Rock

All the information provided below has been extracted from a case study in Brink (1981) for a large road cutting in gneissic granite referred to in Section 4.2 above. These characteristics will be identified and described further (if present) during the detailed geotechnical investigation.

Weathered rock UCS – 85 MPa normal to schistocity, 35 MPa parallel to schistocity. Even in a weathered state, the hardness varies from *hard rock* to *very hard rock*.

Unweathered rock UCS – 310 MPa normal to schistocity, 60 MPa parallel to schistocity. These numbers represent *very hard rock* to *extremely hard rock*.

Discontinuous[4] foliation joints are present though this characteristic should be regarded as an underestimate (Figure 5-1).

Three joint sets (A, B and C) were mapped at the road cutting dipping towards the west, north-northeast and southeast at very steep to near-vertical angles. The orientation of a large joint surface mapped at Option 1 dips towards the south-southwest at a very steep angle (70°/205°); this could possibly represent the conjugate joint for the joint set dipping north-northeast at the road cutting.

Clayey and/or crushed rock gouge is present at the cutting though not observed at the dam site options. It is postulated that this material has been washed away by the river leaving behind the large, open joints as indicated in Figure 5-1 of the right-hand abutment at Option 3.

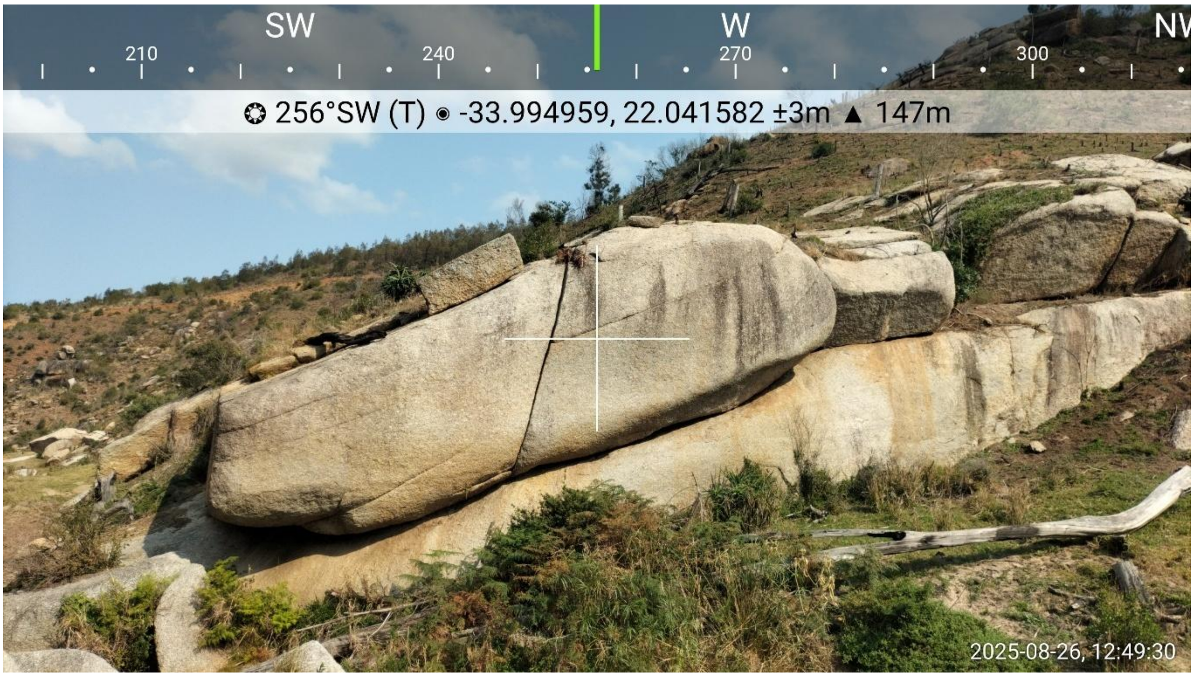

Figure 5-1: Large, open discontinuities and smaller, discontinuous discontinuities exposed at the right-hand abutment at Option 3.

6. General founding conditions

Outcrop is present at all three options with no notable variation in the rock mass properties i.e. field-estimated hardness, discontinuity orientation and surface conditions.

[4] Foliation/joint terminates within the intact rock mass and not against another joint

The river channel runs through the centre of each proposed site. The soil is typically sandy of unknown thickness and fluvial in origin. However, the thickness of the fluvial sand is minimal at Option 2 compared to Option 1 and Option 3. It is noted however that the three sites are within an igneous rock setting. As such, the domed shape of the granite outcrop at the site should be taken as representative of the underground geotechnical profile that will likely consist of domed hard rock with intermittent valleys between – hence, depth to appropriate founding for a dam wall is likely to vary with depth on any of the sites. It should also be noted that subsurface valleys between domed hard rock could present preferential seepage flow paths depending on the degree of weathering in these valleys, and/or the material type that has been deposited in the valleys.

