Ref: AA158200/2020/08/17

17 August 2020

Black Orchid Farming (Pty) Ltd
UFF Agri Asset Management (Pty) Ltd
Office 201
30 Hudson Street
De Water Kant
Cape Town
8001

Attention: Mr Werner Stears

Dear Sir,

PROJECT NO. AA158200 – PROPOSED BONATHABA DAM, WELLINGTON

We refer to your request for us to report on the above.

1. Introduction and background

Black Orchid Farming (Pty) Ltd appointed Ingerop to undertake an investigation into feasible dam options to improve the storage capacity on their Bonathaba Farm properties, which would provide balancing storage for their existing enlistment to irrigate various types of orchards. The Bonathaba properties consist of farm Portions 2, 3, 4, 5 and remainder of Farm 1100. The proposed dam site is situated on an unnamed tributary of the Berg River located on property Portions 2 & 3 of Farm 1100. The recent drought in the Western Cape, the uncertainties of the impact of climate change and job creation by means of expansion to fully utilise existing water rights are the major drivers for this project.

Bonathaba Farms are managed by the UFF Agri Asset Management (Pty) Ltd, for the owner, Black Orchid Farming (Pty) Ltd. Refer to Table 1-1 for a summary of the properties owned by Black Orchid Farming (Pty) Ltd.

The proposed scheme consists of the construction of Bonathaba Dam to a gross storage capacity of 700 000 m^3 with a 16 m wall height to store a large portion of the existing lawful enlistment of 1 105 200 m^3 regulated by the Berg River Irrigation Board. Refer to **Section 2** for a summary of the existing and proposed water uses. A new 500 mm dia HDPE outlet pipe will be constructed underneath the dam embankment and a 500 mm dia PVC pipeline (600 m long) will be connected to an existing 400 mm dia asbestos-cement pipe from the Berg River to fill the dam. The existing 400 mm dia pipe is currently used to irrigate orchards directly from an existing abstraction pump station located on the Berg River and using an existing small dam with a storage capacity estimated < 10 000 m^3 as a balancing dam. Refer to Drawing AA153200-L02 included in **Appendix C** for the proposed layout of the scheme and **Section 4** for a detailed description of the works.

The Bonathaba Dam site is located 21.5 km north northwest of Wellington in the Western Cape as shown on Figure 1-1 below and Drawing AA153200-L01 in **Appendix C**.

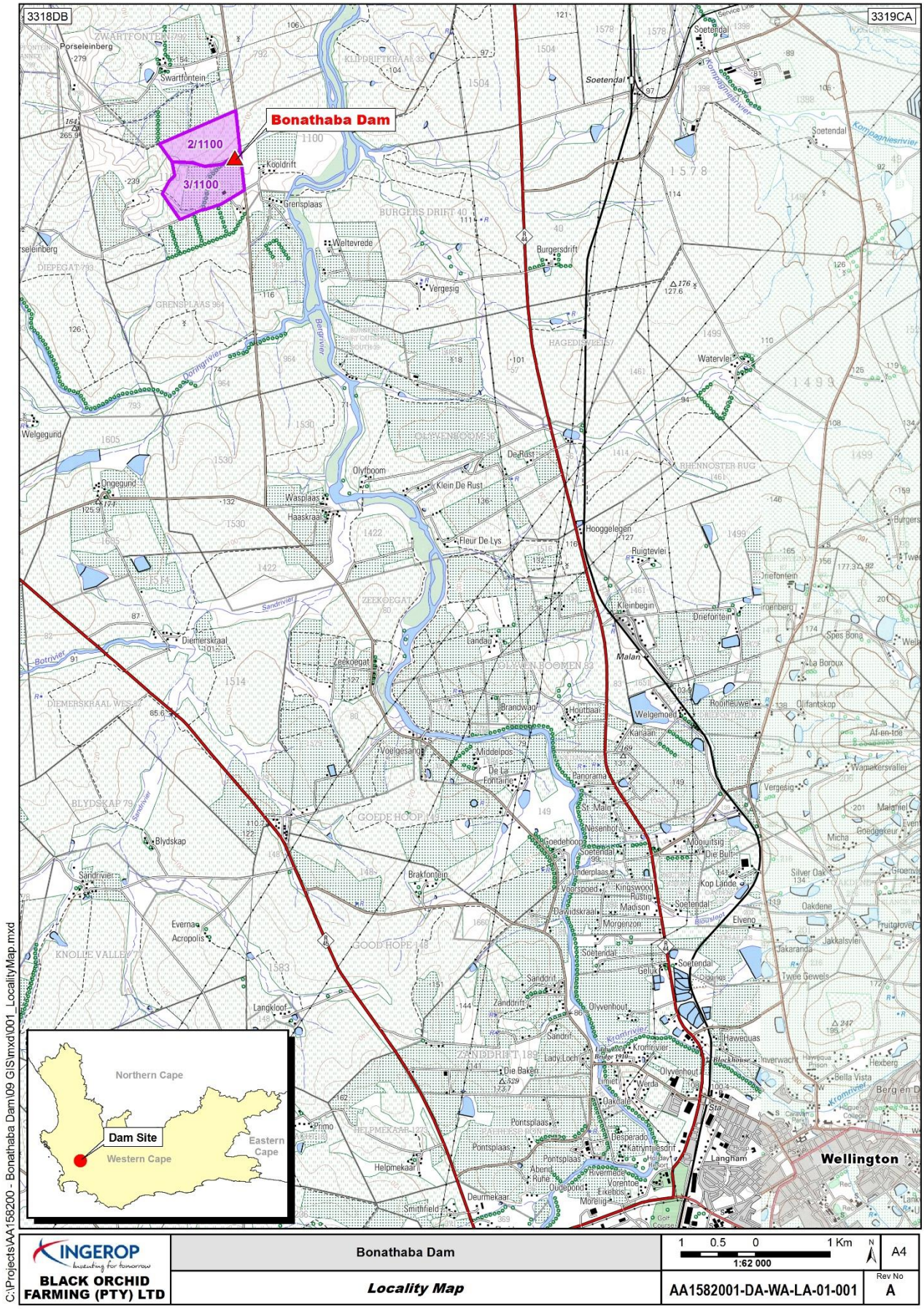

Figure 1-1: Locality map

2. Water rights

The existing water rights are summarised in Table 2-1 below as per the confirmation of the Existing Lawful Use (ELU) on the properties by the Berg River Irrigation Board. The taking of water is not divided between summer and winter enlistment and is thus available during the full year. A copy the confirmation is included in **Appendix A**.

