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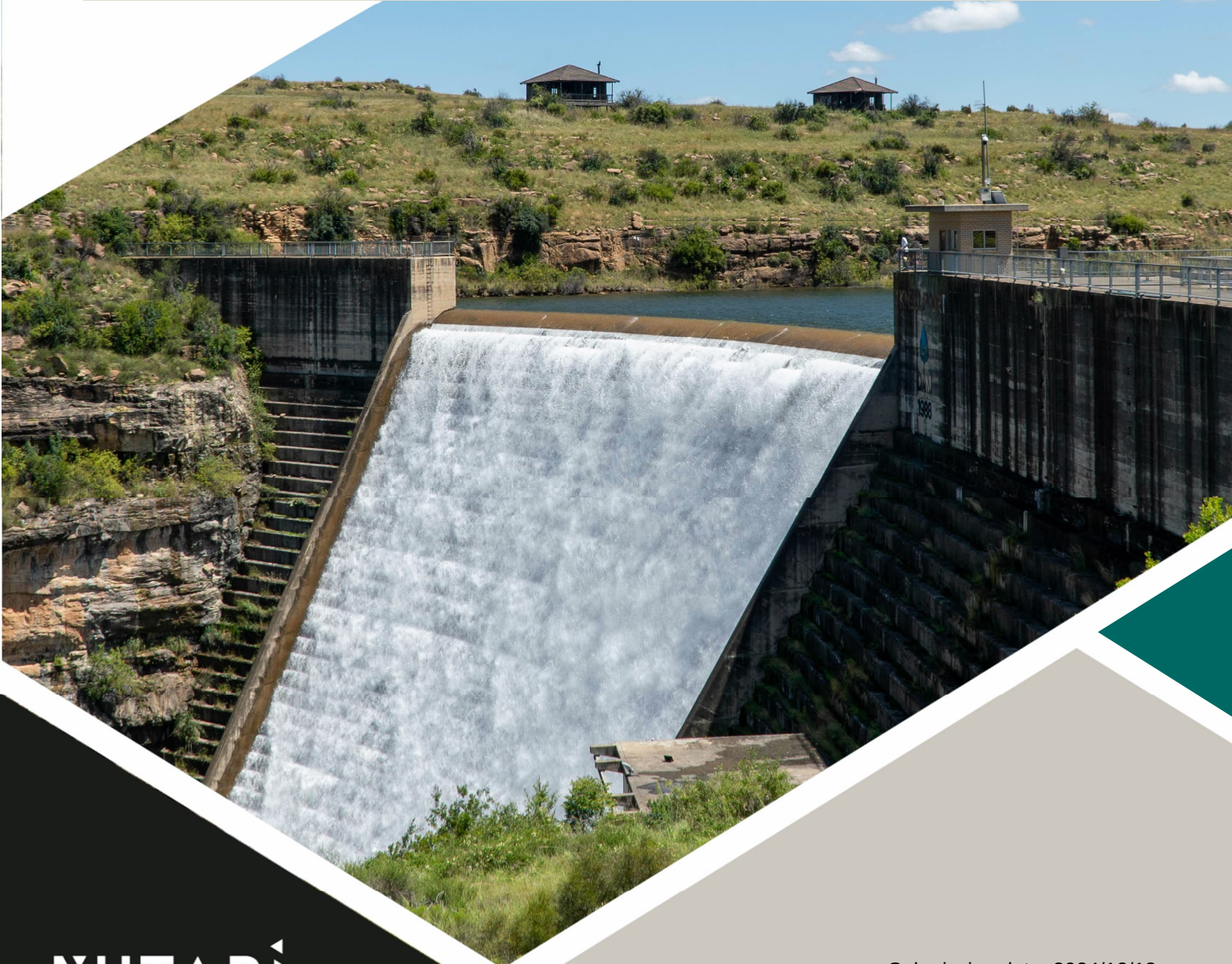
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Greater Mangaung Water Augmentation Project

Topographical Survey and Mapping Report

Xhariep Pipeline Feasibility Study





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Directorate Water Resource Development Planning

Topographical Survey and Mapping Report

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DWS Report Number	:	P WMA 06/D00/00/3423/8
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Report Structure

This report forms part of the following suite for the study:

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4	Data Analysis and Collection Report	P WMA 06/D00/00/3423/4
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7	Geological and Materials Investigations Report	P WMA 06/D00/00/3423/7
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9	Feasibility Design Report - Pipeline, Pump Stations & Reservoirs	P WMA 06/D00/00/3423/9
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11	Feasibility Design Report - Water Treatment Works	P WMA 06/D00/00/3423/11
12	Land Matters	P WMA 06/D00/00/3423/12
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17	Water Use License Application Summary Report	P WMA 06/D00/00/3423/17
18	Integrated Water and Waste Management Plan	P WMA 06/D00/00/3423/18
19	Water Resource Analysis Report	P WMA 06/D00/00/3423/19

Reference

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DWS Report Number: P WMA 06/D00/00/3423/8

Prepared by Zutari (Pty) Ltd

Executive Summary

The Department: Water and Sanitation (DWS) has appointed Zutari for Contract WP11405-142213 to render multi-disciplinary professional services for the Xhariep Pipeline Feasibility Study which forms part of the Greater Mangaung Water Augmentation Project originally identified by the 2012 Reconciliation Strategy. There have been previous independent studies, but each differed in conclusion. The appointment from DWS aims to consolidate the information and consider the Xhariep Pipeline from a national and regional perspective.

The Water Reconciliation Strategy Study for the Larger Bulk Water Supply Systems: Greater Bloemfontein Area (DWS, 2012) (henceforth referred to as the “2012 Reconciliation Strategy”) identified that the Greater Bloemfontein Water Supply System (GBWSS) would need to secure a sustainable water supply for the future water demands in the area. The 2012 Reconciliation Strategy recommended that the development of a major surface water augmentation scheme should be given consideration as a possible option in conjunction with the implementation of various other interventions.

Following the 2012 Reconciliation Strategy, the area experienced water shortages and the investigation of a major surface water augmentation scheme option, now called the Greater Mangaung Water Augmentation Project – Xhariep Pipeline, was accelerated. The Department of Water and Sanitation (DWS, the Client) appointed Zutari in November 2022 to complete the pre-feasibility study, which included reviewing all previous studies, and to undertake the detailed feasibility study of the scheme approved at the end of the pre-feasibility phase of the project.

To undertake the detailed feasibility design, a topographical survey is required of the study area. A competitive tender process was undertaken to appoint a professional service provider for the topographical survey, which resulted in Joubert & Brink Surveys being appointed.

This report summarises the topographical survey and mapping undertaken for the project area. It details the scope, the verification of outputs and the deliverables produced as part of this task. At the end of the report, contact details are provided of respective companies and individuals that can be contacted should any clarification in future be needed of the topographical data produced under this project.

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Acronyms and Abbreviations

ASPRS	:	American Society for Photogrammetry and Remote Sensing
CAD	:	Computer-Aided Design
DEM	:	Digital Elevation Model
DGN	:	Design File format used by MicroStation
DTM	:	Digital Terrain Model
DXF	:	Drawing Exchange Format
DWG	:	Drawing File format used by AutoCAD
ECW	:	Enhanced Compression Wavelet
GCP	:	Ground Control Point
GeoTiff	:	Geo-referenced Tagged Image File Format
GSD	:	Ground Sampling Distance (Centimeter per Pixel)
IGS	:	International GPS Service
ITRF	:	International Terrestrial Reference Frame
KMZ	:	Keyhole Markup Language Zipped file format (Google Earth)
LAS	:	LiDAR Data Exchange Format
LiDAR	:	Light Detection and Ranging
Lo Lo27)	:	Central Meridian Reference (referring to various Lo systems like Lo25, Lo26,
MSL	:	Mean Sea Level
NRB	:	National Road Beacon
POSPac MMS	:	Post-Processed Kinematic Mobile Mapping System
PPS	:	Points per square meter
RMSE	:	Root Mean Square Error
RTK	:	Real Time Kinematic
SAG2010	:	South African Geoid 2010 Model
TMH11	:	Technical Methods for Highways
WGS84	:	World Geodetic System 1984

1 Project Overview

1.1 Introduction

Scheme 1B was the option approved by Department of Water and Sanitation (DWS) at the end of the pre-feasibility study for which the detailed feasibility design needs to be undertaken. To undertake the detailed feasibility design, a topographical survey is required of the study area. A competitive tender process was undertaken to appoint a professional service provider for the topographical survey, which resulted in Joubert & Brink Surveys being appointed.

Joubert & Brink Surveys conducted the ground surveys and used African Consulting Surveyors to conduct the aerial and lidar survey on their behalf. The aerial and lidar survey was undertaken to produce rectified colour images and a digital terrain model (DTM) of the surveyed project area.

The aerial 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. The average points per square meter (pps) was eight (8) on the bulk of the survey, except for areas with bridge or culvert structures where the density was increased to 50 points per square meter.

Digital colour images were 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. Table 1-1 summarises the Lidar imagery resolution.

Table 1-1: Lidar imagery resolution information

Aerial Survey	Resolution
Lidar (Project Area)	8 points per square meter (pps)
Lidar (Structure Areas)	50+ pps
Ortho Imagery	10 Ground Sampling Distance (GSD)

1.2 Equipment Used

Table 1-2 and Table 1-3 list the equipment used to collect the lidar and topographical information respectively.

Table 1-2: Equipment used for lidar information data collection

Equipment	Model
Aircraft	ZS-MBU/ZS-JEO
Laser scanner	Q780/Vux240
Camera	Sony Alpha7R4-24mm/Phase1-50mm

Table 1-3: Equipment used for topographical information data collection

Equipment	Model
Total Station	Leica TS06 Psion Workabout
GNSS System	Trimble R6 Base Trimble R8 Rover Trimble R8s Base and Rover

Equipment	Model
Levelling	Leica Sprinter Barcoded Staff

1.3 Project Extent

The total of the surveyed project area is approximately 15,439 ha as shown in Figure 1-1 and Figure 1-2 respectively.

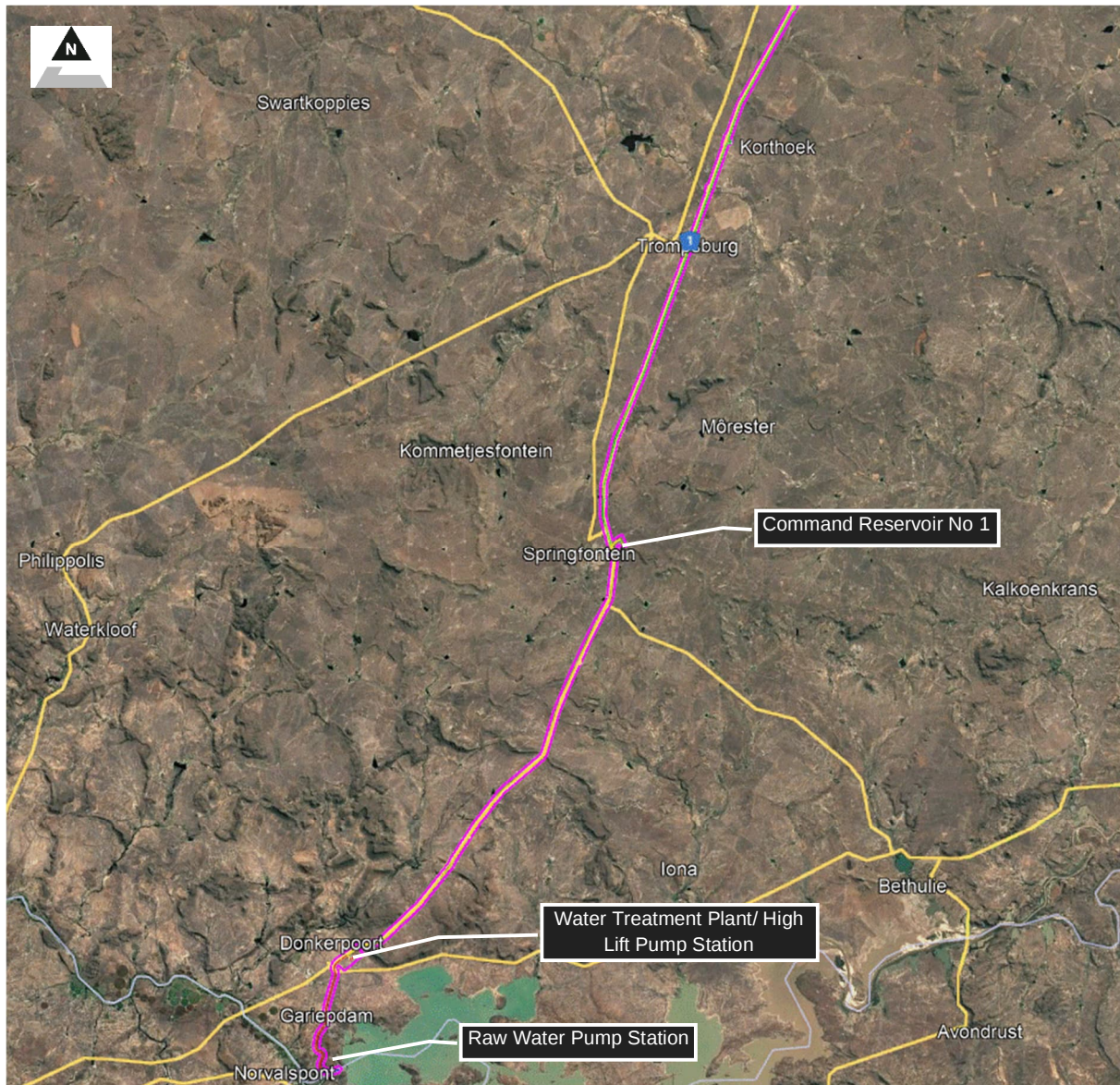


Figure 1-1: Locality map – Lo25

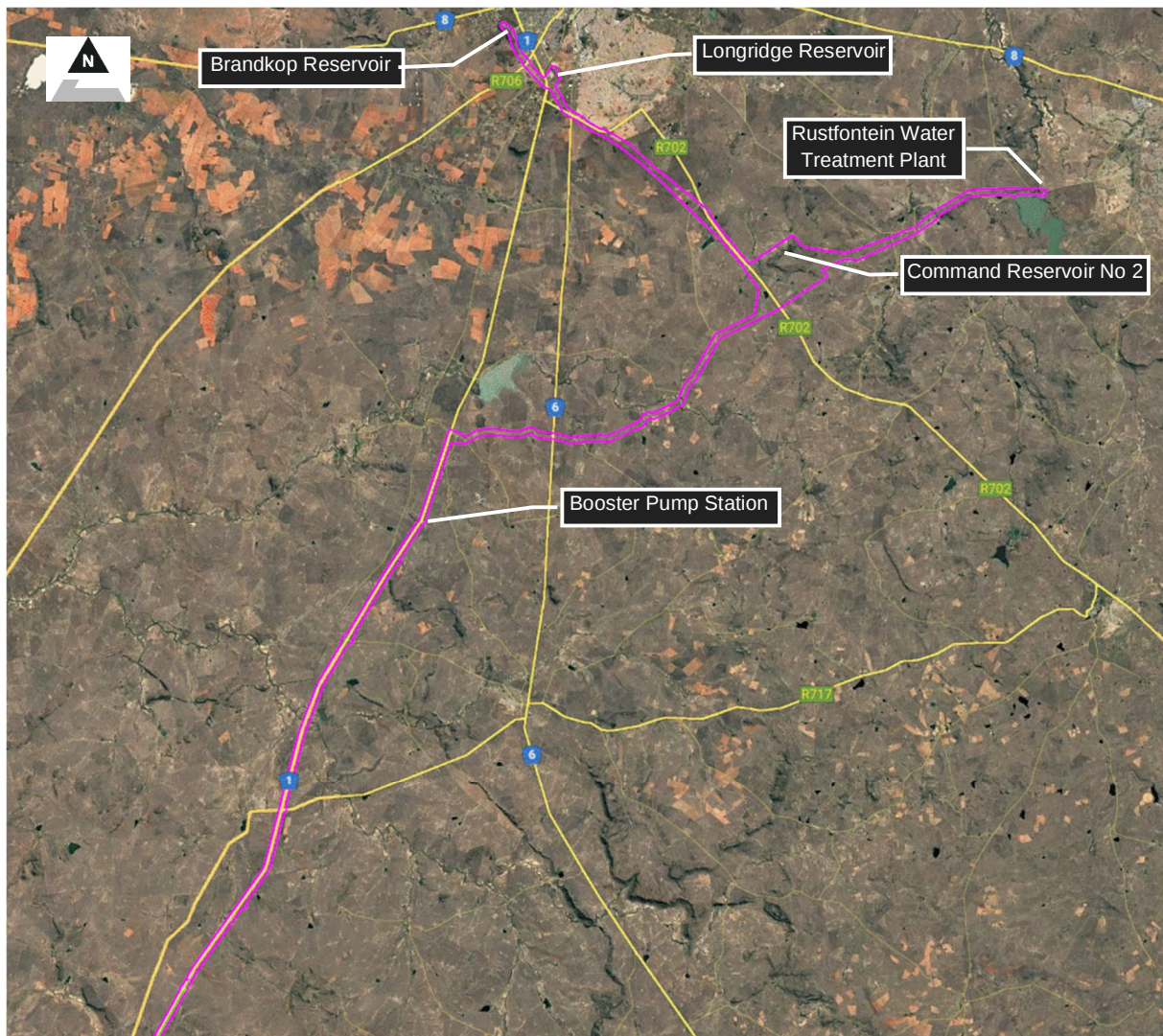


Figure 1-2: Locality map – Lo27

1.3.1 Lo Co-ordinate Systems

The project extends across the boundary line (Lo26) between two Lo systems; Lo25 and Lo27. The Technical Methods for Highways TMH11, Standard Survey Methods, allows the origin Lo to be used should the survey not extend 15 minutes beyond the Lo system. Figure 1-3 illustrates that the survey area extends beyond 15 minutes for both the Lo25 or Lo27 systems.

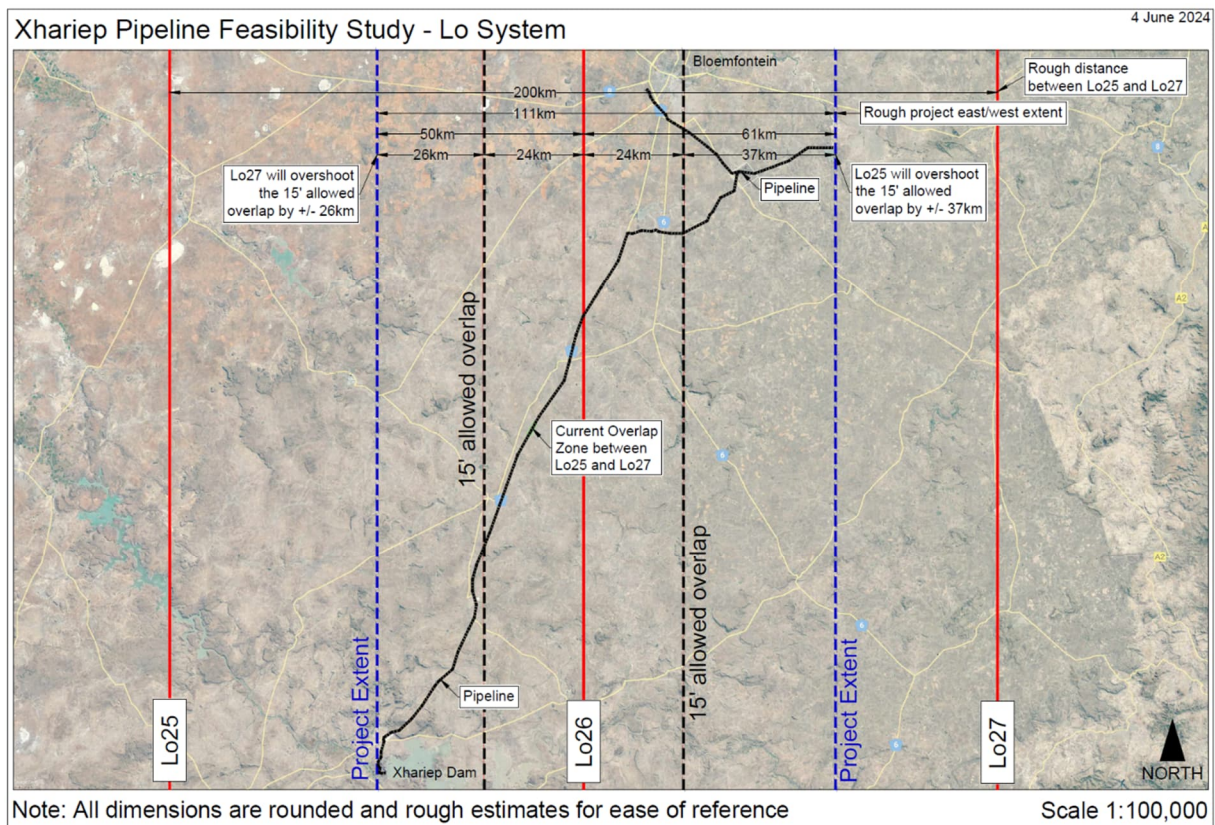


Figure 1-3: Xhariep Pipeline Feasibility Study: Lo System

Furthermore, the Technical Methods for Highways TMH11, Standard Survey Methods states, “It is not permissible to have two survey systems on one electronic CAD sheet. At Lo changes a common sheet which is located on both systems must be duplicated where each is in reference to the relevant Lo system. Continuous Models must be submitted in two separate files where both reflect the overlapping section relevant to the particular Lo system.”

