Profiling Lake Roxburgh Using the Nz Quasigeoid 2005

Maurice William PERWICK, New Zealand

KEY WORDS

GNSS/GPS, Hydrography, Positioning, Geoid.

ADDITIONAL KEYWORDS

Baseline Adjustment, Inclined Plane, CORS, Hydrographic Profiling, NZGeoid05, RTK, Fast Static.

SUMMARY

Profiling Lake Roxburgh – NZGeoid05

Lake Roxburgh is situated in the southern lakes area of the South Island of New Zealand. Roxburgh Dam was built in the 1950's and the resulting siltation has been monitored since that time by surveying 85 cross section profiles established at nominal 450m intervals along the length of the lake. The Lake and Gorge on the Clutha River is 31km in length and varies in width from 50m to 400m and has a fall of some 2.5m during normal flows. The rugged nature of the canyon or gorge limits the propagation of telemetry for receiving real time correction of the GPS receivers and the available satellites in view.

The weather, by way of wind, temperatures around 0°C, rain and snow, required the survey team of five persons in two jet boats to be suitably clothed and in support of each other in the very isolated project area.

This paper will show how heights were obtained from GPS observations of Normal-Orthometric control marks to calculate a site calibration for the hydrographic project. The site calibration, when integrated into the Trimble HydroPro Hydrographic Navigation software project, provides real time water levels for the narrow beam echo sounding of the lake profiles. The use of the 'New Zealand Quasigeoid 2005' (NZGeoid05), to compensate and aid the limited amount of vertical control available in the area, has been essential to upgrade the existing 1993 site calibration to a vertical accuracy of ± 0.05m.

GPS Baseline data was sourced from real time kinematic (RTK) and Fast Static observations in the field and from the CORS on the LINZ PositioNZ website. The baselines were augmented with previous RTK measurements from 2007 and adjusted.

Trimble Geomatics Office (TGO) software was used in the integration of the NZGeoid05 model to correct the ellipsoidal heights to Normal-Orthometric heights. The application of an inclined plane model further reduces any anomalies to produce a site-specific transformation with minimal residuals. Trimble Navedit, HydroDos and 12d software suites were used to produce the plotted sheets of profiles and Excel spreadsheets.

The paper will by way of methodology reports, plans, diagrams and photos show how this complex profiling survey was planned, executed and processed.

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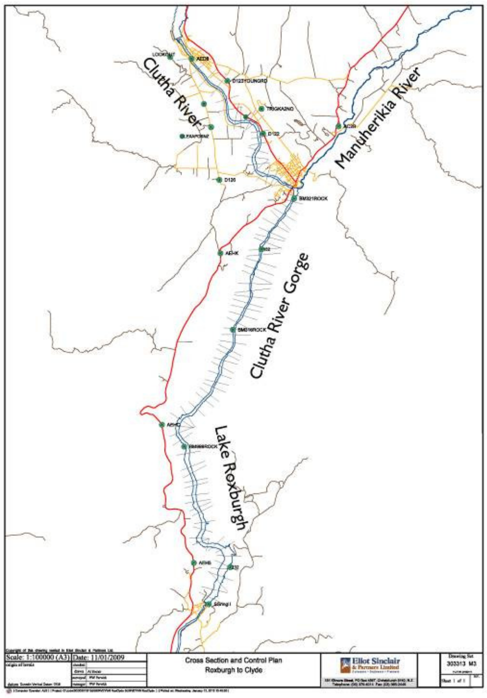
1. INTRODUCTION

Lake Roxburgh is situated on the Clutha River, New Zealand's biggest river, in the South Island of New Zealand, and is used primarily for hydroelectric power generation.

The river and gorge is prone to flooding during intense periods of rainfall which can cause damage to the town of Alexandra.



Lake Roxburgh, Central Otago, South Island, New Zealand

Discharge spilling water at dusk, Roxburgh

It was proposed to flush the river and transport sediment through the gorge to the lake proper during these flooding periods by managing the lake levels. This would, over time, deepen the river, increase the hydraulic efficiency and reduce any flooding effects.

Our company first tendered to monitor the effectiveness of the river flushing and sediment redistribution in 1993 and continue this work to date.

