LAKE ILLAWARRA
HYDROGRAPHIC SURVEY REPORT

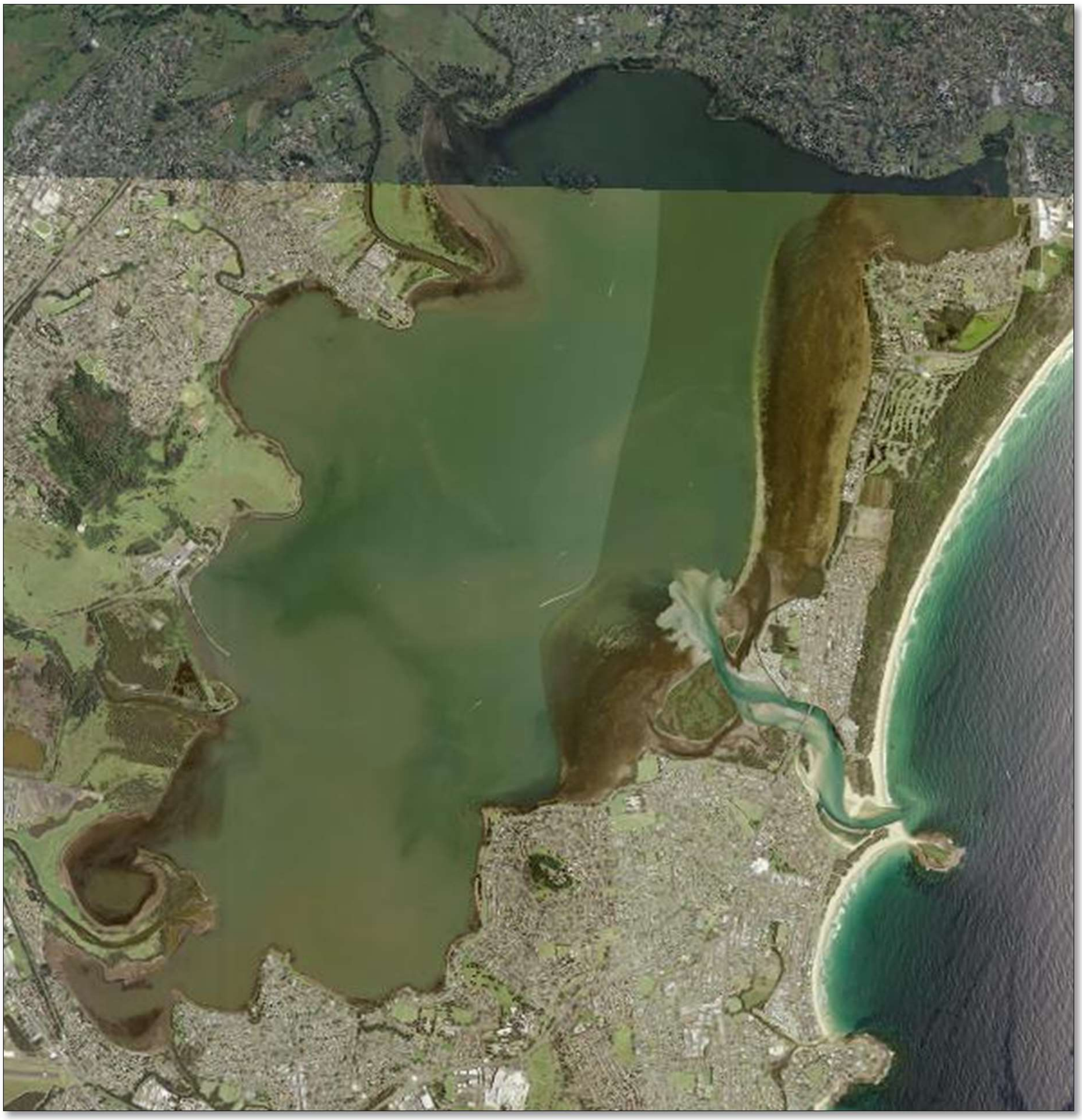

Image: Lake Illawarra (NSW Spatial Services [SIX Maps, 29 Jul 23])

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MARINE

LAND

AERIAL

HCS Job Ref: **HCS539**

Survey Date Start: **29 Aug 22**

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Report Date: **18 Nov 23**

Revision History

Revision #	Date	Comments	Issued by
1	19 Oct 22	Draft for Client comment	Richard Cullen
2	18 May 23	First issue	Richard Cullen
3	05 Jun 23	Amendments on data coverage as per client supplied markups on pdf files	Richard Cullen
4	30 Jul 23	Format updated to reflect Client preferences. Inclusion of Acknowledgement of Country. Removed Lake Illawarra entrance analysis. Inclusion of an executive summary. Addition of Lake tributaries analysis.	Richard Cullen
5	26 Sep 23	Format amendments as per Client preferences	Richard Cullen
6	28 Oct 23	Format amendments as per Client preferences Regenerate graphics with new colour gradients	Richard Cullen
7	18 Nov 23	Additional updates to graphic keys, descriptives of area trends, merging of tributary and lake areas into one labelled graphic, generate one sediment variation plot for entire lake and tributaries.	Richard Cullen

Acknowledgement

Wollongong City Council has prepared this document with financial assistance from the NSW Government through its Coastal Management Program. This document does not necessarily represent the opinions of the NSW Government or Department of Planning and Environment.

Acknowledgement of Country

We acknowledge the Traditional Custodians of the land on which our city is built, the Aboriginal people of Dharawal Country.

We recognise and appreciate their deep connection to this land, waters and the greater community.

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Executive Summary

A bathymetric survey of Lake Illawarra was conducted to enable an analysis of sedimentation and erosion within the lake based upon historical data. There were four different techniques used, dependant on water depth and other physical constraints. The methods included Real Time Kinematic (RTK) by foot and boat, Single Beam (SBES) and Multi Beam Echo Sounders (MBES) by boat.

There is a limitation on the use of echo sounders within the area due to depth, seagrass and sediment type. In general, there was a requirement to have a depth of at least 300mm in order for the acoustic echo to be received successfully.

As the lake is tidal, and the project required area coverage by sounder for the majority of the area, the survey was constrained by the highest of the tides for each month thus slowing progress due to the small tide window each day and month.

Data collection was conducted as close as possible along historical survey lines (2008) so that a comparison could be made during analysis. As there are differences in the position of datasets, this does have a direct influence on the analysis not only for calculating percentage changes in volume but also in the visualisation of profiles.

Sedimentation and erosion have been observed within the Lake and tributaries. Graphical representation of those processes are presented in Appendix 3. Most of the erosion was found on the banks and outer bends of the tributaries with sedimentation on the lower parts of tributaries and the Lake basin. Detailed results are described in Section 4 of the report.

Broadly, results from statistical analysis utilising the hydrographic survey software 'Hypack', report a mean difference between 2008 and 2022/23 surveys of 0.16m shallower across the entire lake dataset. In context, 0.15m is in the order or the quoted uncertainty of datasets used for the vertical solution and should therefore be considered in this regard. There are many factors that contribute to uncertainty, some of which are identified within the analysis.

Changes in specific lake areas can be driven by factors such as, but not limited to: storm water flows from tributaries and drainage systems, proximity to the entrance and rate of tidal stream flow, type of sediment in location, amount of vegetation within or surrounding the area, and leeward or windward side of the typical seasonal winds.

1 INTRODUCTION

1.1 Project Overview

Lake Illawarra is a highly valued natural resource within the Illawarra region, and is immensely important from an ecological, social, cultural, and economic perspective. Balancing the existing modified environment with the community's aspirations for use and enjoyment of the Lake is extremely complex given the many threats and challenges it is facing.

Since the disbandment of the Lake Illawarra Authority (LIA) in 2014, management of Lake Illawarra is primarily the responsibility of Wollongong City Council (WCC) and Shellharbour City Council (SCC), with support from State Agencies such as the Department of Planning and Environment (DPE) – Environment, Energy and Science, DPE – Crown Lands, and DPI Fisheries.

To ensure coordinated management of Lake Illawarra across all responsible agencies a Coastal Management Program (CMP) has been prepared. It was certified and gazetted in late 2020. Through the course of preparing the Lake Illawarra CMP a list of threats to the condition and values of Lake Illawarra were identified. A threat may include a driver (issue, activity, or process) that results in a detrimental impact or consequences to the values or benefits of the lake.

One of the actions (FB3) in the Lake Illawarra CMP requires a bathymetric survey to be conducted across the whole of Lake Illawarra, including up to the tidal limit of all tributaries. This action was included in the CMP due to extensive community feedback during the public exhibition period regarding concerns that the lake is becoming shallower. A previous bathymetric survey was undertaken in 2008 by the NSW Government as part of the state's coastal surveying program. Wollongong City Council and Shellharbour City Council (in association with the Lake Illawarra CMP Project Management Team) engaged Hydrographic and Cadastral Survey to undertake a contemporary bathymetric survey of Lake Illawarra and its tributaries followed by a comparative assessment with the 2008 bathymetric survey.

This project provides information on the current status and recent changes of the topography of the Lake's bed, indicating the depth of water across the Lake. The comparative results determined if and where sedimentation is occurring. This information will be used to inform future projects outlined in the CMP.

2 STUDY AREA

Lake Illawarra's shoreline runs along the Local Government Area (LGA) of Wollongong City and Shellharbour City. The Lake lies between the Illawarra escarpment and the Pacific Ocean on the New South Wales coast with an entrance open to the ocean. The study area excluded the entrance channel as this area has a separate study. The following areas were surveyed for the analysis and are represented at Figure 29:

2.1 Main Lake

- Lake 1: Warrawong to west of Berkely Boat Ramp
- Lake 2: Koona Bay
- Lake 3: Haywards Bay
- Lake 4: Muddy Bay North
- Lake 5: Lake Centre

2.2 Tributaries

- Albion Creek
- Brooks Creek
- Duck Creek
- Hooka Creek
- Horsely Creek
- Macquarie Rivulet
- Mullet Creek
- Mullet Creek Tank Trap
- Oaky Gully

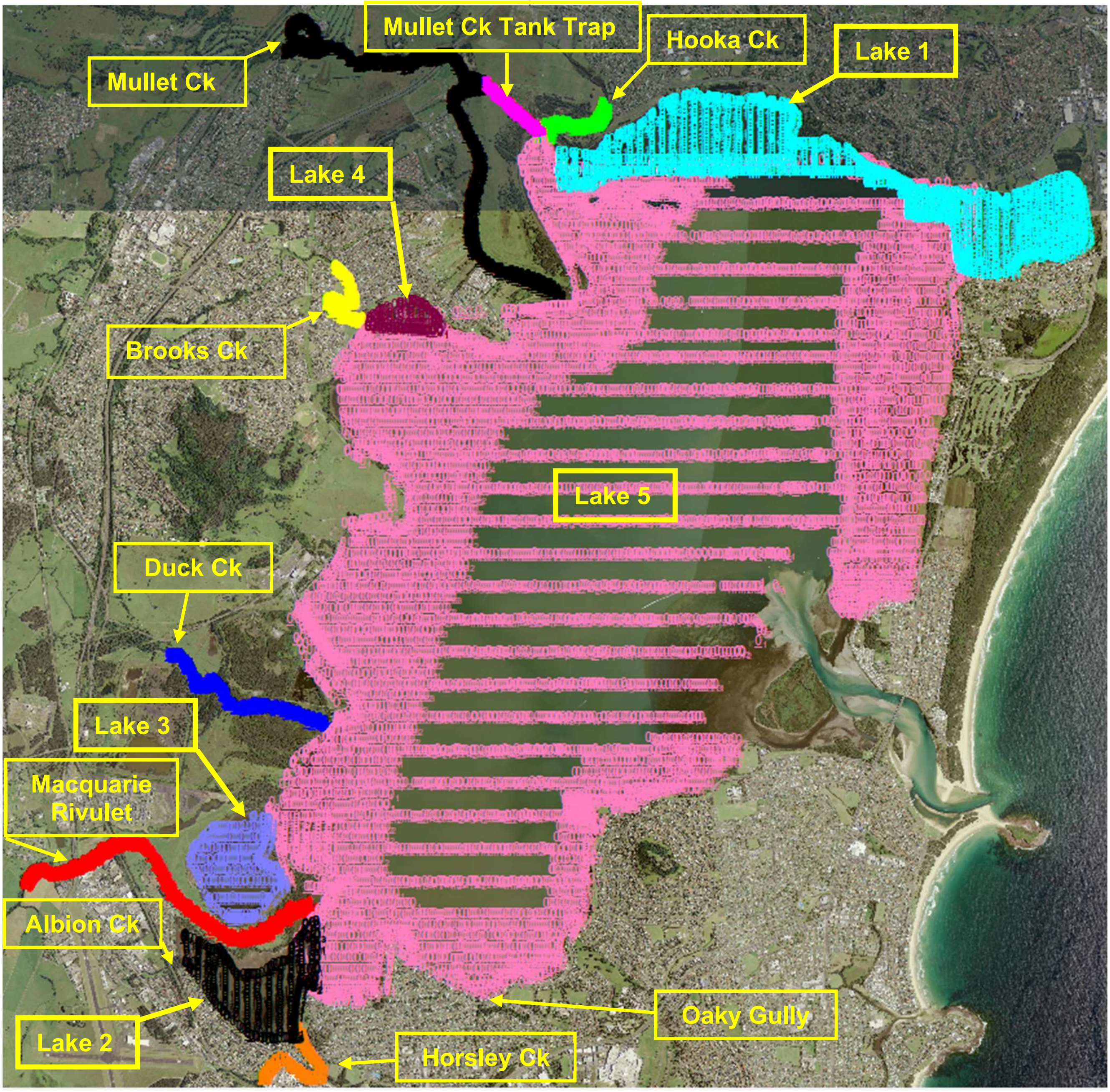

Figure 1: Lake Focus Areas

3 METHODS AND EQUIPMENT

3.1 Overview - Data Collect and Analysis of Historical Data

New survey data of the main lake has been collected using Global Navigation Satellite System (GNSS) and acoustic survey techniques. This data has then been assessed against historical data. Baseline surveys for the main Lake originate from 2008 dataset collected by the Office of Environment and Heritage (OEH), and were exported from the Australian Ocean Data Network (AODN) Portal. There are numerous complexities with the analysis, and these are explained through the report when required.

Data collection was conducted as close as possible along the 2008 survey line profiles (Figure 2) so that a comparison could be made during analysis. As there are differences in the position of datasets, this does have a direct influence on the analysis not only for calculating percentage changes in volume but also in the visualisation of profiles. Within the centre of the lake, only every forth survey line was covered. In all other areas, the historical lines were run.

Figure 2: 2008 survey profiles (white lines)

3.2 Survey Equipment and Methods

The survey of Lake Illawarra required use of the Global Navigation Satellite System (GNSS) for positioning and determination of heights and echosounders. The GNSS receivers utilised a Networked Transport of RTCM via Internet Protocol (NTRIP) to receive corrections from the New South Wales (NSW) network of Continuous Operating Reference Stations (CORS).

The GNSS receivers were used in Real Time Kinematic (RTK) mode and interfaced with the Single Beam and Multi Beam Echo Sounders. When the RTK receiver was used in standalone, it was pole mounted and the surveyor either walked the lake or used the equipment from in the survey boat when in very shallow water. A flat plate was fitted to the pole so that there was no penetration of the lakebed in this case.

There is a limitation on the use of echo sounders within the area due to depth, seagrass and sediment type. In general, there was a requirement to have a depth of at least 300mm in order for the acoustic echo to be received successfully. Additional constraints included safety for surveyors who could not walk all areas of the lake due to very soft sediment.

As the lake is tidal, and the project required full area coverage as could be achieved, it was necessary to use the single beam sounder for the majority of the area. The survey was constrained by the highest of the tides for each month because of this, thus slowing progress due to the small tide window each day a high tide was available through the month.

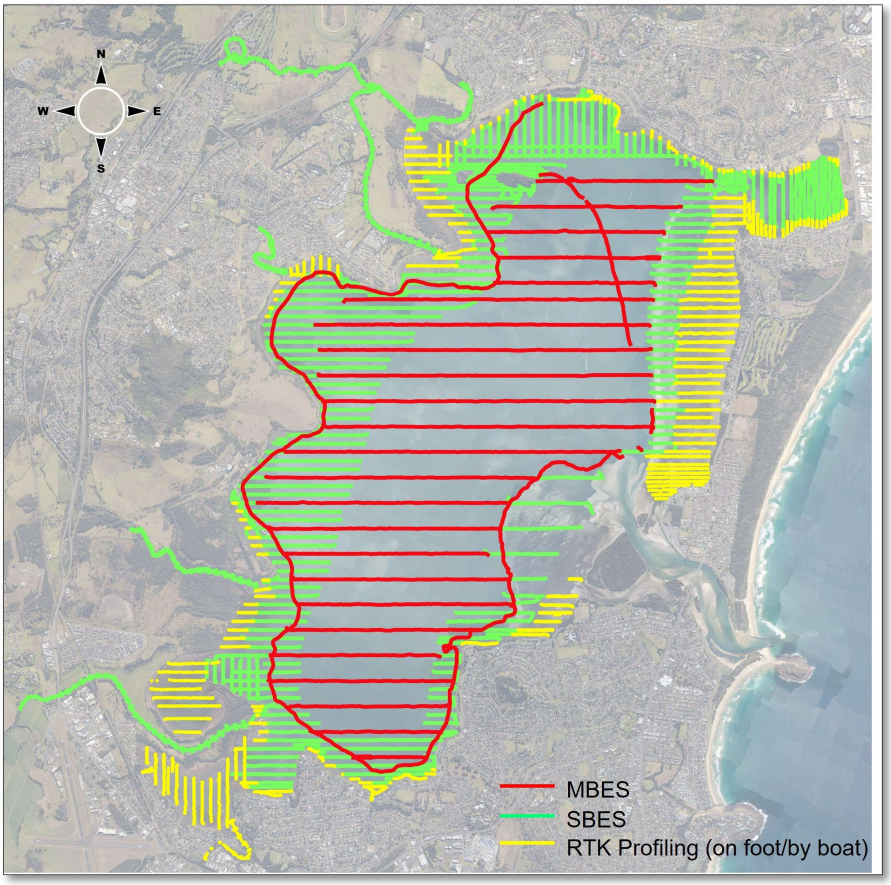

Figure 3: Methods used across lake.

3.2.1 Multi Beam Echo Sounder (MBES)

The operational limitation for MBES use is mainly water depth. For this reason, MBES was used for the centre of the lake only where depths were generally 2m to 3m. In shallow waters coverage is reduced as depth decreases and therefore becomes more like a single beam. Despite this, HCSurvey identified there to be a benefit to ensure coverage across the historical data and some appreciation of the lake floor features due to the increased resolution.

A confirmation of accuracy of the equipment is undertaken on the day of survey by measuring the distance from the water surface to the bottom with a lead line, comparing measurement with MBES depth recorded, adding the distance from MBES to water surface. If these results are similar, i.e., within ±0.15 it means the data collected is within acceptable tolerances.

Post calibrations and validations, the MBES was used to cover the centre of the lake across every fourth survey line from the 2008 dataset and to conduct a circumnavigation of the slope/bank contour representing zero height datum.

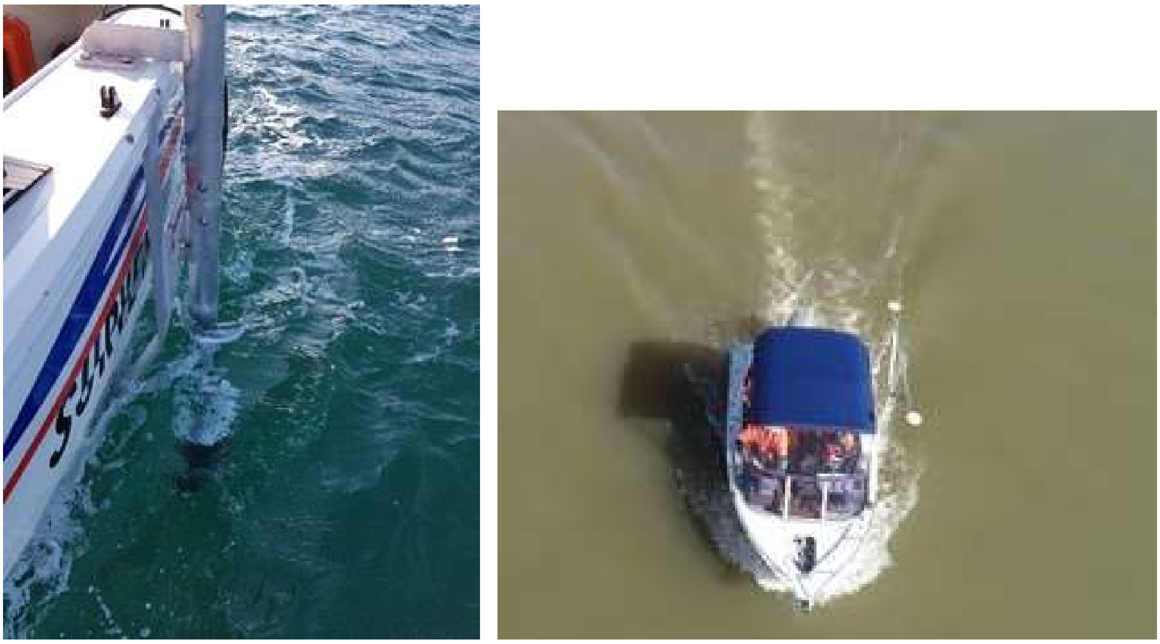

Figure 4: Survey conducted using multi beam echosounder (MBES)

3.2.2 Single Beam Echo Sounder (SBES)

SBES was used to overlap with the MBES data and complete all historical lines from as close to the shoreline as possible out to the MBES perimeter line as per Figure 2.

