water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam (WP0485)

Topographical Surveys Report






February 2021

Department of Water and Sanitation
Directorate: Options Analysis

POST FEASIBILITY BRIDGING STUDY FOR THE PROPOSED BULK CONVEYANCE INFRASTRUCTURE FROM THE RAISED CLANWILLIAM DAM

APPROVAL

Title	:	Topographical Surveys Report
DWS Report Number	:	P WMA 09/E10/00/0417/7
Consultants	:	Aurecon South Africa (Pty) Ltd
Report status	:	Final v2
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STUDY TEAM

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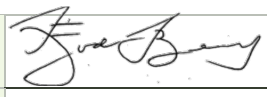
Approver signature	
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DEPARTMENT OF WATER AND SANITATION

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Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam

TOPOGRAPHICAL SURVEYS REPORT

February 2021

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Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam

Reports produced as part of this project are indicated below.

Bold type indicates this report.

Report Index	Report Number	Report Title
1		Inception Report
2	P WMA 09/E10/00/0417/2	Capacity Building & Training Year 1
3	P WMA 09/E10/00/0417/3	Capacity Building & Training Year 2
4	P WMA 09/E10/00/0417/4	Water Requirements Assessment
5	P WMA 09/E10/00/0417/5	Distribution of Additional Available Water
6		Existing Infrastructure and Current Agricultural Development Sub-Report
7	P WMA 09/E10/00/0417/6	Existing Conveyance Infrastructure and Irrigated Land
8		Suitable Agricultural Areas and Land Ownership Report
9		Evaluation of Development Options Sub-Report
10	P WMA 09/E10/00/0417/10	Suitable Areas for Agricultural Development
11		Right Bank Canal Design Sub-Report
12		Conceptual Design Sub-Report
13		Environmental Screening Sub-Report
14		Jan Dissels and Ebenhaeser Schemes Design Sub-Report
15	P WMA 09/E10/00/0417/13	Feasibility Design
16	**P WMA 09/E10/00/0417/7**	**Topographical Surveys**
17	P WMA 09/E10/00/0417/8	Geotechnical Investigations
18	P WMA 09/E10/00/0417/9	Soil Survey
19		Financial Viability of Irrigation Farming Sub-Report
20	P WMA 09/E10/00/0417/11	Agricultural Production and Farm Development
21		Right Bank Canal Cost Analysis Sub-Report
22		Socio-Economic Impact Analysis Sub-Report
23	P WMA 09/E10/00/0417/12	Socio-Economic Impact Analysis
24	P WMA 09/E10/00/0417/14	Record of Implementation Decisions Report
25	P WMA 09/E10/00/0417/1	Main Report
26	P WMA 09/E10/00/0417/15	Historically Disadvantaged Farmers Report

Concise Description of the Content of Study Reports

Report Index	Report Number	Report Title and Description of Content
1		Inception The report forms part of the contract and stipulates the scope of work for the study, the contract amount and the contract period. It contains a detailed description of tasks and methodology, a study programme, human resource schedule, budget and deliverables. The Capacity Building and Training Plan has been included.
2	P WMA 09/E10/00/0417/2	Capacity Building & Training Year 1 Describes the range of capacity building and training activities planned for the study, and the activities undertaken during the first year of the study, including field-based training, training workshop 1 and mentorship of DWS interns through secondment.
3	P WMA 09/E10/00/0417/3	Capacity Building & Training Year 2 Describes the range of capacity building and training activities planned for the study, and the activities undertaken during the second year of the study, including field-based training, training workshop 2 and mentorship of DWS interns through secondment.
4	P WMA 09/E10/00/0417/4	Water Requirements Assessment Provides an analysis of the existing water use and current water allocations in the study area, and addresses ecological water requirements, water use for irrigated agriculture and projections for future use, current domestic and industrial water use and projections for future use, water use for hydropower and water losses in the water supply system.
5	P WMA 09/E10/00/0417/5	Distribution of Additional Available Water Confirms the volume of additional water available for development, after water has been reserved for the current water uses, as well as making recommendations on how the additional yield should be distributed among water use sectors and water users.
6		Existing Infrastructure and Current Agricultural Development Sub-Report Provides an overview of the extent and general condition of the current bulk water storage and conveyance infrastructure. This report also provides an overview of the locality and extent of the existing agricultural areas determined by reviewing Geographic Information System (GIS) data obtained from various sources.
7	P WMA 09/E10/00/0417/6	Existing Conveyance Infrastructure and Irrigated Land An update of the Sub-Report, providing a refinement of the current agricultural water requirements following evaluation of the current crop types, an assessment of the desirability of diverting releases for downstream irrigators via the Clanwilliam Canal and Jan Dissels River, to meet the summer ecological flows in the lower Jan Dissels River, and presents an Implementation Action Plan with costs.

Report Index	Report Number	Report Title and Description of Content
8		Suitable Agricultural Areas and Land Ownership Sub-Report Description of the collection of information and the preparation undertaken for the analysis of options, which includes a summary of existing irrigated areas and water use, cadastral information, land ownership, environmental sensitivity, soils suitability, water quality considerations and constraints, and the initiation of the process to identify additional areas suitable for irrigation.
9		Evaluation of Development Options Sub-Report Describes the salient features, costs and impacts of identified potential irrigation development options for new irrigation development in the lower Olifants River. This provides the background and an introduction to the discussions at the Options Screening Workshop held in December 2018.
10	P WMA 09/E10/00/0417/10	Suitable Areas for Agricultural Development Describes the supporting information, process followed and the salient features, costs and impacts of identified potential irrigation development options for new irrigation development in the lower Olifants River. Recommends the preferred options to be evaluated at feasibility level.
11		Right Bank Canal Feasibility Design Sub-Report Describes the Design Criteria Memorandum, based on best practice in engineering and complying with recognised codes and standards. Description of route alignments and salient features of the new Right Bank canal. Feasibility-level design of bulk infrastructure, including evaluation of capacities, hydraulic conditions, canal design, surface flow considerations, canal structures, power supply and access roads. Operational considerations and recommendations.
12		Conceptual Design Sub-Report Describes the scheme layouts at a conceptual level and infrastructure components to be designed, alternatives to consider or sub-options, and affected land and infrastructure, as well as the updated recommended schemes for new irrigation development.
13		Environmental Screening Sub-Report Describes and illustrates the opportunities and constraints, and potential ecological risks/impacts and recommendations for the short-listed bulk infrastructure development options at reconnaissance level. Describes relevant legislation that applies to the proposed irrigation developments.
14		Jan Dissels and Ebenhaeser Schemes Feasibility Design Sub-Report Describes the Design Criteria Memorandum, based on best practice in engineering and complying with recognised codes and standards. Description of route alignments and salient features of the Jan Dissels and Ebenhaeser schemes. Feasibility-level design of bulk infrastructure, including evaluation of capacities, hydraulic conditions, intake structures, balancing dams and reservoirs, rising mains and gravity pipelines and trunk mains where relevant, power supply and access roads. Operational considerations and recommendations.

Report Index	Report Number	Report Title and Description of Content
15	P WMA 09/E10/00/0417/13	Feasibility Design Description of the approach to and design of selected bulk infrastructure at feasibility level, with supporting plans and implementation recommendations.
16	P WMA 09/E10/00/0417/7	Topographical Surveys Describes the contour surveys for the proposed identified bulk infrastructure conveyance routes and development areas, the surveying approach, inputs and accuracy, as well as providing the survey information.
17	P WMA 09/E10/00/0417/8	Geotechnical Investigations Presents the findings of geotechnical investigations of the various identified sites, as well as the approach followed, field investigations and testing, laboratory testing, interpretation of findings and geotechnical recommendations.
18	P WMA 09/E10/00/0417/9	Soil Survey Describes the soil types, soil suitability and amelioration measures of the additional area covering about 10 300 ha of land lying between 60 to 100 m above river level, between the upper inundation of the raised Clanwilliam Dam and Klawer.
19		Financial Viability of Irrigation Farming Sub-Report Describes the findings of an evaluation of the financial viability of pre-identified crop-mixes, within study sub-regions, and advises on the desirability of specific crops to be grown in these sub-regions. It includes an evaluation of the financial viability of existing irrigation farming or expanding irrigation farming, as well as the identification of factors that may be obstructive for new entrants from historically disadvantaged communities.
20	P WMA 09/E10/00/0417/11	Agricultural Production and Farm Development This report will focus on policy, institutional arrangements, available legal and administrative mechanisms as well as the proposed classes of water users and the needs of each. This would include identifying opportunities for emerging farmers, including grant and other types of Government and private support, and a recommendation on the various options and opportunities that exist to ensure that land reform and water allocation reform will take place through the project implementation.
21		Right Bank Canal Cost Analysis Sub-Report Provides an economic modelling approach to quantify the risk of the failure of the existing main canal and the determination of the economic viability of the construction of the new right bank canal to reduce the risk of water supply failure.
22		Socio-Economic Impact Analysis Sub-Report Describes the socio-economic impact analysis undertaken for the implementation of the new irrigation development schemes, for both the construction and operational phases. This includes a description of the social and economic contributions, the return on capital investment, as well as the findings of a fiscal impact analysis.