The proposed storage application is summarised in Table 2-2.

Table 2-1: Summary of ELU

Property Description	Existing water enlistment (ha)	Existing water enlistment (m^3) - @ 6 000 m^3/ha/a
Portion 2 of Farm 1100	30.00	180 000
Portion 3 of Farm 1100	35.00	210 000
Portion 4 of Farm 1100	33.00	198 000
Portion 5 of Farm 1100	38.00	228 000
Remainder of Farm 1100	48.20	289 200
	Total	**1 105 200**

Table 2-2: Proposed Section 21(b) - storing of water application

Property Description	Existing water enlistment (m^3) - @ 6 000 m^3/ha/a	Proposed licence application for 21(b) – storing of water (m^3)
Portion 2 of Farm 1100	180 000	700 000
Portion 3 of Farm 1100	210 000	
Portion 4 of Farm 1100	198 000	
Portion 5 of Farm 1100	228 000	< 10 000 m^3
Remainder of Farm 1100	289 200	
Totals	**1 105 200**	**~710 000**

Table 2-2 above shows the required dam capacity for the construction of Bonathaba Dam to a gross storage capacity of 700 000 m^3. This proposed 21(b) - storage of water equates to 64% storage of the total existing ELU 21(a) – taking of water for the properties.

To summarise the Water Use License Applications for the proposed developments:

- **Section 21 (b) – storing of water to the total amount of 710 000 m^3;**
- **Section 21 (c) & (i) – impeding the flow/altering the banks of a river for all associated infrastructure of the proposed scheme summarised in Section 4.**

3. Available surface water

The catchment of the proposed dam is located in the quaternary catchment G10D, which consists of a catchment area of 688 km^2 and Mean Annual Precipitation (MAP) of 625 mm. The catchment MAP's from WRC 2012 study (Bailey & Pitman, 2015) and Wide Area Augmentation System (WAAS, 2007) Satellites are shown in Figure 3-1.

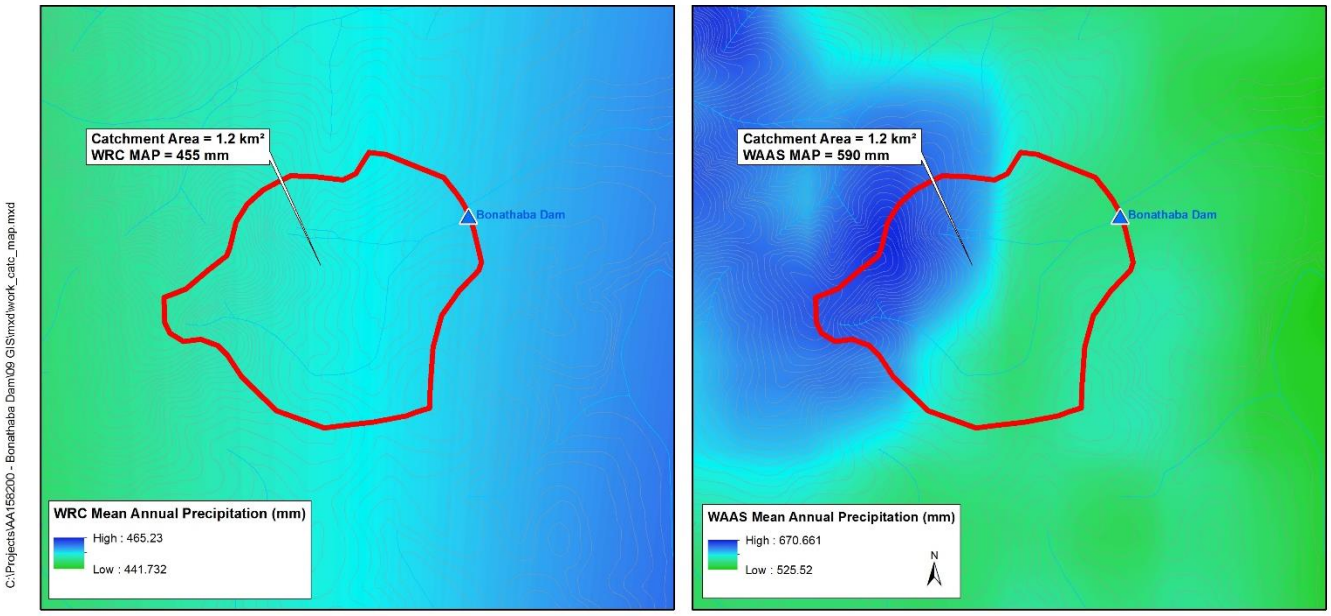

Figure 3-1: Dam catchment area with weighted MAP's (WRC – left, WAAS – right)

The catchment MAP's from WRC 2012 study (Bailey & Pitman, 2015) and Wide Area Augmentation System (WAAS, 2007) Satellites shows MAP's of 455 mm/a and 590 mm/a, respectively. The WRC MAP is considered more representative for the catchment area, which is predominately cultivated.

The appropriate runoff percentage was assumed based on observed runoff in other parts of the Western Cape for the quaternary catchment G10D (Ninham Shand, 2009). The runoff percentage of the entire G10D quaternary catchment is 29%, which is considered to be higher than the runoff percentage for the Bonathaba Dam catchment area, due to the lower MAP value and considering the cultivated state of the catchment area which contains contour channels to prevent erosion. The estimated runoff percentage for the site-specific catchment characteristics is 10%.