The primary limitation of this system is based upon depth, physics of acoustics and capability of modern electronics. The SBES has a minimum depth for its operation ranging from 0.2m to 0.3m from the transducer to the lakebed, any readings closer than this distance would not be recorded.

To confirm the accuracy of the system on each day of collection a verification is undertaken where a metallic plate is lowered in the water below the sonar. The distance lowered is known, thereafter compared against the distance measured by the sounding system. If this difference is within tolerance (±0.15m), it means the equipment is functioning correctly.

Figure 5: Survey conducted using Single beam echosounder (SBES)

3.2.3 Real Time Kinematic (RTK)

For the RTK data collection there were two different means of collection either by boat or on foot, as described below.

Data collected via boat was recorded by one person in the team moving the boat over the desired location and a second team member lowering the RTK attached to a pole into the water until the pole reached the ground below. Once the pole was level and the RTK receiver was ready a point would be recorded. This process was repeated along the profiles approximately every 10-20 meters to provide enough data to accurately show changes in elevation below the water level and comparison with historical data.

The other method of RTK collection undertaken was by foot, this was conducted as some areas were ultra shallow for boats to be used for the task. Two methods were used for on foot observations (1) a single person was required to walk with the RTK receiver on a pole and (2) a single person was required to walk with the RTK receiver attached to a backpack.

For this method it is important to note the height of the pole or backpack in order to record the elevation of the bottom appropriately. On each day of observations, a verification is undertaken on a State Survey Mark to confirm operation and accuracies of the system.

Figure 6: RTK observations by boat (left) and on foot (right)

Figure 7: RTK Collection on foot using backpack

3.1 Statistical Analysis

To generate a height difference dataset, Triangular Irregular Networks (TIN) were created for each survey (2008 and 2022/23). Using the hydrographic software Hypack, it was then possible to provide the analysis of data.

Between the 2008 and 2022/23 surveys, a mean difference of 0.16m across the entire dataset (lake and tributaries) was computed.

A sigma distribution histogram presented below (Figure 8) offers a clear depiction of how the differences in the dataset comparison between the 2008 and 2022/23 surveys are distributed across various ranges.

The data is centred around the mean difference of approximately 0.16m, which is indicated by the relatively high frequencies in the -1s and +1s bins. Majority of compared points showed changes in height within the range of -1 standard deviation to +1 standard deviation from the mean, where 87.41% sigma values are in the range of -0.13m to +0.45m.

Statistics can however be very misrepresentative without due regard to the factors influencing the calculation. The survey data in this case and for the historical dataset, have a vertical uncertainty in the order of ±0.15m and should therefore be considered in this regard.

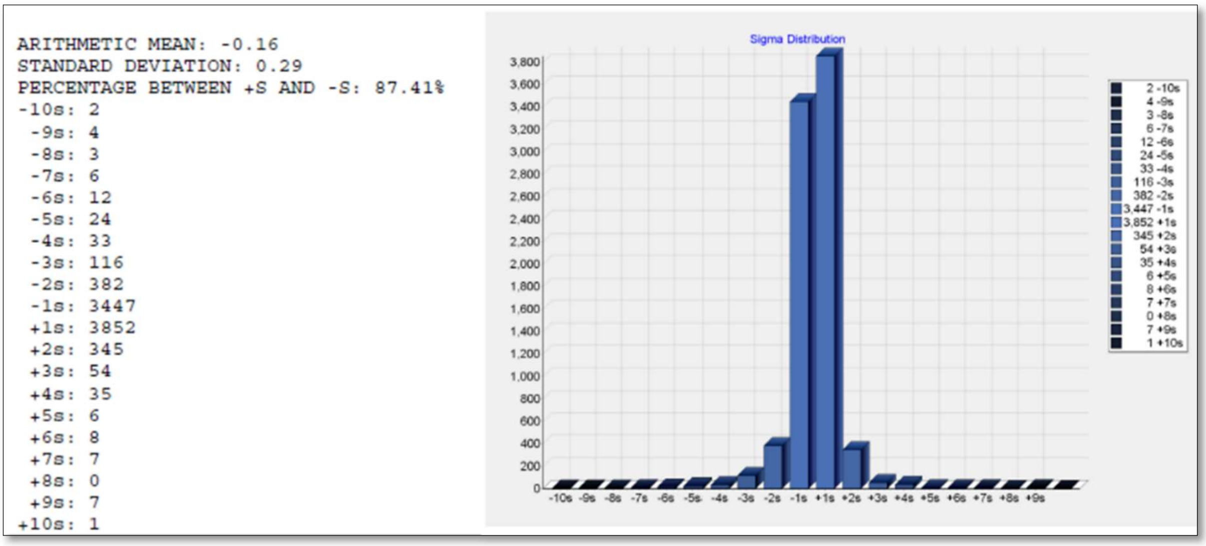

Figure 8: Hypack statistical analysis comparing 2008 – 2022/2023 surveys

3.2 Constraints

Shallow areas with dense seagrass patches reduced data coverage normally expected either by causing the vessel's propeller to accumulate vegetation when the skipper had to stop to remove material or for observations by foot over soft sediment - for these situations, the survey team had to disembark one member to continue the data collection by foot up to the last point from historical data.

Another constraint observed related to seagrass was during processing the data from sounding systems, more evident on the shallow areas and edges of the lake. The existence of underwater vegetation, the variation of its heights during periods of high and low tides, as well as a possible seasonal variation increases the difficulty in determining the real bottom of the lake in those sections.

Access to Hooka Creek and Brooks Creek from the Lake are shallow which stopped the vessel from entering those tributaries on the 20 Mar 23. A smaller vessel was deployed to survey those locations.

Figure 9: Seagrass coverage at Hooka Bay

Figure 10: Seagrass coverage and depth of water at Haywards Bay

4 RESULTS

Comparing the data sets from 2008 and 2022/23 surveys for the Lake and Tributaries using the methods described at Section 3 above, it was possible to identify the trend of height change across the area. Figure 11 shows the height change distribution for the entire dataset where a difference of approximately 0.2m was observed.

Results outcomes are presented in detail in this section (4.1 – 4.15) and in Appendix 3 where profiles, difference plots and graphical representation of shallower/deeper areas are presented. The analysis was performed using historical data from 2008 as required by the project brief (Q1001203) and the most recent surveys conducted by HCSurvey (2022/2023) across the lake and tributaries.

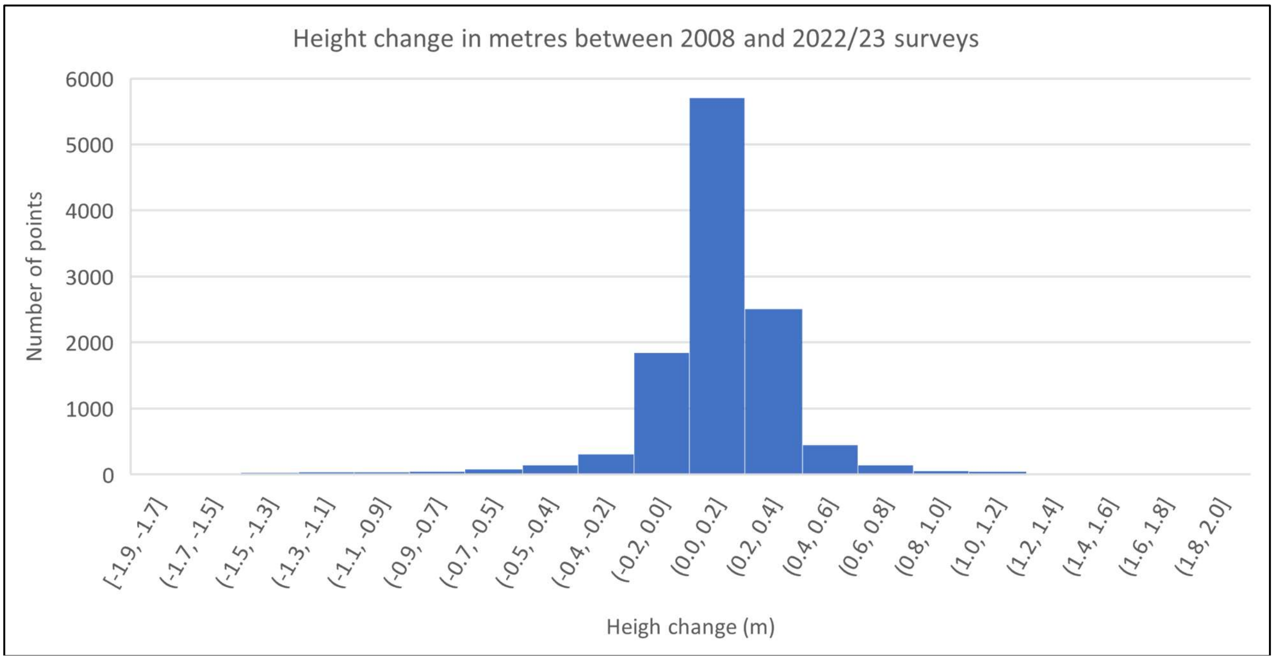

Figure 11: Height change distribution comparing 2008 – 2022/2023 surveys.

Comparing surveys 2008 and 2022/2023 (Figure 12), it was possible to identify the reduction of deep areas (green/dark green) and increase of the shallower (orange). Sedimentation may have occurred at the following bays: Koona, Haywards, Burroo and Karoo.

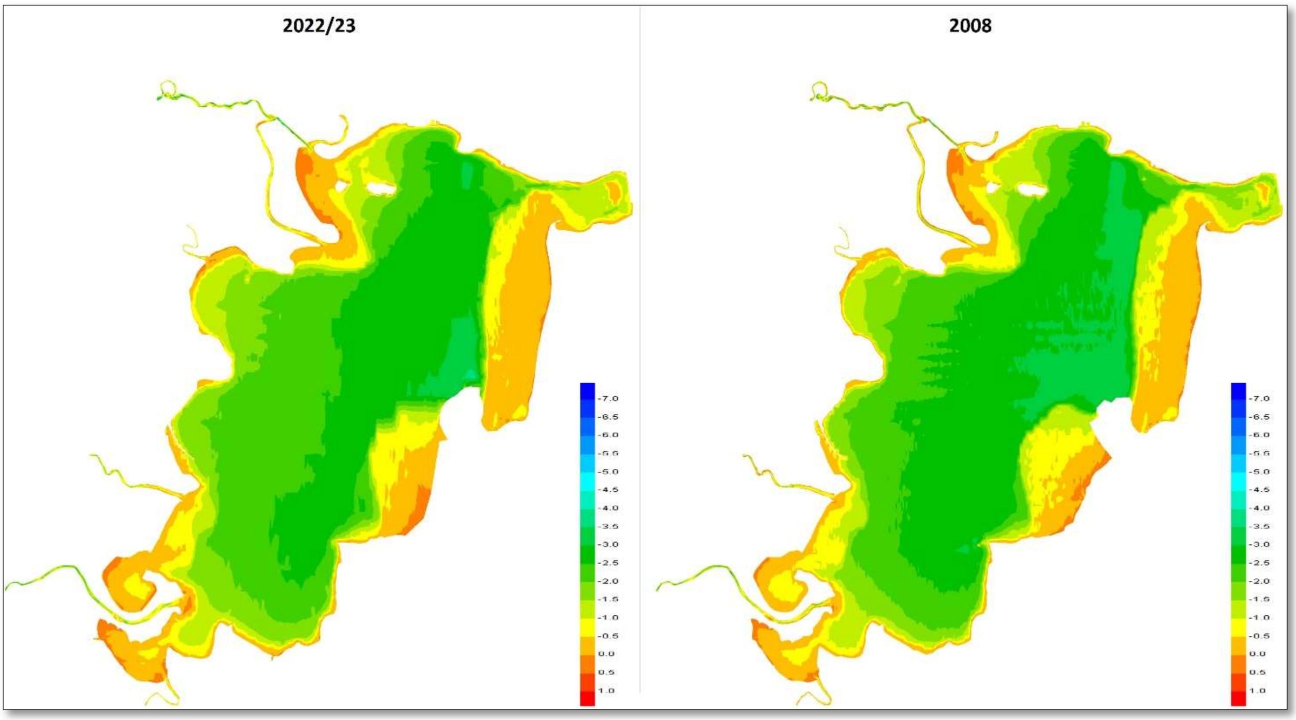

Figure 12: Height changes in metres between 2022/2023 and 2008 surveys

A large part of the lake showed change in elevations since the 2008 survey. Figure 13 presents the shallower/higher areas in red (sediment transport in) and the deeper/lower areas in blue (sediment transport out).

The amount of sedimentation or erosion is generally small (Figure 11), and realistically, a high proportion of the analysed variation in sediment is generated by the combined uncertainty values of the measurement equipment, survey methods and environmental influences during the survey, rather than sediment transportation itself.

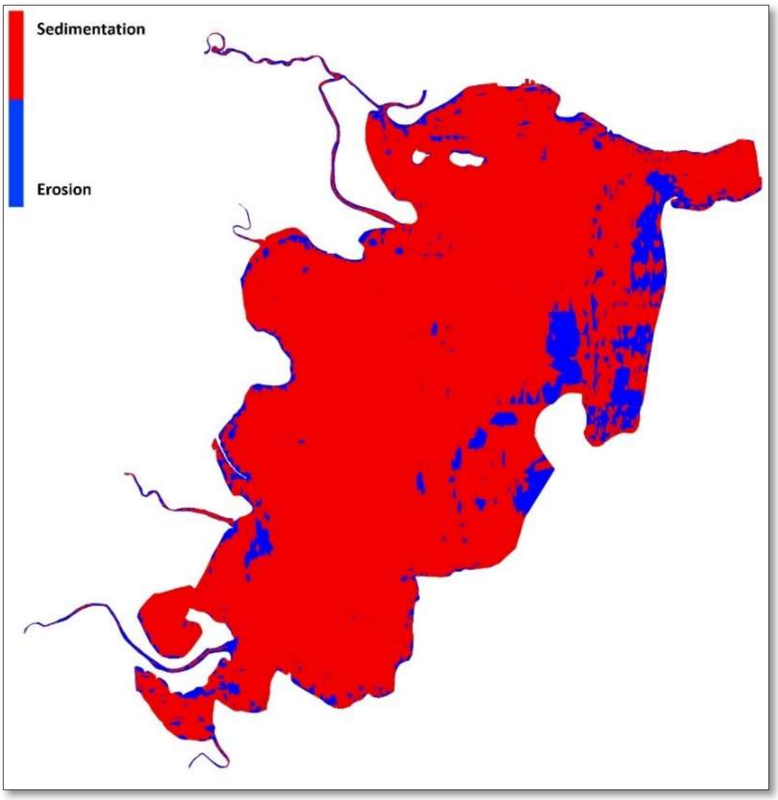

Figure 13: High/Low difference between 2008 – 2022/2023 showing areas where sedimentation or erosion may have occurred.

Sedimentation was observed adjacent to Macquarie Rivulet and Mullet Creek deltas, in the area of influence of the lake entrance channel, along the shelf extending from the lake entrance towards North and within Primbee Bay/Jones Bay.

Erosion was noticed in some areas of the central part of the lake however not significantly. Similar process was observed on banks in the lake and tributaries (Albion and Brooks).

Further analysis of individual cross sections for each area defined previously have showed sedimentation/erosion in the order of ±0.20m on average in the 15 year gap between datasets.

Within the time span between analysed datasets, it is estimated that the rate of sedimentation/erosion was approximately ±0.013m per year.

For the presentation of results, the Lake was divided in sections as per the alignment and presence of historical data (Lake 1, Lake 2, Lake 3, Lake 4, Lake 5 and tributaries).

Following is a description of the lake areas, tributaries, and brief results. Appendix 3 presents the profiles comparing 2008 and 2022/23 surveys for the above areas.

4.1 Overall Lake Variation Plot

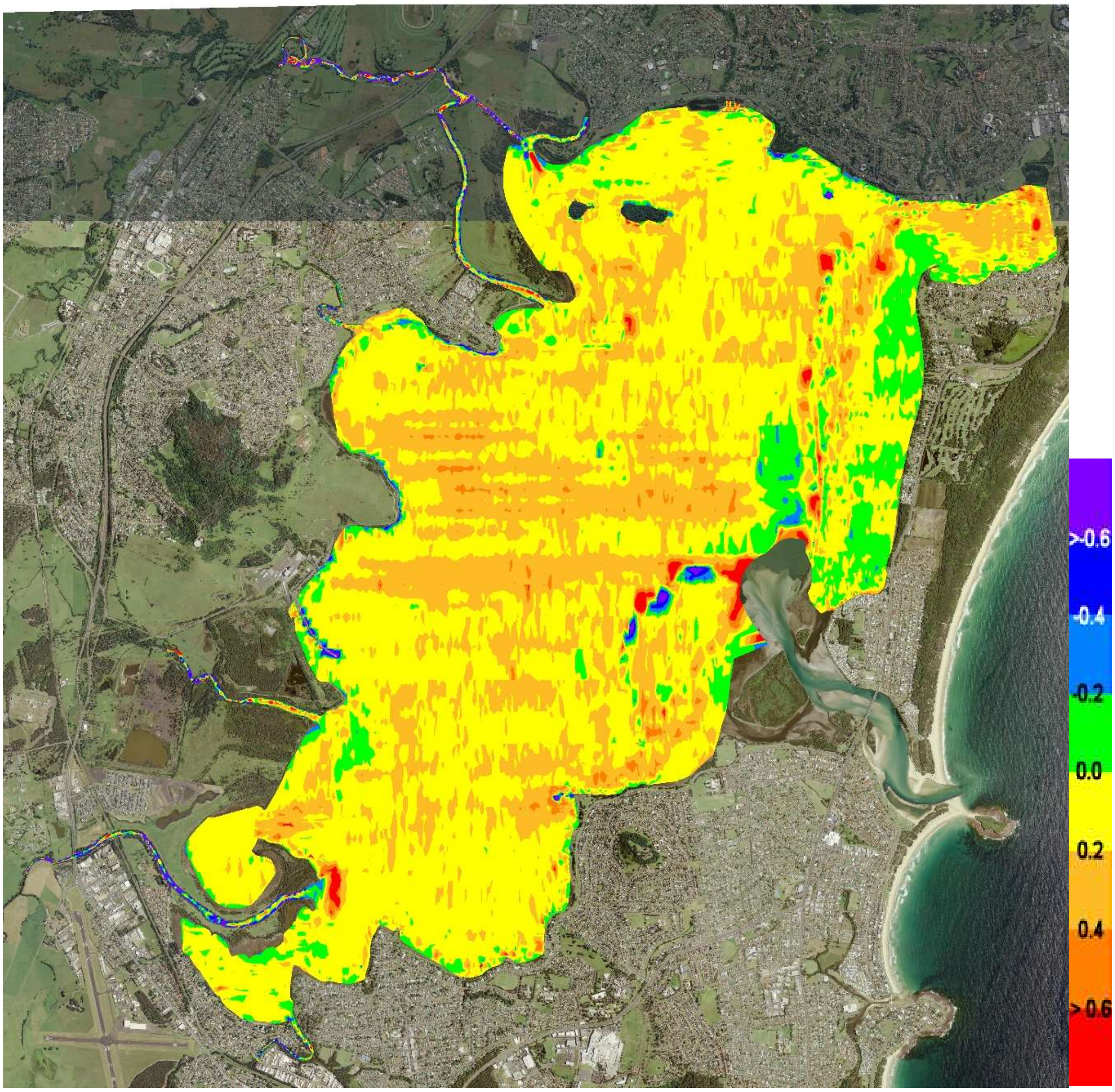

Figure 14: Entire project area difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening.