The Lo system is approximately 200km wide and therefore 15 minutes translates to approximately 24km. This project extends 61km east of Lo26 and 50km west of Lo26. In the former, it is 37 km over the 15-minute limit and on the latter, it is 26km over the 15-minute limit. This project has therefore been conducted with two Lo systems, both with its own control, survey data and cadastral information. The overlap is approximately 1km in width.

1.3.2 Topographical Survey Areas Excluded

Sections of the proposed pipeline route and infrastructure tie-in locations required access to the surveyor to survey details (e.g. invert and soffit levels) of the structures.

Access to sections of the project were not granted by the respective landowners and/or authorities. As such, no detailed topographical surveys are available at structures located with the following sections:

- ▶ Farm Lieuw Kop No. 101 (refer to Figure 1-4)
- ▶ Farm Zuurfontein No. 266 (refer to Figure 1-4)
- ▶ Farm Linde's Vley No. 908 (refer to Figure 1-4)
- ▶ Farm Bewee No. 93 (refer to Figure 1-4)
- ▶ Farm Helderpoort No. 907 (refer to Figure 1-4)
- ▶ Farm Erfpos No. 1465 (refer to Figure 1-4)
- ▶ Farm Annex No. 2522 (refer to Figure 1-4)
- ▶ Brandkop reservoir (refer to Figure 1-5)
- ▶ Rustfontein River Stream (authorities removed the surveyor from site whilst bush clearing: refer to Figure 1-4)

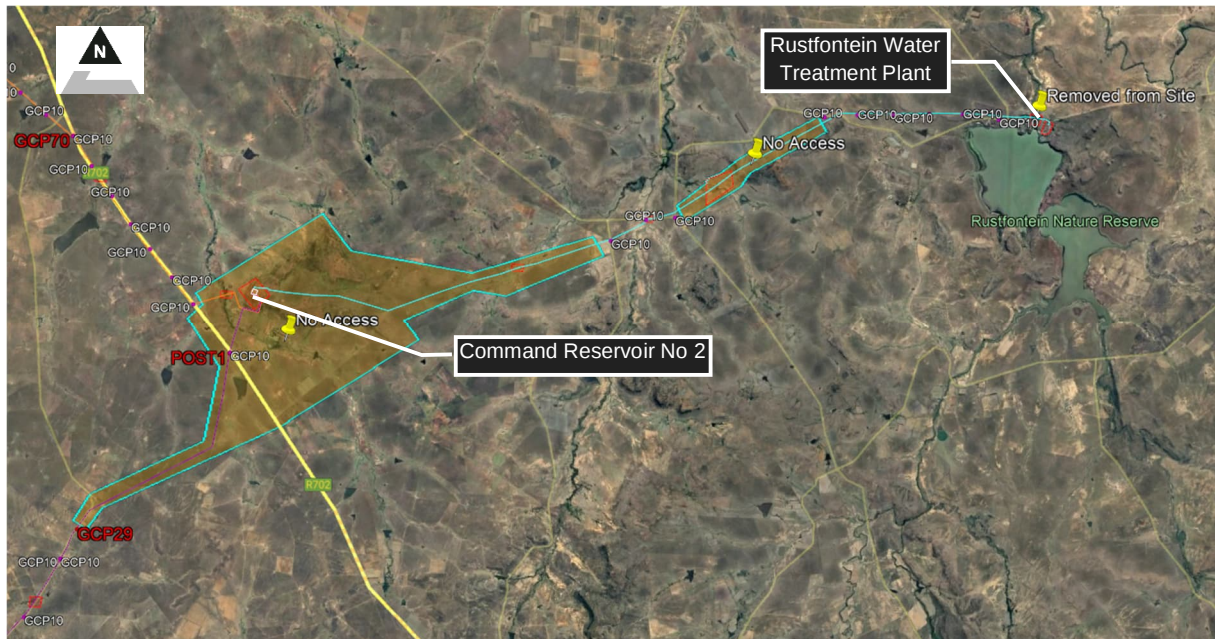


Figure 1-4: No access area near Command Reservoir No 2

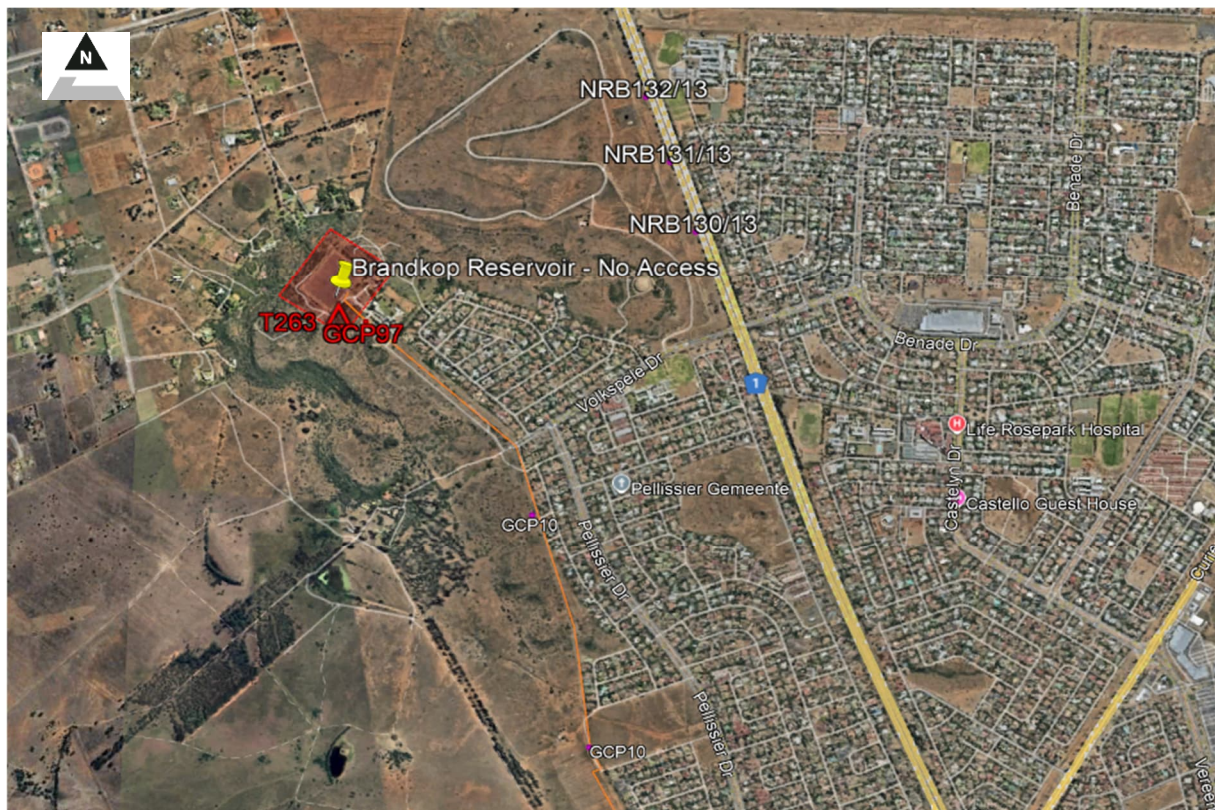


Figure 1-5: No access area near Brandkop Reservoir

1.3.3 Control Point surveys excluded

Joubert & Brink installed ground control points (GCPs) along the entire pipeline route, spaced 1km apart. In the Lo27 section, no access was granted to the hatched areas shown in Figure 1-4 and Figure 1-5, meaning that no GCPs could be installed in these areas.

2 Ground Survey

2.1 Ground Control Points

Ground control points were installed and surveyed by Joubert and Brink and their coordinate values were used for the vertical and horizontal checks on the full aerial LiDAR survey.

A spreadsheet with a list of existing control points in both the Lo25 and Lo27 sections was provided to Joubert and Brink to supplement the number of benchmarks installed under this project.

All controls were fixed from existing National Road Beacons (NRB) located along the N1 for the Lo25 survey area. Most of the NRB for this section were, however, either destroyed due to construction activities by others or not found on site. A traverse therefore had to be completed between existing beacons located and calibrated to both sides. All controls for this section were double levelled, i.e. levelled from a known point through the unknown points and then closed back on a known point.

Most of the existing NRB were found for the Lo27 survey area. NRB and Trig beacons were used to fix this section of the project area. Along the N1 section of the area, only NRB were used to fix new control. The points along the N1 were double levelled from NRB beacons. The rest of the rural farmland were fixed using Trig beacons and NRB beacons. A Post Processing method was used to fix points at strategic locations. These points, together with NRB and Trig beacons, were used to undertake the traverse, whereafter calibrations were completed on both ends of the survey.

The Hartebeesthoek94 Lo25 and Lo27 datum was used. The coordinates for the Lo25 and Lo27 ground control points are listed in Table 2-1 and Table 2-2, respectively.

Table 2-1: Ground control points coordinates: Lo25

Name	Known Y	Known X	Orthometric Height (masl)
GCP200	-47,966.358	3,389,494.669	1,215.865
GCP201	-46,435.486	3,389,325.917	1,247.393
GCP202	-46,332.329	3,389,374.854	1,240.824
GCP203	-46,604.821	3,389,623.217	1,211.607
GCP204	-46,192.372	3,389,450.041	1,229.773
GCP205	-46,678.510	3,388,351.930	1,277.966
GCP206	-46,115.423	3,387,708.299	1,311.232
GCP207	-46,325.545	3,386,693.629	1,287.629
GCP208	-46,923.887	3,385,856.042	1,275.746
GCP209	-46,941.132	3,384,822.980	1,267.854
GCP210	-47,188.447	3,383,820.733	1,272.783
GCP211	-47,483.664	3,382,846.611	1,263.399
GCP212	-47,710.913	3,381,858.865	1,267.729
GCP213	-47,534.272	3,381,526.239	1,268.355
GCP214	-47,895.335	3,380,967.076	1,269.141
GCP215	-48,277.767	3,380,693.095	1,273.771
GCP216	-48,724.691	3,380,393.004	1,283.758
GCP217	-49,047.554	3,380,172.755	1,295.599
GCP218	-49,687.878	3,379,788.532	1,321.673
GCP219	-50,650.589	3,379,563.408	1,343.228

Name	Known Y	Known X	Orthometric Height (masl)
GCP220	-51,563.962	3,379,193.351	1,350.647
GCP221	-52,402.383	3,378,404.350	1,355.286
GCP222	-53,032.356	3,377,832.075	1,353.613
GCP223	-53,742.099	3,377,195.072	1,331.613
GCP224	-54,396.142	3,376,597.616	1,352.428
GCP225	-55,144.833	3,375,701.939	1,350.723
GCP226	-55,774.593	3,374,927.396	1,346.023
GCP227	-56,406.320	3,374,150.529	1,353.237
GCP228	-57,027.262	3,373,361.612	1,365.630
GCP229	-57,545.930	3,372,506.678	1,365.408
GCP230	-58,098.258	3,371,675.866	1,367.773
GCP231	-58,652.284	3,370,842.336	1,368.567
GCP232	-59,257.474	3,369,932.211	1,398.238
GCP233	-59,936.892	3,369,058.064	1,400.607
GCP234	-60,431.531	3,368,436.639	1,395.344
GCP235	-61,123.918	3,367,555.532	1,412.338
GCP236	-61,791.063	3,366,987.755	1,420.200
GCP237	-62,613.538	3,366,319.334	1,430.126
GCP238	-63,344.601	3,365,725.053	1,442.969
GCP239	-63,845.161	3,365,321.713	1,459.977
GCP240	-64,590.838	3,364,491.397	1,465.033
GCP241	-64,949.203	3,363,322.806	1,441.600
GCP242	-65,248.579	3,362,357.512	1,445.890
GCP243	-65,480.085	3,361,611.980	1,471.868
GCP244	-65,938.179	3,360,460.509	1,465.573
GCP245	-66,318.415	3,359,567.645	1,471.199
GCP246	-66,743.059	3,358,565.223	1,482.424
GCP247	-67,125.780	3,357,798.862	1,459.902
GCP248	-67,587.296	3,356,845.515	1,459.145
GCP249	-68,019.931	3,355,952.115	1,457.023
GCP250	-68,442.672	3,355,082.775	1,466.999
GCP251	-68,939.024	3,354,184.519	1,464.101
GCP252	-69,432.032	3,353,301.677	1,480.284
GCP253	-69,896.490	3,352,426.699	1,486.598
GCP254	-70,055.547	3,351,470.799	1,493.874
GCP255	-70,190.132	3,350,444.497	1,514.749
GCP256	-70,056.685	3,351,462.167	1,494.160
GCP257	-70,311.777	3,349,446.706	1,535.715
GCP258	-70,100.871	3,348,481.965	1,538.179
GCP259	-70,054.893	3,348,254.990	1,535.054
GCP260	-69,858.338	3,347,496.329	1,532.448

Name	Known Y	Known X	Orthometric Height (masl)
GCP261	-69,609.223	3,346,535.092	1,534.370
GCP262	-69,442.053	3,345,757.812	1,540.419
GCP263	-69,476.642	3,344,595.586	1,526.662
GCP264	-69,511.189	3,343,559.830	1,531.277
GCP265	-69,613.057	3,342,988.754	1,530.344
GCP266	-69,874.336	3,342,027.742	1,534.100
GCP267	-70,124.117	3,341,052.345	1,528.951
GCP268	-70,391.670	3,340,100.288	1,510.939
GCP269	-70,740.881	3,339,161.866	1,505.784
GCP270	-71,147.697	3,338,247.391	1,498.669
GCP271	-71,546.431	3,337,328.152	1,492.885
GCP272	-72,005.323	3,336,284.007	1,499.703
GCP273	-72,349.773	3,335,499.548	1,497.831
GCP274	-72,775.132	3,334,535.806	1,495.357
GCP275	-73,103.104	3,333,648.011	1,482.549
GCP276	-73,464.325	3,332,712.982	1,476.998
GCP277	-73,887.107	3,331,593.342	1,477.300
GCP278	-74,155.244	3,330,836.476	1,469.164
GCP279	-74,513.726	3,329,908.188	1,457.101
GCP280	-74,846.824	3,329,017.882	1,445.604
GCP281	-75,178.608	3,328,141.825	1,445.990
GCP282	-75,554.642	3,327,097.137	1,430.068
GCP283	-75,918.016	3,326,155.576	1,423.891
GCP284	-76,246.303	3,325,216.957	1,428.403
GCP285	-76,596.133	3,324,273.255	1,416.391
GCP286	-77,018.031	3,323,135.303	1,404.142
GCP287	-77,417.334	3,322,058.020	1,396.492
GCP288	-77,808.753	3,321,002.231	1,395.505
GCP289	-78,168.708	3,320,029.288	1,387.474
GCP290	-78,496.603	3,319,146.174	1,390.021
GCP291	-78,816.386	3,318,283.612	1,393.878
GCP292	-79,151.443	3,317,379.541	1,403.719
GCP293	-79,499.071	3,316,442.022	1,410.917
GCP294	-79,836.791	3,315,529.854	1,416.049
GCP295	-80,193.721	3,314,566.803	1,427.603
GCP296	-80,516.923	3,313,695.039	1,438.043
GCP297	-81,096.046	3,312,535.552	1,439.875
GCP298	-81,650.791	3,311,559.568	1,437.454
GCP299	-82,291.658	3,310,433.973	1,437.408
GCP299A	-82,784.298	3,309,566.736	1,438.278
GCP299B	-83,298.664	3,308,662.095	1,437.691

Name	Known Y	Known X	Orthometric Height (masl)
GCP299C	-83,776.386	3,307,823.215	1,440.292
GCP300	-84,286.605	3,306,961.846	1,444.460
GCP301	-84,783.682	3,306,094.910	1,450.593
GCP302	-85,277.366	3,305,226.381	1,457.609
GCP500	-46,324.214	3,389,614.346	1,223.022
GCP501	-46,532.089	3,389,771.407	1,207.570
GCP502	-48,404.202	3,381,735.301	1,272.415
GCP503	-48,236.423	3,381,548.272	1,273.851
GCP504	-47,956.529	3,381,294.858	1,272.652
GCP505	-48,497.878	3,381,047.418	1,276.292
GCP506	-48,786.797	3,380,750.568	1,281.143
GCP507	-49,276.891	3,380,429.144	1,295.667
GCP508	-49,662.943	3,380,756.932	1,292.723
GCP509	-49,188.970	3,381,205.745	1,283.664
GCP510	-48,850.687	3,381,342.819	1,279.243
GCP511	-70,312.626	3,347,951.007	1,537.662
GCP512	-70,763.563	3,347,722.654	1,547.523
GCP513	-70,812.384	3,347,961.098	1,556.973
GCP514	-71,003.705	3,348,243.346	1,575.537
GCP515	-71,189.778	3,348,182.993	1,570.778
GCP516	-71,083.530	3,347,844.677	1,556.343
GCP517	-70,990.616	3,347,555.447	1,547.022

Table 2-2: Ground control points coordinates: Lo27

Name	Known Y	Known X	Orthometric Height (masl)
GCP10	78,782.209	3,259,638.607	1,409.003
GCP11	77,724.798	3,259,701.912	1,414.651
GCP12	76,707.884	3,259,886.838	1,407.506
GCP13	75,659.503	3,259,919.696	1,408.505
GCP13	75,659.503	3,259,919.696	1,408.505
GCP14	74,762.732	3,259,849.485	1,420.434
GCP15	73,741.337	3,259,808.151	1,440.280
GCP16	72,779.183	3,259,726.232	1,426.766
GCP17	71,888.660	3,259,313.866	1,421.688
GCP18	70,989.977	3,258,860.539	1,426.824
GCP19	70,179.167	3,258,304.914	1,423.227
GCP2	85,815.837	3,260,065.695	1,405.773
GCP20	69,434.197	3,257,947.212	1,414.268
GCP21	68,530.913	3,257,565.875	1,417.967
GCP22	67,634.861	3,257,103.667	1,417.924
GCP24	66,958.879	3,256,344.844	1,422.755

Name	Known Y	Known X	Orthometric Height (masl)
GCP25	66,654.382	3,255,495.339	1,428.904
GCP26	66,018.389	3,254,748.971	1,429.160
GCP27	65,032.955	3,253,014.770	1,440.878
GCP28	65,032.952	3,253,014.767	1,440.886
GCP29	64,591.582	3,252,139.333	1,448.297
GCP299B	109,884.086	3,308,893.477	1,437.648
GCP299C	109,421.004	3,308,046.373	1,440.271
GCP3	85,051.311	3,260,086.851	1,400.931
GCP300	108,925.814	3,307,176.208	1,444.441
GCP301	108,443.847	3,306,300.700	1,450.592
GCP302	107,965.319	3,305,423.673	1,457.572
GCP303	107,486.315	3,304,545.195	1,465.686
GCP304	106,944.240	3,303,711.232	1,455.983
GCP305	106,355.907	3,302,896.365	1,440.936
GCP306	105,774.733	3,302,077.596	1,428.126
GCP307	105,220.293	3,301,291.816	1,418.637
GCP308	104,502.307	3,300,274.970	1,414.234
GCP309	103,930.436	3,299,465.297	1,407.957
GCP310	103,352.576	3,298,646.642	1,405.472
GCP311	102,893.311	3,297,996.220	1,400.239
GCP312	102,315.824	3,297,178.039	1,396.184
GCP313	101,742.168	3,296,365.194	1,396.160
GCP314	101,297.789	3,295,471.818	1,405.510
GCP315	101,049.566	3,294,494.206	1,391.067
GCP316	100,882.563	3,293,736.453	1,388.214
GCP317	100,623.532	3,292,791.334	1,384.752
GCP318	100,386.805	3,291,844.500	1,379.711
GCP319	100,132.204	3,290,826.467	1,372.507
GCP320	99,900.035	3,289,898.457	1,368.379
GCP321	99,669.622	3,288,965.805	1,370.759
GCP322	99,427.616	3,287,956.554	1,364.924
GCP323	99,173.671	3,286,991.896	1,348.356
GCP324	98,938.897	3,286,054.107	1,344.899
GCP325	98,677.474	3,285,010.182	1,350.866
GCP326	98,382.835	3,284,068.319	1,338.464
GCP327	98,040.529	3,283,151.077	1,331.312
GCP328	97,732.725	3,282,333.997	1,331.789
GCP329	97,327.176	3,281,286.997	1,343.882
GCP330	96,966.893	3,280,376.382	1,360.618
GCP331	96,441.522	3,279,491.104	1,361.433
GCP332	95,931.848	3,278,641.076	1,361.466