1.1 Existing Survey Profiling Methods

Following construction of the Roxburgh Dam in the 1950's, a geodetic survey was carried out up the river to locate cross-section reference marks from which to measure the profile of the river/lake using a traditional tag-line system for offset, and Current Meter and Columbus Weight for measuring depth from a Hamilton jet boat for depth. The profiling work took months to survey and the data was sparse.

1.2 Proposed Survey Methods - 1993

It was proposed to use DGPS positioning and a Narrow Beam Echo Sounder to profile the lake and river. Water levels would be determined by spirit level from the existing end points. However, the earlier surveys had been carried out using an outmoded 'National Yard' coordinate system which contained scale and rotation issues.

The client proposed that we re-coordinate and re-height the control onto a Transverse Mercator Projection using 'A North Circuit' in Geodetic Datum 1949 and Alexandra Height Datum.

The new survey would allow the end point coordinates to be transformed to WGS-84 as this would fit with our proposal to use DGPS positioning.

Initialisation Bar in operation

In the field, we used Trimble RTK1 (L1), a precursor of RTK OTF GPS, to survey the majority of the end points when good sky and constellation configuration were available and favourable.

Fast Static observations were also carried out to further strengthen the control network. The lake, river gorge and river is 30km in length and very narrow. Control is generally less than 3km to the side, which makes the network weak in Azimuth and height, but adequate for the task in hand.

The GPS Baseline data was processed using Trimble GPSurvey, a precursor of Trimble TGO and Trimble TBC. The other end points (not GPS observable) were connected to the control by traditional EDM traversing using Geodimeter and Sokkisha Total Stations.

It should be remembered that a limited constellation of NavStar satellites were in operation and selective availability was active.

1.3 Initial Planning of Survey Control

The vectors between control marks on the old 'National Yard' plans were processed using SDRMAP and transformed to fit the new Geodetic Datum 1949 coordinates. This allowed us to navigate to the marks which, although witnessed with a concrete post, many of these had suffered from frost heave, and collapsed and were often not immediately visible through the scrub and foliage. Further, the marks which were galvanised bolts in a concrete block, were often buried and often took some extensive digging to expose the mark. Without a more accurate coordinate, these could well have been impossible to find.

Profile End Point - Concrete Post destroyed by frost

Profiling with tape & staff

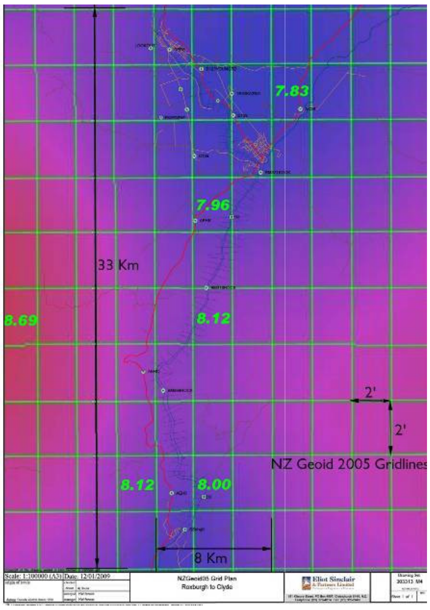
Around the Alexandra area of the Clutha River, the shoreline is heavily vegetated with dense willows and it was essential to be able to access the river bank and measure up from the boat to the mark (often 100m back). These river margins often flood and the thick silt deposits require more digging to expose the mark, often a metre down.

Two methods of surveying under dense canopy were employed. The first was to use Fast Static observations with the antennae on a tripod close to the ground which proved to be quite effective as it reduced the proximity effect of the leaf canopy above. The second was by EDM traverse into the mark from control points established using RTK or Fast Static methods out in the open areas alongside the river.