4.2 Lake 1 (Warrawong to west of Berkeley boat ramp)

- Sedimentation trend of approximately 0.15m in the exposed central northern area.
- Shoaling noticed within Berkley boat ramp area.
- A shoaling area was noticed at profile 539_ML1_47 in the order of 1.0m
- The eastern bay shows shoaling of 0.4m and more however this is likely attributed to the density of seagrass in the area.

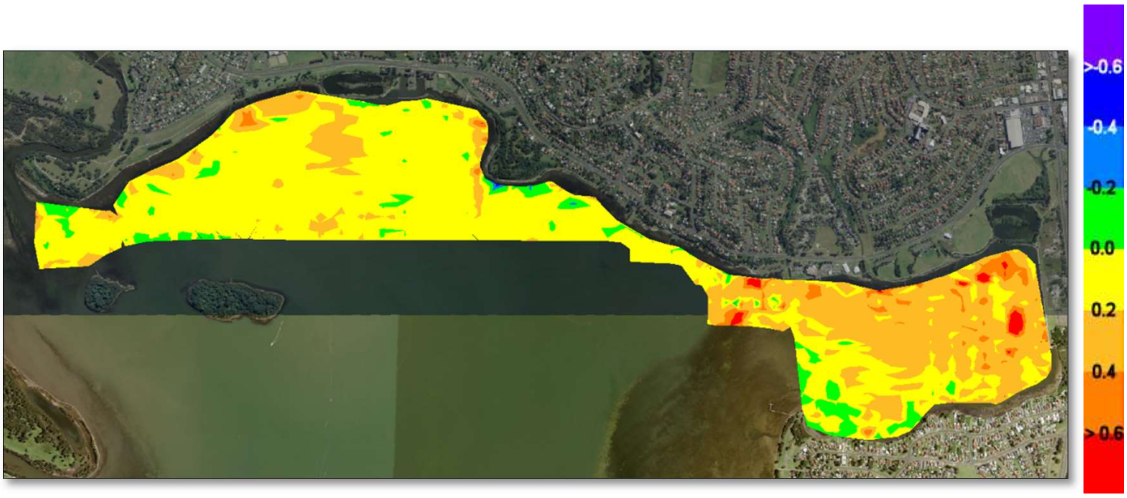

Figure 15: Lake 1 difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheets 1 and 5).

4.3 Lake 2 (Koona Bay)

- Sedimentation trend of approximately 0.06m
- Possible deeper area at the mouth of Horsley Creek

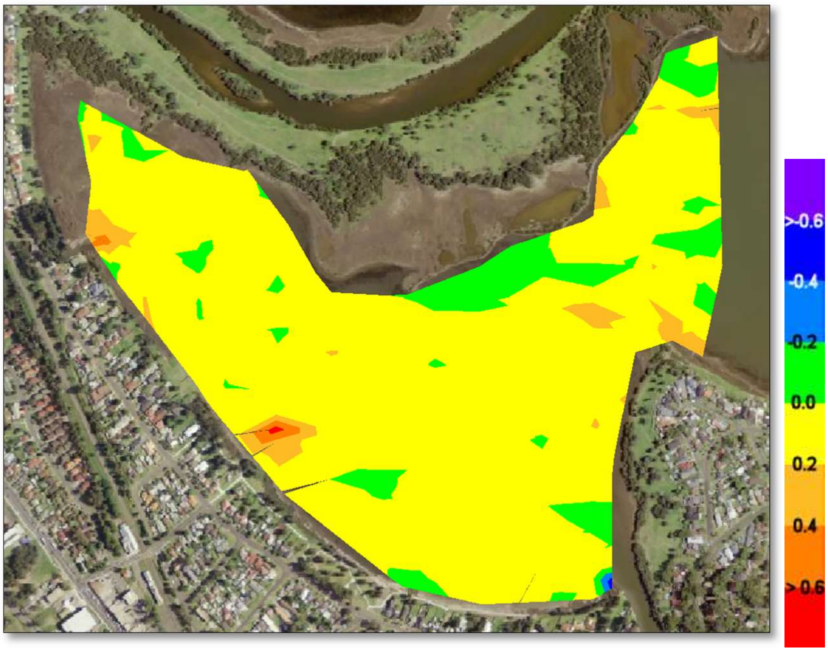

Figure 16: Lake 2 difference plot between 2008 and 2022/2023 surveys surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 4).

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4.4 Lake 3 (Haywards Bay)

- Deepening of approximately 0.12m on average.
- Noticeable shoaling area at the western side of the bay in the order 0.2m, where dense patches of seagrass were found.

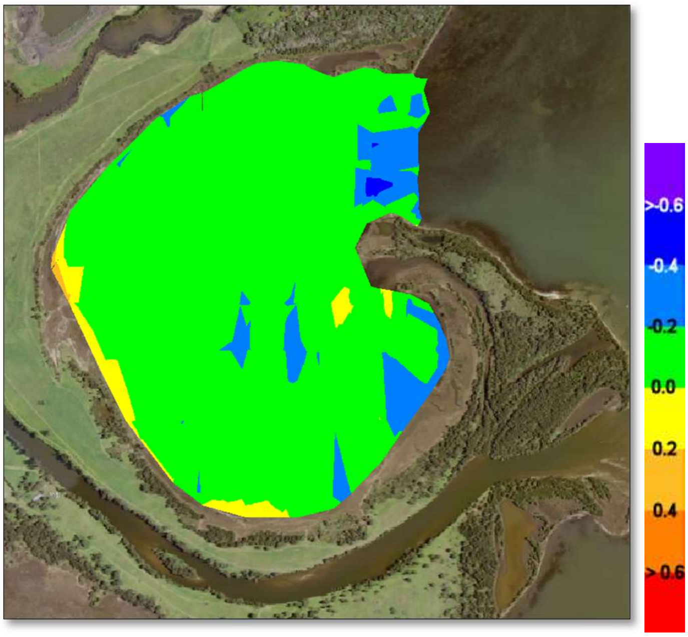


Figure 17: Lake 3 difference plot between 2008 and 2022/2023 surveys surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 4).

4.5 Lake 4 (Muddy Bay North)

- Sedimentation trend ranging from 0.2-0.5m adjacent to Brooks Creek inlet and existing jetty in the middle of bay.
- Erosion (deeper area) observed at an area east of existing jetty.

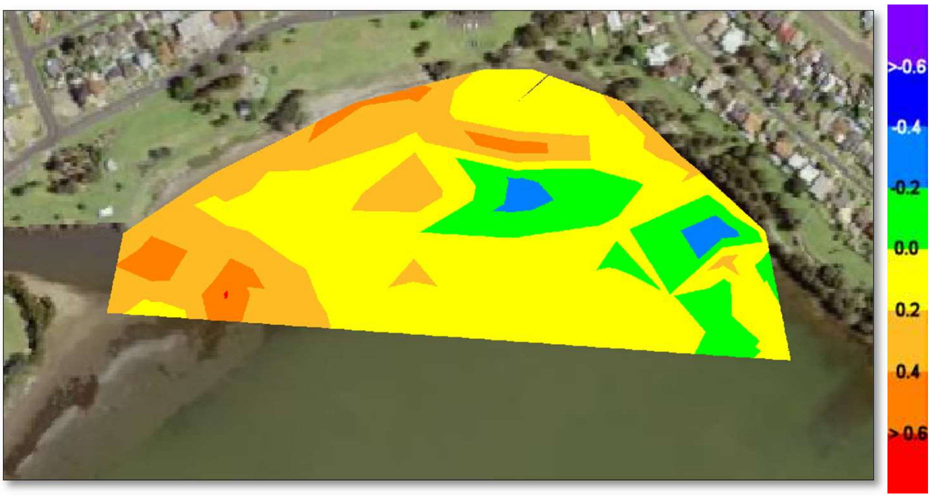


Figure 18: Lake 4 difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 2).

4.6 Lake 5 (Lake Centre)

- Sedimentation trend of approximately 0.15m.
- Greatest shoaling area found adjacent to lake entrance of approx. 2.5m (This is a common river/inlet affect associated with tide cycles and mobile sediment types. The area is subject to another study and the affect does not normally, nor has it been demonstrated to be, a primary influence across the rest of the Lake with respect to catchment sedimentation).
- Shoaling identified on the delta of Macquarie Rivulet of approx. 1.0m.

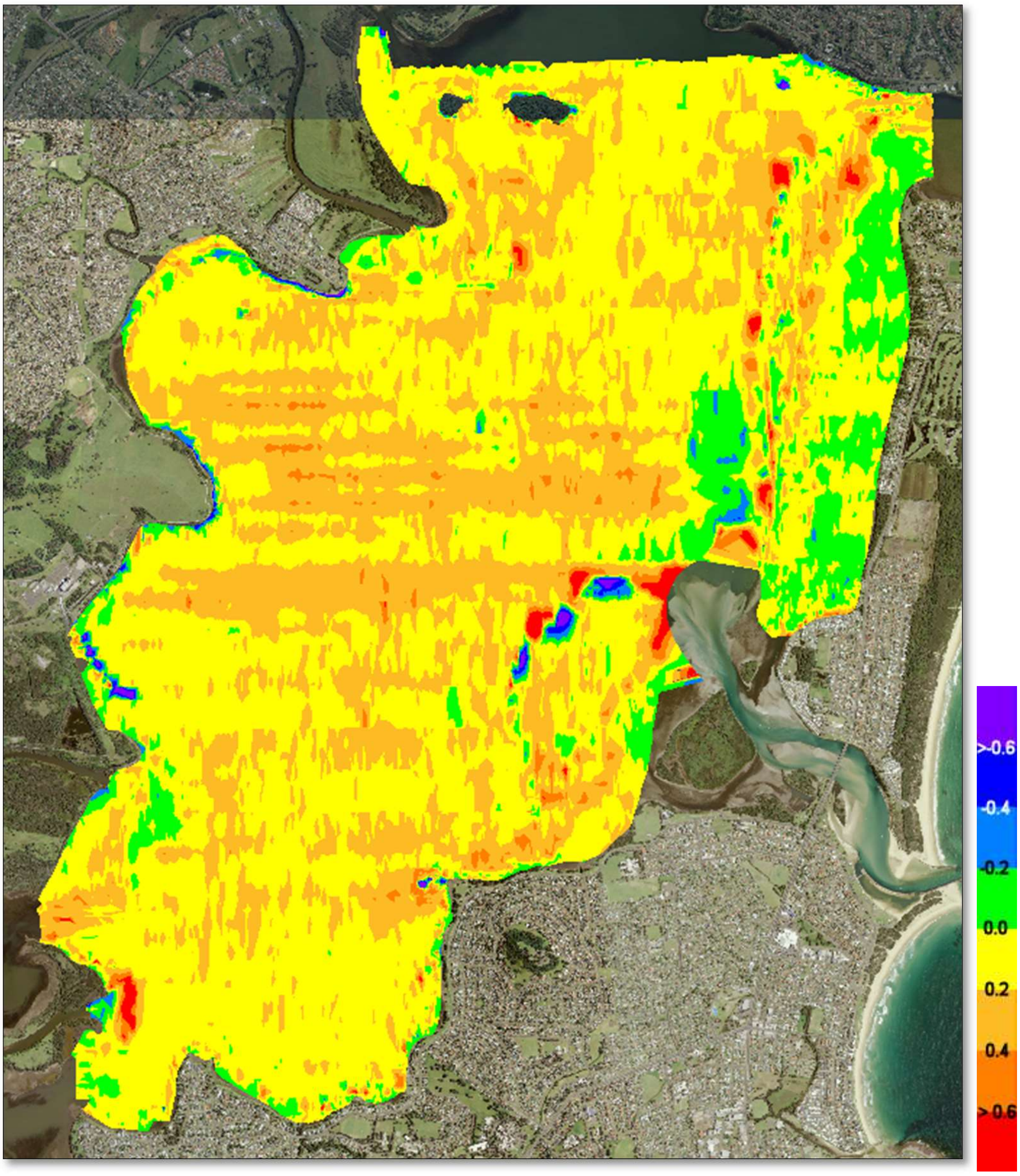


Figure 19: Lake 5 difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 1-5).

4.7 Albion Creek

- In general, it shows an erosion trend of 0.06m along the creek.
- Potential erosion on banks.

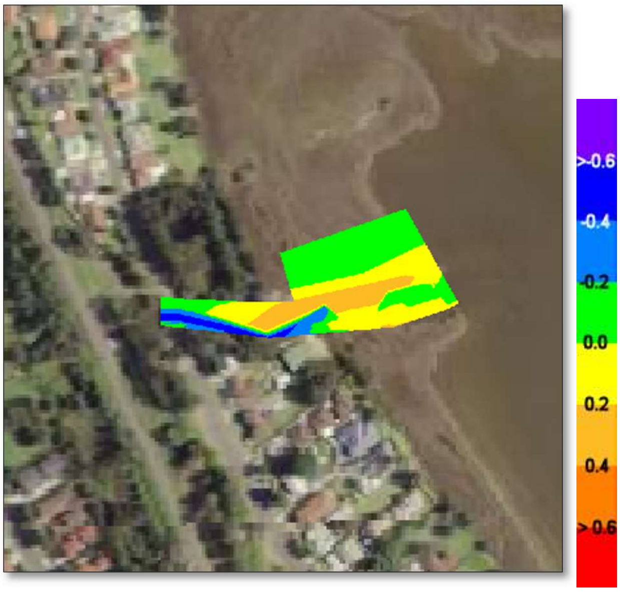


Figure 20: Albion Creek difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 4).

4.8 Brooks Creek

- Shoaling was observed in the bottom half and mouth of the creek reaching approximately 1m in elevation change in areas.
- Two thirds of the creek shows deepening of up to 0.6m with isolated areas deeper than this. The lows and highs undulate throughout the creek.

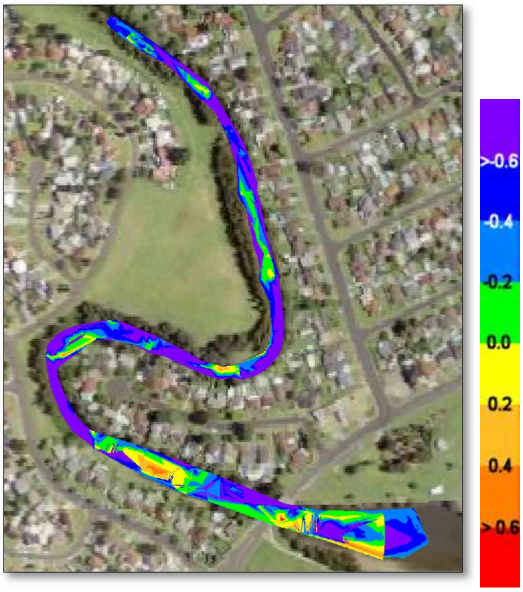


Figure 21: Brooks Creek difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 2).

4.9 Duck Creek

- Majority of the areas within the creek channel showing a shoaling trend, particularly at the bottom half near the Lake.
- Potential erosion on banks along the creek, noticeable in the top half adjacent to the outside bends

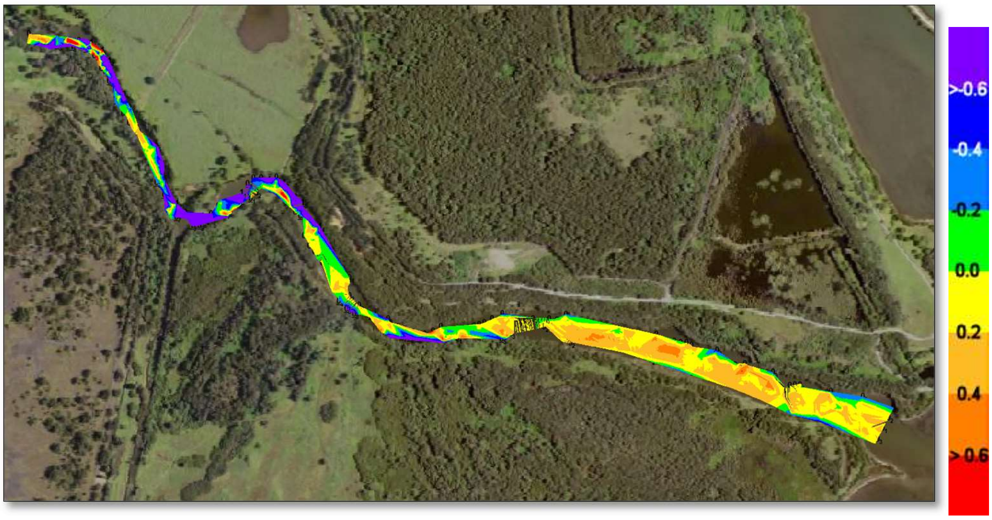


Figure 22: Duck Creek difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 4).

4.10 Hooka Creek

- Shoaling of up to 0.60m observed in the middle of the channel
- Potential erosion on banks along the creek, most notably adjacent to Mullet Creek Tank Trap

Figure 23: Hooka Creek difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 2).

4.11 Horsley Creek

- Shoaling observed along central section of the creek
- Potential erosion on banks within the top half of the creek

Figure 24: Horsley Creek difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 5).

4.12 Macquarie Rivulet

- Shoaling trend observed within the channel at distinct locations as seen in Figure 25.
- Potential erosion on banks exceeding 1.5m in some areas adjacent to outside bends.

Figure 25: Macquarie Rivulet difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 5).

4.13 Mullet Creek

- Most noticeable shoaling observed from the junction of Mullet Creek Tank Trap along the centre of the creek to its interface with the main lake.
- Potential erosion on banks adjacent to outside bends.

Figure 26: Mullet Creek difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 2).

4.14 Mullet Trap Tank

- Shoaling observed adjacent to the junction with Mullet Creek and near a bridge downstream.
- Potential erosion on banks along the creek from a bridge at the top section towards Hooka Creek and Lake Illawarra.

Figure 27: Mullet Creek Tank Trap difference plot between 2008 and 2022/2023 surveys – Negative values = possible erosion/deepening (data within Plan 539-1 Sheet 2).

4.15 Oaky Gully

- Profiles shown are results from 2022/2023 survey.
- No historical data present on the dataset available therefore the key relates to AHD height variations.

Figure 28: Oaky Gully heights from 2022/2023 (data within Plan 539-1 Sheet 4).

5 CONCLUSIONS

The comparison of historical information (2008) with recent surveys (2022/2023) conducted on Lake Illawarra and tributaries (Albion Creek, Brooks Creek, Duck Creek, Hooka Creek, Horsley Creek, Macquarie Rivulet, Mullet Creek, Mullet Creek Tank Trap, Oaky Gully) aimed to determine whether there was sedimentation or erosion within those water bodies.

Analysis provided results showing a potential trend of sedimentation within the entire survey area when comparing 2008 and 2022/23 datasets in the order of 0.16m, which equates to a rate of 0.01m per year between 2008 and 2022/23 surveys. Greater height differences were observed adjacent to creek deltas (i.e. Macquarie Rivulet ±1.00m) or near the lake entrance (subject of another study, where other studies have found substantial change has occurred).

On the other hand, erosion has occurred along the creek banks reaching ±1.00m in height change over the period between both surveys. This is in line with the sedimentation trend observed within the creek channels and may have influenced the accumulation of material on the lake bottom.