Therefore, for the proposed Bonathaba Dam, with a catchment size of 1.2 km^2 and a MAP of 455 mm, the estimated MAR (Mean Annual Runoff) was calculated as 54 600 m^3/a. The estimated MAR equates only to 5.5% of the total proposed dam capacity, which is considered negligible due to the losses in storage due to evaporation. Considering the small MAR and the highly modified state of the 1.6 km long natural tributary before the Berg River confluence, ecological water requirements (EWR) releases is considered to be negligible. This should be confirmed by the freshwater consultant to determine whether any EWR releases should be implemented in the operation of the dam.

4. Proposed scheme

The project is proposed to include the following developments listed below which are shown on Figure 4-1 and Drawing AA158200-DA-WA-LA-002 included in **Appendix C**. A summary of the project drawings is listed in Table 4-1.

The water balance calculations are included in **Appendix E** indicating that the water availability for irrigation as well as confirm the optimised required dam size. It was found that the 700 000 m^3 storage could supply irrigation for 134 ha with an 85% assurance of supply. It was therefore decided to apply for the construction of a dam with a storage capacity of 700 000 m^3.

4.1. Dams

- Construction of Bonathaba Dam to a gross storage capacity of 700 000 m^3 with an earthfill embankment with a wall height of 16.0 m and a 500 mm dia HDPE Class PE100 PN8 outlet pipe connected to a pump station located at the downstream toe of embankment.
- Existing balancing dam on portion 5 of farm 1100 to remain as is.

4.2. Pipelines and pump station

- Construction of a new pump station located at the downstream toe of the proposed Bonathaba Dam, approximate footprint 50 m^2.
- New 500 mm dia PVC Class 8 pipeline (600 m long) constructed within the existing gravel road reserve situated on edge of orchards, from pump station to tie into existing 400 mm asbestos-cement pipe which is connected to pump station located on the banks of the Berg River.

4.3. Access roads

- A 5 m wide gravel access road will be constructed around the entire dam basin and embankment.

Table 4-1: Drawing reference summary

Drawing Description	Drawing Number (Appendix C)	Report Figure
Locality Map	AA158200-DA-WA-LA-01-001	Figure 1-1
Proposed Scheme Layout	AA158200-DA-WA-LA-01-002	Figure 4-1
Plan Layout of proposed Bonathaba Dam – Option 1	AA158200-DA-WA-LA-01-003	Figure 4-2

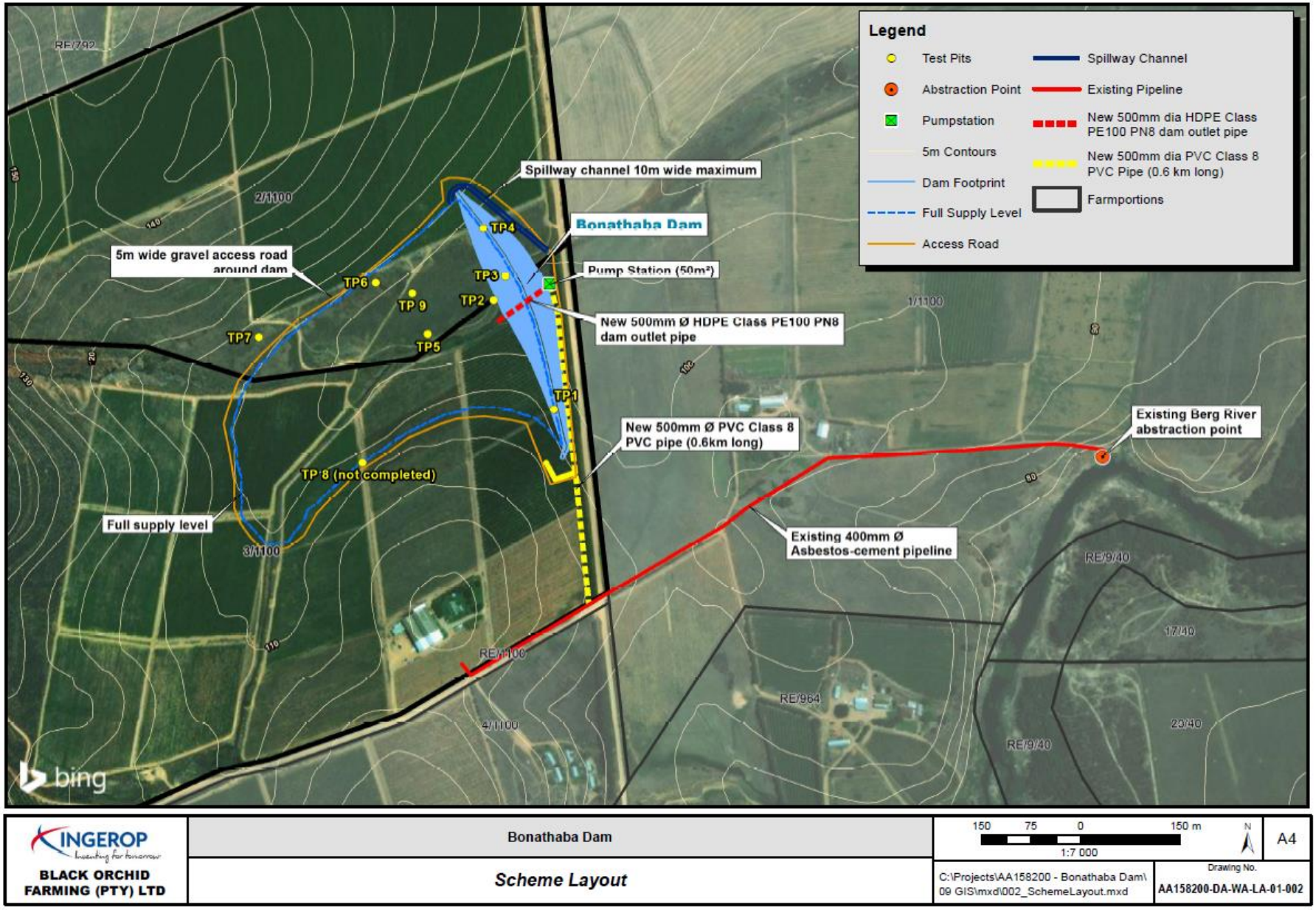

Figure 4-1: Proposed scheme layout of Bonathaba Dam

5. Geotechnical

5.1. Regional geology

The regional geology map (3318 Cape Town, 1:250 000 series) (RSA, 2015) indicates that Bonathaba Dam is possibly underlain by greywacke, phyllite, schist, limestone (CRe) from the Moorreesburg Formation as shown in **Figure 5-1** below. A geological fault line is situated on the opposite side of the Berg River.