Report Index	Report Number	Report Title and Description of Content
23	P WMA 09/E10/00/0417/12	Socio-Economic Impact Analysis Synthesis of agricultural economic and socio-economic analyses undertaken, providing an integrated description of agricultural production and farm development and socio-economic impact analysis, as well as the analysis of the right bank canal costs and benefits.
24	P WMA 09/E10/00/0417/14	Record of Implementation Decisions Describes the scope of the project, the specific configuration of the schemes to be implemented, the required implementation timelines, required institutional arrangements and the required environmental and other approval requirements and mitigation measures, to ensure that the project is ready for implementation.
25	P WMA 09/E10/00/0417/1	Main Report Provides a synthesis of approaches, results and findings from the supporting study tasks and interpretation thereof, culminating in the study recommendations. Provides information in support of the project funding motivation to be provided to National Treasury.
26	P WMA 09/E10/00/0417/15	Historically Disadvantaged Farmers Report Describes the activities undertaken by an independent consultant to evaluate existing HDI Farmers policies and legislative context, identify, map and analyse prospective HDI farmers and potential land for new irrigation, as well as propose a mechanism for the identification and screening of HDI farmers.

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Acronyms

DTM	digital terrain model
LiDAR	Light Detection and Ranging
ASPRS	American Society for Photogrammetry and Remote Sensing
MSL	mean sea level

1 Project Overview

The topographical survey was undertaken by Southern Mapping to produce rectified colour images and a digital terrain model (DTM) of the surveyed project area.

The topographical survey was carried out using an aircraft mounted Light Detection and Ranging (LiDAR) system that scanned the ground below, resulting in a dense DTM of the ground surface and objects above the ground.

Digital colour images were also taken from the aircraft and rectified to produce colour orthophotos of the surveyed project area.

The survey was flown at a height of approximately 800m and ortho images with an 8cm pixel resolution have been produced.

1.1 Equipment Used

Aircraft: Cessna F406 (ZS-SSY).

Laser Scanner: Optech Orion M300 (*12SEN306*).

Camera: Phase One IXU RS-1000.

1.2 Project Extent

The total of the surveyed project area is approximately 11 030 ha.

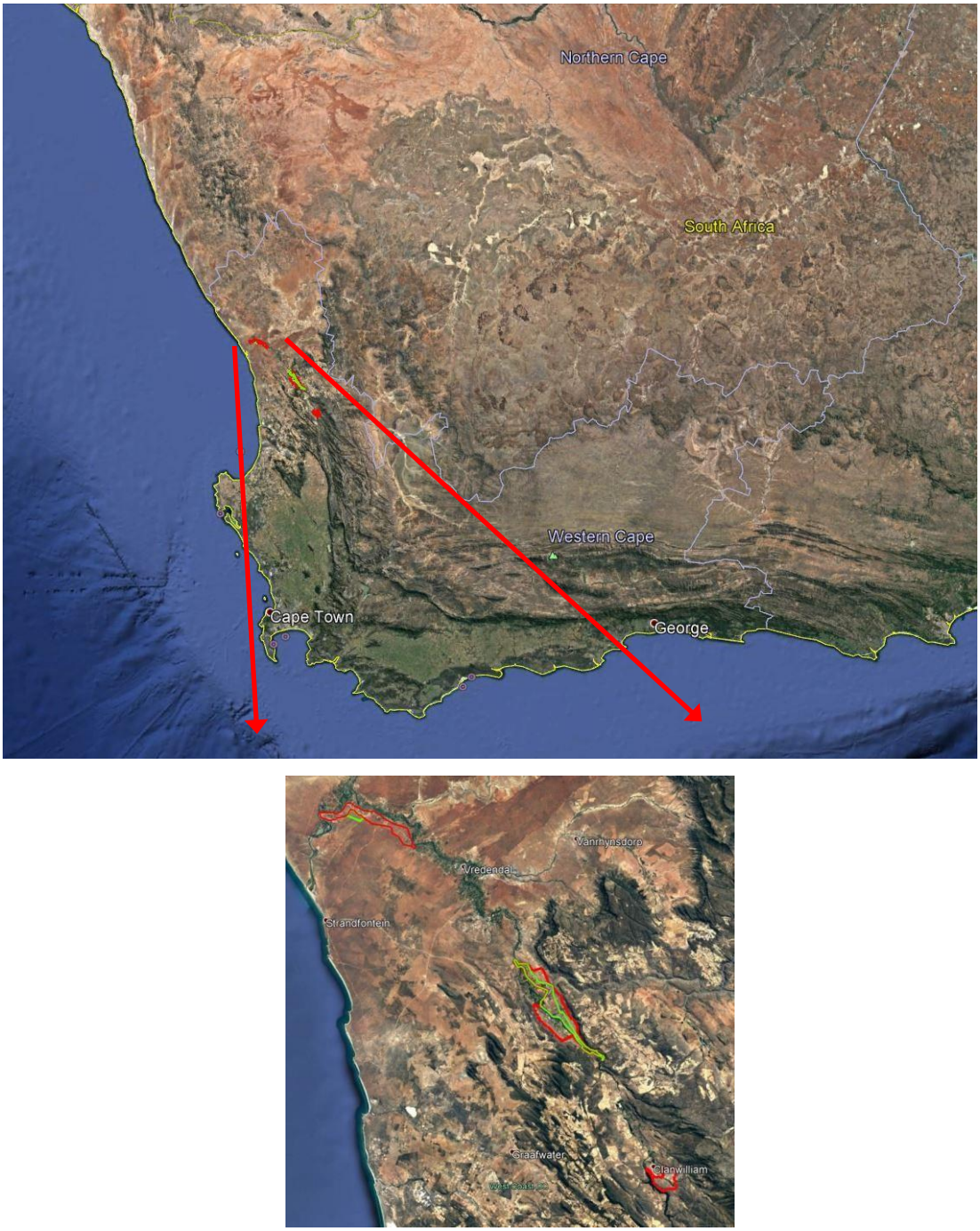

Figure 1.1: Locality Map

Three additional areas were surveyed as variation SGP2019_42_V01 with a total surveyed area of 353.08 ha.

The additional three areas are displayed and highlighted in red below.

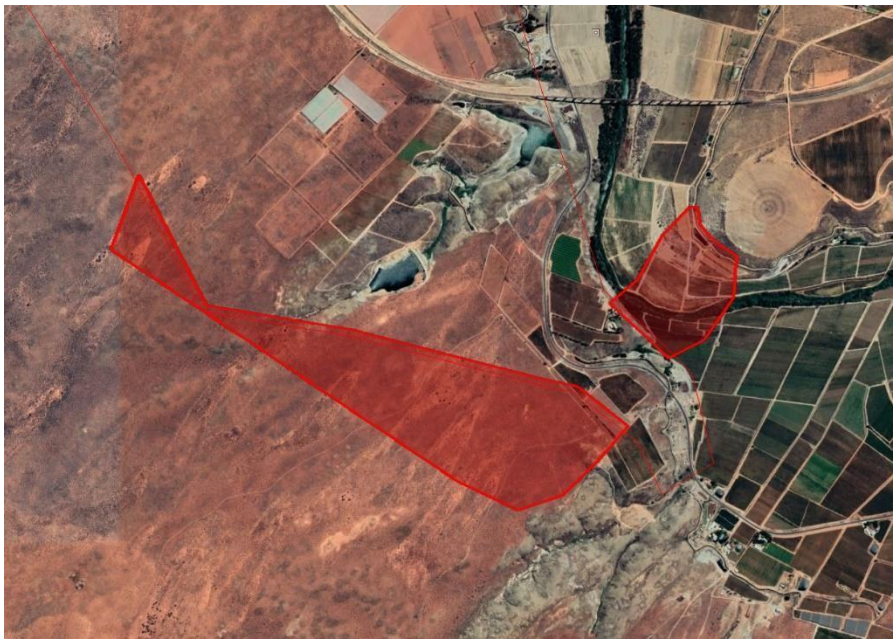

Figure 1.2: Area 1 and 2

Figure 1.3: Area 3

2 Ground Control Points

Ground control points were placed and surveyed by GeoAfrika Surveys and their coordinate values were used for the vertical and horizontal checks on the full aerial LiDAR survey. The approach, findings and accuracies achieved are described in the report included in **Appendix 5**, which has been checked and approved by DWS Survey Services.