6 APPENDIX 1 – TIMELINE OF SURVEY ACTIVITIES

Survey Date	Areas Surveyed	Methods Used
29/08/2022	Northern Lake Illawarra area	MBES undertaking profile lines
30/08/2022	Southern Lake Illawarra area	MBES undertaking profile lines
20/09/2022	North-eastern corner Lake Illawarra	SBES undertaking profile lines
26/10/2022	North and Eastern side Lake Illawarra	MBES undertaking perimeter survey
13/01/2023	Eastern side Lake Illawarra	RTK points and Lidar collection
23/01/2023	Eastern side Lake Illawarra	RTK profiling in shallow areas
27/01/2023	Eastern side Lake Illawarra	RTK profiling in shallow areas
31/01/2023	Southern side Lake Illawarra and Oaky Gully	RTK profiling in shallow areas
01/02/2023	Horsley Inlet and Albion Creek	RTK Profiling in shallow areas
15/02/2023	Eastern side Lake Illawarra	RTK Profiling in shallow areas
27/02/2023	Koona Bay	RTK Profiling in shallow areas
28/02/2023	Haywards Bay	RTK Profiling in shallow areas
01/03/2023	Koona Bay	RTK Profiling in shallow areas
02/03/2023	Northern Lake Illawarra area	RTK Profiling in shallow areas
06/03/2023	Griffin Bay and Eastern side Lake Illawarra	SBES/RTK Profiling in shallow areas
08/03/2023	Eastern side Lake Illawarra	RTK Profiling in shallow areas
15/03/2023	Northwester/West side Lake Illawarra	SBES undertaking profile lines
16/03/2023	West side Lake Illawarra	SBES undertaking profile lines
17/03/2023	Macquarie Rivulet	SBES undertaking profile lines
20/03/2023	Mullet Creek	SBES undertaking profile lines
21/03/2023	Mullet/Brooks Creek Southwest side of Lake	SBES undertaking profile lines
22/03/2023	Duck Creek	SBES undertaking profile lines
30/05/2023	Adjacent to Duck and Brooks Creeks	RTK profiling in shallow areas
31/05/2023	Adjacent to Hooka and Mullet Creeks	RTK profiling in shallow areas
01/06/2023	Southern area and adjacent to Brooks Ck	RTK profiling in shallow areas
02/06/2023	Windang area	RTK profiling in shallow areas

Table 1: Timeline of survey events

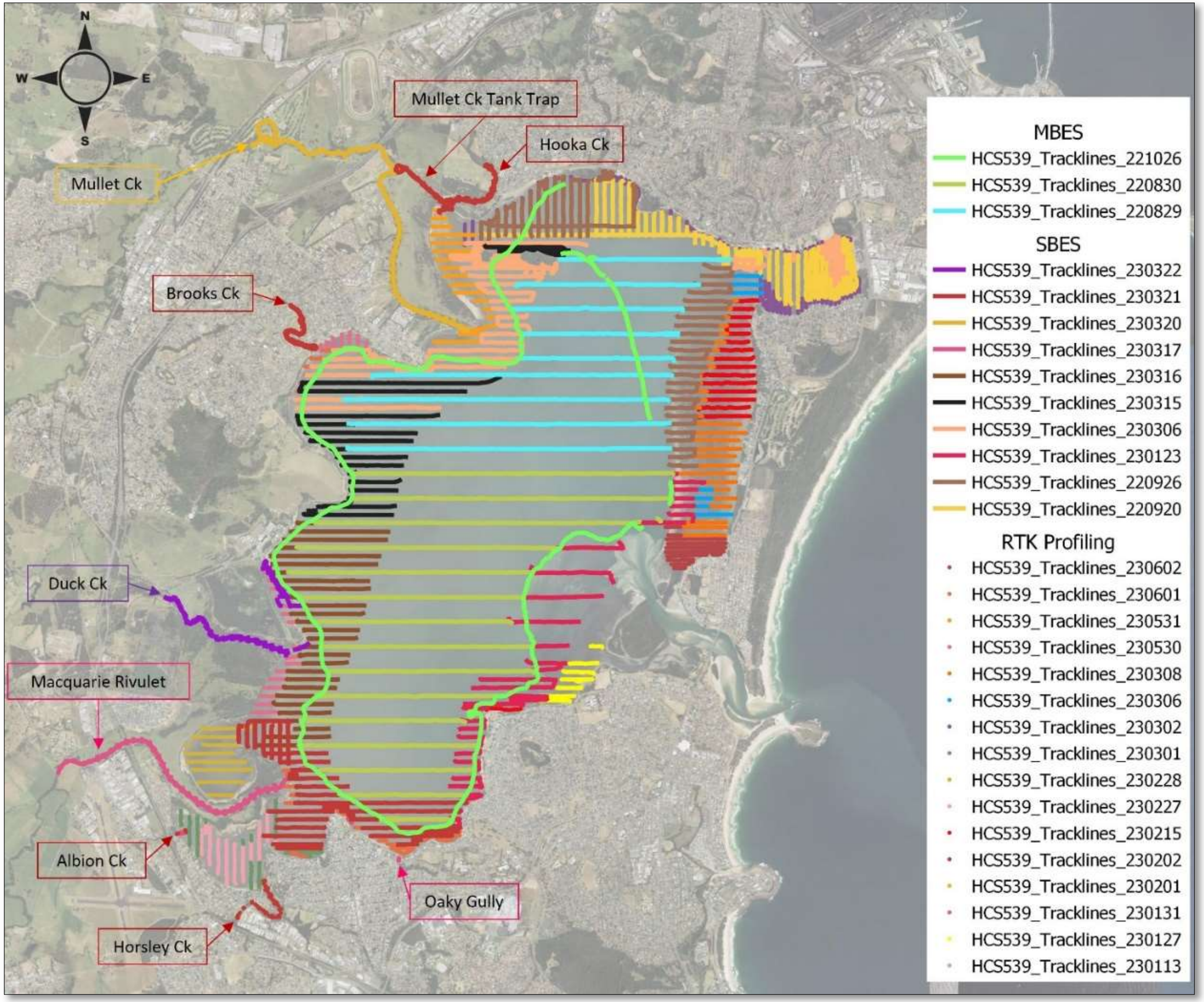


Figure 29: Compilation of survey methods and dates on Lake Illawarra (YYMMDD e.g. 230113)

7 APPENDIX 2 – TECHNICAL

7.1 REFERENCES

7.1.1 References:

A. Project Brief – Q1001203: Lake Illawarra Bathymetry Project – Request for Quotation 09 May 2022
B. Australian Ocean Data Network (AODN) Portal

- Datasets obtained from AODN/Clinet for analysis:
  - NSWOEH_20080401_LakeIllawarra_STAX_IllawarraLake2008_AHD_MGA.xyz
  - IllawarraLake2008 sections AHD MGA.xyz

C. IHO C13 – Manual of Hydrographic Surveying

7.2 INTRODUCTION

7.2.1 Site address/location:

- Lake Illawarra, Wollongong/Shellharbour, NSW (Figure 1).

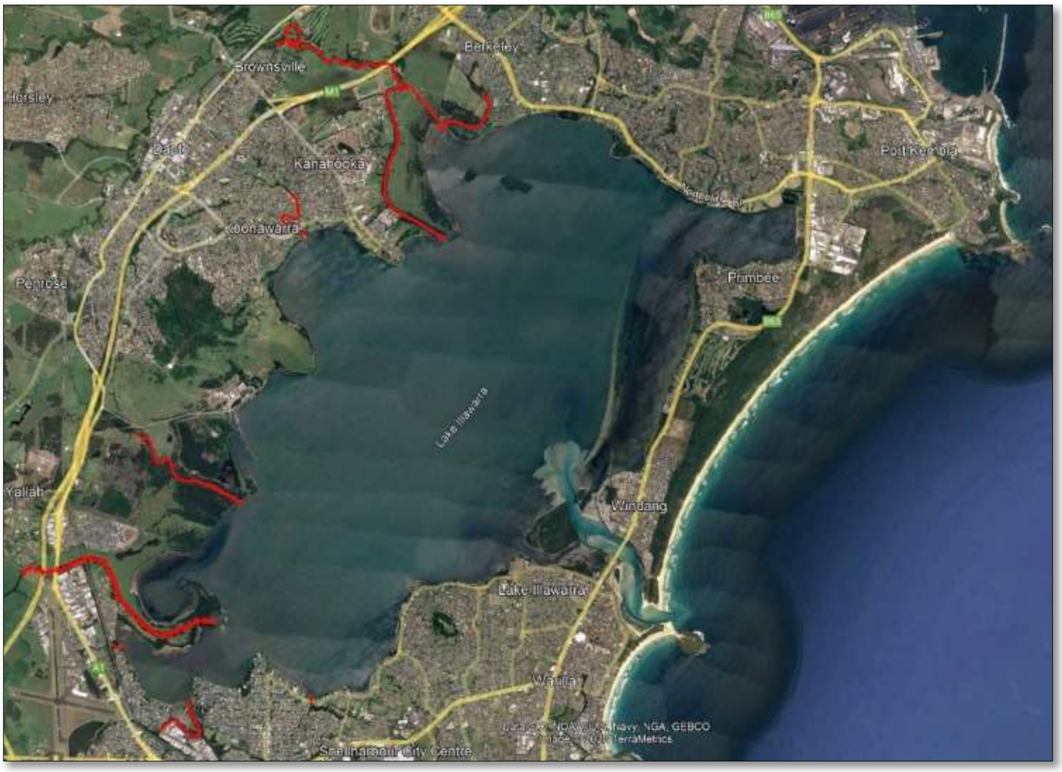


Figure 30: Survey location at Lake Illawarra and tributaries.

7.3 METHOD OF SURVEY

7.3.1 HORIZONTAL POSITIONING

- Soundings are referred to MGA co-ordinates on the GDA2020 datum.

Geodetic Parameters	
Datum	Geocentric Datum of Australia 2020 (GDA2020)
Ellipsoid	Geodetic Reference System 1980 (GRS80)
Semi-Major Axis (a)	6 378 137.000m
Inverse Flattening (1/f)	298.25722101

Projection Parameters	
Grid	Map Grid of Australia 2020 (MGA2020)
Projection	UTM Zone 56
Central Meridian	153° East
Latitude Origin	0° North
False Easting	500 000m
False Northing	10 000 000m
Scale Factor at Central Meridian	0.9996
Units	International metre

Table 2: Project Geodetic Parameters

- The following control points were used to validate positioning and vertical solution of the CORS:

Permanent Survey Mark	Eastings (MGA56)	Nothings (MGA56)	AHD Height
SS 121192	302759.701mE	6182372.800mN	5.115m
PM 16852	304453.886mE	6176522.697mN	1.758m
PM 16683	301169.829mE	6173914.472mN	4.157m
SS11684	302700.616mE	6175766.407mN	2.522m
SS11710	301525.928mE	6175131.032mN	7.266m
PM16693	299370.634mE	6173648.35mN	4.919m
PM16724	298014.119mE	6173584.142mN	3.019m
SS88866	304926.308mE	6179867.063mN	1.864m
SS121363	304925.558mE	6180010.348mN	1.650m

Table 3: Control Survey Marks

7.3.2 Method of obtaining horizontal position

- Real Time Kinematic (RTK) corrections from Position Partners All Day RTK were received through the survey software NTRIP caster and interfaced with the positioning system.
- For Multibeam Echosounder (MBES), where NTRIP was not available, post processing was conducted using the .000 Applanix log files and 1sec RINEX data from the Port Kembla Continuous Operating Reference Station (CORS). Post processing corrects for both vertical and horizontal displacement due to the loss of RTK corrections.

7.3.3 Navigation Validation (NavVal) method and frequency

- MBES – The known position of pylon in the survey area is compared with the position of the same pylon when surveyed by sounding.
- A sounding run is made passed a pylon of known position and observed in the sounding data.
- The position of the pylon outer edge is compared with the calculated outer edge and a validation result calculated.
- SBES – A static navigation validation is carried out on each survey day using a state survey mark (SSM).
- The survey project configuration is updated with the antenna height on a survey pole without the transducer.
- 120 seconds of data is logged in the survey software while occupying the survey mark.
- This is immediately reviewed in the survey software against the position of the SSM using the software measuring tool to confirm horizontal uncertainty lies within the expected tolerance for the survey.
- Vertical height is also checked for conformance.
- Post survey, the .RAW file is then imported to a spreadsheet and an analysis conducted.
- Vertical offsets identified are then used as in post processing of the sounding data. This offset is normally always in the order of the initial visual inspection on the day of survey.

7.3.4 Dynamic (NavVal) method

- MBES – As per validation methods statement.
- SBES – Not applicable

7.3.5 Rejection criteria for horizontal position data

- MBES – Loss of Narrow Lane solution or inability to post process to a fixed solution.
- SBES – Loss of RTK fixed solution which could not be resolved during post processing.

7.4 VERTICAL DATUM

7.4.1 Tidal height measurement method

- No observed tidal data was used for establishment of a vertical datum.
- Water level within the lake were recorded using an independent receiver to verify RTK tide corrections when reducing soundings to vertical datum.

7.5 DEPTH MEASUREMENT

7.5.1 Methods used to determine depths

- A NORBIT Wide Beam Multibeam Sonar (iWBMS) was used to determine depths in deep areas within the lake area. Utilising a MBES in deeper water allowed wider footprint of data acquisition when surveying over historical data.
- Processing of MBES soundings consisted in applying a filter to the average surface removing noise within ±0.1m, where a 500mm shoal bias surface was exported as final results.
- SBES surveys were completed in shallow and/or hazardous areas. Least depths were used to generate a full density minimum depth in true position.
- AusGeoid2020 separation file has been used to reduce data from Ellipsoid to Orthometric (AHD71).

7.5.2 Echo sounder frequency(s)

- Norbit iWBMS – 400kHz
- Ceeducer Pro/Cee Echo SBES – 200kHz

7.5.3 Method and frequency of calibration, including all associated equipment

- A full patch test calibration was carried out prior to commencing survey activities on every MBES survey day. All settings were zeroed prior to the patch test to provide a pre and post review of motion artefacts. The patch test results are as follows:

Date	Pitch (deg)	Roll (deg)	Yaw (deg)	Latency (sec)
29 Aug 22	1.50	0.05	-1.00	0.05
30 Aug 22	1.50	0.05	-1.00	0.05
26 Oct 22	-1.50	0.00	-6.00	0.01

Table 4: Patch Test results

- MBES - While in the survey area, a lead line check was conducted. The multibeam swath was narrowed, the measured “lead line” was lowered below the transducer to compare against the nadir depth. Results of this lead line validation are presented in the following table.

Date / Time (UTC)	Nadir plus draft	Lead line minus penetration	Delta Depth
29 Aug 2022 / 4:31	2.05 + 0.674 = 2.724	2.79 – 0.1 = 2.69	0.03
30 Aug 2022 / 05:17	1.47 + 0.664 = 2.134	2.12 – 0.05 = 2.07	0.06
26 Oct 2022 / 0215	2.35 + 0.684 = 3.034	3.165 – 0.09 = 3.075	0.04

Table 5: MBES lead line results

- SBES data was validated using a bar check. An aluminium disc was lowered at set intervals beneath the sonar. If stream was not conducive to facilitate a bar check then a marked pole or lead line was used to measure the water level and compared with sonar results.

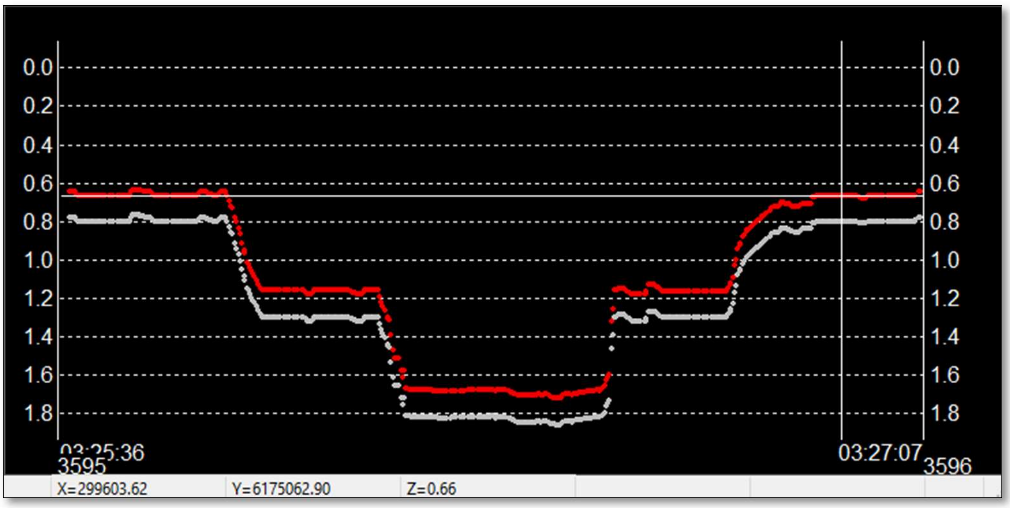


Figure 31: Bar check result (21 Mar 2022)

Date / Time (UTC)	Nadir plus draft	Lead line minus penetration / Bar depth	Delta Depth
20 Sep 2022 / 00:04	1.16 + 0.29 = 1.45	1.46	0.01
25 Sep 2022 / 22:30	0.83 + 0.33 = 1.16	1.33 – 0.12 = 1.21	0.05
23 Jan 2023 / 22:30	0.65 + 0.21 = 0.86	0.85	0.01
06 Mar 2023 / 04:38	1.24 + 0.30 = 1.54	1.50	0.04
15 Mar 2023 / 04:27	2.22 + 0.30 = 2.52	2.50	0.02
16 Mar 2023 / 03:10	1.77 + 0.30 = 2.07	2.00	0.07
17 Mar 2023 / 01:45	1.77 + 0.30 = 2.07	2.00	0.07
20 Mar 2023 / 00:58	2.22 + 0.30 = 2.52	2.50	0.02
21 Mar 2023 / 03:26	1.84 + 0.20 = 2.04	2.00	0.04
22 Mar 2023	Compared against survey on 16 Mar 23		0.05

Table 6: SBES lead line/ barcheck results

- A comparison of data from SBES and MBES showed an average difference of approximately ±0.2m where the latter was deeper. After checking tide solutions for both methods it was concluded that a vertical shift for the multibeam data of the same difference order should be applied.

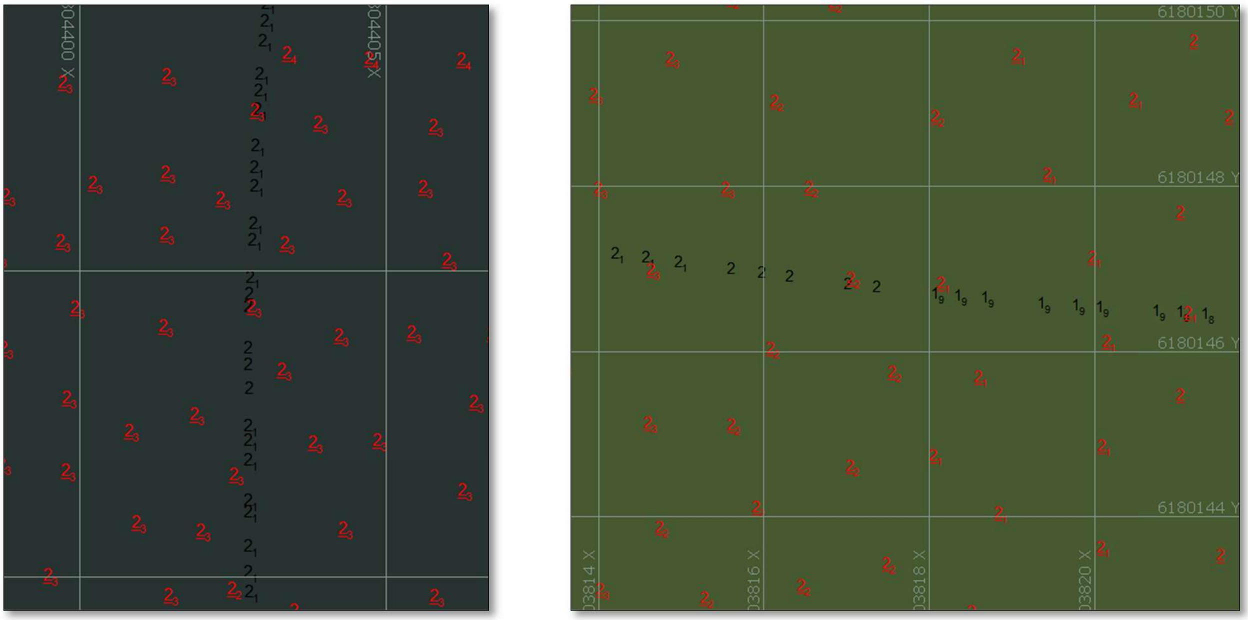


Figure 32 – (Left) Day 1 and Day 3 comparison (red MBES, black SBES) and (Right) Day 1 and Day 4 comparison (red MBES, black SBES).

- Figure 29 illustrates the geographic areas covered on any given day of survey. This can be used to cross match against environmental events between survey periods to aid in flood modelling.

7.5.4 Method used to negate or compensate for transducer motion (heave)

- MBES – Applanix Inertial Navigation System (INS) integrated into transducer head resolves heave, pitch, roll.
- SBES – In the processing phase, 1sec RTK tide data was averaged over 10sec to reduce heave.

7.5.5 Limiting lake conditions that would affect the quality of the survey

- Sea State (SS) is the recognised maritime method of providing a quantitative value for wave height (Table 7).
- The limiting sea state that would affect quality is considered to be the midrange of SS3.

WMO Sea State (SS) Code	Wave height	Characteristics
0	0 m	Calm (glassy)
1	0 to 0.1 m	Calm (rippled)
2	0.1 to 0.5 m	Smooth (wavelets)
3	0.5 to 1.25 m	Slight
4	1.25 to 2.5 m	Moderate

Table 7: WMO Sea State definitions

7.5.6 Settlement/squat of transducers at survey vessel's sounding speed

- The system utilises ellipsoidal survey techniques and therefore squat is not required to be accounted for as the reduced depth is based on the antenna height at an observation rate of 1Hz.