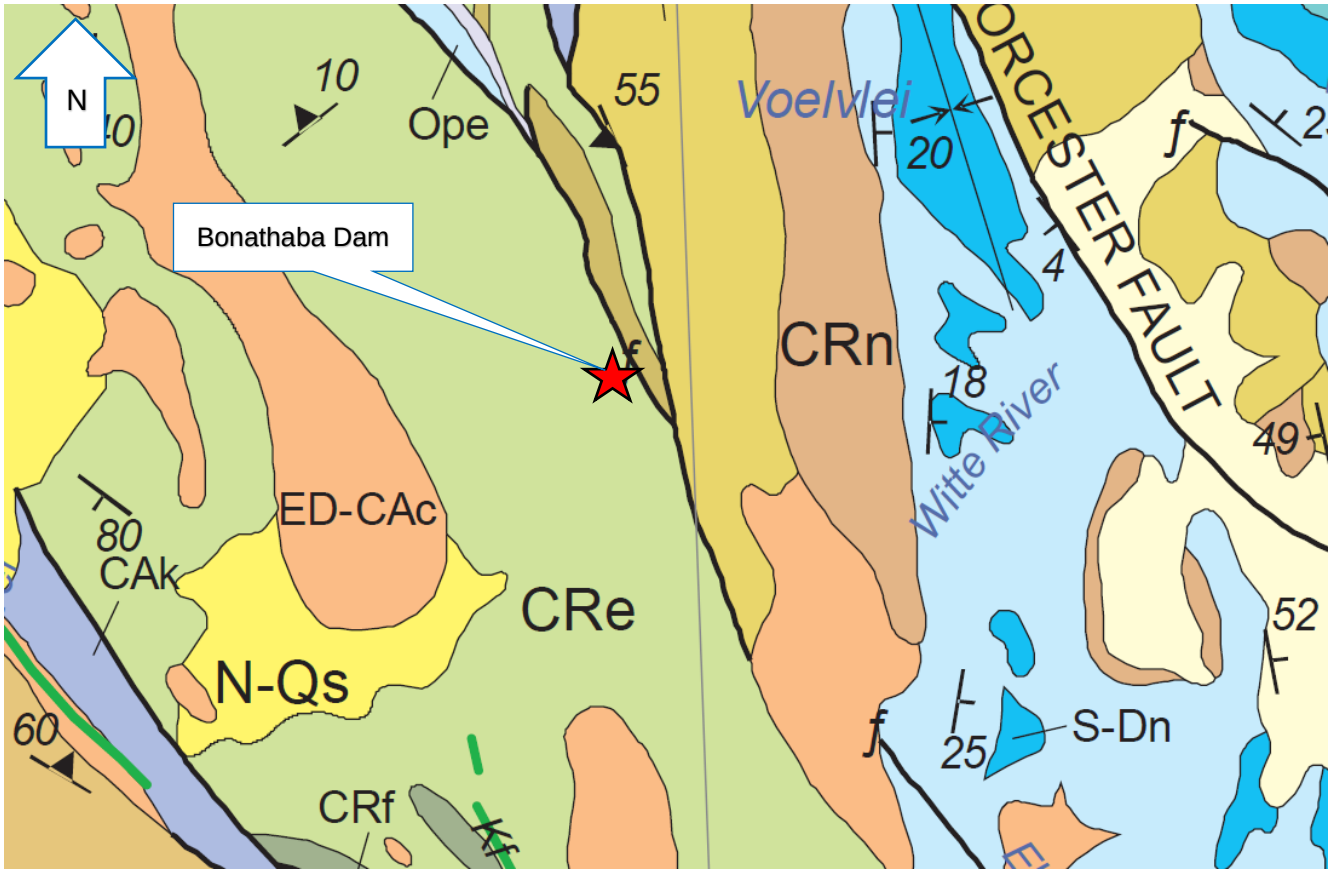

Figure 5-1: Regional geology at dam sites (marked with red asterisks)

5.2. Geophysical survey

The client appointed GEOSS South Africa (Pty) Ltd to complete a geophysical survey of the proposed Bonathaba Dam site. The purpose of the study is to assess the subsurface conditions at the proposed dam wall site. This is to delineate areas that may potentially be associated with leakage/fractured zones below the proposed new dam wall site. The full GEOSS report is included in **Appendix B** of this report.

Field work was conducted on the 4th of March 2020 which included field structural mapping and a geophysical survey. The geophysical survey was conducted using the electrical resistivity tomography methods to identify areas in the subsurface that may be associated with leakage/fractured zones below the proposed new dam wall. The resistivity survey was done in the vicinity of the proposed crest line (~480 m) of the proposed dam wall and extended at both ends resulting in a total length of 720 meters as shown in Figure 5-7 below.

Figure 5-2: Aerial layout and alignment of Resistivity Traverse (Res_Line_1)

As shown in Figure 5-8 below, the data from the ERT survey shows zones of thicker unconsolidated material cover towards the edges of the profile at higher elevations in the topography. This decreases towards the centre of the valley area where the stream is located (stations 160 - 420). In areas of lower resistivity (80 – 200 ohm.n) to depths of ~20 mbgl moderately weathered bedrock is expected, grading into competent bedrock with depth. Around stations 220 – 250 the data from the ERT survey shows a relatively homogeneous, vertical anomaly that is anticipated to either be a dolerite intrusion (there are several dykes mapped in the regional setting) or highly metamorphosed (hard) bedrock. The edges of this anomaly are expected to be associated with fractured bedrock, hence may act as a preferential flow path for water, therefore, identified as a high-risk zone for leakage once dam wall has been constructed.