2. 2009 SURVEY

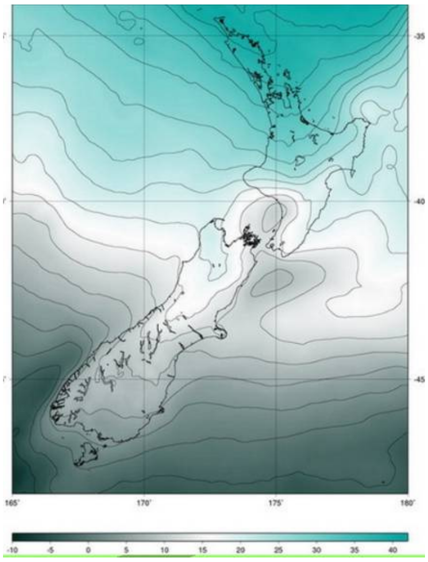
2.1 Philosophy

The use of Geoid Correction Models has not been widespread in New Zealand to date as the models tended to be coarsely configured and lacked precision over a country with distinct gravitational variation.



'N' Values - Survey Area

The Quasi Orthometric Geoid correction model NZGeoid05 was generated at 2' arc grid spacing. Trimble New Zealand Ltd customised the model for New Zealand and Trimble users.



Geiod Separation Values - LINZ

The New Zealand Institute of Surveyors Land Surveyor's conference in Napier 2008 saw a number of presentations showing the benefits and limitations of integrating the Geoid Correction Model into a site calibration to best fit GPS or GNSS observations onto a projection and height datum.

2.2 Historic Use of Inclined Plane Site Calibration

In the early 1990's RTK GPS was single frequency and limited in range, primarily because telemetry was the weakest link but also due to the constraints of the current ionospheric modelling and surveys tended to be quite small, e.g. 3km x 3km, as it was too difficult to get better range from the radios. However, by 1994 the advent of dual frequency Trimble RTK GPS OTF receivers meant that initialisations could be established while moving and led to us carrying out coastal profiling surveys using RTK GPS for measuring tide in areas remote from a Tide Gauge.

We had also found licensed frequency telemetry receivers with high speed modems (9600 Baud) with effective ranges of 10-15km with good repeatability as all the background infrastructure of GPS had progressed to support and make use of the dual frequency system.

The use of inclined plane site calibrations became necessary as in New Zealand the separation between GPS ellipsoidal heights and Orthometric Heights was in the order of 3-6cm/km from the Base.

Sites could be extended to 20km x 20km with residuals of 0.05-0.08m which proved adequate for many survey tasks. However, the original survey of Lake Roxburgh in 1993/1994, through the location of the control along the adjacent State Highway 8, meant that it could only be treated as a single cell.

In subsequent years, as new sections were added and extended north to the Clyde Dam, two site calibrations were used. The original site calibrations south of the Alexandra Bridge and a second calibration which was developed to the north with additional new height control down the west side of the Clutha River.

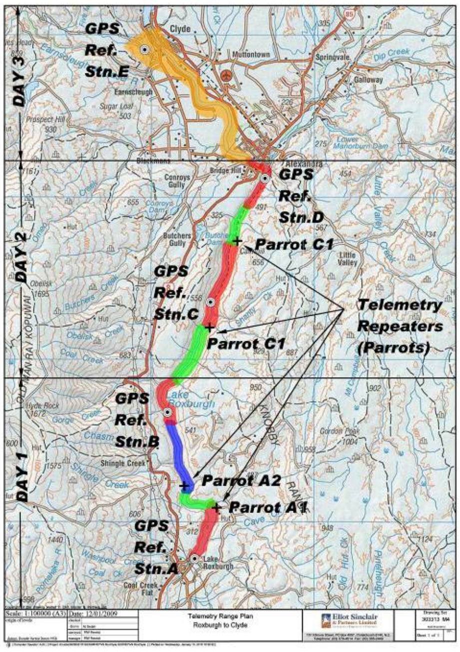
This latter site calibration was supported by a new GPS Reference Station high in the hills above the Clyde Dam, known as 'Lookout'. The location of this Base Station solved a number of issues, but especially improved the radio telemetry reception down on the river amongst the willow trees.

'Lookout' GPS Reference Point

Land and hydro survey in progress

The use of high gain collinear UHF aerials further enhanced the reception. This meant that the water level could at last be reliably determined by RTK GPS on the boat as well as from the shore, although care had to be taken when bringing the vessel on Dead Reckoning into the bank under the willow canopy not to damage the aerial.