The coordinates are as follow:

Coordinate system: Hartebeesthoek94 WG19:

Table 1: Ground control points coordinates

Name	Known Y	Known X	Orthometric Height (m) [MSL]
NRB133-11	26 764.87	3 537 103.15	81.38
NRB148-11	29 302.79	3 534 586.49	65.63
NRB162-11	31 399.16	3 533 054.88	69.23
NRB172-11	33 120.31	3 531 416.68	81.41
SGP194201	7 896.86	3 565 953.71	184.18
SGP194202	9 648.22	3 564 541.29	196.94
SGP194203	6 101.19	3 561 972.07	200.99
SGP194204	7 103.44	3 563 649.68	119.69
SGP194205	19 859.48	3 540 936.72	67.95
SGP194206	25 516.33	3 536 386.39	58.66
SGP194207	28 633.14	3 530 340.33	81.16
SGP194208	31 973.49	3 526 966.74	83.48
SGP194209	35 426.40	3 523 359.85	63.52

Name	Known Y	Known X	Orthometric Height (m) [MSL]
SGP194213	26 669.38	3 533 711.67	90.89
SGP194214	23 637.40	3 538 574.32	82.74
SGP194216	33 505.27	3 525 663.73	47.80
SGP194217	21 592.04	3 539 684.90	88.16
SGP194218	56 229.53	3 501 151.03	19.83
SGP194219	57 830.17	3 497 394.23	36.33
SGP194220	60 316.03	3 496 577.92	42.06
SGP194221	64 087.88	3 494 212.23	6.87
SGP194222	69 094.38	3 492 913.69	33.75
SGP194223	70 948.54	3 495 497.65	62.09
SGP194224	67 928.13	3 493 949.99	77.24
SGP194225	65 703.61	3 495 494.80	54.03
SGP194226	62 679.96	3 496 781.97	74.94

**The signs of YX will change in CAD.*
**Please also refer to the accompanying ground survey list file for further details.*

2.1 Field Survey

Additional field survey was conducted for four areas. Appendices 2 to 4 provides the location of the field work, heights as well as the descriptions. Images have been attached on a separate link.

3 Survey Datums

There are two principle global datums, namely WGS84 and ITRF which are defined by the US Government (NGA and US Air Force) and IGS respectively. On the African tectonic plate relative positions will generally remain stable and absolute positions will move in a predictable manner.

The current WGS 84 and the latest ITRF coordinates are usually within 1 to 2 cm difference as WGS84 is realigned to the latest ITRF on a regular basis. i.e. WGS84 (G1762) matches ITRF 2014. Thus, the datums WGS84 and ITRF2014 are interchangeable for all practical purposes with modern coordinates.

Coordinates based on old WGS84 or early ITRF versions may be significantly different when compared to the latest coordinates, e.g. ITRF1994 – ITRF2008 approx. 0.50 m, ITRF2008 – ITRF2014 approx. 0.07 m.

4 LiDAR Point Processing, Calibration, Transformations and Editing

4.1 LiDAR Point Processing

The trajectories were calculated based on a single base. The trajectory for each flight was post processed using *POSPac MMS* software and outputs a smoothed "best estimated" trajectory for the laser scanner and camera positions.

Subsequently, the LiDAR points were processed into raw ENH points, using Optech's *LMS* Survey Suite.

4.2 LiDAR Point Calibration

Overlapping LiDAR points from adjacent aircraft trajectories were used to check the LiDAR calibration for heading, roll, pitch and scale.

These values were then used to make small flight-specific adjustments to the LiDAR data.

4.3 LiDAR Point Transformations

The survey was originally calculated on the ITRF2014 (WGS84) datum and WG19 projection. The survey was converted to the Hartebeesthoek94 datum using the Calvinia Trignet shift values in the table below.

Table 2: Calvinia Trignet shift values

	Known Y	Known X
Shift (m)	0.63	0.39

The SAG2010 geoidal model was used to convert the ellipsoidal heights to orthometric heights. The orthometric points were further adjusted to the mean sea levelled heights provided by GeoAfrika Surveys.

4.3.1 LiDAR Point Editing

A first run automatic classification was carried out on the raw LiDAR points using *TerraSolid's TerraScan* software to classify the LiDAR points into ground hits and non-ground hits. This results in a greater than 80% correct classification. After this, a strenuous manual classification was carried out over the required area to edit the points thus minimizing gross classification errors that may have occurred in the automatic classification process.

Every LiDAR point has been classified according to the project requirement. A classification assigned to it that defines the type of object that has reflected the laser pulse. The different classes are defined using numeric integer codes in the LAS files. Classification codes were defined by the American Society for Photogrammetry and Remote Sensing (ASPRS) for LAS formats 1.1, 1.2, 1.3 and 1.4. Please refer to Appendix 1, listing the LAS classification codes defined by ASPRS for these LAS versions.

5 Orthophoto Rectification Procedure

Images were rectified by identifying common pixel points in overlapping image tiles using a process known as tie-pointing.

After completion of the tie-point process, all images were adjusted for optimum heading, roll, pitch and scale values so as to ensure a seamless image mosaic was obtained. The image tiles are 800m square in size and were output with a pixel size of 8cm in ECW format.

Figure 5.1: Rectified Image

6 Accuracies

6.1 Vertical Accuracy

The ground control points have been compared to the full LiDAR ground surface and used as a vertical check on the data.

The vertical accuracies supplied in the two tables below are for the comparison against:

i. The orthometric heights computed using the SAG2010 geoidal model.
ii. The orthometric heights levelled to the mean sea level (MSL) using a local geoid.

The local geoidal model was derived from the provided MSL heights. This local geoid was used to adjust the orthometric heights to match the levelled ground control heights.

The results of the orthometric heights adjusted using the SAG2010 geoid model are as follows: Coordinate system: Hartebeesthoek94 WG19.

Table 3: results of the orthometric heights adjusted

Name	Known Y	Known X	Known Z [Ground Elevation - MSL]	LIDAR Z	Dz
NRB133-11	-26 764.87	-3 537 103.15	81.38	81.42	+0.04
NRB148-11	-29 302.79	-3 534 586.49	65.63	65.68	+0.05
NRB162-11	-31 399.16	-3 533 054.88	69.23	69.28	+0.05
NRB172-11	-33 120.31	-3 531 416.68	81.41	81.45	+0.04
SGP194201	-7 896.86	-3 565 953.71	184.18	184.19	+0.01
SGP194202	-9 648.22	-3 564 541.29	196.94	196.91	-0.03
SGP194203	-6 101.19	-3 561 972.07	200.99	201.03	+0.04
SGP194204	-7 103.44	-3 563 649.68	119.69	119.71	+0.02
SGP194205	-19 859.48	-3 540 936.72	67.95	67.97	+0.02
SGP194206	-25 516.33	-3 536 386.39	58.66	58.62	-0.04
SGP194207	-28 633.14	-3 530 340.33	81.16	81.14	-0.02
SGP194208	-31 973.49	-3 526 966.74	83.48	83.39	-0.09
SGP194209	-35 426.40	-3 523 359.85	63.52	63.52	+0.00
SGP194213	-26 669.38	-3 533 711.67	90.89	90.88	-0.01
SGP194214	-23 637.40	-3 538 574.32	82.74	82.67	-0.07
SGP194216	-33 505.27	-3 525 663.73	47.80	47.81	+0.01
SGP194217	-21 592.04	-3 539 684.90	88.16	88.13	-0.03
SGP194218	-56 229.53	-3 501 151.03	19.83	19.89	+0.06
SGP194219	-57 830.17	-3 497 394.23	36.33	36.38	+0.05
SGP194220	-60 316.03	-3 496 577.92	42.06	42.11	+0.05
SGP194221	-64 087.88	-3 494 212.23	6.87	6.84	-0.03
SGP194222	-69 094.38	-3 492 913.69	33.75	33.72	-0.03