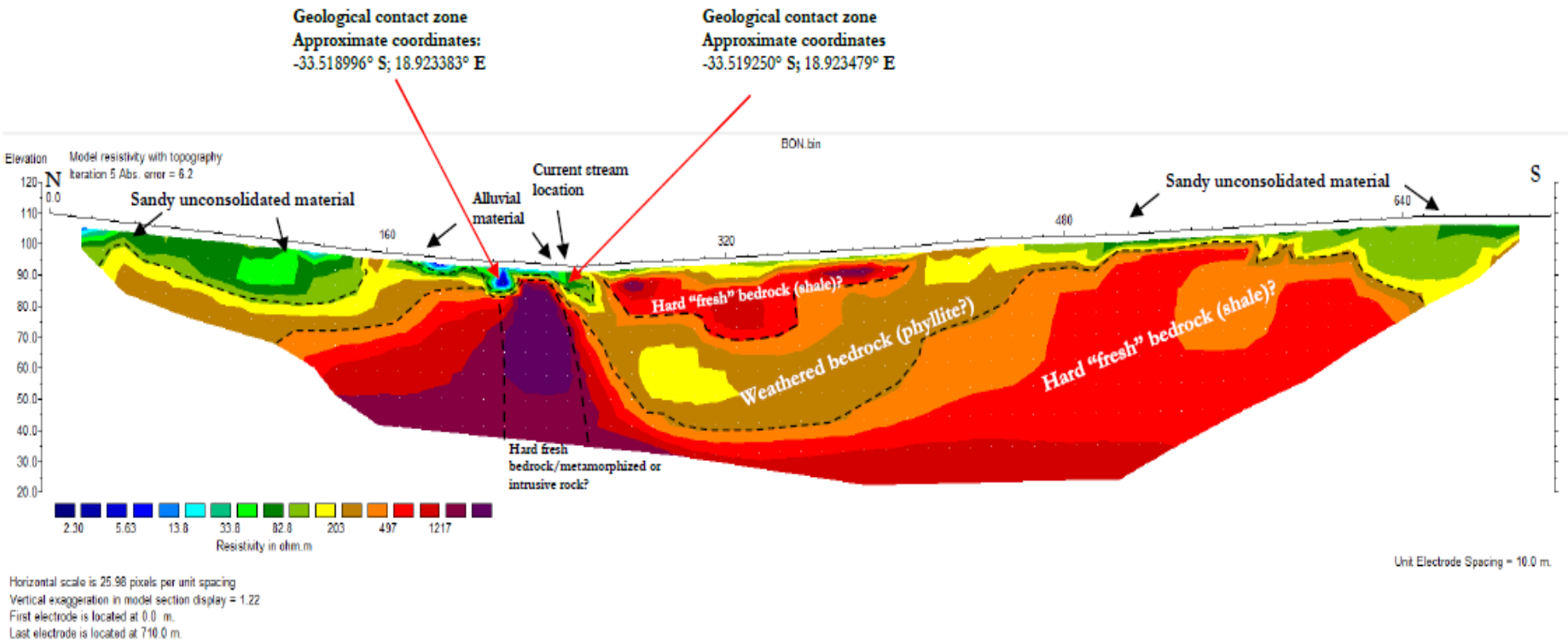

Figure 5-3: Inverted resistivity profile of Res_Line_1 showing investigation depth as elevation (masl)

From the ERT survey conducted and field observations, potential leakage is expected in geological contact zones/change in lithology between shale (sedimentary)/phyllite (metamorphic)/dolerite (igneous).

For the structural integrity of the dam wall it is recommended that excavations are made to a depth where competent bedrock is intersected. Care should be taken during the detail design and construction phases to sufficiently address the possible discontinuities or potential leakage that is expected in the above-mentioned geological contact zones/ change in lithology. Options to address this includes foundation grouting or a clay blanket following the discontinuities to the end of the dam basin.

5.3. Foundation and construction materials

Geotechnical test pits were excavated along the centreline of the proposed earthfill embankment and dam basin on the 19th of February 2020, to determine the depth of the core trench and availability of the construction materials in the dam basin. A total of 8 test pits were excavated as shown in **Figure 5-2**. Refer **to Figure 5-3** to **Figure 5-5** for photographs of some of the test pits.

Three basin samples (TP 5, 6 and 9) were taken to the laboratory for further testing. Testing methods that were requested on the samples include foundation indicators, SCS double hydrometer (dispersivity), permeability and crump test (dispersivity).

The foundation conditions appear to acceptable for the proposed Bonathaba Dam provided that the core trenches are taken sufficiently deep. The estimated founding level of the core trench is estimated to be up to 8 m deep in the central basin section and 6 m deep on average, into slightly weathered and hard shale rock. Where fractured bedrock is expected on the geological contacts the excavation may be deeper.

From the test results it can be summarised that the dam sites contain sufficient clay and general fill material to be placed in the core trench, core, general fill and gravel capping zones. Sufficient sand quantities is also available in the upper layers of the dam basin (refer to TP 5 test pit profile). Rock and gravel material will be readily available from essential excavations and existing stockpiles on the farm.