The 2009 survey undertook to define the site calibration as a single cell which used a combined incline plane and Geoid Model solution. The survey sought to replicate the 1993/1994 survey using similar methodology, but to incorporate the survey work while, essentially, carrying out the biannual sedimentation hydrographic survey. Further, the Base Station sites would be increased by one around Section 37D to provide a better connection through the lower part of the River Gorge. Plus, Fast Static data would be available from the LINZ PositioNZ CORS Station 'LEXA'.



Reference Stations & Telemetry

The survey did not expect to visit every end point mark, but to measure sufficient to get an idea of what changes had occurred in the gorge through fault movement and from incorporating the NZ Geiod 05 correction model. Previous RTK measurements from 2007 would be added into the solution.

The idea was to create a transformation to real time model the water levels from the jet boat while profiling, hence minimising the land survey content of the job. Shoaling areas still require land survey profiling methods. It is necessary to carry out position and height checks on existing marks for each new Base Station used.

The land survey is utilised in two ways, in that it provides a real connection to the existing end points and, hence, shoreline water level, and it also can be used to QA the hydro navigation system.

2.3 River Levels in HydroPro Navigation System

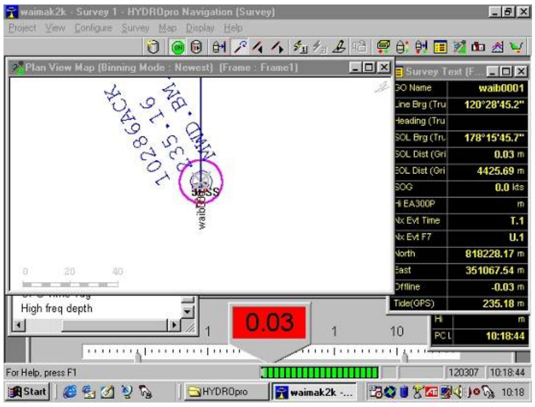
The Trimble HydroPro system allows RTK GNSS positions (WGS-84) to be transferred to normal Orthometric heights through the use of standard transformations which may be modified by inclined plane and Geoid Correction Models. Further, the system can also adopt a previously processed 'site calibration' by Trimble TGO or TBC software. Hence, both the HydroPro Navigation System and the land survey TSC2 system have the same operating parameters.

It is usual to 'start the Base' using the TSC2 and then field check the boat's positioning and water level using the land survey system with the boat pulled alongside the rocky shore or beach. It is also possible to 'topo' a small patch of the river bed and then sound across it to later compare the full reduction of the hydrographic data.

Doctors Point Reference Station

It is possible to QA the navigation system on shore by establishing a reference point near the boat ramp and parking the Transducer and GPS over that mark. By additionally setting up a runline and graphics, it can easily prove that the navigation parameters are correct and that the correct coordinates and water level are being generated.

Note, the vessel is over the mark and the tide value is similar to the on-screen values.



Navigation check

3. FAST STATIC CONTROL PROCEDURE

3.1 Introduction

The isolation of the site required establishing two receivers on known Geodetic marks each day on the way to launching the two boats. Two RTK GPS Base Stations would be established on new and old reference marks and moved as required to support the hydrographic survey and to measure additional baselines by logging Fast Static observations simultaneously as logistics allowed. It was important to know which end points had been surveyed in 2007 to ensure that these were connected to new or different reference points to strengthen the final adjustment of the dataset. Further, it is essential when adopting previously observed datasets, that the origin of those vectors is connected to directly, either by Fast Static or RTK observations, otherwise the network is disjointed and prohibits adjustment.

The second receiver was established over a selected control mark and left for the day until retrieved in the dark. The mid latitudes suffer short daylight hours during winter (May to October). Note, all receiver sets have spare battery and antennae cables plus two independent 12 volt power supplies are connected to the Trimble 4000 SSE. This receiver has the facility to swap between power sources should one go below a threshold voltage without power shutdown and is able to continuously log data through that changeover.