Name	Known Y	Known X	Known Z [Ground Elevation - MSL]	LIDAR Z	Dz
SGP194223	-70 948.54	-3 495 497.65	62.09	62.05	-0.04
SGP194224	-67 928.13	-3 493 949.99	77.24	77.23	-0.01
SGP194225	-65 703.61	-3 495 494.80	54.03	54.02	-0.01
SGP194226	-62 679.96	-3 496 781.97	74.94	74.95	+0.01

Average Dz	0.002
Minimum Dz	-0.09
Maximum Dz	+0.06
Average magnitude	+0.027
Root mean square	+0.035
Std deviation	+0.036

The results of the mean sea levelled heights are as follows:
Coordinate system: Hartebeesthoek94 WG19.

Table 4: Mean sea levelled heights

Name	Known Y	Known X	Known Z [MSL]	LIDAR Z	Dz
NRB133-11	-26 764.87	-3 537 103.15	81.38	81.38	0.00
NRB148-11	-29 302.79	-3 534 586.49	65.63	65.63	0.00
NRB162-11	-31 399.16	-3 533 054.88	69.23	69.23	0.00
NRB172-11	-33 120.31	-3 531 416.68	81.41	81.41	0.00
SGP194201	-7 896.86	-3 565 953.71	184.18	184.18	0.00
SGP194202	-9 648.22	-3 564 541.29	196.94	196.94	0.00
SGP194203	-6 101.19	-3 561 972.07	200.99	200.99	0.00
SGP194204	-7 103.44	-3 563 649.68	119.69	119.69	0.00
SGP194205	-19 859.48	-3 540 936.72	67.95	67.95	0.00

Name	Known Y	Known X	Known Z [MSL]	LIDAR Z	Dz
SGP194206	-25 516.33	-3 536 386.39	58.66	58.66	0.00
SGP194207	-28 633.14	-3 530 340.33	81.16	81.16	0.00
SGP194208	-31 973.49	-3 526 966.74	83.48	83.48	0.00
SGP194209	-35 426.40	-3 523 359.85	63.52	63.52	0.00
SGP194213	-26 669.38	-3 533 711.67	90.89	90.89	0.00
SGP194214	-23 637.40	-3 538 574.32	82.74	82.74	0.00
SGP194216	-33 505.27	-3 525 663.73	47.80	47.80	0.00
SGP194217	-21 592.04	-3 539 684.90	88.16	88.16	0.00
SGP194218	-56 229.53	-3 501 151.03	19.83	19.83	0.00
SGP194219	-57 830.17	-3 497 394.23	36.33	36.33	0.00
SGP194220	-60 316.03	-3 496 577.92	42.06	42.06	0.00
SGP194221	-64 087.88	-3 494 212.23	6.87	6.87	0.00
SGP194222	-69 094.38	-3 492 913.69	33.75	33.75	0.00
SGP194223	-70 948.54	-3 495 497.65	62.09	62.09	0.00
SGP194224	-67 928.13	-3 493 949.99	77.24	77.24	0.00
SGP194225	-65 703.61	-3 495 494.80	54.03	54.03	0.00
SGP194226	-62 679.96	-3 496 781.97	74.94	74.94	0.00

Average Dz	0.00
Minimum Dz	0.00
Maximum Dz	0.00
Average magnitude	0.00
Root mean square	0.00
Std deviation	0.00

**The above is in CAD format.*

6.2 Horizontal Accuracy

Pre-marked check points were digitized on the orthophotos and the derived coordinates were compared with the ground survey values.

The results are as follows:

Coordinate system: Hartebeesthoek94 WG19**.**

Table 5: Derived coordinates were compared with the ground survey values

Name	Known Y	Known X	Orthophoto Y	Orthophoto X	dY(m)	dX(m)	dS(m)
NRB133-11	-26 764.87	-3 537 103.15	-26 764.85	-3 537 103.10	0.02	0.05	0.05
NRB148-11	-29 302.79	-3 534 586.49	-29 302.77	-3 534 586.51	0.02	-0.02	0.03
NRB162-11	-31 399.16	-3 533 054.88	-31 399.16	-3 533 054.90	0.00	-0.02	0.02
NRB172-11	-33 120.31	-3 531 416.68	-33 120.31	-3 531 416.71	0.00	-0.03	0.03
SGP194201	-7 896.86	-3 565 953.71	-7 896.84	-3 565 953.72	0.02	-0.01	0.02
SGP194202	-9 648.22	-3 564 541.29	-9 648.22	-3 564 541.31	0.00	-0.02	0.02
SGP194203	-6 101.19	-3 561 972.07	-6 101.17	-3 561 972.08	0.02	-0.01	0.02
SGP194204	-7 103.44	-3 563 649.68	-7 103.44	-3 563 649.71	0.00	-0.03	0.03
SGP194205	-19 859.48	-3 540 936.72	-19 859.46	-3 540 936.74	0.02	-0.02	0.03
SGP194206	-25 516.33	-3 536 386.39	-25 516.32	-3 536 386.40	0.01	-0.01	0.01
SGP194207	-28 633.14	-3 530 340.33	-28 633.13	-3 530 340.35	0.01	-0.02	0.02
SGP194208	-31 973.49	-3 526 966.74	-31 973.49	-3 526 966.76	0.00	-0.02	0.02
SGP194209	-35 426.40	-3 523 359.85	-35 426.38	-3 523 359.87	0.02	-0.02	0.03
SGP194213	-26 669.38	-3 533 711.67	-26 669.38	-3 533 711.69	0.00	-0.02	0.02
SGP194214	-23 637.40	-3 538 574.32	-23 637.38	-3 538 574.33	0.02	-0.01	0.02
SGP194216	-33 505.27	-3 525 663.73	-33 505.28	-3 525 663.74	-0.01	-0.01	0.01
SGP194217	-21 592.04	-3 539 684.90	-21 592.04	-3 539 684.93	0.00	-0.03	0.03
SGP194218	-56 229.53	-3 501 151.03	-56 229.54	-3 501 151.05	-0.01	-0.02	0.02

Name	Known Y	Known X	Orthophoto Y	Orthophoto X	dY(m)	dX(m)	dS(m)
SGP194219	-57 830.17	-3 497 394.23	-57 830.08	-3 497 394.20	0.09	0.03	0.09
SGP194220	-60 316.03	-3 496 577.92	-60 315.95	-3 496 577.94	0.08	-0.02	0.08
SGP194221	-64 087.88	-3 494 212.23	-64 087.82	-3 494 212.32	0.06	-0.09	0.11
SGP194222	-69 094.38	-3 492 913.69	-69 094.36	-3 492 913.77	0.02	-0.08	0.08
SGP194223	-70 948.54	-3 495 497.65	-70 948.59	-3 495 497.62	-0.05	0.03	0.06
SGP194224	-67 928.13	-3 493 949.99	-67 928.13	-3 493 950.01	0.00	-0.02	0.02
SGP194225	-65 703.61	-3 495 494.80	-65 703.53	-3 495 494.82	0.08	-0.02	0.08
SGP194226	-62 679.96	-3 496 781.97	-62 679.93	-3 496 782.01	0.03	-0.04	0.05
Pixel Size = 0.08m							
Average from known position					0.01	-0.01	0.03
Maximum dY(m), dX(m) & dS(m)					0.09	0.05	0.11
Minimum dY(m), dX(m) & dS(m)					-0.05	-0.09	0.01
Standard deviation					0.01		

**Above is in CAD format*

7 Deliverables

- CAD design files in Microstation DGN, DWG and DXF format showing:

  i.Orthophoto tiles and LiDAR point block layout.

  ii.The surveyed project area with boundaries.

  iii. Contours at 0.5m, 1m and 2m intervals.