Name	Known Y	Known X	Orthometric Height (masl)
GCP333	95,276.817	3,277,548.871	1,368.946
GCP334	94,775.946	3,276,714.344	1,380.146
GCP335	94,255.136	3,275,845.308	1,383.069
GCP336	93,727.812	3,274,966.086	1,405.631
GCP337	93,261.059	3,274,187.053	1,414.349
GCP338	92,858.433	3,273,516.167	1,412.698
GCP339	92,408.741	3,272,769.296	1,418.640
GCP340	91,740.722	3,271,651.763	1,429.304
GCP341	91,275.412	3,270,918.684	1,420.364
GCP342	90,723.214	3,270,058.082	1,412.976
GCP343	90,208.139	3,269,255.262	1,405.141
GCP344	89,636.635	3,268,364.021	1,403.373
GCP345	88,996.363	3,267,365.145	1,423.837
GCP346	88,645.972	3,266,798.619	1,439.223
GCP347	88,467.048	3,266,275.238	1,429.263
GCP348	88,218.470	3,265,506.895	1,412.752
GCP349	87,905.568	3,264,551.764	1,404.777
GCP350	87,597.799	3,263,607.739	1,396.213
GCP351	87,218.308	3,262,445.303	1,384.645
GCP352	86,975.472	3,261,700.014	1,386.571
GCP353	86,630.405	3,260,641.943	1,397.888
GCP354	86,426.005	3,260,031.306	1,398.710
GCP354	86,426.005	3,260,031.306	1,398.710
GCP37	60,393.202	3,246,863.423	1,427.912
GCP4	84,492.717	3,259,792.972	1,414.532
GCP48	49,503.448	3,243,105.545	1,398.233
GCP49	48,521.099	3,242,452.836	1,390.205
GCP5	83,560.345	3,259,442.110	1,428.230
GCP50	47,672.006	3,242,353.725	1,398.577
GCP518	88,546.783	3,267,194.022	1,438.651
GCP519	88,397.890	3,266,874.253	1,441.779
GCP520	88,284.668	3,266,473.728	1,432.061
GCP55	43,481.355	3,239,266.115	1,407.647
GCP56	42,522.815	3,239,151.767	1,407.156
GCP57	41,466.791	3,239,096.954	1,396.117
GCP58	40,443.274	3,239,028.554	1,408.210
GCP59	39,464.177	3,238,988.360	1,395.957
GCP6	82,535.494	3,259,402.846	1,416.207
GCP60	38,396.009	3,239,095.815	1,376.625
GCP64	61,536.055	3,245,492.432	1,420.977
GCP65	62,183.124	3,244,746.309	1,425.102

Name	Known Y	Known X	Orthometric Height (masl)
GCP66	62,859.722	3,243,967.300	1,435.452
GCP67	63,450.474	3,243,280.157	1,440.776
GCP68	64,044.489	3,242,495.735	1,415.783
GCP69	64,679.990	3,241,657.211	1,408.387
GCP7	81,579.685	3,259,513.783	1,411.628
GCP70	65,246.319	3,240,818.126	1,425.914
GCP70	65,246.340	3,240,818.079	1,425.888
GCP71	66,068.033	3,240,248.087	1,420.864
GCP72	66,840.472	3,239,641.778	1,413.928
GCP73	67,514.341	3,239,072.093	1,425.225
GCP74	68,369.126	3,238,437.535	1,423.556
GCP75	69,163.323	3,237,792.390	1,416.373
GCP76	69,977.821	3,237,142.522	1,411.977
GCP77	70,695.914	3,236,544.822	1,405.183
GCP78	71,501.961	3,235,916.112	1,410.707
GCP79	72,263.677	3,235,312.079	1,412.084
GCP8	80,535.327	3,259,563.963	1,404.288
GCP80	73,124.296	3,234,782.761	1,410.493
GCP81	74,073.048	3,234,274.466	1,417.443
GCP82	74,905.338	3,233,815.114	1,423.489
GCP83	75,671.622	3,233,370.447	1,427.323
GCP84	76,401.950	3,232,954.334	1,423.206
GCP85	76,903.835	3,232,656.026	1,418.970
GCP86	77,357.187	3,231,737.029	1,419.370
GCP87	77,865.313	3,230,889.054	1,431.644
GCP88	78,095.453	3,230,603.929	1,424.264
GCP89	77,661.690	3,230,011.734	1,437.532
GCP9	79,626.985	3,259,225.800	1,398.449
GCP90	77,923.769	3,229,256.126	1,465.782
GCP91	79,107.583	3,230,065.870	1,413.121
GCP92	79,745.404	3,229,327.938	1,414.309
GCP93	80,184.380	3,228,786.557	1,428.355
GCP94	80,768.196	3,227,960.457	1,437.588
GCP95	81,165.029	3,227,308.249	1,439.762
GCP96	81,420.445	3,226,391.710	1,465.791
GCP97	82,080.201	3,225,659.340	1,485.484

*In South Africa positive X-values are used as the standard, whereas software packages such as Civil3D uses an international survey grid that is based on negative X-values. This requires the signs of YX to be changed in the software packages to ensure the outputs are based on a Southern Hemisphere orientation.

2.2 Field Survey

Field topographical surveys were conducted for areas where bulk infrastructure comprising large structures will be located, e.g. the Raw Water Pump Station, Water Treatment Plant and High Lift Pump Station, Command Reservoir No.1 and Booster Pump Station. The field topographical survey for Command Reservoir No. 2 could not be completed due to access not provided by the landowner.

Additional field topographical surveys, which supplements the Lidar survey, were also undertaken at all streams, river and culvert crossings along the proposed pipeline route.

2.3 Installation of Ground Control Points

Control consists of Ground Control Points (12mm iron peg in tar as shown in Figure 2-1) and normal benchmarks (12mm iron peg encased in concrete as shown in Figure 2-2).

The Real Time Kinematic (RTK) method was used to fix all benchmarks and Ground Control Points (GCPs). All benchmarks and GCPs along the N1 levelled. The rest of the GCPs and benchmarks were double polar (i.e. verifying or fixing an unknown point from two different known points) with GPS.

Primary Points are known points that form part of the existing National Road Beacon (NRB) network. Extra primary points were placed with Post Processing method. The existing and additional primary points were used to fix the intermediate control, namely the GCPs and benchmarks.

Appendix B contains a list of the Lo25 and Lo27 GCPs, whereas Appendix C contains the verification list of checks undertaken for the Lo25 and Lo27 GCPs.



Figure 2-1: Benchmark within tared road



Figure 2-2: Benchmark within field

3 Survey Datums

Coordinate System:

The Lidar data was collected in International Terrestrial Reference Frame (ITRF) 2014 and supplied in Hartebeeshoek94 Lo25 and Lo27 projection.

Horizontal Datum:

Grid: *Transverse Mercator Central meridian 25° E and 27° E*
Central meridian scale factor 1

Datum: *Hartebeesthoek94*

Reference Frame: *ITRF2014*

Vertical Datum:

Ellipsoid *World Geodetic System 1984 – WGS84*
 $a = 6378137.000$
 $1/f = 298.257223563$

Geoid *SAGEOID 2010*

4 LiDAR Point Processing, Calibration, Transformation and Editing

4.1 LiDAR Point Processing

The trajectories were calculated using the Bloemfontein, Kimberley, De Aar and Aliwal North Trignets, a method known as Smart Base. The trajectory for each flight was post processed using both POSPac MMS and Inertial Explorer software and a smoothed best estimated trajectory was exported and used for both the laser scanner and camera positions.

Subsequently, the LiDAR points were processed into raw points with each point having Easting, Northing and Height, using Riegl 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 and pitch of the aircraft.

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

4.3 LiDAR Point Transformation

The survey was originally calculated using the WGS84 datum. This survey was then converted to Transverse Mercator Projection and South Africa's Hartebeesthoek94 Datum. The area of interest had to be divided, i.e. both Central Meridian Lo25 and Lo27 were used for continuity of the survey as it crosses two latitudes.

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

4.3.1 LiDAR Point Editing

A first run automatic classification was carried out on the raw LiDAR points using Terra Scan from Terra Solid Suite software used to classify the LiDAR points into ground hits and non-ground hits. This results in a greater than 80% correct classification. After this step, manual classification was carried out in the area of interest where points are edited to minimize gross classification errors that may have occurred in the automatic classification process.

Every LiDAR point has been classified according to the project requirement, i.e. a classification is 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. Appendix A contains the LAS classification codes defined by ASPRS for these LAS versions.

5 Orthophoto Rectification Procedure

The Imagery, Trajectories, Ground Control Points and Digital Terrain Model (DTM) serve as inputs to the Orthophoto Rectification Process.

After completion of the tie-point generation process, all images were adjusted for optimum heading, roll, pitch and scale values and processed against surveyed known control. The DTM is used in the Ortho mosaic process to create Georeferenced Ortho output. The image corridor is then finalised to a seamless Ortho mosaic, free of cloud coverage, distortions and misalignments, are then tiled against a 4 square kilometre (sqkm) tile layout grid that stretches along the surveyed route. The resulting Image Tiles (0.556sqkm) at a 10cm GSD (Ground Sampling Distance) are supplied in GeoTiff and ECW formats. Figure 5-1 shows an example of a rectified image within the project area.



Figure 5-1: Rectified image in the South of the Project Area

6 Accuracies

6.1 Vertical Accuracy

The vertical accuracy of the dataset is checked by comparing the known surveyed Ground Control Points against the Classified LiDAR ground surface.

The vertical accuracies presented in Table 6-1 and Table 6-2 reflect the comparison against orthometric heights calculated using the SA Geoid 2010 model. A local geoidal model, derived from the NRB MSL heights, was applied to adjust the orthometric heights to align with the levelled ground control heights.

Table 6-1: Results of the orthometric heights adjusted for Lo25

Name	Known Y	Known X	Known Z	LiDAR Z	Dz (m)
GCP200	47 966.360	-3 389 495.000	1 215.865	1 215.890	0.025
GCP201	46 435.490	-3 389 326.000	1 247.393	1 247.470	0.077
GCP202	46 332.330	-3 389 375.000	1 240.824	1 240.860	0.036
GCP203	46 604.820	-3 389 623.000	1 211.607	1 211.720	0.113
GCP205	46 678.510	-3 388 352.000	1 277.966	1 277.960	-0.006
GCP206	46 115.420	-3 387 708.000	1 311.232	1 311.220	-0.012
GCP207	46 325.550	-3 386 694.000	1 287.629	1 287.630	0.001
GCP208	46 923.890	-3 385 856.000	1 275.746	1 275.690	-0.056
GCP209	46 941.130	-3 384 823.000	1 267.854	1 267.860	0.006
GCP210	47 188.450	-3 383 821.000	1 272.783	1 272.800	0.017
GCP211	47 483.660	-3 382 847.000	1 263.399	1 263.380	-0.019
GCP212	47 710.910	-3 381 859.000	1 267.729	1 267.740	0.011
GCP213	47 534.270	-3 381 526.000	1 268.355	1 268.350	-0.005
GCP214	47 895.340	-3 380 967.000	1 269.141	1 269.140	-0.001
GCP215	48 277.770	-3 380 693.000	1 273.771	1 273.780	0.009
GCP216	48 724.690	-3 380 393.000	1 283.758	1 283.840	0.082
GCP217	49 047.550	-3 380 173.000	1 295.599	1 295.590	-0.009
GCP218	49 687.880	-3 379 789.000	1 321.673	1 321.690	0.017
GCP219	50 650.590	-3 379 563.000	1 343.228	1 343.170	-0.058
GCP220	51 563.960	-3 379 193.000	1 350.647	1 350.500	-0.147
GCP221	52 402.380	-3 378 404.000	1 355.286	1 355.450	0.164
GCP222	53 032.360	-3 377 832.000	1 353.613	1 353.530	-0.083
GCP223	53 742.100	-3 377 195.000	1 331.613	1 331.540	-0.073
GCP224	54 396.140	-3 376 598.000	1 352.428	1 352.340	-0.088
GCP225	55 144.830	-3 375 702.000	1 350.723	1 350.810	0.087
GCP226	55 774.590	-3 374 927.000	1 346.023	1 346.130	0.107
GCP227	56 406.320	-3 374 151.000	1 353.237	1 353.050	-0.187
GCP228	57 027.260	-3 373 362.000	1 365.630	1 365.650	0.020
GCP229	57 545.930	-3 372 507.000	1 365.408	1 365.320	-0.088
GCP230	58 098.260	-3 371 676.000	1 367.773	1 367.590	-0.183

Name	Known Y	Known X	Known Z	LiDAR Z	Dz (m)
GCP231	58 652.280	-3 370 842.000	1 368.567	1 368.410	-0.157
GCP232	59 257.470	-3 369 932.000	1 398.238	1 398.260	0.022
GCP233	59 936.890	-3 369 058.000	1 400.607	1 400.520	-0.087
GCP234	60 431.530	-3 368 437.000	1 395.344	1 395.250	-0.094
GCP235	61 123.920	-3 367 556.000	1 412.338	1 412.460	0.122
GCP236	61 791.060	-3 366 988.000	1 420.200	1 420.140	-0.060
GCP237	62 613.540	-3 366 319.000	1 430.126	1 430.290	0.164
GCP238	63 344.600	-3 365 725.000	1 442.969	1 443.150	0.181
GCP239	63 845.160	-3 365 322.000	1 459.977	1 459.880	-0.097
GCP240	64 590.840	-3 364 491.000	1 465.033	1 464.920	-0.113
GCP241	64 949.200	-3 363 323.000	1 441.600	1 441.580	-0.020
GCP242	65 248.580	-3 362 358.000	1 445.890	1 445.940	0.050
GCP243	65 480.090	-3 361 612.000	1 471.868	1 471.730	-0.138
GCP244	65 938.180	-3 360 461.000	1 465.573	1 465.440	-0.133
GCP245	66 318.420	-3 359 568.000	1 471.199	1 471.280	0.081
GCP246	66 743.060	-3 358 565.000	1 482.424	1 482.440	0.016
GCP247	67 125.780	-3 357 799.000	1 459.902	1 460.000	0.098
GCP248	67 587.300	-3 356 846.000	1 459.145	1 458.960	-0.185
GCP249	68 019.930	-3 355 952.000	1 457.023	1 457.000	-0.023
GCP250	68 442.670	-3 355 083.000	1 466.999	1 466.910	-0.089
GCP251	68 939.020	-3 354 185.000	1 464.101	1 464.060	-0.041
GCP252	69 432.030	-3 353 302.000	1 480.284	1 480.240	-0.044
GCP253	69 896.490	-3 352 427.000	1 486.598	1 486.640	0.042
GCP254	70 055.550	-3 351 471.000	1 493.874	1 493.860	-0.014
GCP255	70 190.130	-3 350 444.000	1 514.749	1 514.670	-0.079
GCP256	70 056.690	-3 351 462.000	1 494.160	1 494.170	0.010
GCP258	70 100.870	-3 348 482.000	1 538.179	1 538.260	0.081
GCP259	70 054.890	-3 348 255.000	1 535.054	1 534.980	-0.074
GCP260	69 858.340	-3 347 496.000	1 532.448	1 532.610	0.162
GCP261	69 609.220	-3 346 535.000	1 534.370	1 534.430	0.060
GCP262	69 442.050	-3 345 758.000	1 540.419	1 540.420	0.001
GCP263	69 476.640	-3 344 596.000	1 526.662	1 526.800	0.138
GCP264	69 511.190	-3 343 560.000	1 531.277	1 531.200	-0.077
GCP267	70 124.120	-3 341 052.000	1 528.951	1 528.970	0.019
GCP268	70 391.670	-3 340 100.000	1 510.939	1 511.030	0.091
GCP269	70 740.880	-3 339 162.000	1 505.784	1 505.870	0.086
GCP270	71 147.700	-3 338 247.000	1 498.669	1 498.760	0.091
GCP271	71 546.430	-3 337 328.000	1 492.885	1 492.990	0.105
GCP272	72 005.320	-3 336 284.000	1 499.703	1 499.600	-0.103
GCP273	72 349.770	-3 335 500.000	1 497.831	1 497.880	0.049
GCP274	72 775.130	-3 334 536.000	1 495.357	1 495.380	0.023

Name	Known Y	Known X	Known Z	LiDAR Z	Dz (m)
GCP275	73 103.100	-3 333 648.000	1 482.549	1 482.610	0.061
GCP276	73 464.330	-3 332 713.000	1 476.998	1 476.980	-0.018
GCP277	73 887.110	-3 331 593.000	1 477.300	1 477.250	-0.050
GCP278	74 155.240	-3 330 836.000	1 469.164	1 469.250	0.086
GCP279	74 513.730	-3 329 908.000	1 457.101	1 457.060	-0.041
GCP280	74 846.820	-3 329 018.000	1 445.604	1 445.720	0.116
GCP281	75 178.610	-3 328 142.000	1 445.990	1 446.080	0.090
GCP282	75 554.640	-3 327 097.000	1 430.068	1 430.080	0.012
GCP283	75 918.020	-3 326 156.000	1 423.891	1 424.000	0.109
GCP284	76 246.300	-3 325 217.000	1 428.403	1 428.340	-0.063
GCP285	76 596.130	-3 324 273.000	1 416.391	1 416.410	0.019
GCP286	77 018.030	-3 323 135.000	1 404.142	1 404.080	-0.062
GCP287	77 417.330	-3 322 058.000	1 396.492	1 396.550	0.058
GCP288	77 808.750	-3 321 002.000	1 395.505	1 395.500	-0.005
GCP289	78 168.710	-3 320 029.000	1 387.474	1 387.480	0.006
GCP290	78 496.600	-3 319 146.000	1 390.021	1 390.040	0.019
GCP291	78 816.390	-3 318 284.000	1 393.878	1 393.890	0.012
GCP292	79 151.440	-3 317 380.000	1 403.719	1 403.810	0.091
GCP293	79 499.070	-3 316 442.000	1 410.917	1 410.910	-0.007
GCP294	79 836.790	-3 315 530.000	1 416.049	1 416.160	0.111
GCP296	80 516.920	-3 313 695.000	1 438.043	1 438.170	0.127
GCP297	81 096.050	-3 312 536.000	1 439.875	1 439.880	0.005
GCP500	46 324.210	-3 389 614.000	1 223.022	1 223.100	0.078
GCP501	46 532.090	-3 389 771.000	1 207.570	1 207.660	0.090
GCP503	48 236.420	-3 381 548.000	1 273.851	1 273.860	0.009
GCP505	48 497.880	-3 381 047.000	1 276.292	1 276.260	-0.032
GCP506	48 786.800	-3 380 751.000	1 281.143	1 281.170	0.027
GCP507	49 276.890	-3 380 429.000	1 295.667	1 295.620	-0.047
GCP510	48 850.690	-3 381 343.000	1 279.243	1 279.230	-0.013
GCP511	70 312.630	-3 347 951.000	1 537.662	1 537.650	-0.012
GCP512	70 763.560	-3 347 723.000	1 547.523	1 547.550	0.027
GCP513	70 812.380	-3 347 961.000	1 556.973	1 556.920	-0.053
GCP514	71 003.710	-3 348 243.000	1 575.537	1 575.520	-0.017
GCP515	71 189.780	-3 348 183.000	1 570.778	1 570.720	-0.058
GCP516	71 083.530	-3 347 845.000	1 556.343	1 556.300	-0.043
GCP517	70 990.620	-3 347 555.000	1 547.022	1 547.090	0.068
Average Dz			0.005		
Minimum Dz			-0.187		
Maximum Dz			0.181		
Average magnitude			0.064		
Root mean square			0.081		