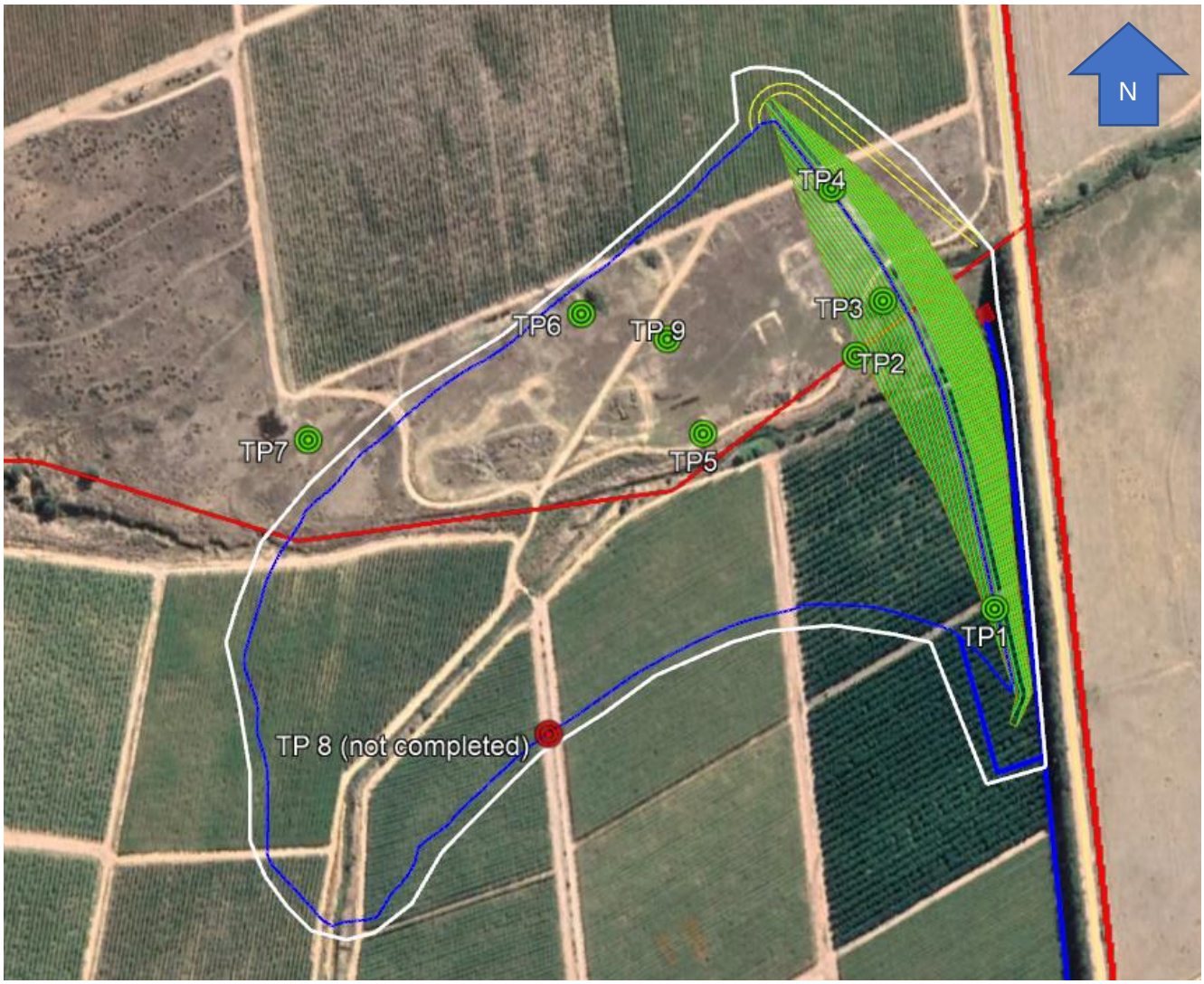

Figure 5-4: Positions of test pits overlaid on the proposed Bonathaba Dam footprint (Option 1)

The results of the abovementioned geotechnical investigation are included in **Appendix B**. Sample results taken from Test Pits 6 and 9 vary between classification from Sandy Lean Clay (CL) and Clayey Sand (SC). Test Pit 5 is classified as poorly graded sand (SP) with a fines content of 37.8%. The dispersivity percentage of Test Pit 6 and 9 is 12.5% and 9.7% which is classified as non-dispersive with the crumb test results showing no reaction. The embankment design will make allowance for mitigation measures to prevent internal erosion of the embankment caused by dispersive soils, such as compaction of the clay core to 98% of Proctor density at Optimum Moisture Content and the inclusion of a filter system to prevent the migration of core material.

Figure 5-5: TP 1 located on the proposed embankment right flank below the embankment footprint

Figure 5-6: View of Test Pit 5 located in the dam basin for borrowing sand (upper soil horizon)

Figure 5-7: View of Test Pit 6 located in the dam basin for borrowing clay (lower soil horizon)

Figure 5-8: View of Test Pit 9 located in dam basin for borrowing clay

6. Dam options analysis

6.1. Location alternatives

A total of 5 sites were initially identified and considered for the proposed Bonathaba Dam, with some locations identified for another balancing dam. Refer to Figure 6-1 for an aerial layout and positions of the 5 investigated sites. Due to the steep topography, expensive construction estimates were calculated for larger storage volume dams on Sites 1-4 and considering the environmental impact of these sites on virgin land, it was decided to only further investigate a large storage option on Site 5.

Figure 6-1: Aerial layout of the various site options investigated

6.2. Dam Site 5 options analysis

A total of 6 dam options were modelled on the proposed dam site 5 all initially aimed for a gross storage capacity of 1 000 000 m^3 although after the dam balance was completed (**Appendix C**) the results showed that the 700 000 m^3 storage option was the optimum solution. Refer to Figure 6-2 below for an aerial layout and a summary of the options analysis is included in **Appendix D**. Dam options 2,3,4 and 6 (all 1000 000 m^3) were used to identify the most economical option, Option 5 was disregarded due to its capacity.

The water/wall ratio represents the volume of water gained per volume of fill required to construct the dam embankment. This is a good indication for selecting the most economical dam centreline. Although Option 6 indicated to be a more economical dam site construction option (with reference to the water/wall ratio), it was concluded that Option 2 poses a more economical combined benefit with less orchards lost. The unit cost of Option 2 is 16.12 compared to 15.24 for Option 6. Option 1 was therefore further listed as the preferred option as this is the 700 000 m^3 storage capacity option on the Option 2 footprint.