The primary RTK Base Station system would be set up adjacent to where the hydrographic survey commenced by the land survey crew and checked against known marks using the Trimble Rover 4700 & TSC2. The hydrographic crew would, during this time, get the hydrographic vessel mobilised and start the Echo Sounder calibration. The land survey crew would then establish the second RTK Base Station on a selected mark and begin Fast Static logging. In some instances, this receiver was configured 'ready to transmit CMR' where it could be used by the land and hydro crews instead of extending the telemetry. When time permitted, this second receiver would be retrieved and shifted to another previously used reference station position as discussed above. Generally, the four Fast Static receivers would log for at least an hour or sufficient to process a baseline if time was of the essence.

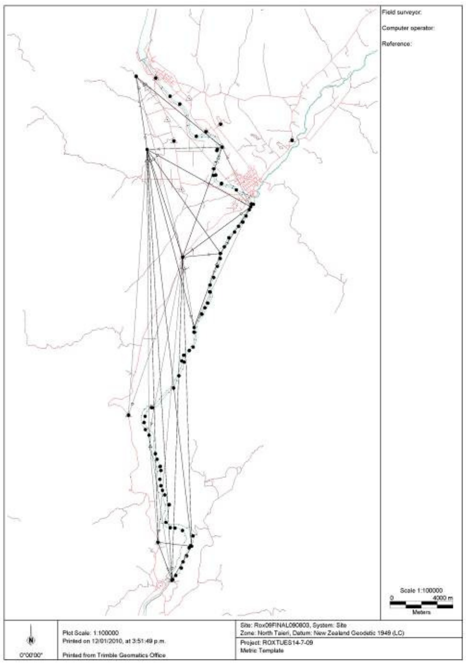
Note, all travel is by jet boat and all gear had to be carried, lifted and passed up some very steep cliffs.

All batteries are sealed lead acid batteries to reduce spill and acid damage to hands and clothes.

3.2 Equipment

- Four Trimble 4000 SSE with L1/L2 antennae.
- One Trimble 4700 with L1/L2 antennae.
- One Trimble MS750 with L1/L2 antennae.
- One Trimble TSC2.
- One Trimble TSCE.
- Toshiba Laptop with Trimble TGO software and Trimble HydroPro.
- Two Hamilton jet boats.
- Three utility vehicles.
- Five personnel - helmsmen and surveyors.

3.3 Field Procedure



One Fast Static receiver was established each day at the First Order Bench Mark AEHK adjacent Butchers Dam. 5km south-west of Alexandra. This receiver logged data at 15 second epochs all day until retrieved each night for downloading and recharging of batteries as the area is subject to hoar frosts. This receiver's data formed the hub of all Fast Static lines during the field operations.

3.4 End of Day Activities

The use of two boats is desirable in an isolated river environment. No voice radio communication is possible to outside agencies, nor is there cellphone coverage down in the gorge. A site specific Safety and Environmental Plan was prepared and agreed with Contact Energy prior to commencing which included a log in/out system and precautions to prevent the spread of didymo and lagarosiphon. The first priority at the end of the day is to ensure that work is programmed to have the boats ready for retrieval at 4.30pm and to notify the lake authority that all men and boats have returned without incident. The fast approach of dusk and darkness does not allow time for rescue efforts if lack of 'sign out' is noted after this time. We have had motor failure in the gorge, and searching for men and boats late into the night in shoaling waters is not for the faint hearted or wise.

Upon the vessels being retrieved, the Fast Static receivers are either retrieved from the side of the highway or restarted by the passing crew and another baseline measured. The remaining crew hold back, until its time to retrieve all the receivers back to the motel. The boat crew refuel the boats with approximately 150 litres of fuel per boat each day. Batteries are retrieved and charged overnight. The hydro crew back-up the navigation computer to USB memory sticks. The field crew arrive, charge batteries and download the Fast Static receivers and Trimble data controllers. Baselines are processed and residuals observed.

The next days logistics are planned and then the crews shower, eat and sleep.

3.5 Final Night

After the last field day, all the data is combined to ensure that sufficient baselines and RTK vectors have been observed and all checks to known marks are acceptable. The data is, again, independently archived, field notes, files archived and batteries charged. The boat crews are held on standby should anything amiss is found during the final field check in the motel.

If all is well, they are advised that the project is closed and the next lake up the road is ready to go. However, if, as sometimes happens, a line is missed or a check measurement is required, then a short mobilisation can be carried out. Generally, if the planning of the job has been extensive and the execution gone well, then the field work is checked off as satisfactory.