Name	Known Y	Known X	Known Z	LiDAR Z	Dz (m)
Std deviation			0.081		

The above values are in meters (m)

Table 6-2: Results of the orthometric heights adjusted for LO27

Name	Known Y	Known X	Known Z	LiDAR Z	Dz (m)
GCP2	-85 815.800	-3 260 066.000	1 405.770	1 405.780	0.010
GCP3	-85 051.300	-3 260 087.000	1 400.930	1 400.910	-0.020
GCP4	-84 492.700	-3 259 793.000	1 414.530	1 414.490	-0.040
GCP5	-83 560.400	-3 259 442.000	1 428.230	1 428.160	-0.070
GCP6	-82 535.500	-3 259 403.000	1 416.210	1 416.200	-0.010
GCP7	-81 579.700	-3 259 514.000	1 411.630	1 411.660	0.030
GCP8	-80 535.300	-3 259 564.000	1 404.290	1 404.300	0.010
GCP9	-79 627.000	-3 259 226.000	1 398.450	1 398.460	0.010
GCP10	-78 782.200	-3 259 639.000	1 409.000	1 409.050	0.050
GCP11	-77 724.800	-3 259 702.000	1 414.650	1 414.640	-0.010
GCP12	-76 707.900	-3 259 887.000	1 407.510	1 407.570	0.060
GCP13	-75 659.500	-3 259 920.000	1 408.510	1 408.560	0.050
GCP13	-75 659.500	-3 259 920.000	1 408.510	1 408.560	0.050
GCP14	-74 762.700	-3 259 849.000	1 420.430	1 420.480	0.050
GCP15	-73 741.300	-3 259 808.000	1 440.280	1 440.320	0.040
GCP16	-72 779.200	-3 259 726.000	1 426.770	1 426.830	0.060
GCP17	-71 888.700	-3 259 314.000	1 421.690	1 421.740	0.050
GCP18	-70 990.000	-3 258 861.000	1 426.820	1 426.800	-0.020
GCP19	-70 179.200	-3 258 305.000	1 423.230	1 423.220	-0.010
GCP20	-69 434.200	-3 257 947.000	1 414.270	1 414.270	0.000
GCP21	-68 530.900	-3 257 566.000	1 417.970	1 418.000	0.030
GCP22	-67 634.900	-3 257 104.000	1 417.920	1 417.970	0.050
GCP24	-66 958.900	-3 256 345.000	1 422.760	1 422.710	-0.050
GCP25	-66 654.400	-3 255 495.000	1 428.900	1 428.890	-0.010
GCP26	-66 018.400	-3 254 749.000	1 429.160	1 429.210	0.050
GCP27	-65 033.000	-3 253 015.000	1 440.880	1 440.840	-0.040
GCP29	-64 591.600	-3 252 139.000	1 448.300	1 448.300	0.000
GCP37	-60 393.200	-3 246 863.000	1 427.910	1 427.970	0.060
GCP48	-49 503.500	-3 243 106.000	1 398.230	1 398.230	0.000
GCP49	-48 521.100	-3 242 453.000	1 390.210	1 390.190	-0.020
GCP50	-47 672.000	-3 242 354.000	1 398.580	1 398.590	0.010
GCP55	-43 481.400	-3 239 266.000	1 407.650	1 407.660	0.010
GCP56	-42 522.800	-3 239 152.000	1 407.160	1 407.140	-0.020
GCP57	-41 466.800	-3 239 097.000	1 396.120	1 396.100	-0.020
GCP58	-40 443.300	-3 239 029.000	1 408.210	1 408.200	-0.010
GCP59	-39 464.200	-3 238 988.000	1 395.960	1 395.950	-0.010
GCP60	-38 396.000	-3 239 096.000	1 376.630	1 376.630	0.000

Name	Known Y	Known X	Known Z	LiDAR Z	Dz (m)
GCP64	-61 536.100	-3 245 492.000	1 420.980	1 420.920	-0.060
GCP65	-62 183.100	-3 244 746.000	1 425.100	1 425.070	-0.030
GCP66	-62 859.700	-3 243 967.000	1 435.450	1 435.430	-0.020
GCP67	-63 450.500	-3 243 280.000	1 440.780	1 440.770	-0.010
GCP68	-64 044.500	-3 242 496.000	1 415.780	1 415.780	0.000
GCP69	-64 680.000	-3 241 657.000	1 408.390	1 408.390	0.000
GCP70	-65 246.300	-3 240 818.000	1 425.890	1 425.900	0.010
GCP71	-66 068.000	-3 240 248.000	1 420.860	1 420.910	0.050
GCP72	-66 840.500	-3 239 642.000	1 413.930	1 413.900	-0.030
GCP73	-67 514.300	-3 239 072.000	1 425.230	1 425.150	-0.080
GCP74	-68 369.100	-3 238 438.000	1 423.560	1 423.510	-0.050
GCP75	-69 163.300	-3 237 792.000	1 416.370	1 416.320	-0.050
GCP76	-69 977.800	-3 237 143.000	1 411.980	1 411.890	-0.090
GCP77	-70 695.900	-3 236 545.000	1 405.180	1 405.110	-0.070
GCP78	-71 502.000	-3 235 916.000	1 410.710	1 410.630	-0.080
GCP79	-72 263.700	-3 235 312.000	1 412.080	1 412.040	-0.040
GCP80	-73 124.300	-3 234 783.000	1 410.490	1 410.450	-0.040
GCP81	-74 073.100	-3 234 274.000	1 417.440	1 417.370	-0.070
GCP82	-74 905.300	-3 233 815.000	1 423.490	1 423.460	-0.030
GCP83	-75 671.600	-3 233 370.000	1 427.320	1 427.260	-0.060
GCP84	-76 402.000	-3 232 954.000	1 423.210	1 423.190	-0.020
GCP85	-76 903.800	-3 232 656.000	1 418.970	1 418.910	-0.060
GCP86	-77 357.200	-3 231 737.000	1 419.370	1 419.350	-0.020
GCP87	-77 865.300	-3 230 889.000	1 431.640	1 431.590	-0.050
GCP88	-78 095.500	-3 230 604.000	1 424.260	1 424.210	-0.050
GCP89	-77 661.700	-3 230 012.000	1 437.530	1 437.460	-0.070
GCP90	-77 923.800	-3 229 256.000	1 465.780	1 465.720	-0.060
GCP91	-79 107.600	-3 230 066.000	1 413.120	1 413.040	-0.080
GCP92	-79 745.400	-3 229 328.000	1 414.310	1 414.310	0.000
GCP93	-80 184.400	-3 228 787.000	1 428.360	1 428.320	-0.040
GCP94	-80 768.200	-3 227 960.000	1 437.590	1 437.560	-0.030
GCP95	-81 165.000	-3 227 308.000	1 439.760	1 439.720	-0.040
GCP96	-81 420.500	-3 226 392.000	1 465.790	1 465.740	-0.050
GCP97	-82 080.200	-3 225 659.000	1 485.480	1 485.500	0.020
GCP299C	-109 421.000	-3 308 046.000	1 440.270	1 440.320	0.050
GCP299B	-109 884.000	-3 308 893.000	1 437.650	1 437.750	0.100
GCP300	-108 926.000	-3 307 176.000	1 444.440	1 444.470	0.030
GCP301	-108 444.000	-3 306 301.000	1 450.590	1 450.600	0.010
GCP302	-107 965.000	-3 305 424.000	1 457.570	1 457.640	0.070
GCP303	-107 486.000	-3 304 545.000	1 465.690	1 465.730	0.040
GCP304	-106 944.000	-3 303 711.000	1 455.980	1 456.060	0.080

Name	Known Y	Known X	Known Z	LiDAR Z	Dz (m)
GCP305	-106 356.000	-3 302 896.000	1 440.940	1 441.010	0.070
GCP306	-105 775.000	-3 302 078.000	1 428.130	1 428.190	0.060
GCP307	-105 220.000	-3 301 292.000	1 418.640	1 418.710	0.070
GCP308	-104 502.000	-3 300 275.000	1 414.230	1 414.260	0.030
GCP309	-103 930.000	-3 299 465.000	1 407.960	1 408.040	0.080
GCP310	-103 353.000	-3 298 647.000	1 405.470	1 405.530	0.060
GCP311	-102 893.000	-3 297 996.000	1 400.240	1 400.280	0.040
GCP312	-102 316.000	-3 297 178.000	1 396.180	1 396.230	0.050
GCP314	-101 298.000	-3 295 472.000	1 405.510	1 405.500	-0.010
GCP315	-101 050.000	-3 294 494.000	1 391.070	1 391.090	0.020
GCP316	-100 883.000	-3 293 736.000	1 388.210	1 388.240	0.030
GCP317	-100 624.000	-3 292 791.000	1 384.750	1 384.750	0.000
GCP318	-100 387.000	-3 291 845.000	1 379.710	1 379.660	-0.050
GCP319	-100 132.000	-3 290 826.000	1 372.510	1 372.470	-0.040
GCP320	-99 900.000	-3 289 898.000	1 368.380	1 368.360	-0.020
GCP321	-99 669.600	-3 288 966.000	1 370.760	1 370.750	-0.010
GCP322	-99 427.600	-3 287 957.000	1 364.920	1 364.910	-0.010
GCP323	-99 173.700	-3 286 992.000	1 348.360	1 348.340	-0.020
GCP324	-98 938.900	-3 286 054.000	1 344.900	1 344.850	-0.050
GCP325	-98 677.500	-3 285 010.000	1 350.870	1 350.870	0.000
GCP326	-98 382.800	-3 284 068.000	1 338.460	1 338.490	0.030
GCP327	-98 040.500	-3 283 151.000	1 331.310	1 331.290	-0.020
GCP328	-97 732.700	-3 282 334.000	1 331.790	1 331.760	-0.030
GCP329	-97 327.200	-3 281 287.000	1 343.880	1 343.920	0.040
GCP330	-96 966.900	-3 280 376.000	1 360.620	1 360.660	0.040
GCP331	-96 441.500	-3 279 491.000	1 361.430	1 361.470	0.040
GCP332	-95 931.900	-3 278 641.000	1 361.470	1 361.470	0.000
GCP333	-95 276.800	-3 277 549.000	1 368.950	1 368.990	0.040
GCP334	-94 776.000	-3 276 714.000	1 380.150	1 380.170	0.020
GCP335	-94 255.100	-3 275 845.000	1 383.070	1 383.100	0.030
GCP336	-93 727.800	-3 274 966.000	1 405.630	1 405.690	0.060
GCP337	-93 261.100	-3 274 187.000	1 414.350	1 414.360	0.010
GCP338	-92 858.400	-3 273 516.000	1 412.700	1 412.720	0.020
GCP339	-92 408.700	-3 272 769.000	1 418.640	1 418.650	0.010
GCP340	-91 740.700	-3 271 652.000	1 429.300	1 429.340	0.040
GCP341	-91 275.400	-3 270 919.000	1 420.360	1 420.400	0.040
GCP342	-90 723.200	-3 270 058.000	1 412.980	1 413.000	0.020
GCP343	-90 208.100	-3 269 255.000	1 405.140	1 405.120	-0.020
GCP344	-89 636.600	-3 268 364.000	1 403.370	1 403.390	0.020
GCP345	-88 996.400	-3 267 365.000	1 423.840	1 423.900	0.060
GCP346	-88 646.000	-3 266 799.000	1 439.220	1 439.240	0.020

Name	Known Y	Known X	Known Z	LiDAR Z	Dz (m)
GCP347	-88 467.100	-3 266 275.000	1 429.260	1 429.220	-0.040
GCP348	-88 218.500	-3 265 507.000	1 412.750	1 412.750	0.000
GCP349	-87 905.600	-3 264 552.000	1 404.780	1 404.790	0.010
GCP350	-87 597.800	-3 263 608.000	1 396.210	1 396.220	0.010
GCP351	-87 218.300	-3 262 445.000	1 384.650	1 384.660	0.010
GCP352	-86 975.500	-3 261 700.000	1 386.570	1 386.620	0.050
GCP353	-86 630.400	-3 260 642.000	1 397.890	1 397.880	-0.010
GCP354	-86 426.000	-3 260 031.000	1 398.710	1 398.700	-0.010
GCP518	-88 546.800	-3 267 194.000	1 438.650	1 438.720	0.070
GCP519	-88 397.900	-3 266 874.000	1 441.780	1 441.830	0.050
GCP520	-88 284.700	-3 266 474.000	1 432.060	1 432.120	0.060
Average Dz			0.003		
Minimum Dz			-0.009		
Maximum Dz			0.100		
Average magnitude			0.035		
Root mean square			0.042		
Std deviation			0.042		

The above values are in meters (m)

6.2 Horizontal Accuracy

The horizontal accuracy was checked against the Premark's visible on the Orthophoto. The differences in the x and y coordinates between the ortho and each Premark are documented and a RMSE (Root Mean Square Error, the measured difference between the actual position of the control points and predicted position of the control points) value is calculated.

The results for the Lo25 and Lo27 systems are listed in

Table 6-3 and Table 6-4, respectively. The coordinate system is Hartebeesthoek94.

Table 6-3: Derived coordinates were compared with the ground survey values (Lo25)

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP202	-0.330064	0.655288	0.278303	0.784728	0.813 (6)
GCP203	0.141127	0.442683	-0.013914	0.464843	0.678 (5)
GCP204	-0.323206	-0.0256097	-0.0755542	0.332906	0.522 (5)
GCP205	-0.271874	0.429132	-0.193003	0.543433	1.217 (6)
GCP206	0.325747	-0.3906	-1.25047	1.34995	2.479 (8)
GCP207	0.683723	0.69805	-0.730592	1.22005	2.302 (5)
GCP208	-0.180542	-0.218287	-0.191467	0.341913	1.564 (3)
GCP209	0.0486121	0.133992	-1.03823	1.04797	2.346 (6)
GCP210	0.00522963	-0.188141	0.464202	0.500907	1.216 (5)
GCP211	-0.14898	-0.304527	-0.948886	1.00763	2.224 (7)
GCP212	0.282222	0.277553	0.176359	0.433345	0.606 (7)
GCP213	0.378638	0.572064	-0.182559	0.709896	0.792 (6)
GCP214	0.45114	0.477619	0.0636257	0.660072	0.564 (8)

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP215	1.03477	0.297864	0.0124578	1.07686	0.590 (12)
GCP216	0.37547	-0.207342	-0.250649	0.496783	0.782 (7)
GCP217	0.734685	0.52116	-0.706665	1.14488	1.396 (8)
GCP218	-0.390541	0.249635	-0.51579	0.693455	3.721 (3)
GCP219	0.65388	0.466733	-0.561316	0.980038	1.674 (8)
GCP220	-0.332443	-0.513125	0.245095	0.658702	1.333 (9)
GCP221	0.456836	0.658325	-0.264655	0.84388	2.012 (9)
GCP222	0.0887847	0.267459	-0.271063	0.391015	2.549 (8)
GCP223	-0.134594	-0.0672238	-0.00235151	0.150466	1.672 (9)
GCP224	-0.0674738	0.176361	-0.022528	0.190166	0.757 (3)
GCP225	-0.0619928	0.243962	0.337976	0.421412	3.825 (3)
GCP226	0.57763	0.0700095	0.193608	0.613223	3.845 (3)
GCP227	0.306512	0.0231965	0.110291	0.326576	3.951 (2)
GCP228	0.453037	0.647212	0.404055	0.887348	2.486 (7)
GCP229	-0.450423	-0.317874	0.221392	0.594087	2.424 (6)
GCP230	0.0416603	0.984699	0.307443	1.03242	3.183 (7)
GCP231	0.435822	0.556981	0.375284	0.800629	2.082 (9)
GCP232	1.20431	-0.187797	0.151223	1.22821	3.738 (3)
GCP233	-1.6681	-0.430156	0.448059	1.77999	4.462 (4)
GCP234	1.18836	0.748722	0.407488	1.46247	2.351 (6)
GCP235	1.00957	0.145529	0.451212	1.11535	5.110 (3)
GCP236	1.0604	-0.204403	0.394977	1.14989	3.634 (3)
GCP237	-0.258821	-0.277744	0.418817	0.565277	2.496 (5)
GCP238	-0.642394	-0.0907148	0.092061	0.655267	2.246 (3)
GCP239	0.349129	1.42446	-0.0360887	1.46706	4.267 (3)
GCP240	-1.87287	0.0363226	0.23042	1.88735	2.940 (6)
GCP241	1.73254	0.867951	0.71356	2.065	3.015 (12)
GCP242	0.99315	-0.237266	0.115756	1.02764	1.398 (10)
GCP243	-0.0515356	0.0839118	0.281367	0.298101	1.755 (6)
GCP244	-0.0277017	0.558513	0.53917	0.776793	2.596 (4)
GCP245	0.316766	0.384191	0.0952211	0.506962	1.673 (4)
GCP246	0.496098	0.149763	-0.323293	0.610787	1.441 (4)
GCP247	0.748871	-0.237917	0.34698	0.858957	2.203 (9)
GCP248	-0.833405	0.0891881	0.789119	1.15119	3.394 (6)
GCP249	1.66891	1.77925	0.427536	2.47665	3.250 (9)
GCP250	0.736388	0.123091	0.0598187	0.748998	1.924 (7)
GCP251	-0.105741	-0.977201	-0.12232	0.990488	2.631 (10)
GCP252	-1.38001	0.176676	0.401236	1.44797	1.961 (6)
GCP253	0.424935	2.08279	-0.206859	2.13574	3.364 (5)
GCP254	1.77874	0.515689	0.622509	1.95381	2.482 (9)
GCP255	-0.321597	-0.239106	0.302768	0.502259	1.345 (5)

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP257	-0.713776	0.907362	0.628808	1.3146	2.464 (8)
GCP258	0.4759	-0.996344	-0.126934	1.11144	2.090 (6)
GCP259	0.0848764	-0.244465	0.195516	0.324336	1.209 (6)
GCP260	-0.122188	-0.381287	0.0356862	0.401974	1.019 (4)
GCP261	0.557398	0.527082	0.310772	0.8277	1.529 (6)
GCP262	-0.637268	1.27757	0.0786544	1.42986	2.140 (5)
GCP263	-0.956695	1.78501	-0.275162	2.04383	1.882 (14)
GCP264	0.0460525	-0.708316	0.0573019	0.712121	1.213 (7)
GCP265	1.08076	1.17599	-0.720802	1.7523	2.315 (9)
GCP266	0.615707	0.806522	0.628094	1.19335	1.775 (8)
GCP267	-0.612003	0.00173044	0.0809947	0.617342	1.570 (5)
GCP268	-0.876345	0.427697	-0.476071	1.08515	1.863 (6)
GCP269	0.429105	-0.297485	0.102643	0.532131	5.894 (4)
GCP270	1.57429	-0.16972	0.483315	1.65553	1.885 (7)
GCP271	-0.292776	0.185359	-0.655825	0.741742	2.215 (6)
GCP272	-0.670181	0.611293	0.378233	0.982793	3.135 (8)
GCP273	0.7659	0.389298	0.416023	0.954584	2.048 (8)
GCP274	-0.183722	-0.0298607	-0.503953	0.537228	1.845 (8)
GCP275	-0.563268	0.570078	0.19197	0.824083	2.066 (7)
GCP276	-0.341221	-0.18423	-0.248258	0.46044	2.168 (8)
GCP277	0.701838	0.0357433	0.0906593	0.708571	1.391 (7)
GCP278	-0.321135	0.364329	0.216301	0.531648	2.471 (8)
GCP279	0.232836	0.260815	0.0826203	0.359253	1.881 (8)
GCP280	0.738652	-0.336046	-0.195121	0.834629	1.637 (7)
GCP281	-0.00298782	0.700359	0.151542	0.716573	2.190 (8)
GCP282	-0.365245	-0.705992	-0.133855	0.806068	1.469 (8)
GCP283	-0.119517	0.0845362	0.278897	0.314983	1.459 (8)
GCP284	0.0501786	0.471063	0.889021	1.00736	2.228 (9)
GCP285	-0.0282185	1.61178	0.301228	1.63993	1.911 (12)
GCP286	0.512355	0.352687	0.139615	0.637486	1.387 (8)
GCP287	0.575258	0.303639	0.000570252	0.650476	1.122 (9)
GCP288	0.173588	0.526026	-0.0583872	0.556996	2.226 (9)
GCP289	0.0210541	-0.610115	-0.191474	0.639801	1.490 (10)
GCP290	-0.361809	-0.117818	0.135864	0.404037	1.321 (10)
GCP291	0.0492467	0.428977	0.688224	0.812465	1.730 (10)
GCP292	0.0567199	0.341507	0.131634	0.370367	1.868 (9)
GCP293	0.270755	1.14183	0.246183	1.19904	1.939 (12)
GCP294	0.832802	1.01827	-0.346595	1.36035	1.789 (9)
GCP295	-0.112944	0.669193	-1.92348	2.03969	3.502 (11)
GCP296	-1.06091	-1.91766	0.923554	2.37822	2.852 (13)
GCP297	-0.148956	0.851024	0.541878	1.01983	1.448 (14)