7.6 DATA COVERAGE

7.6.1 Coverage conducted

- MBES was run following historical dataset line spacing as per engagement specification. Where water depth has not allowed MBES access, SBES has been used to run historic line direction and spacing. Sedimentation and/or presence of seaweed in certain parts of the lake have restricted data collection from both methods.
- Where sounding methods were not practicable, land survey techniques were used (*i.e* RTK profiling, LiDAR).

7.6.2 Echo sounder's pulse repetition rate (PRR) at area average survey depth

- MBES – Variable with depth and swath width
- SBES – 6 to 20Hz

7.6.3 Beam widths

- MBES Along track – 1.9º
- MBES Across track – 0.9º
- MBES Swath width 120º / 512 beams

7.6.4 Survey vessel's speed over ground

- 1 to 6 kts

7.6.5 Sounding line spacing and direction(s)

- MBES - Followed historical profiles as per data set provided and client request
- SBES - Followed historical profiles as per data set provided and client request

7.6.6 Process used to sound berth and channel limits (N/A)

7.7 SOUNDING REDUCTION AND DATA PRESENTATION

7.7.1 Method of data reduction from raw to sounding datum

- The survey was conducted using ellipsoidal survey techniques. Soundings were reduced AHD levels.

7.7.2 Principle and method used in sounding selection

- In accordance with IHO S4 principles B-410a.
- RTK tides applied to provide AHD heights with AusGeoid2020 separation model.
- MBES:
- Data acquisition in Hypack Hysweep 2022 (Q3)/Hypack Hysweep 2023.
- Data processing in Hypack Hysweep 2022 (Q3)/Hypack Hysweep 2023.
- Sound Velocity (SV) applied for each individual survey day.
- Areas which exhibited stepping in vertical solution due to loss of NTRIP provided corrections were rectified using the Applanix .000 files and post processing with the Port Kembla CORS RINEX data. Areas that could not be resolved in this manner were individually processed to compensate for the vertical step by cross matching with the adjacent survey lines.
- Minimum surface was generated at 0.5m from a filtered +/- 0.1m average surface.
- Manual cleaning and verification of areas of concern was conducted post area cleaning.
- Export full density, shoal bias, true position
- SBES:
- Data acquisition in Hypack 2022 (Q3)/Hypack 2023.
- Data processing in Hypack 2022 (Q3)/Hypack 2023.
- Export full density, shoal bias, true position

7.7.3 Principle and process for rounding of selected soundings

- Data set displayed on the plans are IHO format, 1 decimal place.

7.7.4 Positioning of selected soundings

- MBES – Shoal bias in true position
- SBES – Shoal depth in true position

7.7.5 Method of contour generation

- Contours generated from provided data set resolution at 1m intervals for plan production.

7.7.6 Scale of plans

- 1:5000

7.7.7 Digital format of final data

- DXF/DWG
- ASCII
- PDF – Report and plans

7.8 DATA QUALITY AND RETENTION

7.8.1 Method of determining quality of data and statement on meeting the survey uncertainty as required

- It is noted that while daily data correlations are higher in quality, due to the river flow and environmental conditions, depths between survey days can fall outside of uncertainty values. For this reason, Appendix 1 has been produced to identify the days and areas of data collect. This then allows for correlation against environmental conditions.
- Manufacturer specifications are used to populate the vessel configuration file with system uncertainties which are used to generate an assessment of the sounding uncertainty in horizontal and vertical. Additional to this, data comparison is conducted with cross lines, overlapping swaths, tides and the charted depths to determine the +/-Total Uncertainty value of the data holistically. Survey outcomes can then be assessed against a specification for compliance. IHO S44 Edition 6, 2020 is the reference for this survey:

Water Depth (m)	1	3	5	7	9	11	13	15	17	19
Max Allowable TVU 95% **S44 Special (m)**	0.250	0.251	0.253	0.255	0.259	0.263	0.268	0.274	0.281	0.288

Standard of survey achieved:	☒	☐	☐	☐
	S44 Special	S44 Order 1a	S44 Order 1b	S44 Order 2
Max Allowable THU 95%	2m	5m + 5%	5m + 5%	20m +10%
Max Allowable TVU 95% a – uncertainty that does not vary with depth b – uncertainty coefficient that varies with depth	0.25m 0.0075	0.5m 0.013	0.5m 0.013	1m 0.023

Table 8: S44 – Orders of survey

7.8.2 Data Caveats

- Survey data is only valid for the time of survey only due to environmental and other factors which may change the seafloor or deposit features.
- This survey was not conducted for the purpose of navigation.

Surveyor's Details:

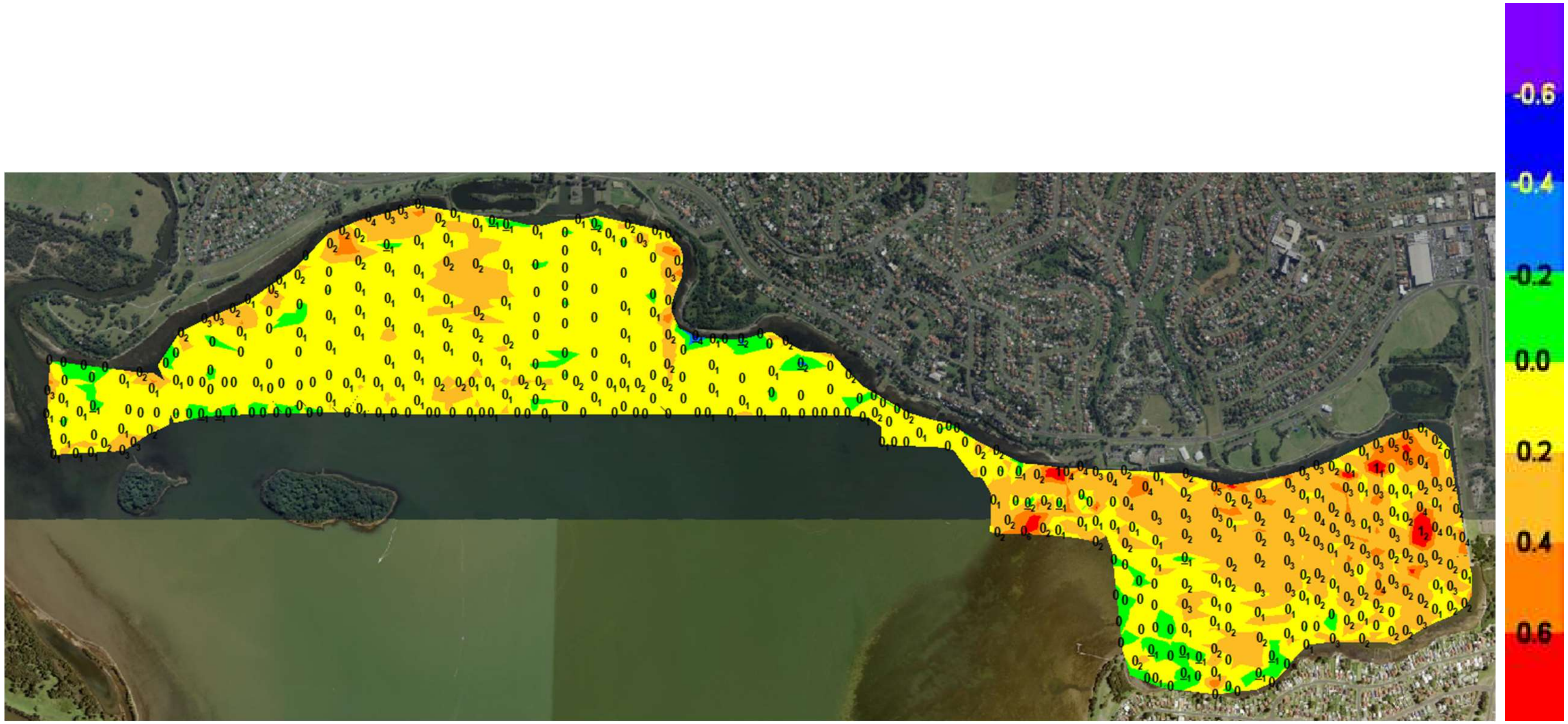
Richard Cullen

GCA Cert. Professional Hydrographic Surveyor - Level 1
Master of Maritime Policy | PGDip Hydrographic Surveying (IHO Cat A)
Dip Spatial Information Services | Cert IV Training & Assessment

8 APPENDIX 3 – LAKE AND TRIBUTARIES PROFILES

LAKE 1

Warrawong to West of Berkley Boat Ramp



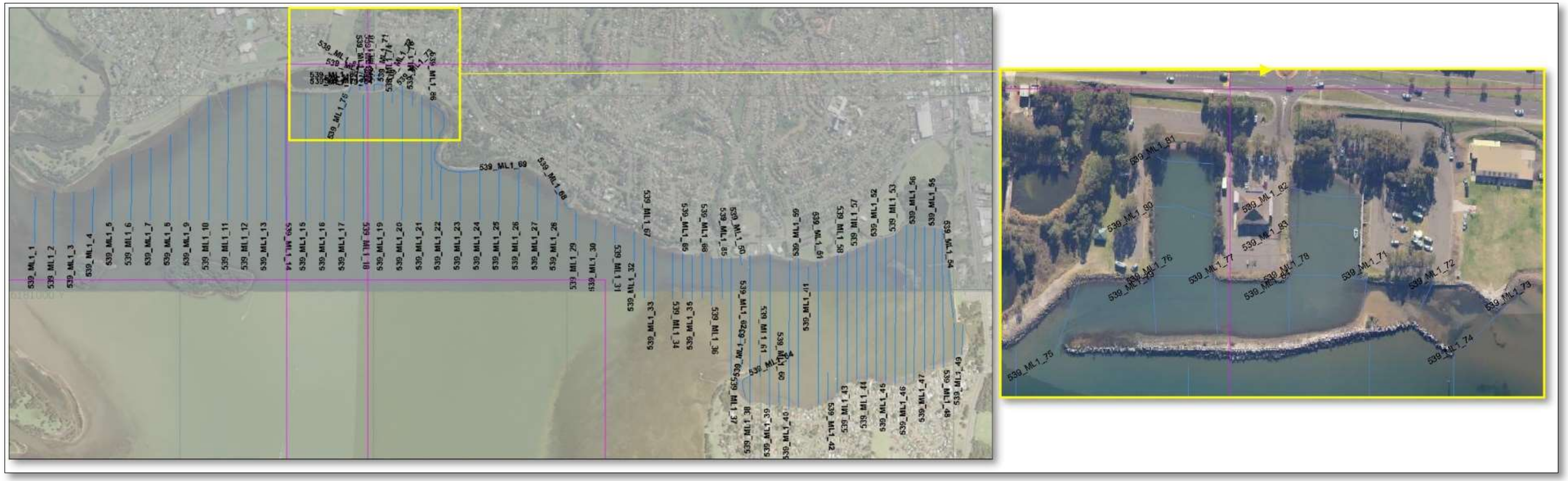
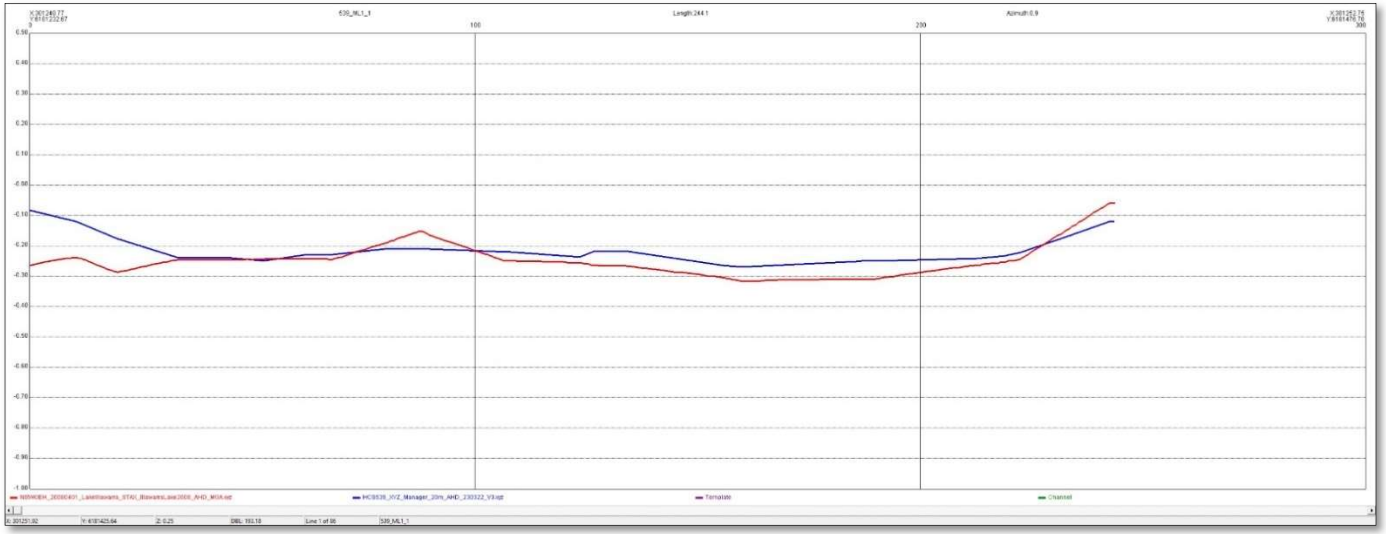


Figure 33: Lake 1 profiles utilised for analysis (data within Plan 539-1 Sheets 1 and 5).



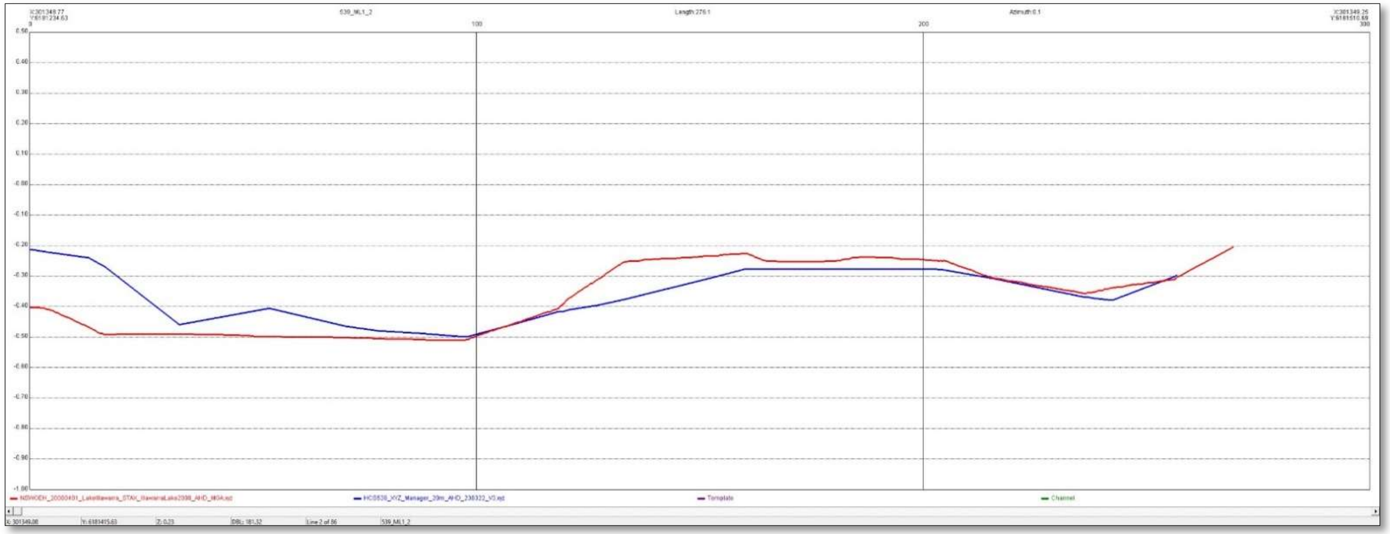


Figure 34: Lake 1 - profiles (red = 2008, blue = 2022/23) 1 and 2.

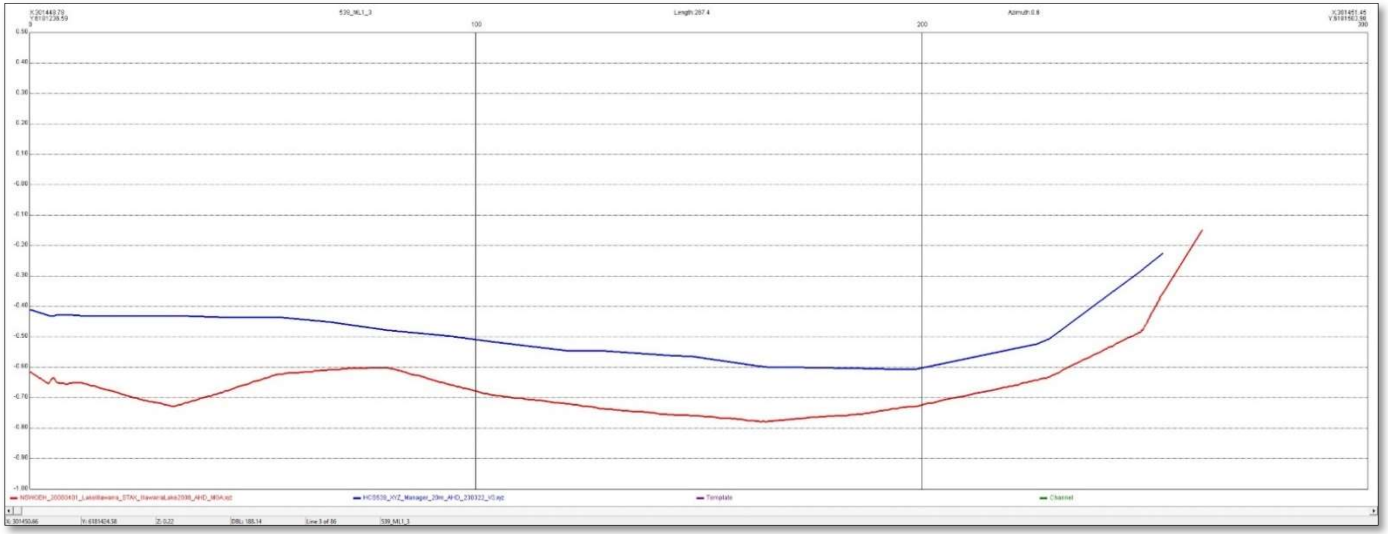
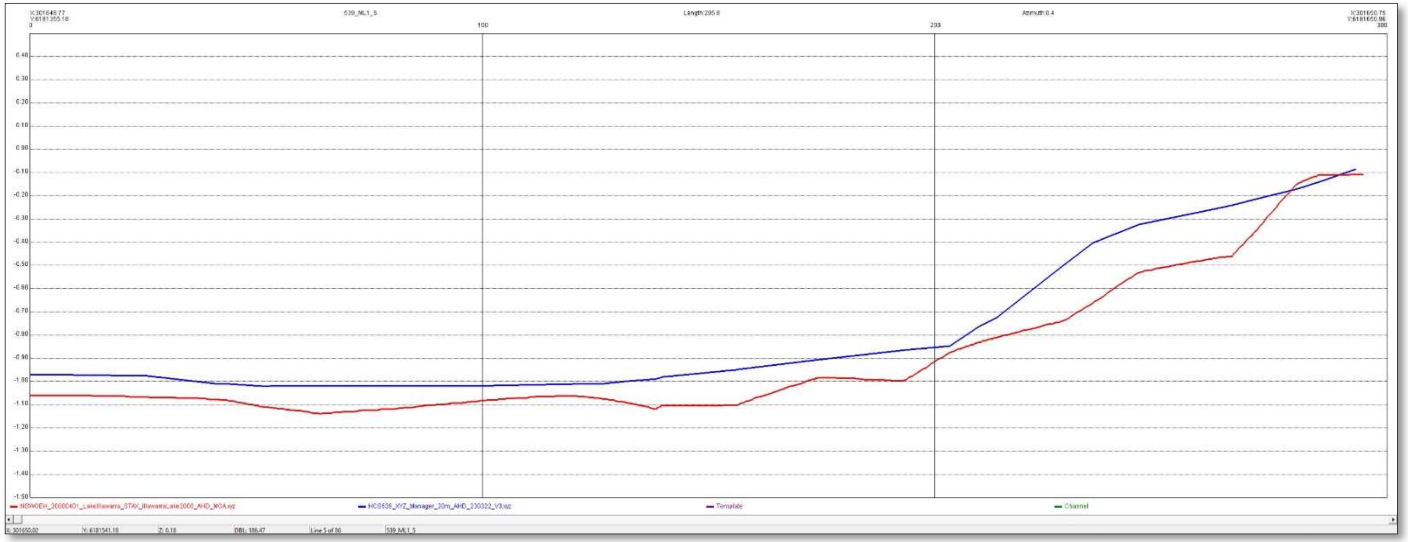


Figure 35: Lake 1 - profiles (red = 2008, blue = 2022/23) 3 and 4.