Option 1 has the greatest number of 'boulders' present along the proposed centreline of the dam wall. These would need to get removed during preparation of the dam wall foundation if it is proven they are founded on poor material.

7. Construction material

7.1. Concrete aggregates

It is likely that the aggregate for the concrete dam wall can be sourced on site extracted from either the outcrop or the very large boulders. Schists (Saasveld Formation, Kaaimans Group) and mudstone and sandstone (Kirkwood Formation, Uitenhage Group) are mapped north and south of the proposed dam sites respectively. Rocks from either formation are not considered suitable for concrete aggregate.

The granite can in general be regarded as good concrete aggregate noting that examples of deleterious alkali-aggregate reaction occurring in concrete containing granite-gneiss aggregate have been reported as far back as 1973 (Brink, 1981). Please note the following with regards to potential alkali-aggregate reaction:

- The percentage, undulatory extinction[5] and the state of the quartz grain size (e.g. microcrystalline quartz or microfractured) are important indicators of potential 'alkali-reactivity'.
  - *The published literature indicates that a percentage SiO_2 greater than 40 % may prove problematic.* The geochemistry analyses undertaken on four Rooiklip Granite samples indicate a *very high percentage of SiO_2 i.e. 71.5 % to 77.9 %.*
  - *An undulatory extinction angle of greater than 15 % is considered problematic. No information is currently available for the Rooiklip Granite based on the published literature used in this report.*
  - *It is unlikely that microcrystalline quartz is present at the three sites given the coarse-grained nature of the granite gneiss. The same can't be said for the 'aplite' dyke which would either require further investigation or not be considered for use as aggregate; it is only present in limited quantities.*
  - *The degree of microfracturing of the quartz grains will need to be determined by petrographic analysis under thin section.*
- It is worth noting that aggregate from the Saldanha-Langebaan pluton and Darling pluton have been used in the construction of the Koeberg Nuclear Power Station and Cape Town harbour works. In addition, the Client's house (constructed 6 years ago) has been founded directly on granite gneiss outcrop approximately 1.7 km upstream of Option 3, no reaction between the

[5] Undulatory extinction in quartz indicates internal strain, a defect in the crystal lattice that increases its susceptibility to alkali-silica reaction (ASR)

foundation cement and the outcrop was observed i.e. the presence of a white to off-white colour residue.

8. Indication of water table based on the vegetation indicators[6]

The drainage, as well as the valley slopes, is covered in invasive tree species. There are three species of *Acacia* which are collectively known as 'wattles' i.e. Black Wattle (*Acacia mearnsii*), Port Jackson (*Acacia saligna*), Rooikrans (*Acacia cyclops*). The average depth to groundwater in the vicinity is 24.8 metres below ground level. The trees significantly impact subsurface water by drastically reducing water availability, please note the following negative impacts:

- These acacias are high-water users, which reduces the amount of water available in catchments and groundwater.
- Dense stands of these invasive trees consume water, leading to lower streamflow and reduced water runoff from affected areas.
- The increased transpiration rates from the dense tree cover can alter the normal water cycle of a catchment area, leading to a decrease in overall water availability.
- The high-water uptake also affects groundwater reserves, further diminishing water resources in invaded areas.

The removal of the Alien Invasive Plants ('AIP/AIPs') will result in increased soil moisture, surface runoff and streamflow, as well as reduce depth to groundwater.

The dominant natural vegetation in the vicinity of the proposed dams is Garden Route Granite Fynbos. This vegetation occurs on granite-derived soils and is dominated by members of the Proteaceae (proteas, pincushions and conebushes) and Asteraceae (daisy) families. A dominance of restios (cape reeds) within the vegetation indicates shallow groundwater, whereas ericaceous fynbos (dominated by members of Ericaceae (Ericas) would indicate a seep. Within the watercourse, riparian vegetation would be dominant if soils were seasonally or permanently high in moisture.

The water table will be considerably higher in the bed of the watercourse, as it is considered a non perennial stream. However, the general lack of riparian vegetation may be a combination of the presence of fire in the natural system, invasion by the AIPs, transformation for grazing and reduced and irregular stream flows.

9. Potential environmental sensitivity linked to the observed geology[7]

Soils derived from granite gneiss, including Rooiklip, are typically sandy and may have low nutrient content. This can result in soils that are less fertile and more prone to erosion.

The nutrient-poor nature of these soils can limit vegetation growth, which may make the area more sensitive to disturbances e.g. removal of the invasive 'wattle' trees.

Granite gneiss-derived soils are often susceptible to erosion, especially in areas with steep slopes or where vegetation cover has been removed. This can lead to sedimentation in nearby water bodies i.e. within the basin of the proposed new dam.

Sandy soils derived from granite gneiss generally have low water retention capacity. This can affect local hydrology, potentially leading to reduced groundwater recharge and increased surface runoff during rainfall events. Standing water is present in sections along the river course indicative of a degree of water retention within the basin. This site characteristic may represent the 'retention

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[6] Google AI-generated response
[7] Google AI-generated response

capacity' of the underlying bedrock as opposed to the soils which will be further defined during the detailed geotechnical investigation.