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP298	1.68594	-0.206684	1.34529	2.16677	3.927 (8)
GCP299	-0.237744	2.05624	-0.169189	2.07684	3.114 (5)
GCP299A	-1.00538	2.27852	0.474611	2.53529	5.623 (6)
GCP299B	0.353919	-0.855788	-1.06361	1.41029	3.928 (8)
GCP299C	0.270044	0.686849	-1.36807	1.55444	3.326 (7)
GCP300	0.864515	-0.635781	0.857918	1.37391	2.511 (6)
GCP301	-0.0568115	0.634508	-1.02428	1.20622	3.721 (7)
GCP302	1.33993	0.159963	-0.286826	1.37959	5.035 (4)
GCP500	0.0782642	0.0782031	-0.0573924	0.124639	0.496 (6)
GCP501	0.398375	0.0154555	-0.0491036	0.401687	0.686 (6)
GCP502	-0.0379118	0.0222588	-0.0104218	0.0451815	0.409 (5)
GCP503	0.262418	-0.558231	0.265563	0.671572	0.771 (7)
GCP504	-0.427194	-0.246056	0.578894	0.760366	0.834 (10)
GCP505	0.432364	-0.132681	0.426142	0.621402	0.791 (10)
GCP506	-0.0546268	0.026584	-0.216305	0.224675	0.598 (9)
GCP507	-0.835234	-0.229876	-0.164684	0.881804	0.704 (10)
GCP508	-0.631829	0.641761	-0.306926	0.951456	0.964 (7)
GCP509	-0.272084	-0.0828424	-0.035999	0.286686	0.482 (5)
GCP510	-0.19498	0.0477219	0.0173098	0.20148	0.513 (4)
GCP511	-0.160934	0.831198	-0.223391	0.875611	1.411 (9)
GCP512	0.365528	1.50258	-0.0270975	1.54664	4.562 (6)
GCP513	-0.68366	0.696354	0.544422	1.11745	2.528 (8)
GCP514	0.529622	-0.368055	-0.327074	0.723147	2.528 (7)
GCP515	1.05394	-0.201182	-7.92E-05	1.07297	1.943 (6)
GCP516	-0.255686	-0.808802	0.0950535	0.853563	2.042 (5)
GCP517	0.417369	0.397176	-0.0912494	0.583328	2.929 (5)
Total	0.676375	0.697954	0.481765	1.08477	2.284

Coordinate system: Hartebeesthoek94 Lo27.

Table 6-4: Derived coordinates were compared with the ground survey values (Lo27)

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP11	1.09936	-0.065247	0.314437	1.1453	3.848 (6)
GCP12	-0.679092	-0.0280204	-0.0617216	0.682467	3.098 (5)
GCP13	0.321497	0.788421	0.0993459	0.857227	2.225 (6)
GCP14	0.123403	0.418646	0.153905	0.462795	1.367 (6)
GCP15	0.229911	-1.87519	-0.0281767	1.88944	3.170 (5)
GCP16	1.11393	-0.416843	-0.210221	1.20781	2.326 (5)
GCP17	-1.21006	-0.0596584	0.520727	1.3187	4.705 (6)
GCP18	-1.56743	0.36707	0.702684	1.75651	4.060 (7)
GCP19	0.112661	-0.848792	-0.581741	1.03516	3.579 (7)
GCP2	0.935679	0.753685	-0.526747	1.31187	2.761 (7)
GCP20	1.29202	1.91503	0.561756	2.37744	5.081 (7)

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP21	1.47071	-1.54392	0.45051	2.17936	5.097 (6)
GCP24	0.46552	-0.443885	1.24892	1.40483	3.866 (9)
GCP25	-0.0593432	1.66773	0.355446	1.70622	7.215 (3)
GCP26	-0.738955	2.0897	-0.149732	2.22156	4.376 (6)
GCP27	0.976047	0.709074	0.431811	1.28137	2.762 (5)
GCP28	2.79797	-2.07833	-1.17966	3.67963	15.296 (5)
GCP29	-1.79987	0.509832	0.403103	1.91362	4.498 (7)
GCP299B	-2.05634	0.503888	-0.0506938	2.11779	4.331 (8)
GCP299C	0.388519	0.185243	1.02342	1.11024	3.475 (7)
GCP3	0.827688	1.15681	0.120427	1.42751	1.988 (6)
GCP300	0.0707126	0.517588	0.691187	0.866393	2.709 (6)
GCP301	0.209394	1.42269	-0.548471	1.53906	2.903 (8)
GCP302	0.93888	-0.801329	0.239055	1.25729	3.413 (4)
GCP303	0.588061	-0.19992	0.00474666	0.621133	1.429 (6)
GCP304	0.056632	-0.24481	0.347975	0.429216	3.174 (5)
GCP305	-0.55598	0.800604	-0.0605633	0.9766	4.235 (3)
GCP306	-0.109972	1.05909	0.217108	1.08669	2.427 (4)
GCP307	1.92306	0.753741	-0.098658	2.06786	2.642 (7)
GCP308	0.640912	-2.15655	-1.94245	2.9723	6.011 (5)
GCP309	-1.50754	1.8136	-0.289368	2.37604	3.220 (8)
GCP310	-0.905294	1.73707	0.577027	2.04204	3.290 (11)
GCP311	0.402679	-1.0253	-0.69059	1.30012	2.555 (7)
GCP312	0.434865	0.940633	0.194896	1.05446	1.633 (8)
GCP313	0.896743	-0.753193	-0.244908	1.19642	2.968 (6)
GCP314	1.11119	-0.562363	-1.24878	1.76365	5.646 (8)
GCP315	-0.286327	0.209117	0.554513	0.658178	1.639 (8)
GCP316	-0.39868	1.83644	0.516272	1.94885	2.543 (10)
GCP317	0.872702	0.151833	-0.82667	1.21163	2.827 (7)
GCP318	0.0810477	0.1402	-0.460899	0.488521	2.336 (5)
GCP319	-0.453421	1.45996	0.690821	1.67759	3.971 (12)
GCP320	1.1474	0.844844	-1.2036	1.86519	5.990 (6)
GCP321	0.901848	-1.04842	-1.66246	2.16248	4.029 (6)
GCP322	-0.331039	0.0676579	-0.0978237	0.351758	1.715 (4)
GCP323	-0.153663	0.156409	0.0484031	0.224542	0.855 (6)
GCP324	-1.78947	0.133601	-0.169145	1.80241	3.361 (6)
GCP327	0.825622	1.50725	0.76977	1.88308	2.359 (15)
GCP328	0.103162	-0.831076	0.126283	0.846922	1.845 (8)
GCP329	0.996256	0.967765	0.831474	1.61878	3.304 (6)
GCP330	0.880682	-0.361266	-2.24541	2.43885	5.478 (7)
GCP331	-1.95654	-0.906095	1.55226	2.65679	4.212 (10)
GCP332	0.5561	1.3217	0.440032	1.49992	2.142 (14)

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP333	0.941216	0.352675	-0.0523199	1.00648	2.173 (14)
GCP334	-0.132822	0.372962	0.154557	0.425007	1.864 (13)
GCP335	0.931777	1.03178	0.0549975	1.39133	2.665 (13)
GCP336	1.15431	-0.257682	-0.33522	1.22931	2.811 (7)
GCP337	-0.473827	0.288252	0.19497	0.58789	3.209 (8)
GCP338	-0.770548	0.680479	0.527179	1.1553	2.635 (9)
GCP339	0.621538	-0.169529	-2.02966	2.12945	4.307 (7)
GCP340	0.0473227	-1.03582	0.965772	1.41699	4.073 (8)
GCP341	-0.0499878	0.452877	-0.290751	0.540493	2.056 (9)
GCP342	-0.63529	0.0902895	0.317564	0.715956	2.980 (12)
GCP343	0.913772	0.950627	0.358001	1.36632	4.199 (11)
GCP344	1.77395	-0.919831	-0.245908	2.01332	3.020 (7)
GCP345	-0.996804	-0.155304	-0.116817	1.01557	2.724 (9)
GCP346	0.102643	0.932029	-0.726976	1.18647	2.464 (15)
GCP347	0.85359	0.314351	0.0336257	0.910254	3.076 (14)
GCP348	1.1708	1.04931	-0.379458	1.61735	2.728 (8)
GCP349	1.49376	1.29632	0.323683	2.00413	5.081 (6)
GCP350	-1.43667	0.922942	0.645473	1.82551	4.240 (5)
GCP351	0.980466	-1.34134	0.529493	1.74381	3.295 (7)
GCP352	-0.0986026	1.82317	0.194156	1.83613	3.256 (6)
GCP353	-0.397124	-0.73516	0.369303	0.913538	1.614 (6)
GCP354	-0.473997	-0.0444431	-0.104918	0.4875	1.457 (10)
GCP37	1.99165	2.6482	0.00160038	3.31355	8.316 (4)
GCP48	1.47483	0.31842	0.131782	1.51456	7.151 (3)
GCP49	0.937536	0.389442	0.208544	1.0364	4.696 (3)
GCP50	0.26706	-0.58985	0.714831	0.964483	2.619 (6)
GCP518	-1.73601	-0.314715	0.415559	1.81258	2.741 (12)
GCP519	-0.77978	0.5587	1.23376	1.56281	2.833 (14)
GCP520	0.697057	-1.72468	0.244421	1.87621	1.892 (12)
GCP55	2.41535	2.21254	0.332336	3.29237	8.330 (5)
GCP56	-0.287393	0.866584	0.437021	1.0122	3.220 (5)
GCP57	-1.77773	-0.281769	0.443043	1.85365	4.723 (6)
GCP58	0.517095	-1.35096	-0.152207	1.45453	4.527 (3)
GCP59	-0.132013	-0.729402	-0.110954	0.749511	3.548 (2)
GCP6	0.593284	-0.29801	0.452745	0.803601	2.848 (6)
GCP60	0.876883	0.537548	0.00691463	1.02856	3.233 (3)
GCP64	-1.1641	-0.388397	1.09316	1.64347	3.664 (9)
GCP65	-0.470712	0.694379	0.161333	0.85426	4.052 (2)
GCP66	0.365447	-0.341647	0.489896	0.700194	1.551 (7)
GCP67	-0.328485	1.59764	0.0892692	1.6335	3.495 (5)
GCP68	0.930518	1.02866	-0.634026	1.52512	3.219 (6)

Label	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)	Image (pix)
GCP69	-0.315023	0.357643	0.230745	0.52952	2.087 (4)
GCP7	0.651537	0.30414	0.150567	0.734623	3.512 (3)
GCP70	0.623745	-1.41033	0.34379	1.57996	3.305 (7)
GCP71	-1.32306	1.31716	0.356102	1.90058	5.890 (3)
GCP72	-0.67147	0.106608	-0.00876053	0.679937	3.287 (5)
GCP73	0.264368	0.295923	-0.347213	0.527274	1.837 (5)
GCP74	-0.280856	0.277513	-0.14394	0.420253	1.738 (6)
GCP75	0.0582853	-0.248423	0.415475	0.487576	2.203 (6)
GCP76	-0.352728	0.422109	0.548581	0.776875	2.264 (8)
GCP77	0.641899	1.20569	0.0521218	1.36691	2.649 (6)
GCP78	-0.301043	0.279372	0.289018	0.502202	1.935 (6)
GCP79	0.955991	-0.0559161	0.668836	1.16807	3.223 (7)
GCP80	-0.56702	1.16096	0.826803	1.53393	3.131 (7)
GCP81	-0.663857	0.150538	0.241711	0.722352	2.735 (4)
GCP82	0.00515891	0.422199	0.168822	0.45473	2.869 (3)
GCP83	-0.15342	-0.321311	0.0947973	0.368463	1.297 (3)
GCP84	-0.125909	-0.567591	0.129481	0.595632	1.437 (6)
GCP85	0.42171	0.229862	-0.035147	0.481571	1.448 (8)
GCP86	-0.226716	0.131949	0.749483	0.794062	5.836 (4)
GCP88	1.58242	0.308168	0.477181	1.68128	3.086 (8)
GCP9	0.150954	0.290409	0.302635	0.445772	2.793 (7)
GCP90	1.35719	3.00576	0.290123	3.3107	4.319 (7)
GCP91	-1.62247	1.10834	0.72066	2.09289	3.893 (6)
GCP92	1.15021	-0.100859	0.216238	1.1747	3.153 (4)
GCP93	-0.778126	0.186791	-0.0129116	0.800336	2.672 (3)
GCP94	-0.812662	-0.0510285	0.219612	0.843358	2.484 (4)
GCP95	1.04934	1.05094	0.120729	1.49002	4.367 (3)
GCP96	-0.750417	-0.0368258	-0.273154	0.799434	1.614 (5)
GCP97	0.0144272	0.0805371	-0.0762906	0.111869	1.084 (5)
Total	0.962217	0.982932	0.610805	1.50503	3.557

7 Deliverables

- The following is a summary of the topographical survey deliverables:
- CAD design files in Microstation DGN, DWG and DXF format showing:
 - o Orthophoto tiles and LiDAR point block layout
 - o The surveyed project area with boundaries
 - o Contours at 0.5m, 1m and 2m intervals (*Note – these contours have been smoothed and are merely an aesthetic representation of the ground shape*)
 - Ortho-rectified aerial images in GEOTIFF and ECW format with an 10cm 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 feature classes as shown in Table 7-1.

Table 7-1: Derived coordinates were compared with the ground survey values

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

The deliverables are supplied in Hartbeeshoek94 Lo25 and Lo27 datum and have adjusted orthometric heights using SA GEOID 2010 and was then levelled to mean sea level.

8 Queries

In case of any queries related to the topographical survey data, the following individuals can be contacted:

Table 8-1: Contact details for topographical survey queries

Name	Role	Company	Number	Email
Ismail Gasant / Abdullah Hunter	Overall coordination of topographical deliverables	Zutari	083 508 7202	Ismail.gasant@zutari.com Abdullah.hunter@zutari.com
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Ronel Williams	Lidar Project Manager	African Consulting Surveyors	066 021 9576	ronel@africansurveyors.com
Kieran Byrch	Lidar Processor	African Consulting Surveyors	086 111 1002	kieran@africansurveyors.com
Daniel Snyman	Field Survey: Team Leader	Joubert & Brink Surveys	076 708 2775	daniel@jbsur.co.za
Hein Biermann	Invoicing & Team coordination	Joubert & Brink Surveys	061 532 1854	jbsur@mweb.co.za

Appendix A

LAS Classification Codes

Classification Values	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 B

Ground Control Points

Ground control points coordinates: Lo25

Name	Known Y	Known X	Orthometric Height (masl)
GCP200	-47,966.358	3,389,494.669	1215.865
GCP201	-46,435.486	3,389,325.917	1247.393
GCP202	-46,332.329	3,389,374.854	1240.824
GCP203	-46,604.821	3,389,623.217	1211.607
GCP204	-46,192.372	3,389,450.041	1229.773
GCP205	-46,678.510	3,388,351.930	1277.966
GCP206	-46,115.423	3,387,708.299	1311.232
GCP207	-46,325.545	3,386,693.629	1287.629
GCP208	-46,923.887	3,385,856.042	1275.746
GCP209	-46,941.132	3,384,822.980	1267.854
GCP210	-47,188.447	3,383,820.733	1272.783
GCP211	-47,483.664	3,382,846.611	1263.399
GCP212	-47,710.913	3,381,858.865	1267.729
GCP213	-47,534.272	3,381,526.239	1268.355
GCP214	-47,895.335	3,380,967.076	1269.141
GCP215	-48,277.767	3,380,693.095	1273.771
GCP216	-48,724.691	3,380,393.004	1283.758
GCP217	-49,047.554	3,380,172.755	1295.599
GCP218	-49,687.878	3,379,788.532	1321.673
GCP219	-50,650.589	3,379,563.408	1343.228
GCP220	-51,563.962	3,379,193.351	1350.647
GCP221	-52,402.383	3,378,404.350	1355.286
GCP222	-53,032.356	3,377,832.075	1353.613
GCP223	-53,742.099	3,377,195.072	1331.613
GCP224	-54,396.142	3,376,597.616	1352.428
GCP225	-55,144.833	3,375,701.939	1350.723
GCP226	-55,774.593	3,374,927.396	1346.023
GCP227	-56,406.320	3,374,150.529	1353.237
GCP228	-57,027.262	3,373,361.612	1365.630
GCP229	-57,545.930	3,372,506.678	1365.408
GCP230	-58,098.258	3,371,675.866	1367.773
GCP231	-58,652.284	3,370,842.336	1368.567
GCP232	-59,257.474	3,369,932.211	1398.238
GCP233	-59,936.892	3,369,058.064	1400.607
GCP234	-60,431.531	3,368,436.639	1395.344
GCP235	-61,123.918	3,367,555.532	1412.338
GCP236	-61,791.063	3,366,987.755	1420.200

Name	Known Y	Known X	Orthometric Height (masl)
GCP237	-62,613.538	3,366,319.334	1430.126
GCP238	-63,344.601	3,365,725.053	1442.969
GCP239	-63,845.161	3,365,321.713	1459.977
GCP240	-64,590.838	3,364,491.397	1465.033
GCP241	-64,949.203	3,363,322.806	1441.600
GCP242	-65,248.579	3,362,357.512	1445.890
GCP243	-65,480.085	3,361,611.980	1471.868
GCP244	-65,938.179	3,360,460.509	1465.573
GCP245	-66,318.415	3,359,567.645	1471.199
GCP246	-66,743.059	3,358,565.223	1482.424
GCP247	-67,125.780	3,357,798.862	1459.902
GCP248	-67,587.296	3,356,845.515	1459.145
GCP249	-68,019.931	3,355,952.115	1457.023
GCP250	-68,442.672	3,355,082.775	1466.999
GCP251	-68,939.024	3,354,184.519	1464.101
GCP252	-69,432.032	3,353,301.677	1480.284
GCP253	-69,896.490	3,352,426.699	1486.598
GCP254	-70,055.547	3,351,470.799	1493.874
GCP255	-70,190.132	3,350,444.497	1514.749
GCP256	-70,056.685	3,351,462.167	1494.160
GCP257	-70,311.777	3,349,446.706	1535.715
GCP258	-70,100.871	3,348,481.965	1538.179
GCP259	-70,054.893	3,348,254.990	1535.054
GCP260	-69,858.338	3,347,496.329	1532.448
GCP261	-69,609.223	3,346,535.092	1534.370
GCP262	-69,442.053	3,345,757.812	1540.419
GCP263	-69,476.642	3,344,595.586	1526.662
GCP264	-69,511.189	3,343,559.830	1531.277
GCP265	-69,613.057	3,342,988.754	1530.344
GCP266	-69,874.336	3,342,027.742	1534.100
GCP267	-70,124.117	3,341,052.345	1528.951
GCP268	-70,391.670	3,340,100.288	1510.939
GCP269	-70,740.881	3,339,161.866	1505.784
GCP270	-71,147.697	3,338,247.391	1498.669
GCP271	-71,546.431	3,337,328.152	1492.885
GCP272	-72,005.323	3,336,284.007	1499.703
GCP273	-72,349.773	3,335,499.548	1497.831
GCP274	-72,775.132	3,334,535.806	1495.357
GCP275	-73,103.104	3,333,648.011	1482.549
GCP276	-73,464.325	3,332,712.982	1476.998
GCP277	-73,887.107	3,331,593.342	1477.300