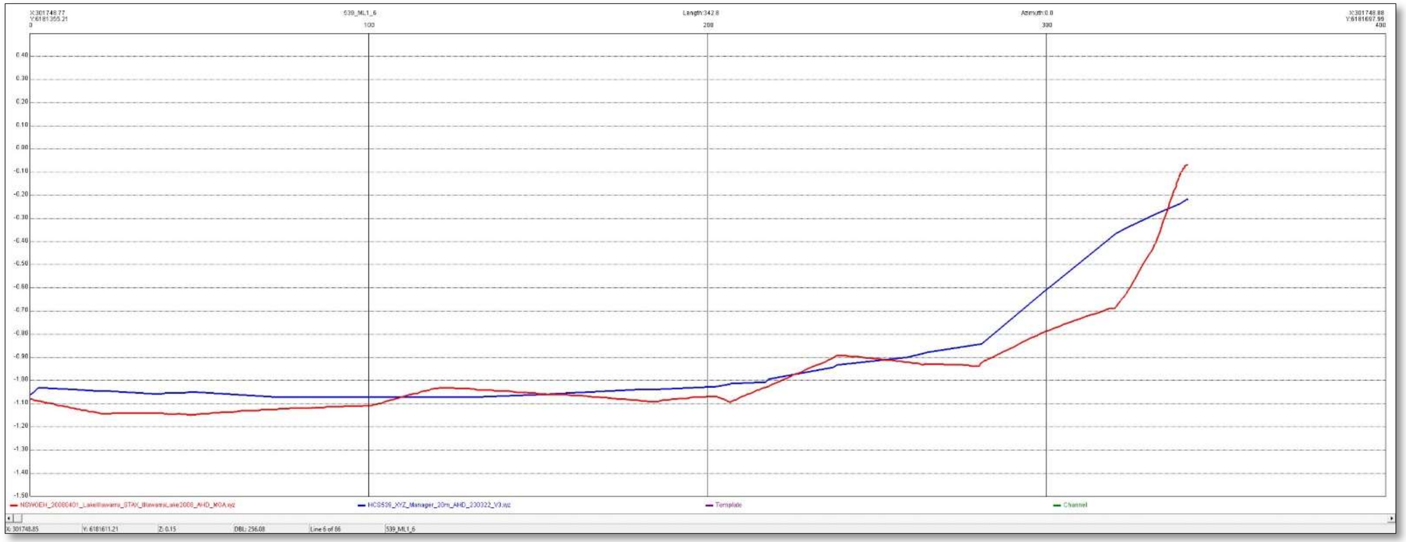


Figure 36: Lake 1 - profiles (red = 2008, blue = 2022/23) 5 and 6.

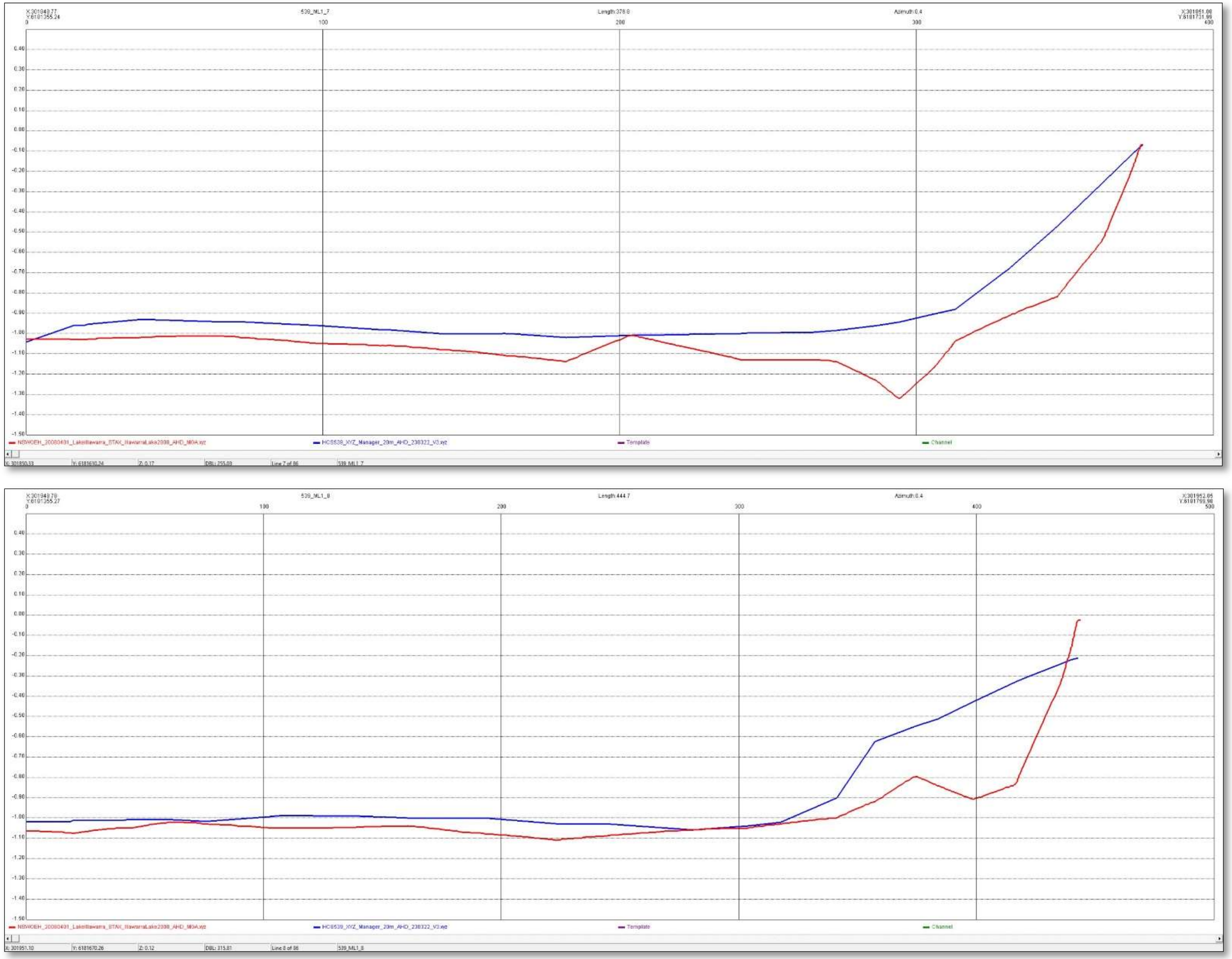
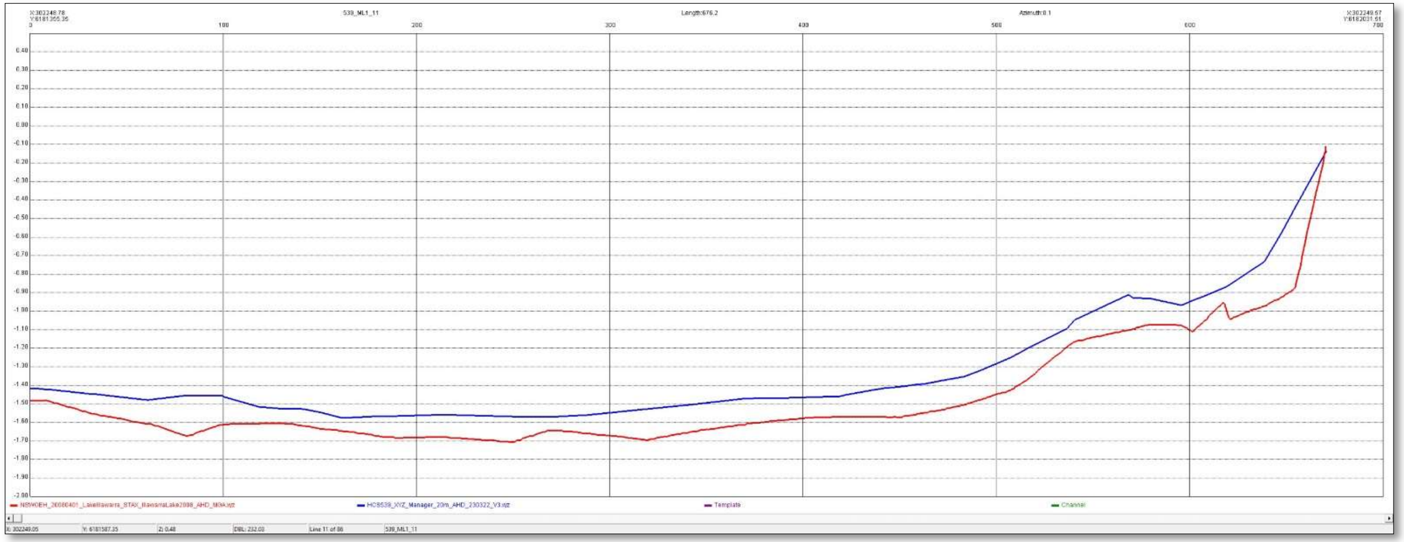


Figure 37: Lake 1 - profiles (red = 2008, blue = 2022/23) 7 and 8.

Figure 38: Lake 1 - profiles (red = 2008, blue = 2022/23) 9 and 10.



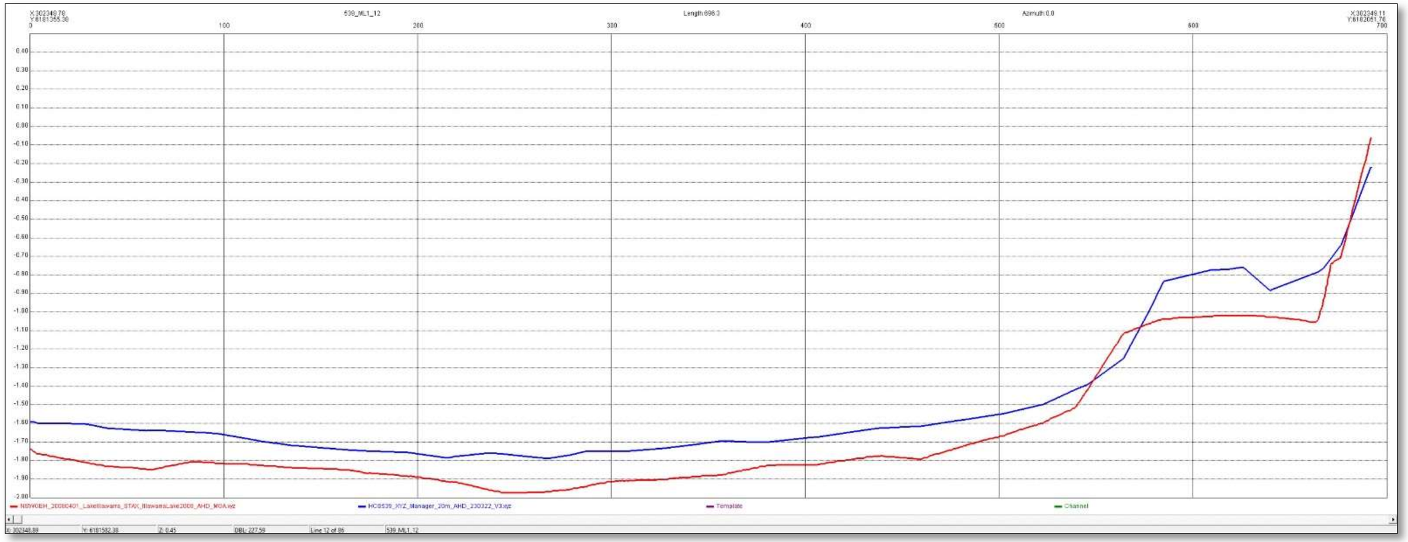
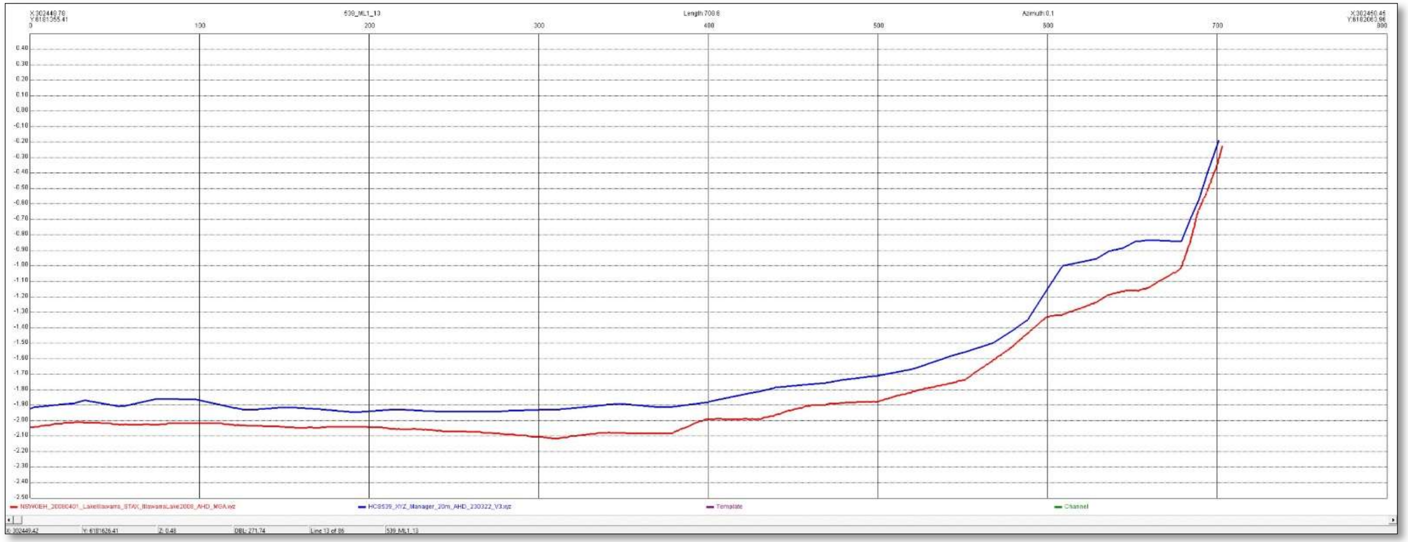


Figure 39: Lake 1 - profiles (red = 2008, blue = 2022/23) 11 and 12.



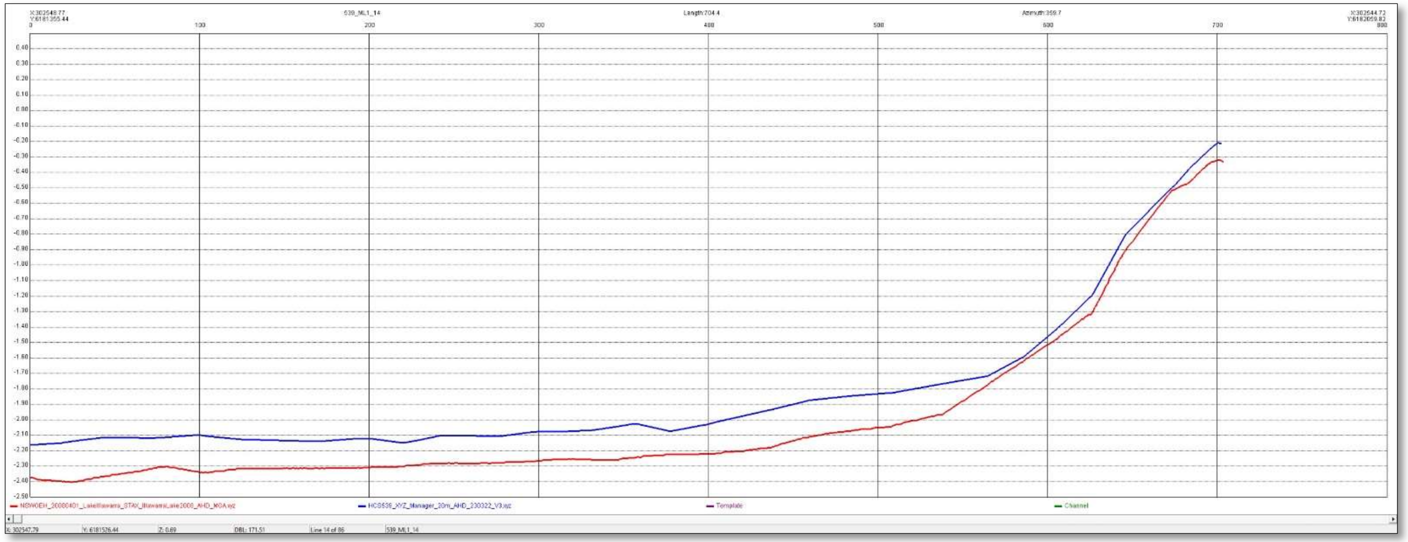
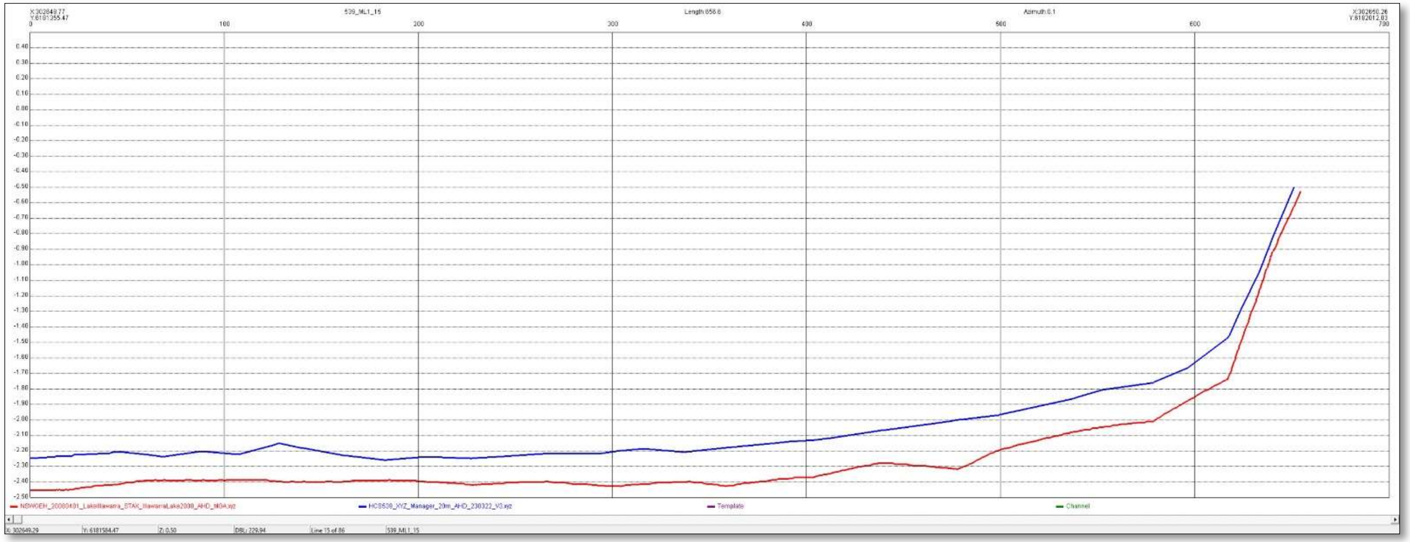


Figure 40: Lake 1 - profiles (red = 2008, blue = 2022/23) 13 and 14.