  **These contours have been smoothed and are merely an aesthetic representation of the ground shape.*

- Ortho-rectified aerial images in ECW format with an 8cm pixel resolution.
- Composite Image in ECW format at 0.5m.
- 1m Raster DEM
- 1m Elevation Grid
- Google Earth Overlay in KMZ format at 0.5m.
- Full LiDAR points in LAS1.4 format with the following feature classes:

Table 6: Feature classes of LiDAR points in LAS1.4 format

Classification Value	Meaning
1	Unclassified
2	Ground
3	Low Vegetation (0.5 – 2m)
4	Medium Vegetation (2 – 5m)
5	High Vegetation (>5m)

- This LiDAR Survey report as well as the Ground Survey list.

*All of the above data are in the **Hartbeesthoek WG19 system,** with orthometric heights as calculated in TerraScan using the SAG2010 geoidal model and levelled to mean sea level.*

8 Queries

In case of any queries please do not hesitate to contact:

Moshidi Mokgukulushi - LiDAR data processor	011 467 2609 or moshidi@southernmapping.com
Jacques Pieterse – Processing Manager [SAGC Registration Number: GTgGISc 1054]	011 467 2609 or jacques@southernmapping.com
Luana Hattingh – Detail Mapping Supervisor [SAGC Registration Number: GTgGISc 1040]	011 467 2609 or luana@southernmapping.com

Appendix 1: LAS Classification Codes

Classification Value	Meaning
0	Created, never classified
1	Unclassified
2	Ground
3	Low Vegetation (0.5 – 2m)
4	Medium Vegetation (2 – 5m)
5	High Vegetation (5m>)
6	Building
7	LowPoint (noise)
8	ModelKeyPoint
9	Water
10	Rail
11	Road Surface
12	Overlap
13	Wire – Guard (Shield)
14	Wire – Conductor (Phase)
15	Power Line & Transmission Tower
16	Wire – Structure Connector (Insulator)
17	Bridge Deck
18	High Noise
19	Stream
20 - 63	Reserved
64 - 255	User Definable

Appendix 2: Field Work Area 1

Name Photo No	Y	X	Z	Code	Desc	Comment
AREA 1						
	20057.855	3541463.878	66.138	STD	STUD	On 092349
STUD2						
STUD3	20124.962	3541440.521	66.148	STD	STUD	Bridge On 092349
STUD4	20169.782	3541424.993	66.163	STD	STUD	Bridge On 092349
C11B C11T	20185.613	3541444.894	66.128	STD	STUD	Bridge On 092346
C12	20179.827	3541402.732	60.327	BCW	Base Canal Wall	Bridge Pathway 101558
C13B	20180.203	3541402.450	60.946	TC	Top Canal Wall	101558
C13T	20161.948	3541362.862	60.907	TC	Top Canal Wall	102424
C14	20149.662	3541326.029	60.412	BCW	Base Canal Wall	Pathway 102424
C15	20149.788	3541325.962	60.656	TC	Top Canal Wall	Brickwork 102424
C16	20182.515	3541440.649	63.985	WL	Water Level	100926
C16+	20183.540	3541440.534	66.130	BL	Bridge Level	092346
13	20187.778	3541439.965	60.338	WL	Water Level	100926
15	20187.471	3541440.390	61.121	CW	Catwalk	0.80 above WL 100926
17	20188.623	3541441.152	61.922	TSLB	Top Slab	100926
23	20184.896	3541428.219	61.088	TC	Top Canal Wall	092423
25	20181.963	3541405.863	60.940	TC	Top Canal Wall	Inlet Pipe 092506
29	20162.601	3541363.101	60.364	WL	Water Level	In Canal 102424
31	20155.665	3541336.926	60.993	TC	Top Canal Wall	Weir 102424
	20170.724	3541390.829	59.054	TP200	Top Outlet Pipe	200 diam 092456
	20170.511	3541390.383	59.047	TP200	Top Outlet Pipe	200 diam 092456

Appendix 3: Field Work Areas 2 & 3

Name	Y	X		Code	Desc	Comment	Photo No
AREA 2							
C24	22220.214	3539899.701	59.034	TC	Top Canal Wall		143959
C25	22319.149	3539902.642	58.950	TC	Top Canal Wall		143703
100	22432.935	3539907.632	58.738	OUT	Top Outlet		
101	22433.106	3539907.457	57.339	OUIL	Inv Outlet		
150	22226.310	3539899.047	59.029	TC	Top Canal Wall		143703
151	22215.893	3539900.101	59.038	TC	Top Canal Wall		143959
152	22211.377	3539901.206	59.004	TC	Top Canal Wall		143959
153	22206.908	3539903.247	58.975	TC	Top Canal Wall		143959
154	22248.348	3539897.066	58.975	TC	Top Canal Wall		143703
158	22290.141	3539899.920	58.936	TC	Top Canal Wall		143703
159	22212.879	3539900.813	59.020	TCG	Top Canal Wall	Gate	143959

Name	Y	X	Z	Codes	Desc	Comment	Photo No
AREA 3-1							
C36	35614.196	3523417.165	48.450	TC	Top Canal Wall		114547
300	35620.310	3523408.321	48.773	FC	Fence Cnr		114547
301	35618.163	3523407.319	48.734	FC	Fence Cnr		114547
302	35616.159	3523410.596	48.641	FC	Fence Cnr		114547
303	35618.056	3523411.670	48.893	FC	Fence Cnr		114547
304	35616.002	3523410.048	48.663	TC	Top Canal Wall		114547
305	35615.794	3523409.872	48.267	WI	Weir	IL	114547
306	35620.826	3523417.878	49.409	CR	Centre Road		114547
307	35622.746	3523401.050	49.399	SLC	SLUIC		114551
308	35621.960	3523398.556	49.410	SLC	SLUIC		114551
309	35621.203	3523400.136	49.399	SLC	SLUIC		114551
310	35623.161	3523399.259	49.412	SLC	SLUIC		114551
311	35623.747	3523399.114	49.438	TC	Top Canal Wall		114551
312	35624.994	3523397.072	49.416	TC	Top Canal Wall		114551
313	35624.831	3523396.902	49.432	TC	Top Canal Wall		114551
314	35624.751	3523396.116	49.431	TC	Top Canal Wall		114551
315	35624.899	3523395.567	49.756	TC	Top Canal Wall		114551

Name	Y	X	Z	Codes	Desc	Comment	Photo No
316	35625.061	3523396.137	49.763	TC	Top Canal Wall		114551
317	35625.160	3523395.993	49.771	TC	Top Canal Wall		114551
318	35628.304	3523397.439	49.746	TC	Top Canal Wall		114551
319	35628.390	3523397.763	49.743	TC	Top Canal Wall		114551
320	35629.492	3523395.420	49.737	TC	Top Canal Wall		114551
321	35628.914	3523395.000	49.734	TC	Top Canal Wall		114551
322	35627.984	3523392.513	49.726	TC	Top Canal Wall		114551
323	35628.323	3523392.240	49.735	TC	Top Canal Wall		114551
324	35628.408	3523392.380	49.738	TC	Top Canal Wall		114551
325	35628.209	3523392.522	49.742	TC	Top Canal Wall		114551
326	35628.336	3523392.183	49.451	TC	Top Canal Wall		114551
327	35622.121	3523403.184	49.338	12IP	12IPC Bent	No 683	114647
328	35641.844	3523382.278	49.396	TC	Top Canal Wall		114647
329	35642.569	3523381.924	49.217	TC	Top Canal Wall		114647
330	35642.209	3523381.992	48.637	WI	Weir	IL	114647
331	35647.074	3523379.993	49.446	SMP	Sump		114647
332	35647.937	3523380.841	49.438	SMP	Sump		114647
333	35648.807	3523379.954	49.413	SMP	Sump		114647
334	35647.962	3523379.064	49.447	SMP	Sump		114647
335	35649.153	3523378.686	49.190	TC	Top Canal Wall	Outlet	114647
336	35648.100	3523377.877	49.234	TC	Top Canal Wall	Outlet	114647
337	35649.371	3523377.233	49.233	TC	Top Canal Wall	Outlet	114647
338	35649.359	3523378.467	49.184	TC	Top Canal Wall	Outlet	114647
339	35648.872	3523378.672	49.193	TC	Top Canal Wall	Outlet	114647
AREA 3-2							
340	36212.163	3523748.082	50.545	TC	Top Canal Wall		131818
341	36211.348	3523747.259	50.997	TC	Top Canal Wall		131818
342	36212.665	3523748.689	50.990	TC	Top Canal Wall		131818
343	36211.544	3523749.679	50.994	TC	Top Canal Wall		131818
344	36211.320	3523749.699	50.982	TC	Top Canal Wall		131818
345	36209.438	3523748.772	50.982	TC	Top Canal Wall	Outlet	131818
346	36206.266	3523751.440	51.004	TC	Top Canal Wall	Outlet	131818
347	36206.229	3523751.979	50.993	TC	Top Canal Wall	Outlet	131818