Name	Known Y	Known X	Orthometric Height (masl)
GCP278	-74,155.244	3,330,836.476	1469.164
GCP279	-74,513.726	3,329,908.188	1457.101
GCP280	-74,846.824	3,329,017.882	1445.604
GCP281	-75,178.608	3,328,141.825	1445.990
GCP282	-75,554.642	3,327,097.137	1430.068
GCP283	-75,918.016	3,326,155.576	1423.891
GCP284	-76,246.303	3,325,216.957	1428.403
GCP285	-76,596.133	3,324,273.255	1416.391
GCP286	-77,018.031	3,323,135.303	1404.142
GCP287	-77,417.334	3,322,058.020	1396.492
GCP288	-77,808.753	3,321,002.231	1395.505
GCP289	-78,168.708	3,320,029.288	1387.474
GCP290	-78,496.603	3,319,146.174	1390.021
GCP291	-78,816.386	3,318,283.612	1393.878
GCP292	-79,151.443	3,317,379.541	1403.719
GCP293	-79,499.071	3,316,442.022	1410.917
GCP294	-79,836.791	3,315,529.854	1416.049
GCP295	-80,193.721	3,314,566.803	1427.603
GCP296	-80,516.923	3,313,695.039	1438.043
GCP297	-81,096.046	3,312,535.552	1439.875
GCP298	-81,650.791	3,311,559.568	1437.454
GCP299	-82,291.658	3,310,433.973	1437.408
GCP299A	-82,784.298	3,309,566.736	1438.278
GCP299B	-83,298.664	3,308,662.095	1437.691
GCP299C	-83,776.386	3,307,823.215	1440.292
GCP300	-84,286.605	3,306,961.846	1444.460
GCP301	-84,783.682	3,306,094.910	1450.593
GCP302	-85,277.366	3,305,226.381	1457.609
GCP500	-46,324.214	3,389,614.346	1223.022
GCP501	-46,532.089	3,389,771.407	1207.570
GCP502	-48,404.202	3,381,735.301	1272.415
GCP503	-48,236.423	3,381,548.272	1273.851
GCP504	-47,956.529	3,381,294.858	1272.652
GCP505	-48,497.878	3,381,047.418	1276.292
GCP506	-48,786.797	3,380,750.568	1281.143
GCP507	-49,276.891	3,380,429.144	1295.667
GCP508	-49,662.943	3,380,756.932	1292.723
GCP509	-49,188.970	3,381,205.745	1283.664
GCP510	-48,850.687	3,381,342.819	1279.243
GCP511	-70,312.626	3,347,951.007	1537.662
GCP512	-70,763.563	3,347,722.654	1547.523

Name	Known Y	Known X	Orthometric Height (masl)
GCP513	-70,812.384	3,347,961.098	1556.973
GCP514	-71,003.705	3,348,243.346	1575.537
GCP515	-71,189.778	3,348,182.993	1570.778
GCP516	-71,083.530	3,347,844.677	1556.343
GCP517	-70,990.616	3,347,555.447	1547.022

Ground control points coordinates: Lo27

Name	Known Y	Known X	Orthometric Height (masl)
GCP10	78,782.209	3,259,638.607	1409.003
GCP11	77,724.798	3,259,701.912	1414.651
GCP12	76,707.884	3,259,886.838	1407.506
GCP13	75,659.503	3,259,919.696	1408.505
GCP13	75,659.503	3,259,919.696	1408.505
GCP14	74,762.732	3,259,849.485	1420.434
GCP15	73,741.337	3,259,808.151	1440.280
GCP16	72,779.183	3,259,726.232	1426.766
GCP17	71,888.660	3,259,313.866	1421.688
GCP18	70,989.977	3,258,860.539	1426.824
GCP19	70,179.167	3,258,304.914	1423.227
GCP2	85,815.837	3,260,065.695	1405.773
GCP20	69,434.197	3,257,947.212	1414.268
GCP21	68,530.913	3,257,565.875	1417.967
GCP22	67,634.861	3,257,103.667	1417.924
GCP24	66,958.879	3,256,344.844	1422.755
GCP25	66,654.382	3,255,495.339	1428.904
GCP26	66,018.389	3,254,748.971	1429.160
GCP27	65,032.955	3,253,014.770	1440.878
GCP28	65,032.952	3,253,014.767	1440.886
GCP29	64,591.582	3,252,139.333	1448.297
GCP299B	109,884.086	3,308,893.477	1437.648
GCP299C	109,421.004	3,308,046.373	1440.271
GCP3	85,051.311	3,260,086.851	1400.931
GCP300	108,925.814	3,307,176.208	1444.441
GCP301	108,443.847	3,306,300.700	1450.592
GCP302	107,965.319	3,305,423.673	1457.572
GCP303	107,486.315	3,304,545.195	1465.686
GCP304	106,944.240	3,303,711.232	1455.983
GCP305	106,355.907	3,302,896.365	1440.936
GCP306	105,774.733	3,302,077.596	1428.126
GCP307	105,220.293	3,301,291.816	1418.637
GCP308	104,502.307	3,300,274.970	1414.234

Name	Known Y	Known X	Orthometric Height (masl)
GCP309	103,930.436	3,299,465.297	1407.957
GCP310	103,352.576	3,298,646.642	1405.472
GCP311	102,893.311	3,297,996.220	1400.239
GCP312	102,315.824	3,297,178.039	1396.184
GCP313	101,742.168	3,296,365.194	1396.160
GCP314	101,297.789	3,295,471.818	1405.510
GCP315	101,049.566	3,294,494.206	1391.067
GCP316	100,882.563	3,293,736.453	1388.214
GCP317	100,623.532	3,292,791.334	1384.752
GCP318	100,386.805	3,291,844.500	1379.711
GCP319	100,132.204	3,290,826.467	1372.507
GCP320	99,900.035	3,289,898.457	1368.379
GCP321	99,669.622	3,288,965.805	1370.759
GCP322	99,427.616	3,287,956.554	1364.924
GCP323	99,173.671	3,286,991.896	1348.356
GCP324	98,938.897	3,286,054.107	1344.899
GCP325	98,677.474	3,285,010.182	1350.866
GCP326	98,382.835	3,284,068.319	1338.464
GCP327	98,040.529	3,283,151.077	1331.312
GCP328	97,732.725	3,282,333.997	1331.789
GCP329	97,327.176	3,281,286.997	1343.882
GCP330	96,966.893	3,280,376.382	1360.618
GCP331	96,441.522	3,279,491.104	1361.433
GCP332	95,931.848	3,278,641.076	1361.466
GCP333	95,276.817	3,277,548.871	1368.946
GCP334	94,775.946	3,276,714.344	1380.146
GCP335	94,255.136	3,275,845.308	1383.069
GCP336	93,727.812	3,274,966.086	1405.631
GCP337	93,261.059	3,274,187.053	1414.349
GCP338	92,858.433	3,273,516.167	1412.698
GCP339	92,408.741	3,272,769.296	1418.640
GCP340	91,740.722	3,271,651.763	1429.304
GCP341	91,275.412	3,270,918.684	1420.364
GCP342	90,723.214	3,270,058.082	1412.976
GCP343	90,208.139	3,269,255.262	1405.141
GCP344	89,636.635	3,268,364.021	1403.373
GCP345	88,996.363	3,267,365.145	1423.837
GCP346	88,645.972	3,266,798.619	1439.223
GCP347	88,467.048	3,266,275.238	1429.263
GCP348	88,218.470	3,265,506.895	1412.752
GCP349	87,905.568	3,264,551.764	1404.777

Name	Known Y	Known X	Orthometric Height (masl)
GCP350	87,597.799	3,263,607.739	1396.213
GCP351	87,218.308	3,262,445.303	1384.645
GCP352	86,975.472	3,261,700.014	1386.571
GCP353	86,630.405	3,260,641.943	1397.888
GCP354	86,426.005	3,260,031.306	1398.710
GCP354	86,426.005	3,260,031.306	1398.710
GCP37	60,393.202	3,246,863.423	1427.912
GCP4	84,492.717	3,259,792.972	1414.532
GCP48	49,503.448	3,243,105.545	1398.233
GCP49	48,521.099	3,242,452.836	1390.205
GCP5	83,560.345	3,259,442.110	1428.230
GCP50	47,672.006	3,242,353.725	1398.577
GCP518	88,546.783	3,267,194.022	1438.651
GCP519	88,397.890	3,266,874.253	1441.779
GCP520	88,284.668	3,266,473.728	1432.061
GCP55	43,481.355	3,239,266.115	1407.647
GCP56	42,522.815	3,239,151.767	1407.156
GCP57	41,466.791	3,239,096.954	1396.117
GCP58	40,443.274	3,239,028.554	1408.210
GCP59	39,464.177	3,238,988.360	1395.957
GCP6	82,535.494	3,259,402.846	1416.207
GCP60	38,396.009	3,239,095.815	1376.625
GCP64	61,536.055	3,245,492.432	1420.977
GCP65	62,183.124	3,244,746.309	1425.102
GCP66	62,859.722	3,243,967.300	1435.452
GCP67	63,450.474	3,243,280.157	1440.776
GCP68	64,044.489	3,242,495.735	1415.783
GCP69	64,679.990	3,241,657.211	1408.387
GCP7	81,579.685	3,259,513.783	1411.628
GCP70	65,246.319	3,240,818.126	1425.914
GCP70	65,246.340	3,240,818.079	1425.888
GCP71	66,068.033	3,240,248.087	1420.864
GCP72	66,840.472	3,239,641.778	1413.928
GCP73	67,514.341	3,239,072.093	1425.225
GCP74	68,369.126	3,238,437.535	1423.556
GCP75	69,163.323	3,237,792.390	1416.373
GCP76	69,977.821	3,237,142.522	1411.977
GCP77	70,695.914	3,236,544.822	1405.183
GCP78	71,501.961	3,235,916.112	1410.707
GCP79	72,263.677	3,235,312.079	1412.084
GCP8	80,535.327	3,259,563.963	1404.288

Name	Known Y	Known X	Orthometric Height (masl)
GCP80	73,124.296	3,234,782.761	1410.493
GCP81	74,073.048	3,234,274.466	1417.443
GCP82	74,905.338	3,233,815.114	1423.489
GCP83	75,671.622	3,233,370.447	1427.323
GCP84	76,401.950	3,232,954.334	1423.206
GCP85	76,903.835	3,232,656.026	1418.970
GCP86	77,357.187	3,231,737.029	1419.370
GCP87	77,865.313	3,230,889.054	1431.644
GCP88	78,095.453	3,230,603.929	1424.264
GCP89	77,661.690	3,230,011.734	1437.532
GCP9	79,626.985	3,259,225.800	1398.449
GCP90	77,923.769	3,229,256.126	1465.782
GCP91	79,107.583	3,230,065.870	1413.121
GCP92	79,745.404	3,229,327.938	1414.309
GCP93	80,184.380	3,228,786.557	1428.355
GCP94	80,768.196	3,227,960.457	1437.588
GCP95	81,165.029	3,227,308.249	1439.762
GCP96	81,420.445	3,226,391.710	1465.791
GCP97	82,080.201	3,225,659.340	1485.484

*The signs of YX will change in CAD.

Appendix C

Ground Control Points Verification Readings

WG25 VERIFICATION READINGS

	Setting Out				Placed/Found			Checked		
CODE	Y	X	Z	Action	Δy	Δx	Δz	Δy	Δx	Δz
BM01	-84 298.627	+3 306 973.483	1443.061	Not Pl	-	-	-	-	-	-
BM10	-75 187.346	+3 328 144.587	1448.957	Placed	-0.002	-0.005	0.007	-	-	-
BM11	-74 526.998	+3 329 909.599	1456.258	Placed	-0.001	0.000	0.028	-	-	-
BM12	-73 895.601	+3 331 594.946	1479.452	Placed	0.001	-0.004	0.029	-	-	-
BM13	-73 123.063	+3 333 659.562	1482.416	Placed	-0.001	0.002	0.032	-	-	-
BM14	-72 359.285	+3 335 509.089	1497.356	Placed	-0.005	-0.005	0.017	0.003	-0.008	-0.001
BM15	-71 558.628	+3 337 332.137	1490.908	Placed	0.007	0.006	0.020	-0.009	-0.013	0.018
BM16	-70 751.408	+3 339 169.286	1504.938	Placed	-0.001	0.004	-0.023	-	-	-
BM17	-70 144.707	+3 341 062.734	1529.182	Placed	0.004	-0.003	0.006	-	-	-
BM18	-69 625.305	+3 342 991.871	1528.625	Placed	0.000	-0.003	0.021	-0.003	-0.002	0.021
BM19	-69 489.001	+3 344 591.365	1526.367	Placed	-0.001	-0.009	0.025	0.014	0.006	-0.014
BM20	-69 621.404	+3 346 531.323	1534.259	Placed	-0.008	-0.009	0.004	-0.008	-0.002	-0.005
BM21	-70 064.302	+3 348 244.196	1535.103	Placed	0.001	-0.007	-0.014	-	-	-
BM22	-70 200.913	+3 350 453.172	1513.312	Placed	-0.005	-0.012	0.014	-0.012	0.003	0.031
BM23	-69 906.986	+3 352 431.418	1485.575	Placed	-0.002	0.009	0.032	-0.008	0.002	0.009
BM24	-68 945.891	+3 354 198.701	1462.551	Placed	0.010	0.006	0.042	-	-	-
BM25	-68 029.886	+3 355 959.793	1454.764	Placed	0.004	-0.002	0.018	-	-	-
BM26	-67 136.485	+3 357 803.501	1458.678	Placed	0.007	-0.001	0.018	-	-	-
BM27	-66 331.150	+3 359 568.999	1470.412	Placed	0.001	0.004	0.019	0.008	-0.002	0.028
BM28	-65 490.212	+3 361 621.120	1473.398	Placed	0.000	0.011	-0.016	-	-	-
BM29	-64 961.115	+3 363 324.863	1438.157	Placed	-0.003	0.004	0.019	0.006	0.001	0.034
BM03	-82 319.653	+3 310 453.587	1435.993	Not Pl	-	-	-	-	-	-
BM30	-63 850.357	+3 365 329.229	1461.159	Placed	0.002	-0.010	0.013	-	-	-
BM31	-62 612.511	+3 366 335.419	1428.592	Placed	-0.001	-0.002	0.024	-	-	-
BM32	-61 130.373	+3 367 568.304	1412.276	Placed	-0.001	0.006	-0.033	-	-	-
BM33	-59 946.157	+3 369 065.684	1403.370	Not Pl	-	-	-	-	-	-
BM34	-58 656.316	+3 370 858.658	1367.686	Not Pl	-	-	-	-	-	-
BM35	-57 556.467	+3 372 512.741	1364.684	Not Pl	-	-	-	-	-	-
BM36	-55 787.617	+3 374 931.404	1345.073	Not Pl	-	-	-	-	-	-
BM37	-54 402.767	+3 376 606.408	1356.297	Placed	-0.001	0.002	-0.018	-0.005	0.003	0.004
BM38	-53 050.254	+3 377 844.904	1351.997	Placed	0.014	0.009	-0.019	0.007	-0.002	-0.022
BM39	-50 644.740	+3 379 575.736	1343.723	Placed	-0.009	0.004	0.015	-0.009	-0.002	0.016
BM04	-80 224.993	+3 314 580.668	1426.616	Not Pl	-	-	-	-	-	-
BM40	-49 039.888	+3 380 192.798	1295.532	Placed	0.003	0.000	0.009	-0.004	-0.014	-0.018
BM41	-47 519.392	+3 381 524.128	1267.736	Placed	0.000	0.002	0.008	-	-	-
BM42	-47 205.593	+3 383 823.991	1272.542	Placed	0.009	-0.004	0.050	-	-	-
BM43	-46 934.524	+3 385 853.796	1274.787	Placed	0.005	0.002	0.060	0.012	-0.034	0.070
BM44	-46 126.939	+3 387 707.850	1310.565	Placed	0.002	0.001	-0.005	0.008	0.009	0.005
BM45	-46 433.122	+3 389 332.569	1247.423	Placed	0.004	-0.006	0.056	0.008	-0.022	0.055
BM05	-79 544.299	+3 316 456.988	1409.133	Not Pl	-	-	-	-	-	-
BM06	-78 201.671	+3 320 041.932	1382.521	Not Pl	-	-	-	-	-	-
BM07	-77 449.833	+3 322 071.077	1395.029	Not Pl	-	-	-	-	-	-
BM08	-76 653.662	+3 324 300.248	1414.796	Not Pl	-	-	-	-	-	-
BM09	-75 926.570	+3 326 168.592	1422.429	Not Pl	-	-	-	-	-	-

GCP200	-47 966.358	+3 389 494.669	1215.865	Not Pl	-	-	-	-	-	-
GCP201	-46 435.486	+3 389 325.917	1247.393	Not Pl	-	-	-	-0.028	-0.049	0.028
GCP202	-46 332.329	+3 389 374.854	1240.824	Not Pl	-	-	-	0.002	-0.016	0.044
GCP203	-46 604.821	+3 389 623.217	1211.607	Placed	0.009	0.003	0.056	-0.003	0.001	0.070
GCP204	-46 192.372	+3 389 450.041	1229.773	Not Pl	-	-	-	0.001	0.003	0.059
GCP205	-46 678.510	+3 388 351.930	1277.966	Placed	0.014	0.000	0.049	0.012	0.006	0.068
GCP206	-46 115.423	+3 387 708.299	1311.232	Placed	0.003	-0.004	-0.028	-0.006	0.000	-0.022
GCP207	-46 325.545	+3 386 693.629	1287.629	Placed	-0.004	0.007	0.036	-0.006	-0.014	0.039
GCP208	-46 923.887	+3 385 856.042	1275.746	Placed	-0.011	-0.006	0.023	0.000	-0.022	0.046
GCP209	-46 941.132	+3 384 822.980	1267.854	Placed	-0.002	-0.003	0.057	-0.007	-0.027	0.058
GCP210	-47 188.447	+3 383 820.733	1272.783	Not Pl	-	-	-	-0.008	0.006	0.046
GCP211	-47 483.664	+3 382 846.611	1263.399	Placed	0.003	-0.005	0.049	0.005	-0.007	0.010
GCP212	-47 710.913	+3 381 858.865	1267.729	Placed	-0.018	-0.003	0.045	-0.009	-0.006	0.011
GCP213	-47 534.272	+3 381 526.239	1268.355	Placed	-0.008	0.009	0.056	-0.002	0.002	0.051
GCP214	-47 895.335	+3 380 967.076	1269.141	Placed	0.006	0.006	0.047	0.004	-0.001	0.038
GCP215	-48 277.767	+3 380 693.095	1273.771	Placed	-0.003	0.006	0.059	-0.009	0.002	0.036
GCP216	-48 724.691	+3 380 393.004	1283.758	Placed	-0.006	-0.005	0.057	0.000	0.001	0.026
GCP217	-49 047.554	+3 380 172.755	1295.599	Not Pl	-	-	-	-0.006	-0.008	0.016
GCP218	-49 687.878	+3 379 788.532	1321.673	Placed	-0.003	0.001	0.031	-0.019	0.007	0.032
GCP219	-50 650.589	+3 379 563.408	1343.228	Placed	-0.003	-0.009	0.019	0.006	0.003	0.006
GCP220	-51 563.962	+3 379 193.351	1350.647	Placed	-0.003	-0.001	0.005	0.006	-0.004	-0.007
GCP221	-52 402.383	+3 378 404.350	1355.286	Placed	0.000	0.002	0.002	-0.003	-0.005	-0.006
GCP222	-53 032.356	+3 377 832.075	1353.613	Placed	0.004	0.009	-0.015	-0.014	-0.006	-0.028
GCP223	-53 742.099	+3 377 195.072	1331.613	Placed	-0.003	0.005	0.026	0.013	-0.007	-0.003
GCP224	-54 396.142	+3 376 597.616	1352.428	Placed	0.012	0.004	0.006	0.011	0.004	0.005
GCP225	-55 144.833	+3 375 701.939	1350.723	Not Pl	-	-	-	-0.020	-0.016	0.007
GCP226	-55 774.593	+3 374 927.396	1346.023	Not Pl	-	-	-	-0.009	0.004	0.013
GCP227	-56 406.320	+3 374 150.529	1353.237	Not Pl	-	-	-	-0.006	-0.015	0.014
GCP228	-57 027.262	+3 373 361.612	1365.630	Not Pl	-	-	-	-	-	-
GCP229	-57 545.930	+3 372 506.678	1365.408	Not Pl	-	-	-	0.008	0.015	-0.034
GCP230	-58 098.258	+3 371 675.866	1367.773	Not Pl	-	-	-	-0.124	0.214	-0.029
GCP231	-58 652.284	+3 370 842.336	1368.567	Not Pl	-	-	-	-	-	-
GCP232	-59 257.474	+3 369 932.211	1398.238	Placed	0.009	-0.001	-0.017	0.025	0.007	-0.029
GCP233	-59 936.892	+3 369 058.064	1400.607	Placed	0.004	0.004	-0.034	0.014	0.015	-0.030
GCP234	-60 431.531	+3 368 436.639	1395.344	Placed	0.003	0.000	-0.023	0.007	-0.008	-0.021
GCP235	-61 123.918	+3 367 555.532	1412.338	Placed	0.012	0.008	-0.018	-0.004	0.006	-0.025
GCP236	-61 791.063	+3 366 987.755	1420.200	Placed	-0.002	-0.011	-0.031	0.009	-0.005	-0.040
GCP237	-62 613.538	+3 366 319.334	1430.126	Placed	0.002	0.001	0.026	-0.005	0.020	0.035
GCP238	-63 344.601	+3 365 725.053	1442.969	Placed	0.001	-0.006	0.024	0.011	-0.010	0.023
GCP239	-63 845.161	+3 365 321.713	1459.977	Placed	0.008	-0.005	0.001	0.010	0.000	0.013
GCP240	-64 590.838	+3 364 491.397	1465.033	Placed	0.013	0.005	-0.003	-	-	-
GCP241	-64 949.203	+3 363 322.806	1441.600	Placed	0.004	0.005	0.015	0.013	-0.018	0.029
GCP242	-65 248.579	+3 362 357.512	1445.890	Placed	0.014	0.001	0.009	0.018	-0.008	0.013
GCP243	-65 480.085	+3 361 611.980	1471.868	Placed	0.005	-0.010	-0.011	0.011	-0.006	-0.009
GCP244	-65 938.179	+3 360 460.509	1465.573	Not Pl	-	-	-	0.007	0.012	-0.050
GCP245	-66 318.415	+3 359 567.645	1471.199	Placed	-0.011	0.002	0.030	-0.005	0.013	0.042
GCP246	-66 743.059	+3 358 565.223	1482.424	Placed	0.006	-0.002	0.018	-	-	-
GCP247	-67 125.780	+3 357 798.862	1459.902	Placed	0.005	0.002	0.021	0.007	-0.004	0.014
GCP248	-67 587.296	+3 356 845.515	1459.145	Placed	0.000	-0.001	0.035	0.027	0.004	0.028
GCP249	-68 019.931	+3 355 952.115	1457.023	Not Pl	-	-	-	0.007	0.022	-0.010