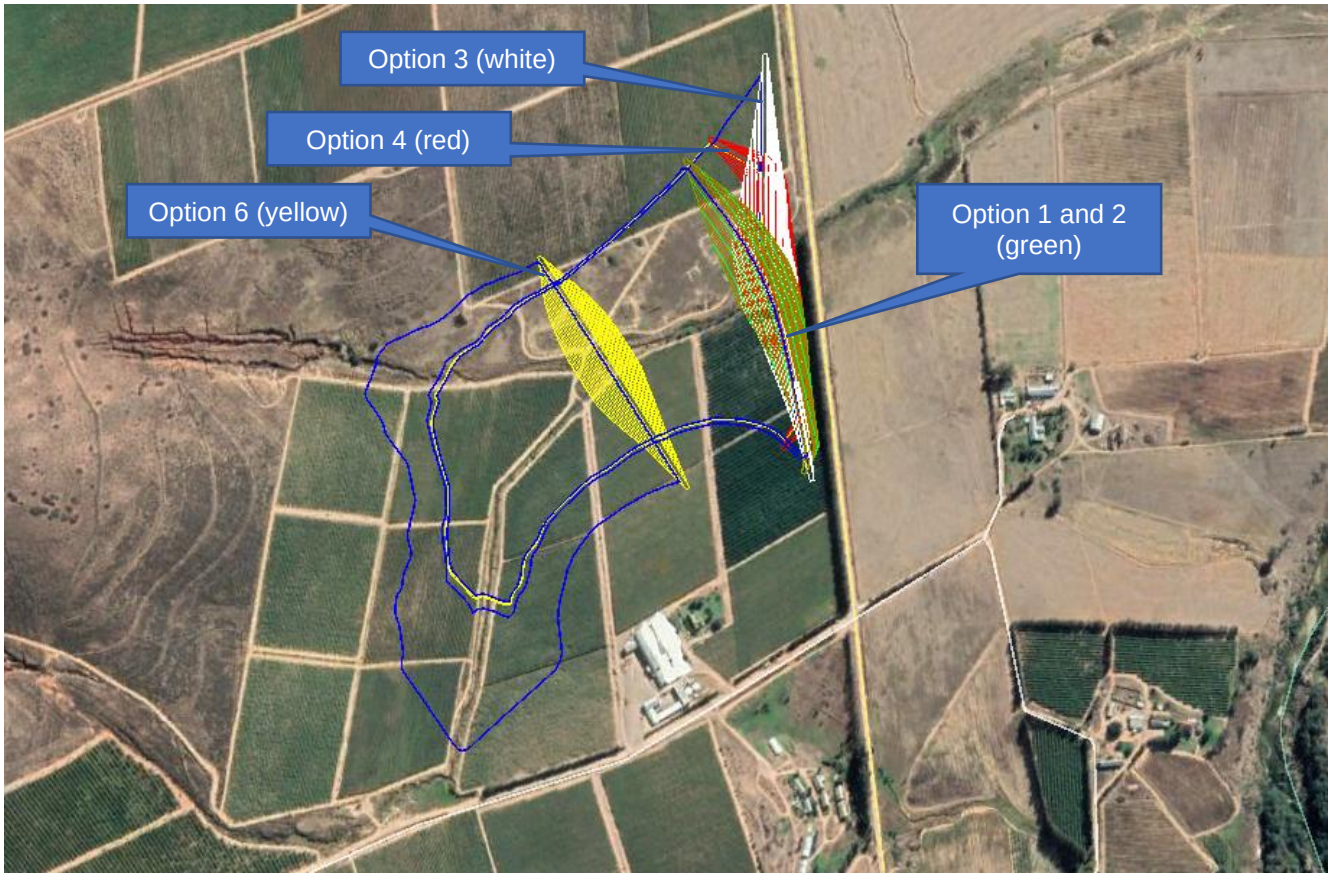

Figure 6-2: Aerial layout of dam options 1, 2, 3, 4 & 6

Table 6-1: Summary of dam option comparison Option 1 for 700 000 m³ storage capacity and Option 2 and 6 for 1000 000 m³

	Option 1 (preferred)	Option 2	Option 6
Proposed NOC (masl)	106.0	108.0	113.3
Proposed FSL (masl)	105.0	107.0	112.3
Freeboard (m)	1.0	1.0	1.0
Maximum wall height (m)	16.0	18.0	16.8
Proposed wall crest width (m)	4	4	4
Downstream slope (Vertical: Horizontal)	1V:2H	1V:2H	1V:2H
Upstream slope ((Vertical: Horizontal)	1V:3H	1V:3H	1V:3H
Fill volume required for dam wall (m³)	112 500	152 000	128 400
Wall length (m)	450	480	377
Capacity without cut from basin (m³)	587 000	848 000	872 000
Water surface area at FSL (Ha)	**12.5**	**15.5**	**15.6**
Total Capacity (m³)	**700 000**	**1 000 000**	**1 000 000**
Estimated core trench volume (m³)	11 800	12 600	9 900
Total earthfill (m³)	**124 300**	**164 600**	**138 300**
Wall Water Ratio (m³)	**5.63**	**6.08**	**7.23**

Minimum downstream level (m)	90.0	90.0	96.5
Maximum Storage depth (m)	13.0	15.0	13.3
Unit Rate R/m³ storage	**17.78**	**16.12**	**15.24**

As part of the irrigation operation, the small existing dam (estimated capacity <10 000 m^3) situated on Portion 5 of Farm 1100, will remain to be utilised as a balancing dam and pumping water from the proposed Bonathaba via existing pipelines to enable irrigation of the lower laying irrigation areas under gravity.