Of course, it should be noted that real time measurements are checked in the field for compliance and action taken if required. We use waterproof field books and checking procedures to maximise the effectiveness of the field procedures, all maps and field information sheets are laminated as this allows us to annotate them using felt tip or spirit based pens and check the resulted in the field.

The TSC2 data recorded also allowed 'inverse checks' and to view water levels in real time.

4. POST PROCESSING

Further to the initial field processing and checks carried out each night, we carry out further analysis and combine other datasets to build a full model. As mentioned previously, data can be obtained from the LINZ (Land Information New Zealand) CORS Receivers through the PositioNZ system. This data is at 30 second epochs. The other datasets for the project were imported from the 2007 survey. Trimble TGO allows datasets to be merged by renaming points to a common name and then recomputing to see the residuals.

	AEHQ0001	769579.548	228248.671	148.872	BM+D122	?	-0.04	-0.01	0.02
	PRE_505	769579.553	228248.685	148.855	CK BM D122				
	PRE_1003	769579.553	228248.685	148.884	CK BM D122				
	PRE_400	769579.568	228248.697	148.972	BM D122				
	PRE_651	769579.590	228248.686	148.882	BM D122				
	CAL_651AJC	769579.591	228248.686	148.855	BM D122				
75	PRE_109	769698.976	227901.682	136.523	BLT R12U				
12U	PRE_108	769725.309	228085.590	143.928	BLT L12U				
	PRE_307	769729.559	228115.240	148.060	IS 307				
	LEXA	769431.582	223480.985	324.168	SS+LEXAPOSNZ	13/07/2009 11:59			
	CAL_501MWP99	769963.770	225186.600	161.281	BM+D126_3				
	PRE_652	769963.770	225186.600	161.281	BM D126/3				
	G_501	769963.778	225186.567	161.298	BM+126_3	16/07/2009 16:00	0.01	-0.03	0.02
	PRE_429	769963.782	225186.598	161.347	BM D126 3				
	PRE_529	769963.782	225186.586	161.275	CK BM D126 3				
	PRE_504	769963.788	225186.563	161.280	CK 126-3				
	PRE_926	769963.788	225186.563	161.299	CK 126-3				
	CAL_905	770010.410	232687.560	201.351	A2CB		0.03	0.02	-0.02
	D3_905A	770010.444	232687.583	201.332	BM+AC2B	16/07/2009 16:43			
	PRE_650	771029.820	228154.690	228.750	TRIG K				
	PRE_656	771029.824	228154.689	228.756	BM Trig K				
	PRE_6	771029.838	228154.674	229.022	TRIG K				
	6_BASE99	771029.805	228154.651	228.893	BM+TRIGKA2NO	?	-0.01	0.00	0.02
	CAL_6_A2NO	771029.810	228154.650	228.870	TRIG K				
76	PRE_308	770248.587	227796.510	150.318	IS 308				
13U	PRE_106	770236.829	227784.249	143.163	BLT L13U				
	PRE_107	770100.594	227617.868	136.134	R13U				
77	PRE_104	770357.025	227486.029	137.509	IT L14U				
14U	PRE_105	770231.892	227423.416	136.134	R14U				
	PRE_322	770219.773	227417.352	0.000	I/P				
	PRE_309	770154.702	227370.043	149.110	IS 309				
	D3_404A	770558.690	227229.830	151.406	SS+D123	16/07/2009 9:41	0.23	0.22	-0.01
	CAL_AEHR	770558.460	227229.610	151.414	D123				
78	PRE_310	770217.866	226976.966	144.899	IS 310				
15U	PRE_102	770379.199	226958.108	139.050	BLT L15U				
	PRE_103	770202.521	226957.672	143.174	R15U				

Control marks - residuals

We were able to seed the project with Fixed Coordinates for two stations at either end of the job to best control scale and rotation and let all observations fit about these points. We further ran a filter to eliminate compromised or observations with excessive residuals. There was sufficient redundant data for this to be valid. The topography and vegetation can have subtle but significant effects on the quality of observations.