GCP250	-68 442.672	+3 355 082.775	1466.999	Placed	-0.002	-0.005	0.017	0.007	-0.004	0.012
GCP251	-68 939.024	+3 354 184.519	1464.101	Placed	0.003	0.005	0.012	0.000	0.005	-0.004
GCP252	-69 432.032	+3 353 301.677	1480.284	Placed	0.001	-0.005	-0.015	-	-	-
GCP253	-69 896.490	+3 352 426.699	1486.598	Placed	-0.005	-0.009	0.027	0.004	0.002	0.009
GCP254	-70 055.547	+3 351 470.799	1493.874	Placed	-0.001	-0.011	0.009	-0.008	0.003	0.001
GCP255	-70 190.132	+3 350 444.497	1514.749	Not Pl	-	-	-	0.000	-0.009	0.025
GCP256	-70 056.685	+3 351 462.167	1494.160	Not Pl	-	-	-	-	-	-
GCP257	-70 311.777	+3 349 446.706	1535.715	Placed	0.006	0.003	0.011	-0.012	-0.004	0.018
GCP258	-70 100.871	+3 348 481.965	1538.179	Placed	-0.005	0.004	0.042	-0.016	-0.012	0.025
GCP259	-70 054.893	+3 348 254.990	1535.054	Placed	0.003	-0.002	0.039	-0.008	-0.004	0.038
GCP260	-69 858.338	+3 347 496.329	1532.448	Placed	-0.013	0.015	0.028	-0.007	-0.004	0.000
GCP261	-69 609.223	+3 346 535.092	1534.370	Placed	-0.006	-0.003	0.007	-0.009	-0.003	-0.003
GCP262	-69 442.053	+3 345 757.812	1540.419	Placed	-0.005	0.005	-0.016	-	-	-
GCP263	-69 476.642	+3 344 595.586	1526.662	Placed	-0.004	-0.004	0.037	0.007	0.009	0.011
GCP264	-69 511.189	+3 343 559.830	1531.277	Placed	0.000	0.001	0.003	-	-	-
GCP265	-69 613.057	+3 342 988.754	1530.344	Placed	0.007	-0.002	0.020	0.005	-0.027	0.015
GCP266	-69 874.336	+3 342 027.742	1534.100	Placed	0.004	0.005	0.004	-	-	-
GCP267	-70 124.117	+3 341 052.345	1528.951	Placed	0.004	0.004	0.012	0.010	-0.004	0.010
GCP268	-70 391.670	+3 340 100.288	1510.939	Placed	-0.005	0.009	0.030	0.009	0.001	0.019
GCP269	-70 740.881	+3 339 161.866	1505.784	Placed	0.009	-0.002	0.041	0.017	-0.002	0.033
GCP270	-71 147.697	+3 338 247.391	1498.669	Placed	0.005	-0.004	0.029	0.009	-0.015	0.008
GCP271	-71 546.431	+3 337 328.152	1492.885	Placed	0.004	0.007	0.035	0.000	-0.005	0.030
GCP272	-72 005.323	+3 336 284.007	1499.703	Placed	-0.001	-0.004	0.028	-	-	-
GCP273	-72 349.773	+3 335 499.548	1497.831	Placed	0.008	-0.001	0.038	0.017	-0.006	0.031
GCP274	-72 775.132	+3 334 535.806	1495.357	Placed	-0.009	0.017	0.016	-	-	-
GCP275	-73 103.104	+3 333 648.011	1482.549	Placed	0.002	-0.002	0.017	0.005	-0.012	-0.007
GCP276	-73 464.325	+3 332 712.982	1476.998	Placed	-0.005	-0.014	0.040	0.004	-0.011	0.022
GCP277	-73 887.107	+3 331 593.342	1477.300	Placed	-0.007	-0.003	-0.022	-0.004	0.004	-0.041
GCP278	-74 155.244	+3 330 836.476	1469.164	Placed	0.001	0.006	0.019	0.005	-0.002	0.019
GCP279	-74 513.726	+3 329 908.188	1457.101	Placed	-0.003	0.002	0.013	0.001	0.011	0.001
GCP280	-74 846.824	+3 329 017.882	1445.604	Placed	0.002	-0.003	0.035	0.027	-0.007	0.046
GCP281	-75 178.608	+3 328 141.825	1445.990	Placed	0.004	-0.006	0.047	-	-	-
GCP282	-75 554.642	+3 327 097.137	1430.068	Placed	0.008	-0.002	0.012	-0.009	0.010	0.030
GCP283	-75 918.016	+3 326 155.576	1423.891	Placed	-0.003	0.007	0.045	-0.004	0.008	0.049
GCP284	-76 246.303	+3 325 216.957	1428.403	Placed	0.002	-0.012	-0.019	-	-	-
GCP285	-76 596.133	+3 324 273.255	1416.391	Placed	0.002	-0.010	0.026	-0.015	0.002	0.029
GCP286	-77 018.031	+3 323 135.303	1404.142	Placed	0.004	-0.007	0.011	-	-	-
GCP287	-77 417.334	+3 322 058.020	1396.492	Placed	-0.003	0.002	0.025	0.001	0.004	0.018
GCP288	-77 808.753	+3 321 002.231	1395.505	Placed	-0.002	-0.006	0.006	-	-	-
GCP289	-78 168.708	+3 320 029.288	1387.474	Placed	0.010	-0.002	0.017	-	-	-
GCP290	-78 496.603	+3 319 146.174	1390.021	Not Pl	-	-	-	-0.007	-0.002	0.026
GCP291	-78 816.386	+3 318 283.612	1393.878	Placed	0.003	-0.005	0.046	-	-	-
GCP292	-79 151.443	+3 317 379.541	1403.719	Placed	0.002	0.001	-0.008	0.001	-0.003	-0.024
GCP293	-79 499.071	+3 316 442.022	1410.917	Placed	-0.004	0.000	0.035	0.005	-0.016	0.025
GCP294	-79 836.791	+3 315 529.854	1416.049	Placed	-0.002	0.000	0.020	-0.005	0.004	0.026
GCP295	-80 193.721	+3 314 566.803	1427.603	Placed	0.004	-0.006	0.032	-0.016	-0.013	0.029
GCP296	-80 516.923	+3 313 695.039	1438.043	Placed	0.002	-0.002	0.008	0.003	-0.007	0.006
GCP297	-81 096.046	+3 312 535.552	1439.875	Placed	0.001	0.003	0.031	-	-	-
GCP298	-81 650.791	+3 311 559.568	1437.454	Placed	-0.004	-0.001	0.026	-0.003	0.015	0.025
GCP299	-82 291.658	+3 310 433.973	1437.408	Placed	0.016	0.009	0.041	-	-	-

GCP299A	-82 784.298	+3 309 566.736	1438.278	Placed	0.000	-0.003	0.047	-0.017	0.006	0.029
GCP299B	-83 298.664	+3 308 662.095	1437.691	Placed	0.008	0.002	0.015	-	-	-
GCP299C	-83 776.386	+3 307 823.215	1440.292	Placed	0.000	0.000	0.029	0.007	0.018	0.016
GCP300	-84 286.605	+3 306 961.846	1444.460	Placed	0.010	0.007	0.016	0.002	0.013	0.010
GCP301	-84 783.682	+3 306 094.910	1450.593	Placed	-0.002	-0.011	0.007	-	-	-
GCP302	-85 277.366	+3 305 226.381	1457.609	Placed	0.005	0.016	0.003	-	-	-
GCP500	-46 324.214	+3 389 614.346	1223.022	Not Pl	-	-	-	-0.015	-0.007	0.052
GCP501	-46 532.089	+3 389 771.407	1207.570	Placed	0.010	-0.003	0.038	-0.010	0.002	0.058
GCP502	-48 404.202	+3 381 735.301	1272.415	Placed	0.006	-0.001	0.029	-0.006	0.007	0.048
GCP503	-48 236.423	+3 381 548.272	1273.851	Placed	-0.003	0.003	0.028	0.005	0.015	0.046
GCP504	-47 956.529	+3 381 294.858	1272.652	Placed	0.003	-0.005	0.035	0.007	0.001	0.055
GCP505	-48 497.878	+3 381 047.418	1276.292	Placed	-0.004	-0.006	0.024	0.005	0.013	0.041
GCP506	-48 786.797	+3 380 750.568	1281.143	Placed	-0.004	0.001	0.014	-0.004	0.008	0.034
GCP507	-49 276.891	+3 380 429.144	1295.667	Placed	0.002	0.005	0.017	-0.008	0.013	0.023
GCP508	-49 662.943	+3 380 756.932	1292.723	Placed	0.005	-0.005	0.009	-0.012	0.010	0.045
GCP509	-49 188.970	+3 381 205.745	1283.664	Placed	0.000	0.005	0.024	0.000	0.009	0.044
GCP510	-48 850.687	+3 381 342.819	1279.243	Not Pl	-	-	-	0.001	0.014	0.039
GCP511	-70 312.626	+3 347 951.007	1537.662	Placed	-0.006	-0.014	0.025	-0.006	0.003	0.002
GCP512	-70 763.563	+3 347 722.654	1547.523	Placed	-0.013	-0.001	0.015	-	-	-
GCP513	-70 812.384	+3 347 961.098	1556.973	Placed	-0.005	-0.009	0.033	-0.004	-0.005	0.025
GCP514	-71 003.705	+3 348 243.346	1575.537	Placed	0.007	-0.002	0.016	-0.005	0.015	0.028
GCP515	-71 189.778	+3 348 182.993	1570.778	Placed	0.004	-0.008	0.005	-0.007	0.000	0.012
GCP516	-71 083.530	+3 347 844.677	1556.343	Placed	-0.005	-0.002	0.028	-0.009	0.006	0.036
GCP517	-70 990.616	+3 347 555.447	1547.022	Placed	-0.013	-0.003	0.035	0.001	0.000	0.049
NR8	-47 973.959	+3 389 492.714	1216.031	Not Pl	-	-	-	-0.039	-0.037	0.068
NRB111/2011	-77 583.610	+3 321 537.020	1396.857	Not Pl	-	-	-	-	-	-
NRB121/2011	-78 847.830	+3 318 297.250	1392.130	Not Pl	-	-	-	0.063	-0.109	-0.041
NRB134/2011	-81 126.019	+3 312 554.804	1439.477	Not Pl	-	-	-	0.000	0.000	0.000
NRB138/2011	-81 678.580	+3 311 581.150	1433.519	Not Pl	-	-	-	0.126	-0.089	-0.025
NRB14/3	-51 573.599	+3 379 200.613	1349.050	Not Pl	-	-	-	-	-	-
NRB140/2011	-82 192.860	+3 310 676.220	1436.675	Not Pl	-	-	-	-0.002	0.009	-0.010
NRB148/2011	-84 135.290	+3 307 260.790	1441.251	Not Pl	-	-	-	0.001	-0.003	0.006
NRB16A/3	-53 239.088	+3 377 590.391	1355.820	Not Pl	-	-	-	0.000	0.000	0.000
NRB22/3	-57 013.086	+3 373 355.574	1365.440	Not Pl	-	-	-	-0.006	-0.081	0.549
NRB22/3N	-57 013.092	+3 373 355.493	1365.989	Not Pl	-	-	-	-0.006	-0.001	-0.012
NRB24A/3	-58 451.842	+3 371 171.406	1373.710	Not Pl	-	-	-	0.025	-0.187	0.015
NRB24A/3N	-58 451.817	+3 371 171.219	1373.725	Not Pl	-	-	-	-0.118	0.208	0.037
NRB26/3	-59 220.405	+3 369 900.690	1408.260	Not Pl	-	-	-	-0.086	0.207	-0.077
NRB29A	-79 727.600	+3 316 207.215	1415.770	Not Pl	-	-	-	0.060	-0.012	0.016
NRB41A/3	-67 373.016	+3 357 322.399	1465.070	Placed	-0.102	0.118	0.026	-0.218	-0.031	0.051
PEN1	-46 859.032	+3 389 722.448	1226.819	Placed	0.008	-0.004	0.047	0.002	0.000	0.047
PEN2	-46 523.881	+3 388 789.801	1272.945	Placed	-0.007	-0.011	0.050	0.003	-0.008	0.051
PEN4	-70 303.134	+3 349 212.385	1535.527	Placed	0.151	-0.040	-0.027	-	-	-

WG27 VERIFICATION READINGS

	Setting Out				Placed/Found			Checked		
CODE	Y	X	Z	Action	Δy	Δx	Δz	Δy	Δx	Δz
T159	+72 244.000	+3 235 465.730	1414.100	Not Pl	-	-	-	-	-	-
NRB101	+106 386.280	+3 302 876.880	1439.776	Found	-0.015	0.016	-0.019	-	-	-
NRB103	+105 807.430	+3 302 062.630	1427.281	Found	-0.012	0.003	-0.003	-	-	-
NRB105	+105 248.820	+3 301 270.070	1417.035	Found	-0.004	0.040	0.047	-	-	-
NRB107	+104 539.260	+3 300 264.620	1413.467	Found	0.026	0.025	0.018	-	-	-
NRB109	+103 961.870	+3 299 448.430	1405.529	Found	0.053	0.023	-0.012	-	-	-
NRB111	+103 387.380	+3 298 629.880	1404.329	Found	0.016	0.030	0.013	-	-	-
NRB113	+102 924.360	+3 297 978.920	1398.624	Found	0.020	-0.007	-0.012	-	-	-
NRB115	+102 346.260	+3 297 162.970	1394.675	Found	0.028	0.005	0.013	-	-	-
NRB117	+101 765.310	+3 296 348.910	1398.670	Found	0.031	0.017	-0.005	-	-	-
NRB119	+101 324.800	+3 295 464.130	1404.491	Found	0.033	0.035	0.006	-	-	-
NRB121	+101 081.790	+3 294 493.040	1389.879	Found	0.015	0.005	-0.005	-	-	-
NRB127	+100 671.750	+3 292 788.260	1383.153	Found	0.001	-0.022	-0.012	-	-	-
NRB129	+100 432.820	+3 291 829.940	1378.358	Found	0.000	-0.022	-0.046	-	-	-
NRB130/13	+80 856.750	+3 225 236.100	1442.346	Not Pl	-	-	-	0.177	-0.096	-0.052
NRB131	+100 170.750	+3 290 825.200	1371.687	Found	-0.021	-0.008	-0.034	-	-	-
NRB131/13	+80 967.940	+3 224 961.190	1439.497	Not Pl	-	-	-	0.196	-0.123	-0.062
NRB132/13	+81 071.700	+3 224 705.590	1434.076	Not Pl	-	-	-	-	-	-
NRB133	+99 948.710	+3 289 892.760	1365.821	Found	0.005	-0.020	-0.042	-	-	-
NRB135	+99 712.430	+3 288 949.630	1369.649	Found	-0.004	-0.010	-0.049	-	-	-
NRB137	+99 460.940	+3 287 942.250	1363.866	Found	0.014	-0.020	-0.036	-	-	-
NRB139	+99 221.300	+3 286 981.100	1347.074	Found	-0.006	-0.030	-0.019	-	-	-
NRB141	+98 986.140	+3 286 042.200	1342.934	Found	0.033	-0.041	-0.033	-	-	-
NRB144	+98 719.430	+3 284 984.950	1347.878	Found	0.002	-0.027	0.014	-	-	-
NRB148	+98 061.710	+3 283 140.430	1328.325	Found	0.025	-0.013	-0.029	-	-	-
NRB149A	+97 757.570	+3 282 326.890	1327.419	Found	0.009	-0.014	-0.048	-	-	-
NRB152	+97 363.540	+3 281 272.770	1342.430	Found	0.024	-0.027	-0.020	-	-	-
NRB157	+96 482.520	+3 279 466.360	1361.519	Found	-0.008	-0.018	-0.001	-	-	-
NRB159	+95 973.410	+3 278 615.070	1360.081	Found	0.004	-0.038	0.004	-	-	-
NRB162	+95 321.860	+3 277 526.140	1367.963	Found	-0.015	-0.025	0.028	-	-	-
NRB168	+93 771.360	+3 274 944.730	1402.974	Found	-0.011	-0.005	0.046	-	-	-
NRB170	+93 296.980	+3 274 154.230	1410.439	Found	-0.002	-0.005	0.059	-	-	-
NRB172	+92 872.600	+3 273 451.440	1409.043	Found	0.011	0.009	-0.048	-	-	-
NRB174	+92 445.680	+3 272 746.670	1421.160	Found	0.012	0.026	0.001	-	-	-
NRB177	+91 779.490	+3 271 627.060	1430.350	Found	0.009	0.007	-0.034	-	-	-
NRB179	+91 314.460	+3 270 902.070	1419.239	Found	-0.004	-0.010	-0.001	-	-	-
NRB181	+90 755.230	+3 270 038.120	1412.022	Found	0.003	0.009	-0.018	-	-	-
NRB183	+90 250.590	+3 269 230.960	1403.554	Found	-0.006	-0.011	-0.020	-	-	-
NRB185	+89 678.230	+3 268 338.500	1401.457	Found	-0.002	0.000	-0.017	-	-	-
NRB188	+89 031.240	+3 267 329.940	1422.396	Found	0.010	-0.018	-0.003	-	-	-
NRB189	+88 513.060	+3 266 261.350	1429.029	Found	0.012	0.008	-0.027	-	-	-
NRB191	+88 265.970	+3 265 500.210	1411.222	Found	-0.010	-0.021	-0.047	-	-	-
NRB193	+87 953.840	+3 264 543.900	1402.988	Found	-0.010	-0.029	-0.036	-	-	-
NRB195	+87 643.260	+3 263 593.370	1394.172	Found	0.004	-0.033	-0.044	-	-	-