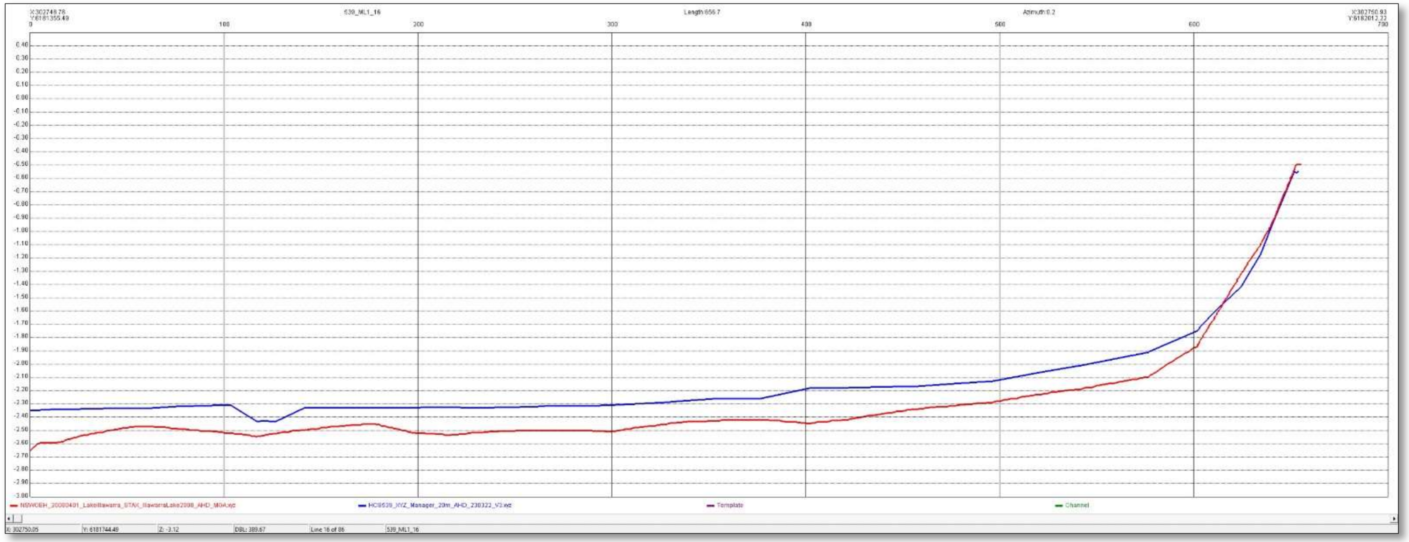
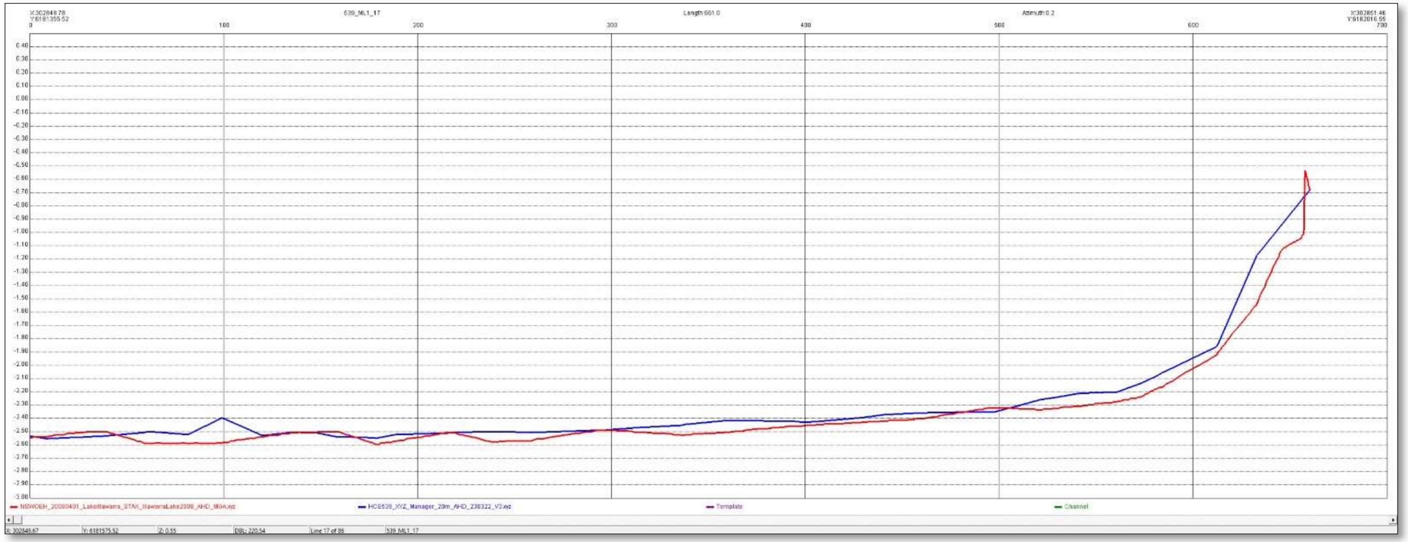


Figure 41: Lake 1 - profiles (red = 2008, blue = 2022/23) 15 and 16.



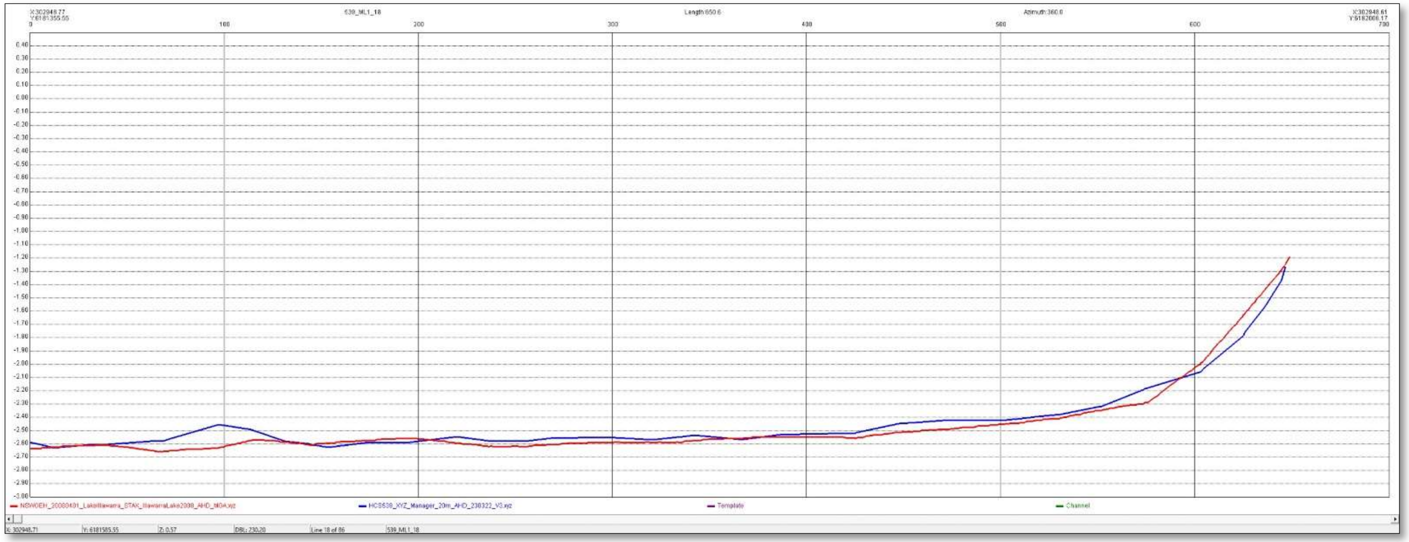
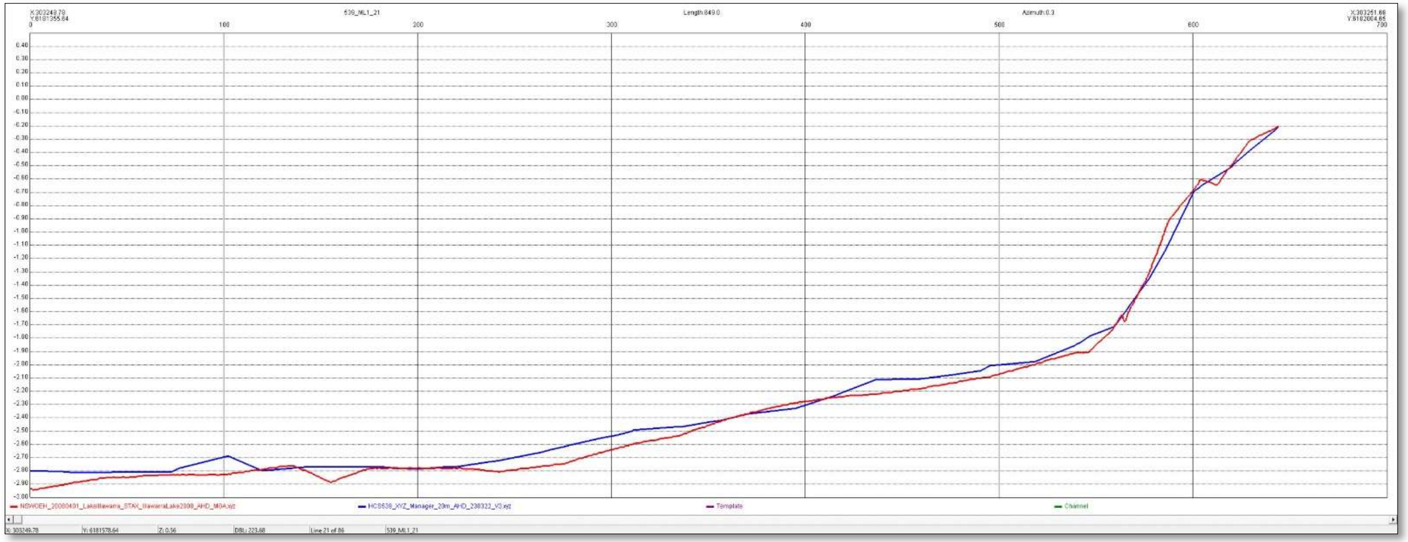


Figure 42: Lake 1 - profiles (red = 2008, blue = 2022/23) 17 and 18.

Figure 43: Lake 1 - profiles (red = 2008, blue = 2022/23) 19 and 20.



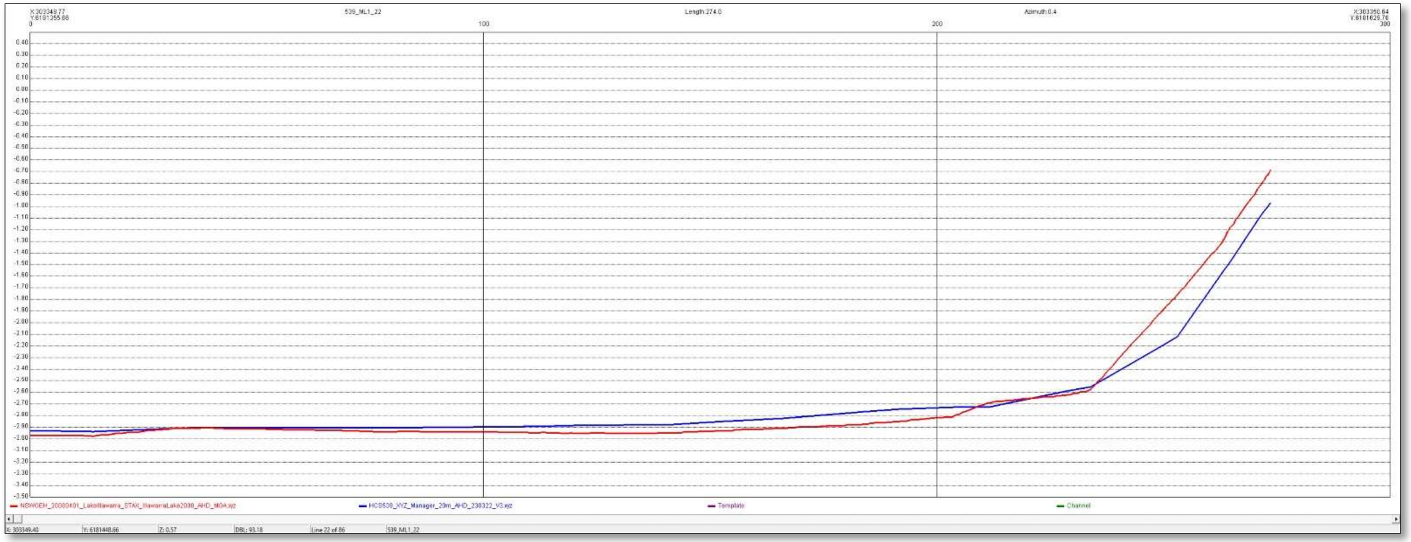


Figure 44: Lake 1 - profiles (red = 2008, blue = 2022/23) 21 and 22.

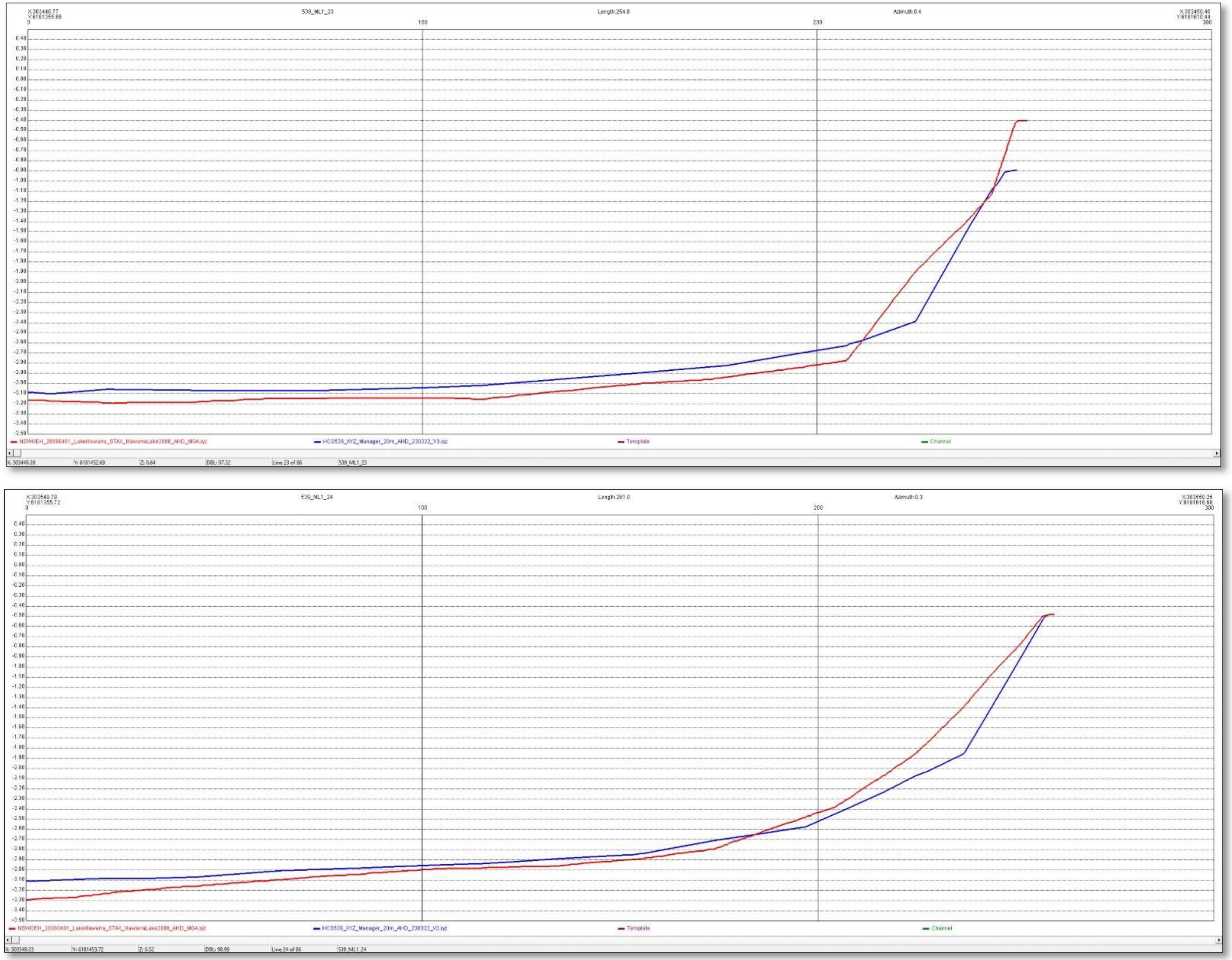
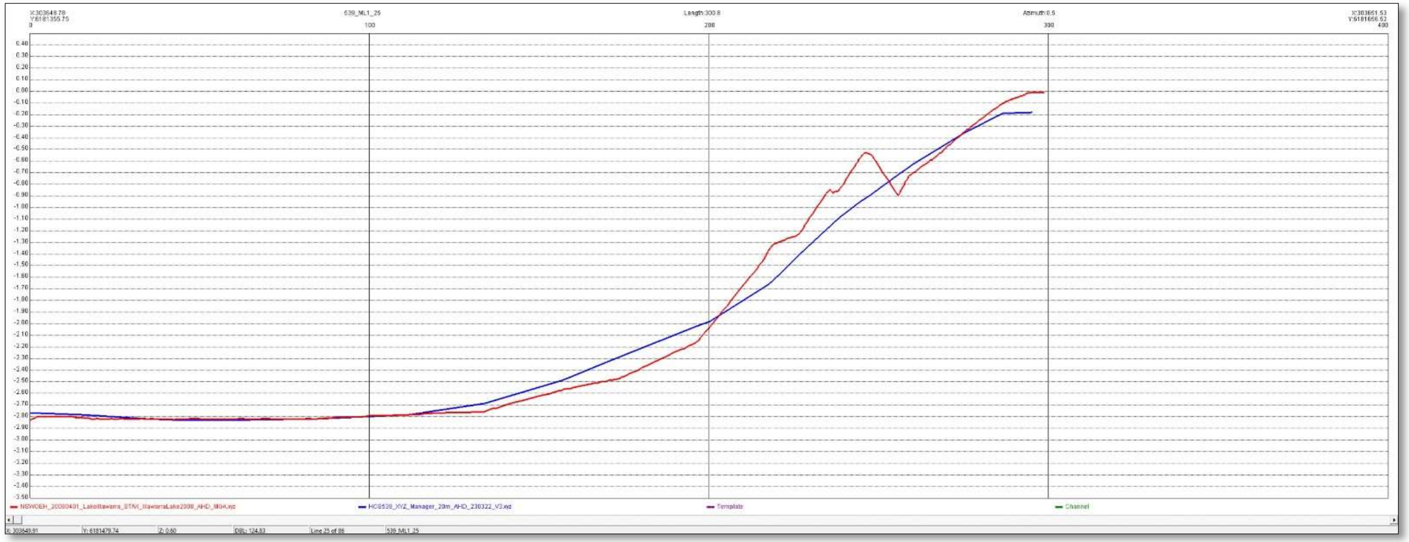


Figure 45: Lake 1 - profiles (red = 2008, blue = 2022/23) 23 and 24.



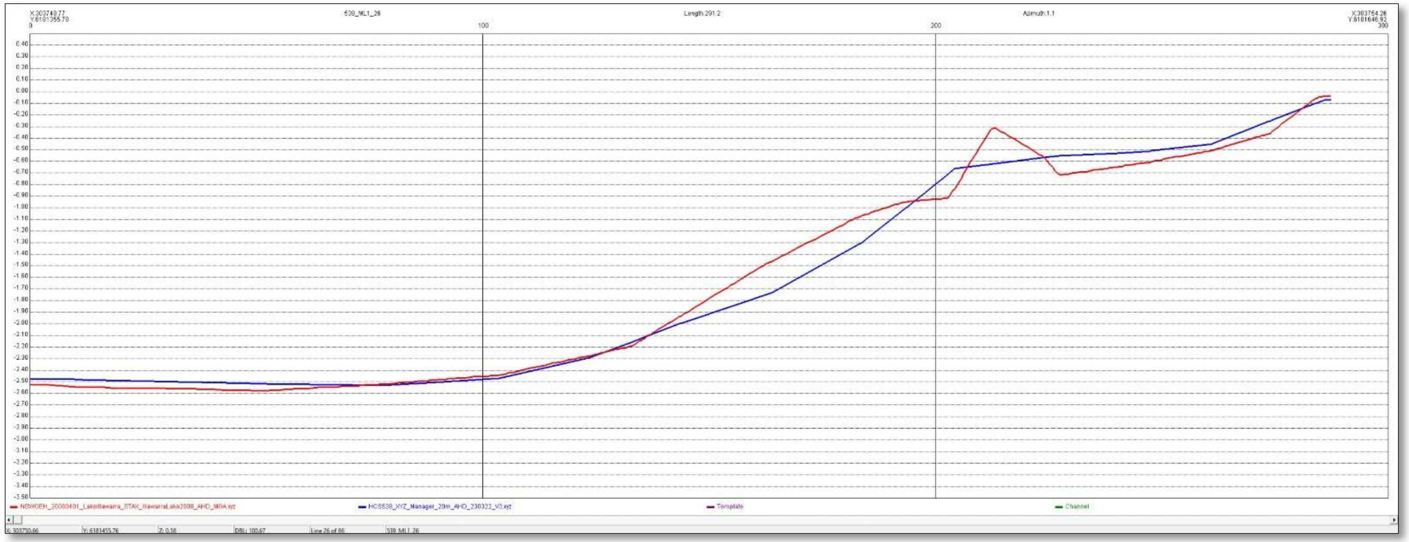


Figure 46: Lake 1 - profiles (red = 2008, blue = 2022/23) 25 and 26.