Roxburgh 2009 Calibration - Control Points - Roxburgh to Clyde

Job 300313
Data source: G:\...\Excel\Rox09 TGO data\ROXJul09 Control Points.xls

NZGD1949 - North Taieri Circuit
Dunedin Vertical Datum 1958

									Old Calibration Comparison		
Line	Pt ID	mN	mE	Ht (2009)	Code	Obs Date/Time	raw WL	dH	dN	dE	dH
	PRE_2	741824.011	224330.000	111.690	BM WW 82/1						
	C003BASE	742169.208	226080.948	133.775	BM+SSringII	14/07/2009 17:08			0.00	-0.02	-0.06
	CAL_3-AJC	742169.211	226080.971	133.831	BM+SSringII						
	PRE_3	742169.211	226080.971	133.831	BM SS Ring II						
1	D1_6001	742202.696	225118.005	131.180	WL+11.48	14/07/2009 11:49	131.24	-0.06			
NEWA	D1_240A	742465.378	226309.566	134.729	IT+LNEWA TOP	14/07/2009 11:56			0.00	-0.01	-0.07
	PRE_240	742465.381	226309.568	134.799	IT LNEWA TOP						
	D1_6002	742469.648	226305.666	131.231	WL+12.00	14/07/2009 12:00	131.31	-0.08			
	PRE_241	742510.335	226006.990	146.611	IT RNEWA						
2	D1_6003	742932.215	226649.324	131.292	WL+12.20	14/07/2009 12:20	131.40	-0.11			
51D	PRE_238	742936.615	226662.468	138.715	BLT L51D						
	D1_238A	742906.521	226652.432	138.632	BLT+L51D	14/07/2009 12:17			0.01	-0.04	-0.08
	PRE_239	743018.643	226323.679	138.183	WR R51D TOP						
3	PRE_250	743325.022	226766.414	137.116	IS 400						
new	D1_250A	743325.041	226766.395	137.046	IS+400	14/07/2009 12:23			0.02	-0.02	-0.07
	PRE_251	743584.544	226625.136	138.713	IS 401						
4	PRE_234	743690.930	226997.924	135.572	BLT L50D						
50D	D1_234a	743699.117	226997.992	135.740	blt+l50d	8/10/2007 13:19 ok			0.18	0.07	0.17
	D1_6004	743710.337	226976.909	131.265	WL+12.34	14/07/2009 12:34	131.41	-0.15			
	PRE_236	743845.285	226696.800	139.394	BLT R50D						
5	D1_6005	744212.401	226149.346	131.249	WL+12.40	14/07/2009 12:40	131.41	-0.16			
new	PRE_252	744221.218	226159.289	133.871	IS 402						
	D1_252A	744221.268	226159.241	133.808	IS+402	14/07/2009 12:38			0.06	-0.06	-0.06
	PRE_253	744244.602	226666.738	137.402	IS 403						
6	PRE_232	744314.324	226313.638	141.184	BLT L49D						
49D	232_0001	744314.499	226313.678	141.066	BLT+L49D	8/10/2007 12:45			0.17	0.04	-0.12
	D1_6006	744362.059	226243.141	131.295	WL+12.46	14/07/2009 12:45	131.47	-0.18			
	PRE_233	744530.968	226836.676	141.290	BLT R49D						
	AEH5_001	744563.029	224173.660	254.635	BM+AEH5	14/07/2009 9:26			-0.10	0.01	-0.01
	CAL_AEH5	744563.130	224173.660	254.707	AEH5						

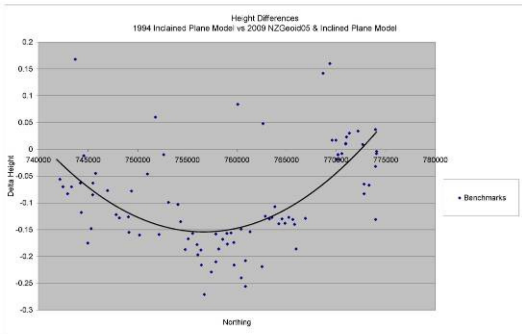
TGO reports were generated for further analysis in Excel. The North, East and Height residuals are displayed. The blue lines highlight the water levels and times of observation for generating a Tidal Curve from the river to reduce the hydrographic depth data.