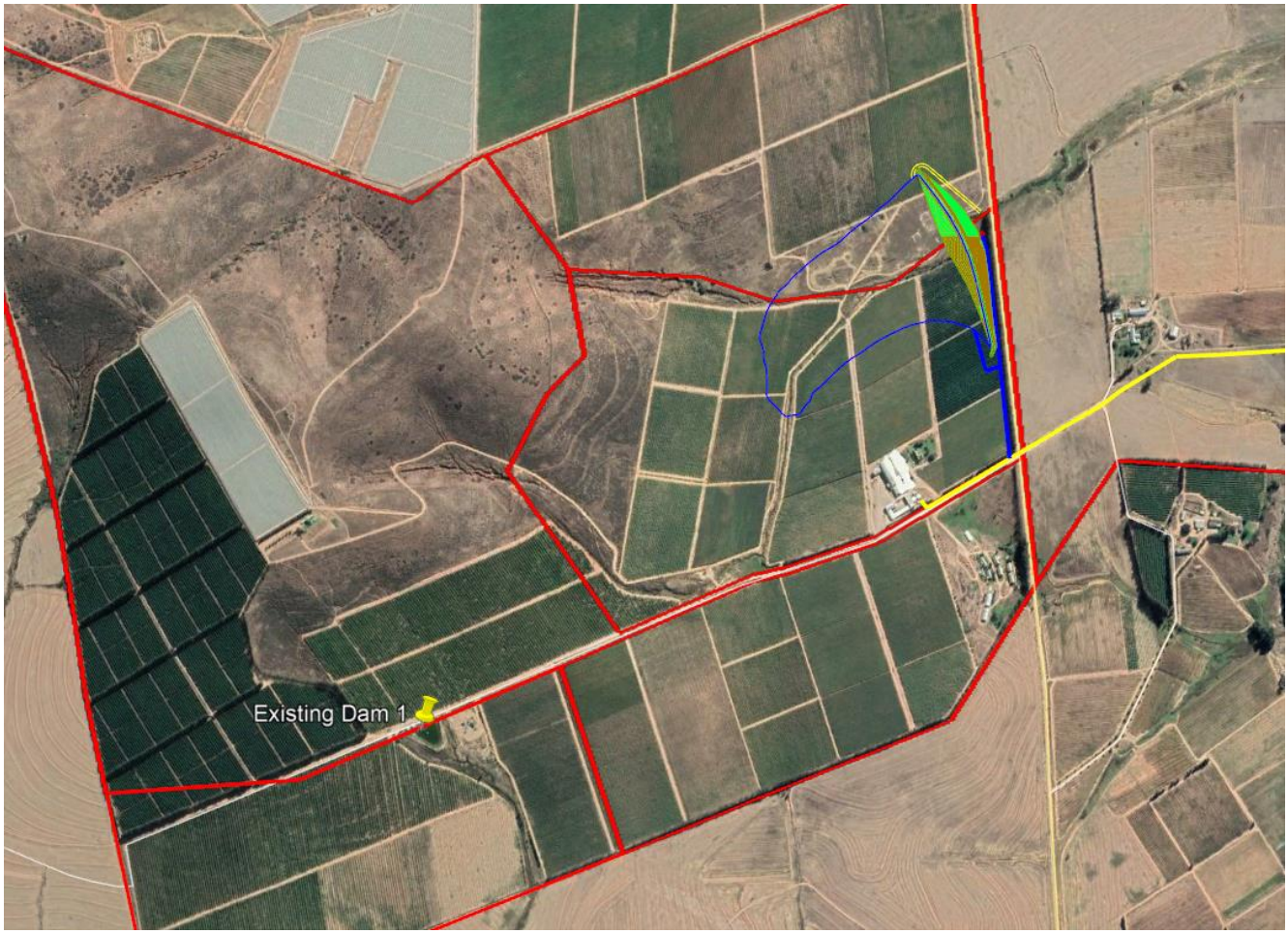

Figure 6-3: Position of existing small balancing dam

6. Legal requirements

6.1. Environmental authorisation

A full Environmental Impact Assessment (EIA) process for the environmental authorisation is required and will be undertaken by Messrs EnviroAfrica Environmental Consultant Services for the construction of the dam and its associated infrastructure.

6.2. Water use license

Applications for Section 21 b), c) and i) water uses will be required. Messrs Schoeman en Vennote will embark on the process.

6.3. Dam safety

The dam safety process will commence with the application for classification of the proposed Bonathaba Dam. A Category II classification are expected for the dam due to the capacity, wall height and expected hazard potential. The design and application for the licenses to construct will follow when the other authorisation processes are further advanced.

7. Project cost estimate

A provisional total project cost estimate for the project (excluding escalation to and during construction) can be summarised as follows. The construction cost estimate for the dam as at feasibility level, including an allowance of R 0.7 million to address the suspect foundation area and for the pipelines and pump stations at reconnaissance level. More investigation work is required on the pipelines, abstraction and pump station infrastructure to bring the level of cost estimate up to the same level.

Item no and description	Cost (million R, excl. VAT)[1)]
1. Construction	
1.1 Bonathaba Dam (Option 1)	7.0
1.2 Pipelines and pump stations	1.1
1.4 Removal/loss of orchards	3.6
1.5 Foundation treatment to minimise leakage	0.7
Sub-total	**12.4**
2. Professional costs	
2.1 Engineering of dams	0.4
2.2 Authorisation processes	0.3
Sub-total	**0.7**
Total	**13.1**

1) Estimated in June 2020

Yours faithfully,

INGEROP SOUTH AFRICA

DJ Hagen Pr.Eng/APP

INGEROP SOUTH AFRICA

C Starke Engineer

INGEROP SOUTH AFRICA

H Botha Eng. Tech.

References

A.K., Dec. 1984. The Revised ASTM Standard on the Unified Soil Classification System. Geotechnical Testing Journal, 7 (4): 216-222

Bailey A.K., Pitman W.V. (2015): Water Resources of South Africa, 2012 Study (WR2012). Water Research Commission, Pretoria, RSA.

Council of Geoscience RSA. (2015). Geological Survey Maps. Republic of South Africa

Geophysical survey for a subsurface foundation assessment for a proposed new dam on Bonathaba, southwest of Hermon, Western Cape, GEOSS Report No: 2020/03-29, dated 13 March 2020

RSA, "National Water Act (No 36 of 1998): Dam Safety Regulations (R139 of 2012)," Republic of South Africa, Pretoria, 2012.

Appendix A – Provided Information

Appendix B – Geotechnical Results

Appendix C – Drawings

Appendix D – Dam Options Analysis Summary

Appendix E – Dam water balance