Name	Y	X	Z	Codes	Desc	Comment	Photo No
348	36206.132	3523752.060	50.984	TC	Top Canal Wall	Outlet	131818
349	36205.752	3523751.683	50.992	TC	Top Canal Wall	Outlet	131818
C39	36207.868	3523750.169	50.988	TC	Top Canal Wall		131818
350	36202.920	3523754.270	50.928	TC	Top Canal Wall		131810
351	36200.769	3523755.966	50.884	TC	Top Canal Wall		131810
352	36200.676	3523756.080	51.044	TC	Top Canal Wall		131810
353	36198.863	3523757.480	51.037	TC	Top Canal Wall		131810
354	36198.820	3523757.533	51.087	TC	Top Canal Wall		131810
400	36235.559	3523728.971	50.503	TC	Top Canal Wall		131820
401	36235.652	3523729.031	49.889	WI	Weir	IL	131820
355	36202.081	3523741.284	50.924	TSLB	Top Slab		
726	36204.246	3523740.741	50.944	TSLB	Top Slab		
727	36202.653	3523743.379	50.917	TSLB	Top Slab		
728	36199.985	3523741.798	50.907	TSLB	Top Slab		
729	36201.620	3523739.148	50.921	TSLB	Top Slab		

Appendix 4: Field Work Area 4

Name	Y	X	Z	Code	Desc	Comment	Photo No
AREA 4-1							
	56603.997	3500817.413	34.860	FC	Fence Corner		154243
	56603.710	3500819.240	34.434	FC	Fence Corner		154243
	56598.740	3500816.849	34.810	FC	Fence Corner		154243
	56598.542	3500818.476	34.467	FC	Fence Corner		154243
	56615.601	3500821.135	34.419	TC	Top Canal Wall		151612
	56616.038	3500822.325	33.197	CB	Canal Bottom		151612
	56615.785	3500824.201	33.180	CB	Canal Bottom		151612
	56615.397	3500825.281	34.417	TC	Top Canal Wall		151612
	56605.378	3500821.075	33.213	IC320	Invert Outlet	320x320 mm	151612
	56605.480	3500820.760	33.255	CB	Canal Bottom		151612
	56605.304	3500821.551	33.225	CB	Canal Bottom		151612
	56605.087	3500822.777	33.181	CB	Canal Bottom		151612
	56605.051	3500823.823	34.395	TC	Top Canal Wall		151612
	56593.861	3500822.264	34.377	TC	Top Canal Wall		151447
	56593.937	3500821.243	33.199	CB	Canal Bottom		151447
500	56594.119	3500820.269	33.201	CB	Canal Bottom		151447
501	56580.728	3500819.010	33.240	LWB	Long Weir Bottom		154302
502	56580.798	3500818.553	33.230	LWB	Long Weir Bottom		154302
503	56580.319	3500820.167	34.400	TC	Top Canal Wall		154302
504	56580.494	3500819.828	33.983	LWT	Long Weir Top		154302
505	56580.227	3500819.736	33.986	LWT	Long Weir Top		154302
506	56580.515	3500818.156	33.955	LWT	Long Weir Top		154302
507	56580.755	3500818.492	33.954	LWT	Long Weir Top		154302
508	56591.441	3500819.806	33.974	LWT	Long Weir Top		151447
509	56591.458	3500819.534	33.958	LWT	Long Weir Top		151447
510	56604.926	3500821.508	33.960	LWT	Long Weir Top		151612

Name	Y	X	Z	Code	Desc	Comment	Photo No
511	56604.920	3500821.197	33.957	LWT	Long Weir Top		151612
512	56604.845	3500820.988	33.214	IC320	Invert Outlet	320x320 mm	151612
513	56604.927	3500821.125	33.173	CB	Canal Bottom		151612
514	56604.947	3500820.650	33.206	CB	Canal Bottom		151612
515	56605.006	3500821.514	34.432	LWT	Long Weir Top		151612
516	56605.231	3500821.527	34.434	LWT	Long Weir Top		151612
517	56605.147	3500819.692	34.449	LWT	Long Weir Top		151612
518	56605.430	3500819.726	34.431	LWT	Long Weir Top		151612
519	56601.289	3500819.926	33.501	TPIPE100	Top Inlet Pipe	100mm	
520	56593.635	3500819.712	33.216	LWB	Long Weir Bottom		151447
521	56593.725	3500819.035	33.195	CB	Canal Bottom		151447
522	56580.493	3500818.064	33.183	LWB	Long Weir Bottom		151519
523	56580.772	3500816.968	33.215	CB	Canal Bottom		151519
524	56579.613	3500816.590	33.225	CB	Canal Bottom		151519
525	56578.678	3500816.471	33.221	CB	Canal Bottom		151519
526	56579.660	3500815.486	33.243	OUTB	Offtake Bottom		151519
527	56578.956	3500815.394	33.226	OUTB	Offtake Bottom		151519
528	56579.301	3500815.480	33.237	IC320	Invert Outlet	320x320mm	151519
529	56572.886	3500817.770	33.180	CB	Canal Bottom		151456
530							
531							
532							
533							
534							
535							
536							
537							
538							
539							
540							
541							

Name	Y	X	Z	Code	Desc	Comment	Photo No
542							
543							
544							
545	56572.267	3500818.800	34.376	TC	Top Canal Wall		151456
546	56572.423	3500817.742	33.189	CB	Canal Bottom		151456
547	56572.704	3500815.650	33.195	CB	Canal Bottom		151456
548	56573.046	3500814.560	34.389	TC	Top Canal Wall		151456
549	56561.527	3500816.919	34.375	TC	Top Canal Wall		151456
550	56561.818	3500815.908	33.194	CB	Canal Bottom		151456
551	56561.636	3500814.738	33.184	CBCL	Canal Bottom	Centre Line	151456
552	56562.020	3500813.690	33.176	CB	Canal Bottom		151456
553	56561.980	3500812.577	34.393	TC	Top Canal Wall		151456
554	56580.550	3500813.941	34.697	HWT	Head Wall Top		151851
555	56578.422	3500813.586	34.690	HWT	Head Wall Top		151851
556	56578.948	3500813.461	32.958	OUTB	Offtake Bottom		151851
557	56580.062	3500813.627	32.968	OUTB	Offtake Bottom		151851
558	56579.562	3500813.516	32.922	IP300	Invert Pipe	300mm	151851
560	56580.221	3500813.698	33.990	OUTT	Offtake Top		151851
561	56578.782	3500813.453	33.988	OUTT	Offtake Top		151851
562	56579.017	3500812.830	33.762	OUTTB	Offtake Bottom		151851
563	56580.208	3500812.995	33.777	OUTTB	Offtake Bottom		151851
564	56580.505	3500811.137	33.753	SLCT	V Gauge Top Wall		151814
565	56580.306	3500811.078	33.744	SLCT	V Gauge Top Wall		151814
566	56579.907	3500811.107	33.284	V	V Gauge	Invert	151814

Appendix 5: Ground Control Points

GeoAfrika Surveys

+27 31 266 8242
+27 12 665 2252

Durban | 15 Acacia Avenue, Westville, 3629
Centurion | 2 Pieter Street, Centurion, 0157

surveys@geoafrika.co.za

www.geoafrika.co.za

Reference: G1585
Enquiries: DJ Biggert
Date: 16 November 2020

Southern Mapping Geospatial
1st Floor Selbourne House
Fourways Golf Park
Roos Street
Fourways

Att.: Mr J Vaughn

Dear Jim

TECHNICAL SURVEY REPORT
SURVEY CONTROL FOR AERIAL MAPPING OF THREE SITES NEAR CLANWILLIAM KLAWER AND LUTZVILLE

Survey Project Description:

Establishment of new survey control for the above project.