We logged the uncorrected tidal data in the boat navigation system and checked that against the land survey crew's roving observations to check consistency in the field. However, we did not use a site calibration in this survey as we were combining the field work and planned to apply the Adjusted Tide Level after we have completed the 2009 site calibration.

4.1 Residual Analysis

Data analysis allowed us to produce a polynomial regression curve of the difference in height between the 2009 and 1993 surveys. This graph showed a good concentration of data around the -0.15m value with some around -0.25m. The source of the error would be made up in part by 1993 data suffering the following:

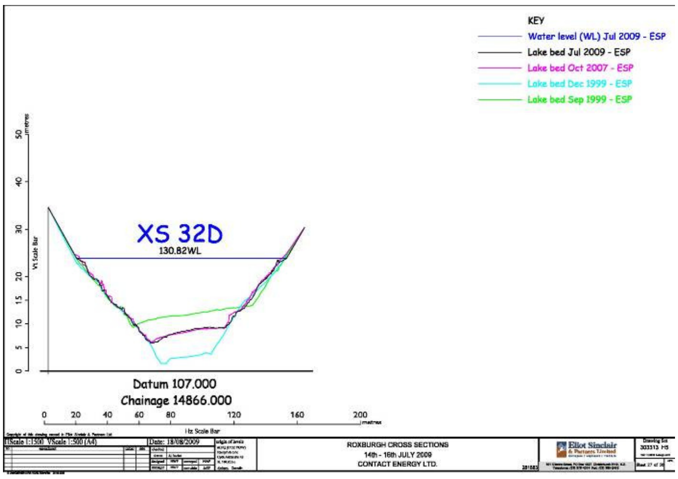
- Less than optimal vertical control available.
- The control is more remote in the Gorge area.
- The Geoid slopes vary in this harsh terrain.
- Lack of a full constellation of satellites.
- Tectonic movement around the fault zones.



The data, with residuals of ±0.05m in height, is generally associated with control data and the control available on the East and West sides of the river north of Alexandra.

4.2 Cross-sections

Selected surveys are used to compile a sheet of profiles to show the stability of the river bed and the effect of any flushing.



The adjacent profile sheet shows very marked river bed reduction in levels for the period September 1999 to December 1999.

However, the river appears to have stabilised in this location for the period 2007 to 2009.

The cross section data was supplied as an Xcel spreadsheet for others to calculate the sediment volume changes.

5. CONCLUSIONS

- The integration of a Geoid correction model into GPS or GNSS surveys enhances the quality of the reduced data.- The combined survey techniques of Real Time Kinematic and Fast Static (Trimble) observations provides a further strength in the field observations.

- Post-processing with TGO, or the like, provides a platform to reduce, combine, adjust, analyse, QA and report survey data.

- The site calibration generated by applying the Geoid 'N' values to the ellipsoidal heights and then applying an 'inclined plane' transformation to further reduce the residuals is very effective.

- The combined site calibration of Geoid Model & Inclined Plane extends the operational survey area and minimises residuals of the field observation.

- The adoption of the site calibration from TGO to Trimble HydroPro Nav is professional and reduces the amount of field checking required considerably. Water levels can be observed in real time in the field.

- Independent field checks using RTK GPS methods by a land surveyor provides the assurance that the navigation system is correctly processing the observations, both on the water and in post-processing reductions.

- Preparation and planning is paramount in any survey task, but more so in a project of this size, location and isolation, and complexity.

- The skill level of those participating in the field work must be extensive, flexible and committed.

- We recommend that the methodology be used in land and hydrographic surveys of this type.

REFERENCES & ACKNOWLEDGEMENTS

- Land Information New Zealand website www.linz.govt.nz

- Trimble Support (New Zealand)

- New Zealand Institute of Surveyors Annual Conferences and Survey Quarterly publications.

- Australasian Hydrographic Society Seminars and Conferences.

- Hydro International publications.

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BIOGRAPHICAL NOTES

Maurice Perwick is a Director of Eliot Sinclair & Partners Ltd, a Christchurch survey, engineering and planning consultancy of some 60+ persons.

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