The Fynbos biome is restricted to nutrient-poor soils. This includes Rooiklip granite gneiss which hosts Garden Route Granite Fynbos, a Critically Endangered vegetation type. Approximately 59 % of the vegetation has been transformed as a result of land use change to cultivation, pine plantations and urban development. In addition, the Garden Route Granite Fynbos is classified as Not Protected, as it is largely not present in any declared Protected Area. A number of species endemic to George Batholith occur in the vegetation type and are threatened by further loss of habitat. Plant species of conservation concern ('SCC') recorded in the vicinity of the proposed dam include *Erica unicolor* subsp. *mutica* (Endangered), *Hermannia lavandulifolia* (Vulnerable), *Pelargonium denticulatum* and *Phylica velutina* (both Near Threatened). Although the dominance of AIPs within the catchment may have displaced these species, it is considered likely that they may still be present with reduced populations. The further loss of habitat as a result of the construction of the dam wall and filling of the dam may further reduce these populations[8].

[8] The loss of 300 $m^2$of indigenous vegetation within a Critical Biodiversity Area, or more than 1 ha outside of one, will trigger the requirement for a Basic Assessment, as per the EIA Regulations of 2014, as amended. *SRK notes that the S24g process commenced during 2019.* In addition, plant and animal species protected by provincial and national legislation will require the relevant permits before they can be damaged or removed. *SRK notes that the permit requirements are also outlined and included in the draft EMPr.*

11. Conclusions and Recommendations

11.1. Geology and rock mass properties

The proposed dam sites are underlain by slightly weathered, coarse-grained granite, and exhibits gneissic banding with steeply dipping orientations, of the Cape Granite Suite, specifically the Rooiklip Granite, which intruded into the older Kaaimans Group. The Kaaimans Group rock types (quartzites, phyllites, and schists) were not observed at the dam sites.

Discontinuous foliation joints were identified along with potentially three joint sets, with steep to near-vertical dips. Spacing between the discontinuities in the rock mass are wide to very wide, with rough planar to undulating surfaces and no visible infill, though infill may have been eroded.

No residual soils were observed at the dam sites, but soils observed consisted of fluvial sand.

The granite exhibits high unconfined compressive strength (UCS), even in weathered states, ranging from 85 MPa (weathered) to 310 MPa (unweathered).

11.2. Foundation Conditions

Outcrop is present at all three dam site options, with minimal variation in rock mass properties observed during the site walkover.

The thickness of fluvial sand is minimal at Option 2 compared to Options 1 and 3. It is noted however that the three sites are within an igneous rock setting. As such, the domed shape of the granite outcrop at the site should be taken as representative of the underground geotechnical profile that will likely consist of domed hard rock with intermittent valleys between – hence, depth to appropriate founding for a dam wall is likely to vary with depth on any of the sites. It should also be noted that subsurface valleys between domed hard rock could present preferential seepage flow paths depending on the degree of weathering in these valleys, and/or the material type that has been deposited in the valleys.

Option 1 has the highest number of boulders along the proposed dam wall centreline, which would require removal if proven that rest on poor quality material.

The river channel is widest at Option1 and Option 3 compared to Option 2.

Option 2 is the most suitable option given the lack of boulders, minimal soil within the proposed footprint and reduced river channel width.

11.3. Construction Material

Granite from the site is generally suitable for concrete aggregate, though the high silica content (71.5%–77.9%) may pose a risk of alkali-silica reaction (ASR).

Further petrographic analysis is required to assess the degree of microfracturing and undulatory extinction in quartz grains.

11.4. Water Retention

Standing water in sections of the river course indicates some degree of water retention within the basin.

The permeability of the discontinuities within the outcrop will require further investigation.

Preferential seepage flow paths in subsurface valleys (between granite domes) will require further investigation.

The landowner has been removing the dense stands of *Acacia* trees over the last handful of years thus the negative impacts described in Section 8 above should have reduced.

Potential environmental sensitivity

Soils derived from granite gneiss, including Rooiklip, are typically sandy and may have low nutrient content. This can result in soils that are less fertile, limiting vegetation growth thus more prone to erosion leading to increased sedimentation in nearby water bodies e.g. dam.

Sandy soils derived from granite gneiss generally have low water retention capacity. This can affect local hydrology, potentially leading to reduced groundwater recharge and increased surface runoff during rainfall events. The latter is considered to be a positive i.e. increased recharge of the dam catchment per rain event. Standing water is present in sections along the river course indicative of a degree of water retention within the basin. This site characteristic may represent the 'retention capacity' of the underlying bedrock as opposed to the soils which will be further defined during the detailed geotechnical investigation.

The proposed dam site hosts Garden Route Granite Fynbos, a Critically Endangered vegetation that has been extensively transformed, including invasion by AIPs. A number of threatened plant species may still be present within the dam catchment area. The correct permits will be required for their damage or removal.

Yours faithfully,

SRK Consulting (South Africa) (Pty) Ltd

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