Survey Project Number: G1585

Surveyed by: Diesel and Munns Inc

Locality of the Survey Area:

Site1:South of Clanwilliam
Site 2 South of Klawer
Site 3 South of Lutzville

Terrain Type Description:

The terrain is undulating with some steep areas.

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Size of the Survey:

The GPS survey covers a stretch of 95kms.
Double run line levelling covers 6kms, 38kms and 28kms for Sites 1,2 and 3 respectively.

Date and duration of the Survey:

The field survey was done in October to November 2019 for a duration of 24 days. The survey of the control beacons was done under the direct supervision of Jonathan Lake (GPr LS0328).

Field surveyors: Sidney Breda, Walter De Villiers and 4 assistants

Instrumentation and equipment used:

Leica GPS System 500
Topcon Hyperlite GPS
Trimble Dini digital level
Ruide digital level
.

Special Aids:

The field survey teams were supported by flagmen.

Survey method applied:

Establishment of horizontal survey control

- Reference should be made to the working plan provided to indicate the observation vectors and the GPS data sheet showing all the occupation times and other field information. This in turn references the actual field book sheets with sketches and other detail.

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- The horizontal fixing of the permanent survey ground control beacons was done utilizing 2 Leica GPS system 500 and 2 Topcon Hyper lite GPS receivers using Static mode.
- Static GPS vectors were used to coordinate 2 control beacons for each of the three sites.
- The tribrachs and ranging rods were checked for any spirit bubble errors at the start and end of the survey.
- 2 control beacons per site were occupied statically for almost 8 hours of logging at 5 second epochs.
- Time overlaps of approximately 30 minutes were observed to the photo control beacons on each site providing two time overlaps per beacon (double polars).
- A single time overlap was observed between control beacons between each of the three sites for two hours.
- GPS Vectors were observed for 30 minutes at 5 second epochs to three trig beacons at each site.
- At trig beacons TR66 and TR63 the vane could not be removed due to rusting so observations were taken on top of the vein.
- On Site 1 two Leica receivers were used so each photo control beacon was visited twice (double polared) from the two control beacons. The control beacons were NRB8-11 and SGP194202. NRB19-11 was also visited.
- On Sites 2 and 3 a Leica receiver was setup on one control point and a Topcon receiver at the other control point nearby. A Topcon receiver was used to visit each photo control beacon for a 30-minute time overlap.
- On Site 2, four existing NRB beacons on the National Route N7/4 were found and used as photo control beacons. One of these, NRB133-11, was used as a control beacon.
- On Site 3 no observations were taken on the NRB beacons as we felt that they were too far away from the site. Connections onto 4 NRB’s at Site 2 should suffice. Two National Benchmarks were found on site and used for the heights with levelling.
- The Geoidal Model SAG 2010 was used for processing all GPS vectors to obtain orthometric elevations of the stations.
- Station Booking Sheets were completed for each station. One landscape and one vertical photo were taken of each beacon visited and Station Sheets with photos were compiled in the office.

- The ITRF 2014 (Epoch 2018.18) system was initially used with Rinex L1,L2 single second data downloaded from the Trignet website for Calvinia, Langebaan and Malmesbury to calculate a value for NRB133-11. This was then held fixed and a value computed for WD1 from NRB133-11 and the three trignet stations. The tie observation to SGP149202 with the three trignet stations was used to calculate its value. NRB8-11 was then computed from SGP149202 and the trignet stations. SG149218 in Site3 was then similarly processed and then WD2. These control beacons were then used to compute the remainder of the occupations.
- A comparison of the ITRF values and the official values is provided in the supplied spreadsheet “ITRF2 Compare”.

This schedule below is an extract from the spread sheet GG1585 ITRF2 COMPARE and shows the direct comparison between the static observed coordinates and the official values.

TRIGNET STATIONS		DY	DX
CALV	CALVINIA	0.391	0.626
LGBN	LANGEBAAN	0.487	0.546
MALM	MALMESBURY	0.450	0.566
	MEANS ADOPTED	**0.443**	**0.579**

There is a systematic shift to be applied. The means above are used for final calculations.

Comparing calculated coordinates to official published coordinates:

CLANWILLIAM TRIG BEACONS		DY	DX
TR4		0.400	0.525
TR63		0.362	0.490
TR66		0.409	0.570

KLAVER TRIG BEACONS		DY	DX
TR77		0.437	0.591
TR91		0.431	0.564
TR95		0.424	0.567
LUTVILLE TRIG BEACONS		DY	DX
TR102		0.415	0.540
TR110		0.431	0.509
TR114		0.433	0.559
CLANWILLIAM NATIONAL ROAD RESERVE BEACONS		DY	DX
NRB8-11		0.404	0.521
NRB19-11		0.431	0.536
LUTZVILLE NATIONAL ROAD RESERVE BEACONS		DY	DX
NRB133-11		0.445	0.587
NRB148-11		0.454	0.549
NRB162-11		0.460	0.579
NRB172-11		0.439	0.583
	OVERALL MEANS	**0.425**	**0.551**

- The above shows a high degree of consistency in comparison of coordinates of the trig beacons and National Road Beacons in the immediate vicinity of each project area.
- The mean differences obtained from the Trignet Stations are very similar to the mean differences found at the trig beacons at each Site and at the SANRAL NRB beacons surveyed.

- I decided to adopt the mean shift obtained from the Trignet beacons to apply to all beacons coordinates to yield final coordinates on the Hartebeeshoek WGS84 coordinate system. The comparisons are then shown in this same spreadsheet and shown below.

  This schedule below is an extract from the spread sheet "G1585 ITRF2 COMPARE" and shows the direct comparison between the static observed coordinates adjusted for a systematic shift found at the Trig Net beacons and the official values. This gives a direct comparison between the finally adopted values and official values

TRIGNET STATIONS		DY	DX
CALV	CALVINIA	0.052	-0.047
LGBN	LANGEBAAN	-0.044	0.033
MALM	MALMESBURY	-0.007	0.013
	MEAN SHIFT	0.000	0.000
CLANWILLIAM TRIG BEACONS		DY	DX
TR4		0.043	0.054
TR63		0.081	0.089
TR66		0.034	0.009
KLAVER TRIG BEACONS		DY	DX
TR77		0.006	-0.012
TR91		0.012	0.015
TR95		0.019	0.012
LUTVILLE TRIG BEACONS		DY	DX
TR102		0.028	0.039
TR110		0.012	0.070
TR114		0.010	0.020

CLANWILLIAM NATIONAL ROAD RESERVE BEACONS		DY	DX
NRB8-11		0.039	0.058
NRB19-11		0.012	0.043
LUTZVILLE NATIONAL ROAD RESERVE BEACONS		DY	DX
NRB133-11		-0.002	-0.008
NRB148-11		-0.011	0.030
NRB162-11		-0.017	0.000
NRB172-11		0.004	-0.004
	AVE. DIFFERENCES	**0.004**	**0.020**

- No Network Adjustment was used in the survey processing. Instead, a systematic shift was applied as described above.

Establishment of vertical survey control

- Reference should be made to the working plan provided to indicate the line levels that were observed and calculation spreadsheet “G1585 MEANS”.
- SANRAL National Road Beacons were adopted for control point level calculations. These SANRAL beacons are based on the National Precise Level network and are far more accurate than adopting trigonometrical beacon elevations.
- Two levelling teams were used to do the levelling.
- Two peg tests were done every day for each of the two instruments used and no unexpected differences were found.
- No differences between forward and reverse levelling were out of THM11 specification.