NRB198	+87 255.570	+3 262 436.240	1383.260	Found	0.007	-0.015	-0.013	-	-	-
NRB198	+87 255.570	+3 262 436.240	1383.260	Found	0.007	-0.015	-0.013	-	-	-
NRB199	+87 117.480	+3 262 022.010	1383.482	Not Pl	-	-	-	-	-	-
NRB2	+86 619.983	+3 260 652.038	1397.720	Found	0.012	-0.022	-0.010	-	-	-
NRB2	+86 619.983	+3 260 652.038	1397.720	Found	0.012	-0.022	-0.010	-	-	-
NRB200	+87 010.270	+3 261 692.920	1385.817	Not Pl	-	-	-	-	-	-
NRB3	+86 313.684	+3 259 700.516	1395.880	Not Pl	-	-	-	-	-	-
NRB69B	+96 902.850	+3 280 363.960	1374.027	Found	0.020	-0.138	-0.020	-	-	-
NRB73B	+94 762.240	+3 276 714.680	1380.716	Found	0.037	-0.029	0.015	-	-	-
NRB85A	+88 693.070	+3 266 780.210	1442.987	Found	-0.003	0.006	-0.005	-	-	-
NRB93	+108 475.760	+3 306 285.260	1449.414	Found	0.022	-0.020	0.001	-	-	-
NRB95	+107 997.140	+3 305 408.240	1456.678	Found	0.013	0.014	0.029	-	-	-
NRB97	+107 519.600	+3 304 529.190	1465.432	Found	-0.001	-0.003	0.025	-	-	-
NRB99	+106 962.870	+3 303 695.420	1455.579	Found	0.003	-0.003	-0.045	0.000	0.005	0.001
T263	+82 180.950	+3 225 640.410	1501.300	Not Pl	-	-	-	0.206	-0.073	-0.097
BM1	+108 913.590	+3 307 187.642	1443.051	Not Pl	-	-	-	-	-	-
CHECK1	+49 504.026	+3 243 103.291	1398.195	Not Pl	-	-	-	-0.014	-0.012	-0.008
DAM1	+38 137.943	+3 239 124.897	1372.304	Not Pl	-	-	-	0.000	0.000	0.000
GCP10	+78 782.209	+3 259 638.607	1409.003	Placed	0.002	0.001	0.001	0.005	-0.001	-0.017
GCP11	+77 724.798	+3 259 701.912	1414.651	Placed	-0.002	0.006	-0.008	-0.019	0.012	0.042
GCP12	+76 707.884	+3 259 886.838	1407.506	Placed	-0.001	0.009	-0.006	-0.009	0.020	0.031
GCP13	+75 659.503	+3 259 919.696	1408.505	Placed	0.008	0.008	-0.005	0.011	0.006	-0.009
GCP13	+75 659.503	+3 259 919.696	1408.505	Placed	0.008	0.008	-0.005	0.011	0.006	-0.009
GCP14	+74 762.732	+3 259 849.485	1420.434	Placed	0.005	0.001	0.003	-	-	-
GCP15	+73 741.337	+3 259 808.151	1440.280	Placed	0.001	-0.004	-0.005	0.013	0.006	0.014
GCP16	+72 779.183	+3 259 726.232	1426.766	Placed	0.001	0.000	0.000	-	-	-
GCP17	+71 888.660	+3 259 313.866	1421.688	Placed	0.008	-0.001	-0.005	0.002	0.001	0.004
GCP18	+70 989.977	+3 258 860.539	1426.824	Placed	0.003	0.002	-0.003	-	-	-
GCP19	+70 179.167	+3 258 304.914	1423.227	Placed	0.004	0.001	-0.004	-0.002	-0.011	-0.015
GCP2	+85 815.837	+3 260 065.695	1405.773	Not Pl	-	-	-	0.003	-0.008	0.021
GCP20	+69 434.197	+3 257 947.212	1414.268	Placed	0.005	0.001	0.000	0.003	-0.012	-0.041
GCP21	+68 530.913	+3 257 565.875	1417.967	Placed	0.000	-0.004	-0.007	-	-	-
GCP22	+67 634.861	+3 257 103.667	1417.924	Placed	0.001	-0.003	-0.011	-	-	-
GCP24	+66 958.879	+3 256 344.844	1422.755	Placed	-0.001	0.002	-0.009	-0.003	0.026	0.031
GCP25	+66 654.382	+3 255 495.339	1428.904	Placed	-0.005	-0.002	-0.007	-	-	-
GCP26	+66 018.389	+3 254 748.971	1429.160	Placed	0.006	-0.004	-0.009	-0.014	-0.015	0.010
GCP27	+65 032.955	+3 253 014.770	1440.878	Not Pl	-	-	-	-	-	-
GCP28	+65 032.952	+3 253 014.767	1440.886	Placed	0.004	0.004	-0.001	0.004	0.002	0.004
GCP29	+64 591.582	+3 252 139.333	1448.297	Placed	-0.004	0.005	-0.001	-	-	-
GCP299B	+109 884.086	+3 308 893.477	1437.648	Placed	0.008	-0.010	-0.003	-	-	-
GCP299C	+109 421.004	+3 308 046.373	1440.271	Placed	0.003	-0.012	0.004	-	-	-
GCP3	+85 051.311	+3 260 086.851	1400.931	Placed	0.001	0.005	-0.002	0.004	-0.008	-0.001
GCP300	+108 925.814	+3 307 176.208	1444.441	Placed	-0.001	0.005	0.003	-0.002	-0.001	0.009
GCP301	+108 443.847	+3 306 300.700	1450.592	Placed	0.001	0.004	-0.001	-0.011	-0.004	0.008
GCP302	+107 965.319	+3 305 423.673	1457.572	Not Pl	-	-	-	0.000	0.021	0.026
GCP303	+107 486.315	+3 304 545.195	1465.686	Not Pl	-	-	-	-0.001	0.006	-0.005
GCP304	+106 944.240	+3 303 711.232	1455.983	Placed	0.000	0.003	-0.038	0.005	0.001	0.031
GCP305	+106 355.907	+3 302 896.365	1440.936	Placed	-0.015	-0.001	0.015	0.004	0.003	0.013
GCP306	+105 774.733	+3 302 077.596	1428.126	Placed	0.007	0.014	-0.023	-0.012	-0.019	0.031
GCP307	+105 220.293	+3 301 291.816	1418.637	Placed	0.014	0.024	0.040	-0.021	-0.019	0.043

GCP308	+104 502.307	+3 300 274.970	1414.234	Placed	0.030	0.033	0.019	-0.034	-0.035	0.018
GCP309	+103 930.436	+3 299 465.297	1407.957	Placed	0.013	0.017	-0.015	-0.010	-0.015	0.016
GCP310	+103 352.576	+3 298 646.642	1405.472	Placed	0.005	0.017	0.000	-0.005	-0.022	-0.010
GCP311	+102 893.311	+3 297 996.220	1400.239	Not Pl	-	-	-	-0.014	-0.018	0.051
GCP312	+102 315.824	+3 297 178.039	1396.184	Placed	0.020	0.032	-0.024	-0.019	-0.024	0.035
GCP313	+101 742.168	+3 296 365.194	1396.160	Placed	0.020	0.025	3.958	-0.022	-0.023	3.977
GCP314	+101 297.789	+3 295 471.818	1405.510	Placed	0.020	0.014	-0.002	-0.020	-0.017	-0.003
GCP315	+101 049.566	+3 294 494.206	1391.067	Placed	-0.002	0.000	-0.003	-0.003	0.014	-0.003
GCP316	+100 882.563	+3 293 736.453	1388.214	Placed	0.001	0.002	0.002	0.006	0.015	-0.016
GCP317	+100 623.532	+3 292 791.334	1384.752	Placed	0.006	-0.002	-0.014	0.004	0.010	-0.023
GCP318	+100 386.805	+3 291 844.500	1379.711	Placed	0.001	0.001	-0.044	0.001	0.003	-0.047
GCP319	+100 132.204	+3 290 826.467	1372.507	Placed	-0.002	0.002	-0.042	0.009	-0.022	-0.050
GCP320	+99 900.035	+3 289 898.457	1368.379	Placed	0.000	0.004	-0.046	0.001	0.002	-0.058
GCP321	+99 669.622	+3 288 965.805	1370.759	Placed	0.001	0.000	-0.057	0.003	0.001	-0.054
GCP322	+99 427.616	+3 287 956.554	1364.924	Placed	-0.002	0.000	-0.035	0.004	0.001	-0.050
GCP323	+99 173.671	+3 286 991.896	1348.356	Placed	0.000	-0.001	-0.021	-0.003	0.001	-0.017
GCP324	+98 938.897	+3 286 054.107	1344.899	Placed	0.002	0.001	-0.025	-0.001	-0.002	-0.030
GCP325	+98 677.474	+3 285 010.182	1350.866	Placed	0.000	0.001	0.008	-0.009	-0.007	0.006
GCP326	+98 382.835	+3 284 068.319	1338.464	Placed	-0.002	0.003	0.004	-0.008	0.005	-0.009
GCP327	+98 040.529	+3 283 151.077	1331.312	Placed	0.003	0.008	-0.043	0.008	0.006	-0.049
GCP328	+97 732.725	+3 282 333.997	1331.789	Placed	0.003	-0.005	-0.037	-0.005	-0.001	-0.021
GCP329	+97 327.176	+3 281 286.997	1343.882	Placed	0.000	0.000	0.006	-0.014	0.013	0.019
GCP330	+96 966.893	+3 280 376.382	1360.618	Placed	-0.001	0.004	-0.005	-0.003	0.003	0.002
GCP331	+96 441.522	+3 279 491.104	1361.433	Placed	-0.003	-0.002	-0.002	0.002	0.040	-0.013
GCP332	+95 931.848	+3 278 641.076	1361.466	Placed	0.005	-0.003	-0.008	0.010	0.031	-0.046
GCP333	+95 276.817	+3 277 548.871	1368.946	Placed	0.003	-0.001	0.001	0.007	0.036	-0.043
GCP334	+94 775.946	+3 276 714.344	1380.146	Placed	0.004	0.002	0.005	0.007	0.046	-0.002
GCP335	+94 255.136	+3 275 845.308	1383.069	Placed	0.007	-0.008	0.028	-0.013	0.051	0.047
GCP336	+93 727.812	+3 274 966.086	1405.631	Placed	-0.007	0.008	0.049	0.008	0.041	-0.014
GCP337	+93 261.059	+3 274 187.053	1414.349	Placed	0.004	0.004	0.074	0.005	0.027	-0.011
GCP338	+92 858.433	+3 273 516.167	1412.698	Placed	-0.002	0.005	-0.048	-0.003	-0.004	-0.036
GCP339	+92 408.741	+3 272 769.296	1418.640	Placed	0.002	0.001	-0.025	0.000	0.005	-0.008
GCP340	+91 740.722	+3 271 651.763	1429.304	Placed	0.003	0.004	-0.035	-0.007	-0.009	0.005
GCP341	+91 275.412	+3 270 918.684	1420.364	Placed	-0.002	0.004	-0.017	-0.010	-0.001	-0.033
GCP342	+90 723.214	+3 270 058.082	1412.976	Placed	-0.007	0.001	-0.005	-0.012	0.006	-0.032
GCP343	+90 208.139	+3 269 255.262	1405.141	Placed	-0.003	0.003	0.005	-0.015	0.005	-0.045
GCP344	+89 636.635	+3 268 364.021	1403.373	Placed	0.001	-0.001	-0.007	-0.015	0.007	-0.032
GCP345	+88 996.363	+3 267 365.145	1423.837	Placed	0.000	0.000	0.006	-0.014	-0.007	0.012
GCP346	+88 645.972	+3 266 798.619	1439.223	Placed	0.002	0.002	-0.003	-0.012	0.005	-0.014
GCP347	+88 467.048	+3 266 275.238	1429.263	Placed	0.002	0.000	-0.038	-0.003	-0.009	-0.039
GCP348	+88 218.470	+3 265 506.895	1412.752	Placed	0.002	-0.002	-0.037	-0.004	-0.003	-0.041
GCP349	+87 905.568	+3 264 551.764	1404.777	Placed	0.002	0.001	-0.036	-0.005	0.011	-0.027
GCP350	+87 597.799	+3 263 607.739	1396.213	Placed	0.001	-0.002	-0.057	-0.007	-0.013	-0.037
GCP351	+87 218.308	+3 262 445.303	1384.645	Placed	-0.002	0.000	-0.011	-0.001	-0.004	-0.009
GCP352	+86 975.472	+3 261 700.014	1386.571	Placed	0.000	0.003	0.012	-0.001	0.001	-0.009
GCP353	+86 630.405	+3 260 641.943	1397.888	Placed	0.005	0.000	0.000	0.008	0.003	0.018
GCP354	+86 426.005	+3 260 031.306	1398.710	Placed	0.002	0.001	-0.006	0.007	-0.004	-0.002
GCP354	+86 426.005	+3 260 031.306	1398.710	Placed	0.002	0.001	-0.006	0.007	-0.004	-0.002
GCP37	+60 393.202	+3 246 863.423	1427.912	Placed	0.004	-0.003	-0.007	-	-	-
GCP4	+84 492.717	+3 259 792.972	1414.532	Placed	-0.003	0.010	0.003	0.010	-0.001	0.000

GCP48	+49 503.448	+3 243 105.545	1398.233	Not Pl	-	-	-	-	-	-
GCP49	+48 521.099	+3 242 452.836	1390.205	Placed	-0.001	-0.004	0.000	-0.016	-0.002	0.009
GCP5	+83 560.345	+3 259 442.110	1428.230	Placed	-0.002	0.005	-0.001	0.006	0.000	-0.026
GCP50	+47 672.006	+3 242 353.725	1398.577	Placed	0.010	0.000	0.005	-	-	-
GCP518	+88 546.783	+3 267 194.022	1438.651	Placed	-0.007	-0.016	-0.002	-0.005	-0.020	-0.005
GCP519	+88 397.890	+3 266 874.253	1441.779	Placed	-0.002	-0.005	0.004	-0.002	-0.002	0.004
GCP520	+88 284.668	+3 266 473.728	1432.061	Placed	-0.009	0.014	0.002	-0.007	0.007	0.003
GCP55	+43 481.355	+3 239 266.115	1407.647	Placed	-0.002	0.026	0.001	-0.012	0.007	0.009
GCP56	+42 522.815	+3 239 151.767	1407.156	Placed	-0.011	0.000	0.003	0.008	0.010	-0.007
GCP57	+41 466.791	+3 239 096.954	1396.117	Placed	0.012	-0.002	-0.004	0.009	-0.009	0.005
GCP58	+40 443.274	+3 239 028.554	1408.210	Placed	0.003	0.001	0.000	-	-	-
GCP59	+39 464.177	+3 238 988.360	1395.957	Placed	0.008	0.006	-0.001	-	-	-
GCP6	+82 535.494	+3 259 402.846	1416.207	Placed	-0.001	0.005	-0.003	0.007	0.001	-0.016
GCP60	+38 396.009	+3 239 095.815	1376.625	Placed	0.001	0.008	0.005	0.004	0.005	0.006
GCP64	+61 536.055	+3 245 492.432	1420.977	Placed	-0.001	-0.009	-0.002	-	-	-
GCP65	+62 183.124	+3 244 746.309	1425.102	Placed	-0.005	0.000	-0.006	0.005	-0.009	0.003
GCP66	+62 859.722	+3 243 967.300	1435.452	Placed	-0.008	-0.004	-0.005	-0.004	0.005	0.004
GCP67	+63 450.474	+3 243 280.157	1440.776	Placed	-0.005	-0.015	0.008	0.017	0.011	0.005
GCP68	+64 044.489	+3 242 495.735	1415.783	Placed	-0.002	0.001	0.004	-0.005	0.001	0.001
GCP69	+64 679.990	+3 241 657.211	1408.387	Not Pl	-	-	-	0.007	0.008	-0.013
GCP7	+81 579.685	+3 259 513.783	1411.628	Placed	0.005	0.003	0.000	0.005	-0.004	-0.005
GCP70	+65 246.319	+3 240 818.126	1425.914	Not Pl	-	-	-	0.021	-0.047	-0.021
GCP70	+65 246.340	+3 240 818.079	1425.888	Not Pl	-	-	-	0.000	0.000	0.005
GCP71	+66 068.033	+3 240 248.087	1420.864	Placed	-0.011	0.001	0.000	0.013	-0.002	-0.005
GCP72	+66 840.472	+3 239 641.778	1413.928	Placed	-0.004	-0.003	-0.003	0.004	0.008	-0.025
GCP73	+67 514.341	+3 239 072.093	1425.225	Not Pl	-	-	-	0.015	0.000	-0.022
GCP74	+68 369.126	+3 238 437.535	1423.556	Placed	-0.004	0.004	-0.005	-0.001	-0.001	-0.015
GCP75	+69 163.323	+3 237 792.390	1416.373	Placed	-0.003	0.003	0.000	-0.003	-0.016	-0.005
GCP76	+69 977.821	+3 237 142.522	1411.977	Placed	0.003	0.002	-0.008	0.006	-0.011	-0.009
GCP77	+70 695.914	+3 236 544.822	1405.183	Placed	0.003	0.002	0.001	0.004	-0.007	-0.002
GCP78	+71 501.961	+3 235 916.112	1410.707	Placed	-0.006	0.005	0.006	0.013	-0.007	0.000
GCP79	+72 263.677	+3 235 312.079	1412.084	Placed	0.002	0.005	0.003	-	-	-
GCP8	+80 535.327	+3 259 563.963	1404.288	Placed	0.016	0.005	0.002	0.010	0.011	-0.017
GCP80	+73 124.296	+3 234 782.761	1410.493	Placed	-0.001	0.005	0.002	0.009	-0.003	-0.007
GCP81	+74 073.048	+3 234 274.466	1417.443	Placed	0.004	-0.011	0.011	-0.013	-0.006	-0.013
GCP82	+74 905.338	+3 233 815.114	1423.489	Placed	-0.004	-0.006	-0.002	0.008	-0.004	0.011
GCP83	+75 671.622	+3 233 370.447	1427.323	Placed	0.000	0.004	-0.003	0.023	-0.026	-0.022
GCP84	+76 401.950	+3 232 954.334	1423.206	Placed	-0.004	-0.004	-0.003	-	-	-
GCP85	+76 903.835	+3 232 656.026	1418.970	Placed	-0.006	-0.010	-0.001	0.002	-0.004	-0.002
GCP86	+77 357.187	+3 231 737.029	1419.370	Placed	-0.005	-0.001	-0.001	0.012	0.002	0.001
GCP87	+77 865.313	+3 230 889.054	1431.644	Not Pl	-	-	-	-0.117	0.023	-0.015
GCP88	+78 095.453	+3 230 603.929	1424.264	Placed	0.007	0.005	0.003	-	-	-
GCP89	+77 661.690	+3 230 011.734	1437.532	Placed	-0.006	0.002	-0.011	0.008	0.003	-0.009
GCP9	+79 626.985	+3 259 225.800	1398.449	Placed	0.001	-0.001	-0.001	0.006	0.004	-0.027
GCP90	+77 923.769	+3 229 256.126	1465.782	Placed	0.001	-0.006	0.005	0.001	0.004	-0.002
GCP91	+79 107.583	+3 230 065.870	1413.121	Placed	-0.008	-0.004	0.003	-0.003	-0.009	0.002
GCP92	+79 745.404	+3 229 327.938	1414.309	Placed	-0.005	0.000	-0.006	0.003	0.001	0.022
GCP93	+80 184.380	+3 228 786.557	1428.355	Placed	0.000	-0.002	0.005	0.014	0.002	0.013
GCP94	+80 768.196	+3 227 960.457	1437.588	Placed	-0.006	0.024	-0.005	-	-	-
GCP95	+81 165.029	+3 227 308.249	1439.762	Placed	-0.002	-0.005	0.001	-0.009	-0.002	-0.007

GCP96	+81 420.445	+3 226 391.710	1465.791	Placed	-0.004	0.008	0.018	-0.015	0.026	0.007
GCP97	+82 080.201	+3 225 659.340	1485.484	Not Pl	-	-	-	0.202	-0.059	0.000
PEN10	+45 369.278	+3 239 705.690	1406.358	Placed	0.008	0.004	0.002	0.000	0.000	0.013
POST1	+60 396.661	+3 246 876.877	1427.281	Not Pl	-	-	-	0.000	0.000	-0.005
POST1	+60 396.661	+3 246 876.877	1427.281	Not Pl	-	-	-	0.000	0.000	-0.005
TREK1	+100 163.701	+3 291 033.442	1379.779	Not Pl	-	-	-	-	-	-
TREK2	+99 435.546	+3 287 955.547	1364.154	Not Pl	-	-	-	-	-	-
TREK3	+98 569.083	+3 284 607.616	1349.546	Not Pl	-	-	-	-	-	-
TREK4	+96 924.142	+3 280 321.224	1363.162	Placed	-0.009	-0.002	0.000	-	-	-
TREK5	+93 244.796	+3 274 185.006	1414.764	Not Pl	-	-	-	-	-	-
TREK6	+88 631.845	+3 266 795.209	1441.017	Not Pl	-	-	-	-	-	-