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ITRF GPS heights are corrected for a systematic shift at the Three Trignet stations of +0.087 and then a localised shift based on the NRB beacons of-0.094. Levelled heights are based on NRB beacons and National Benchmark heights as explained in below

CLANWILLIAM SITE

BASED ON HEIGHT DERIVED FROM GPS OBS TO NRB8-11 AND NRB19-11
(There is no direct comparison to level benchmarks on this site)

					FINAL			MEAN-
FROM	**TO**	**DIFF**	**TMH11**	**NAME**	**HEIGHT**		**GPS OBS**	**GPS OBS**
				P02	196.943		196.937	0.006
P02	83A	-0.003	0.012					
83A	83B	-0.009	0.009					
83B	P01	0.002	0.011	P01	184.178		184.183	-0.005
		-0.010	0.019					
P01	CP1	-0.014	0.017					
CP1	P04	-0.006	0.021	P04	119.694		119.697	-0.003
		-0.020	0.027					
P04	CP2	-0.005	0.014					
CP2	P03	0.002	0.015	P03	200.987		200.991	-0.005
		-0.003	0.021					

KLAWER SITE

BASED ON NRB LISTED HEIGHTS

					FINAL			FINAL-
FROM	**TO**	**DIFF**	**TMH11**	**NAME**	**HEIGHT**		**GPS OBS**	**GPS OBS**
				NRB133	81.376		81.387	-0.011
NRB133	NRB146	0.006	0.021	NRB146	67.961			
NRB146	NRB148	0.003	0.008	NRB148	65.631		65.641	-0.010
NRB148	NRB151	-0.008	0.010	NRB151	70.729			
NRB151	NRB157	0.014	0.012	NRB157	59.484			
NRB157	NRB162	-0.007	0.012	NRB162	69.232		69.257	-0.025
NRB162	NRB165	-0.004	0.012	NRB165	60.491			

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NRB165	NRB167	-0.004	0.009	NRB167	66.410			
NRB167	NRB172	0.015	0.013	NRB172	81.413		81.419	-0.006
NRB172	NRB178	-0.001	0.014	NRB178	80.836			
NRB178	SK26	-0.013	0.015					
SK26	SK25	0.012	0.017					
SK25	SK12	-0.016	0.018					
SK12	P16	-0.004	0.013	P16	47.800		47.761	0.039
				P05	67.955		67.945	0.009
P05	SK24	0.010	0.013					
SK24	P17	0.000	0.013	P17	88.158		88.135	0.023
					88.158			
P17	SK23	-0.005	0.012					
SK23	P14	0.001	0.013	P14	82.741		82.702	0.039
				P14	82.741			
P14	SK22	0.002	0.008					
SK22	SK21	0.007	0.017					
SK21	P06	0.007	0.012	P06	58.658		58.630	0.028
		0.016	0.023					
				P06	58.658			
P06	SK20	0.002	0.012					
SK20	P13	-0.006	0.016	P13	90.891		90.865	0.026
		-0.004	0.020					
					90.891			
P13	SK19	-0.005	0.011					
SK19	P07	-0.005	0.020	P07	81.155		81.093	0.062
				P07	81.155			
P07	SK18X	0.012	0.012					
SK18X	SK17	0.004	0.010					
SK17	SK16	0.002	0.012					
SK16	SK15	0.004	0.013					
SK15	SK14	-0.004	0.013					
SK14	P08	-0.003	0.011	P08	83.476		83.433	0.042

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				P08	83.476			
P08	SK13	0.012	0.007					
SK13	SK12	-0.002	0.013					
SK12	P16	-0.004	0.013	P16	47.800		47.761	0.039
				P16	47.800			
P16	SK11	0.013	0.013					
SK11	SK10	-0.005	0.013					
SK10	P09	0.006	0.014	P09	63.519		63.489	0.030

LUTZVILLE SITE

BASED NO LEVELING BENCHMARKS

THIS DOES INTRODUCE A DIFFERENCE WITH GPS HEIGHTS BUT ACCEPT THE BENCHMARK HEIGHTS

					FINAL			FINAL-
FROM	**TO**	**DIFF**	**TMH11**	**NAME**	**HEIGHT**		**GPS OBS**	**GPS OBS**
				P18	19.833		19.800	0.033
P18	5A18	0.004	0.015		57.975			
5A18	SBU1	-0.009	0.015					
SBU1	SBU2	-0.002	0.015					
SBU2	P19	0.006	0.012	P19	36.330			
				P19	36.330		36.258	0.071
P19	5A24	0.008	0.016		42.088			
5A24	SBU3	0.010	0.014					
SBU3	SBU4	-0.002	0.013					
SBU4	P26	-0.014	0.016	P26	74.939		74.887	0.052
				P19				
P19	5A24	0.008	0.016					
5A24	P20	0.000	0.010	P20	42.062		41.977	0.085
				P20				
P20	SBU5	0.004	0.013					
SBU5	SBU6	0.004	0.012					
SBU6	SBU7	-0.003	0.011					
SBU7	P21	-0.003	0.013	P21	6.868		6.739	0.129

				P21				
P21	SBU8	-0.005	0.016					
SBU8	P25	-0.005	0.010	P25	54.032		53.919	0.113
				P25				
P25	SBU9	-0.004	0.015					
SBU9	P24	0.005	0.016	P24	77.244		77.140	0.104
		0.000	0.022					
				P24				
P24	SBU10	0.004	0.011					
SBU10	P22	0.010	0.010	P22	33.751		33.661	0.090
				P22				
P22	SBU11	0.001	0.012					
SBU11	SBU12	0.002	0.012					
SBU12	P23	-0.013	0.013	P23	62.089		62.000	0.089

- The Clanwilliam site was linked to NRB8-11 and NRB19-11 by GPS observations. The differences found here were applied to get GPS height at SG194201. This was used to base the levels on. Final spirit levelled heights are compared with GPS heights with a high degree of difference.
- The Klawer site was based on the mean differences found at the 9 NRB's. found. The comparisons with GPS values at all the beacons, was good.
- The Lutzville site was based on two National Level Benchmarks found on site. The comparisons with GPS observations shows a constant difference of about 0.1m

Cadastral Information:

- The Digital Cadastral Compilation was obtained from the Surveyor-General office in Cape Town. A diagram or General Plan was downloaded from the Surveyor-General for each property. A visual inspection was carried out to see if there were any obvious differences. The back of each diagram was inspected to see if all the deductions and servitudes had been considered.

- An Aktex printout was obtained for each property in the area and present owner details added.
- Four arch-lever files will be supplied indicating the data consulted.

Delays due to unforeseen circumstances:

None

Survey Projection System and height datum:

Projection: WGS84 LO 19
Height Datum: Mean Sea Level as defined by existing NRB Beacons and two National Benchmarks

Accuracies obtained and out of Specification Tolerances accepted.

The horizontal accuracy conforms to Class A.

The vertical accuracy was within TMH11 specification.

Records submitted:

A separate schedule will be provided as an Annexure A to this report.

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ANNEXURE A

SURVEY CONTROL FOR AERIAL MAPPING OF THREE SITES NEAR CLANWILLIAM KLAWER AND LUTZVILLE

DIRECTORIES AND FILES ON CD

G1585 CADASTRAL

G1585 Matzikama Cederberg Mun.dwg
G1585 Matzikama Cederberg Mun.kmz

G1585 CALCULATIONS AND WORKING PLAN

G1585 CALCULATIONS YX

G1585 FINAL COORDINATE LIST.xls
G1585 ITRF2 COMPARE - FINAL COORDINATES.xls

G1585 CALCULATIONS Z

G1585 MEANS.xls
G1585 RUIDE LEVELING.xls
G1585 TRIMBLE LEVELING.xls

G1585 WORKING PLAN.dwg
G1585 WORKING PLAN.kmz

G1585 PICS

*.JPG

G1585 REPORT

G1585 SURVEY Report.doc
G1585 ANNEXURE A - index of info supplied.xls

G1585 STATION INFO

G1585 STATION FIELD BOOK SHEETS

G1585 STATION FIELD BOOK SHEETS.pdf

G1585 STATION SHEETS

STATION NAME.xls

G1585 GPS DATA SHEET.xls

G1585-GPS-RAW

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G1585 LEICA-RAW

Various data files in subdirectories

G1585 TOPCON HIPERLITE - RAW

Various data files in subdirectories

G1585 RINEX

Various data files

G1585-LEVELING-RAW

Various RAW data files in subdirectories

G1585 RAW DATA LEVELING

Various RAW data files in subdirectories

HARD COPY SUPPLIED

FROM CD

G1585 FINAL COORDINATE LIST.xls
G1585 ITRF2 COMPARE - FINAL COORDINATES.xls
G1585 MEANS.xls
G1585 SURVEY Report.doc
G1585 GPS DATA SHEET.xls

OTHER

4 Arch-lever Box Files

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