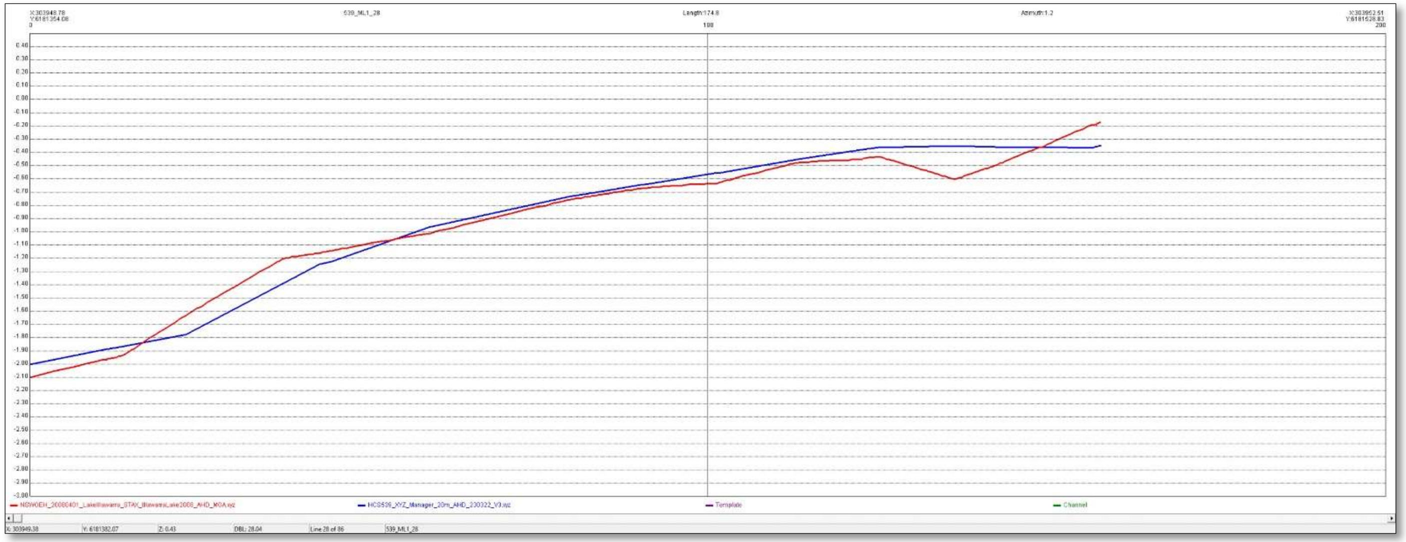
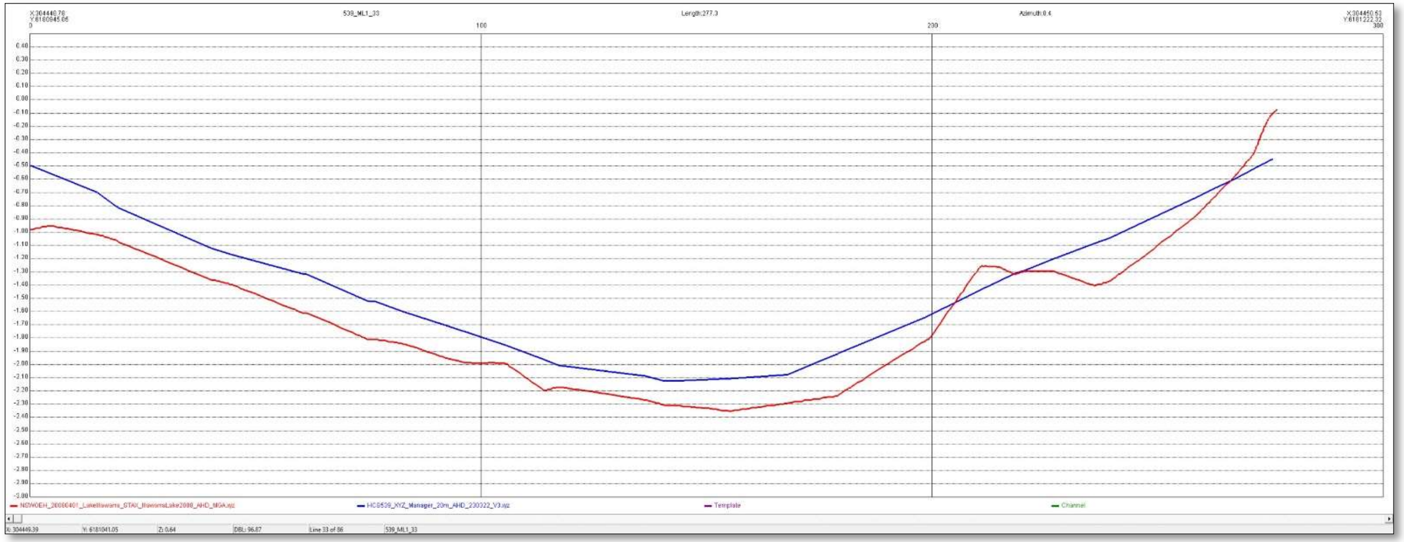


Figure 47: Lake 1 - profiles (red = 2008, blue = 2022/23) 27 and 28.

Figure 48: Lake 1 - profiles (red = 2008, blue = 2022/23) 29 and 30.

Figure 49: Lake 1 - profiles (red = 2008, blue = 2022/23) 31 and 32.



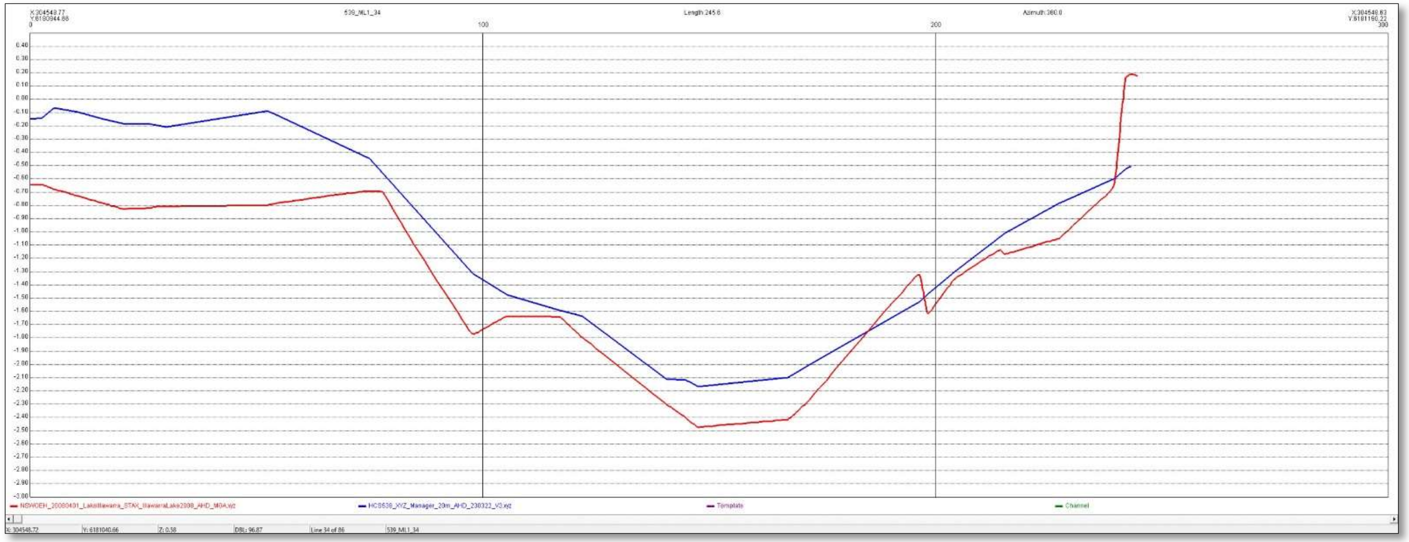


Figure 50: Lake 1 - profiles (red = 2008, blue = 2022/23) 33 and 34.

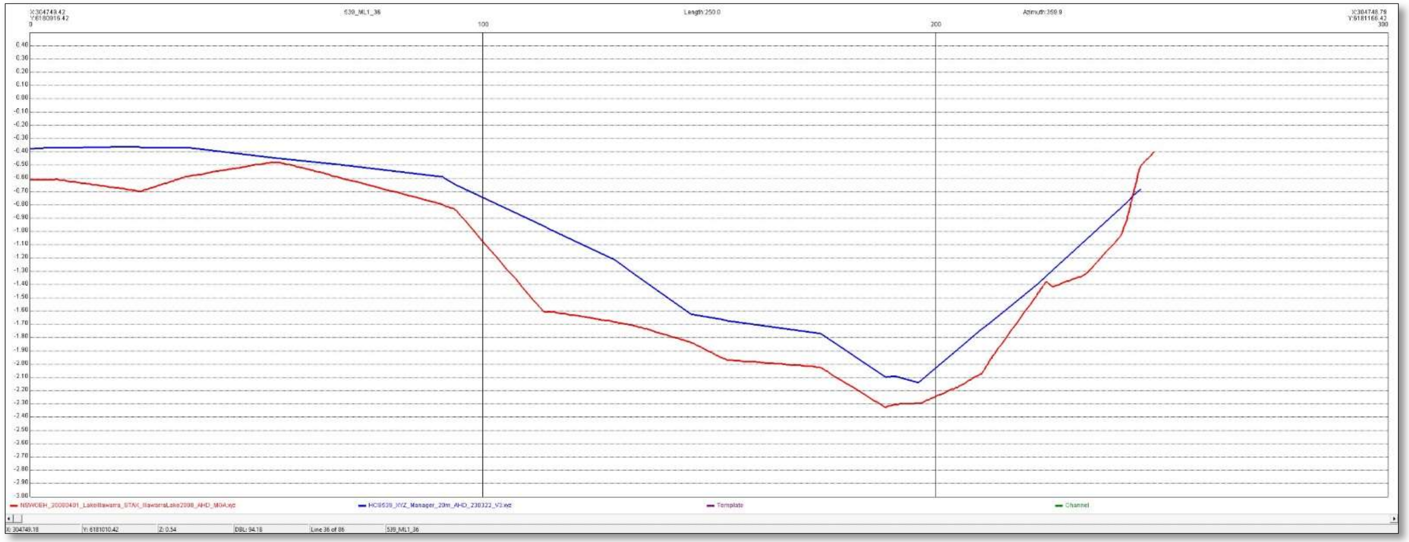
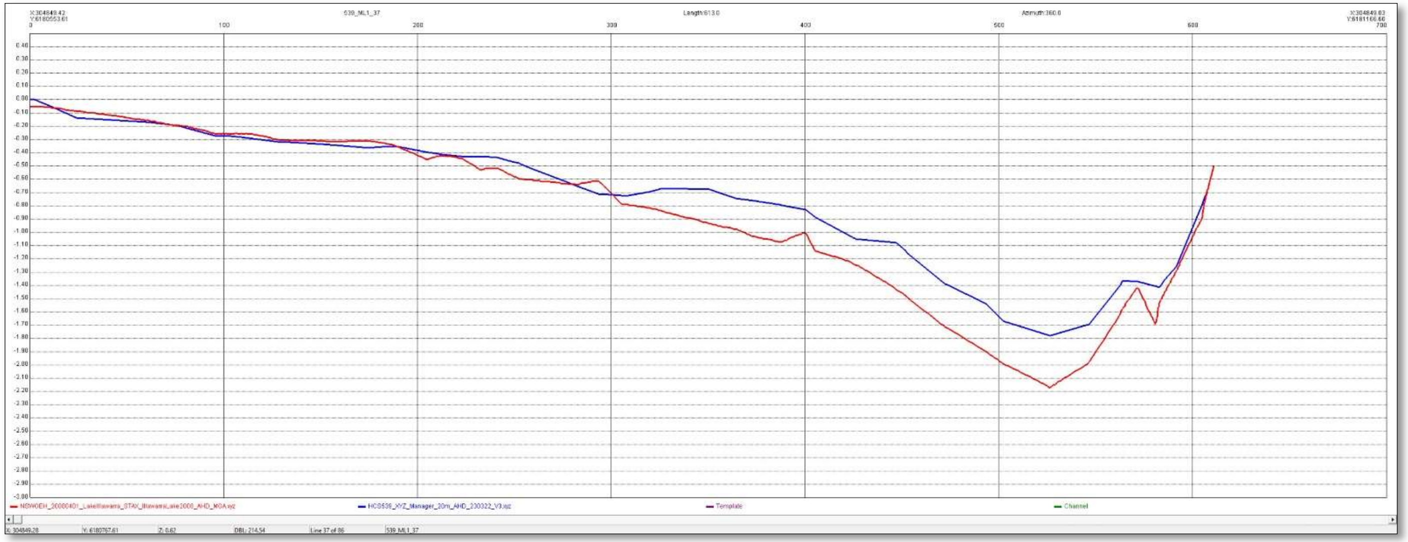


Figure 51: Lake 1 - profiles (red = 2008, blue = 2022/23) 35 and 36.



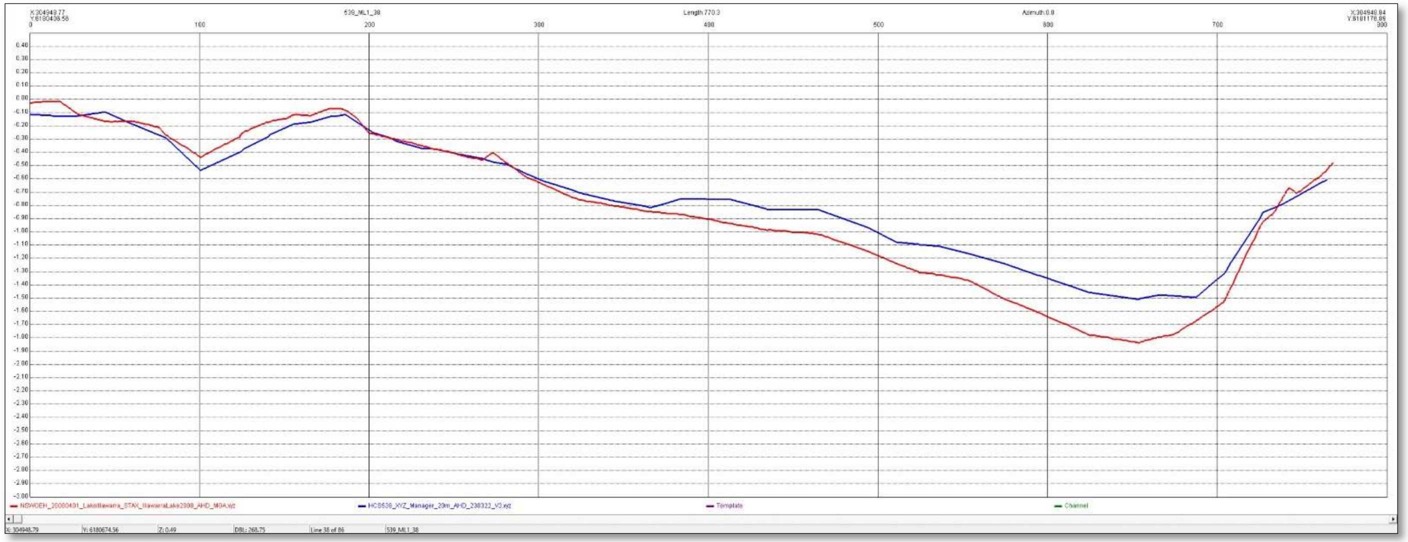
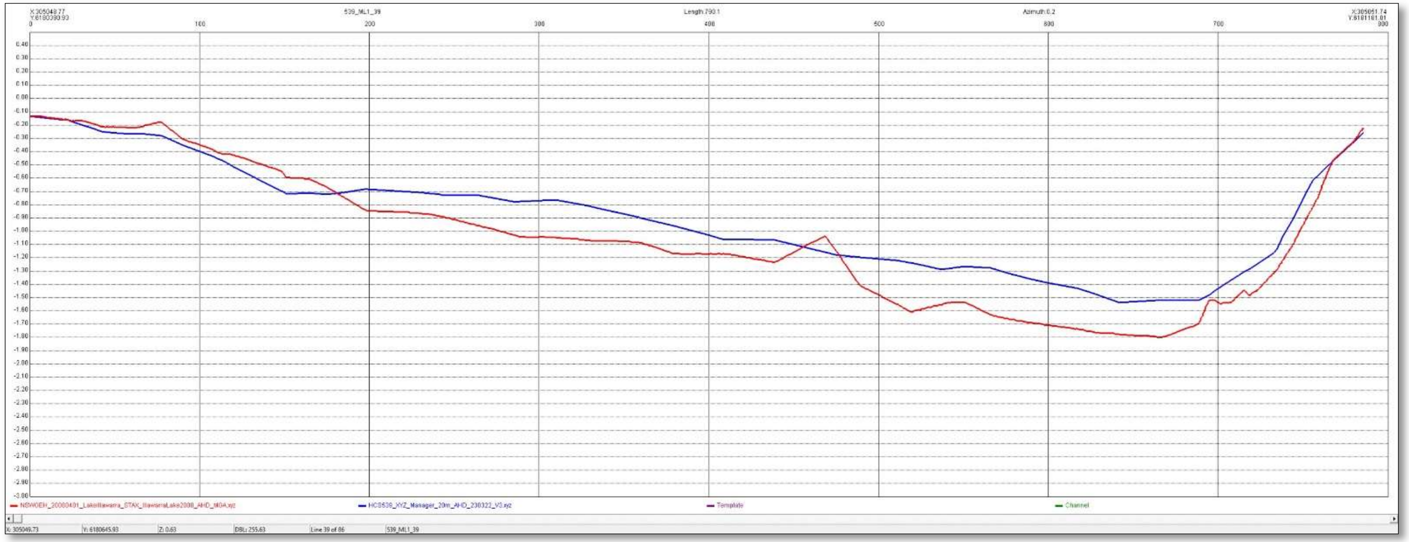


Figure 52: Lake 1 - profiles (red = 2008, blue = 2022/23) 37 and 38.



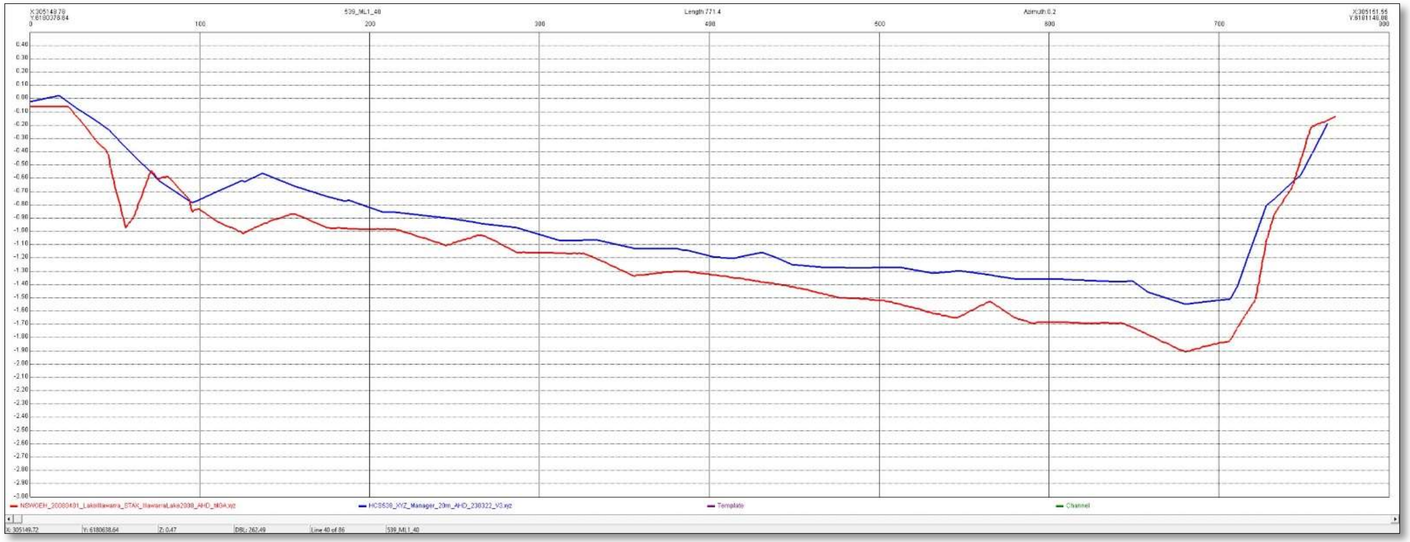


Figure 53: Lake 1 - profiles (red = 2008, blue = 2022/23) 39 and 40.

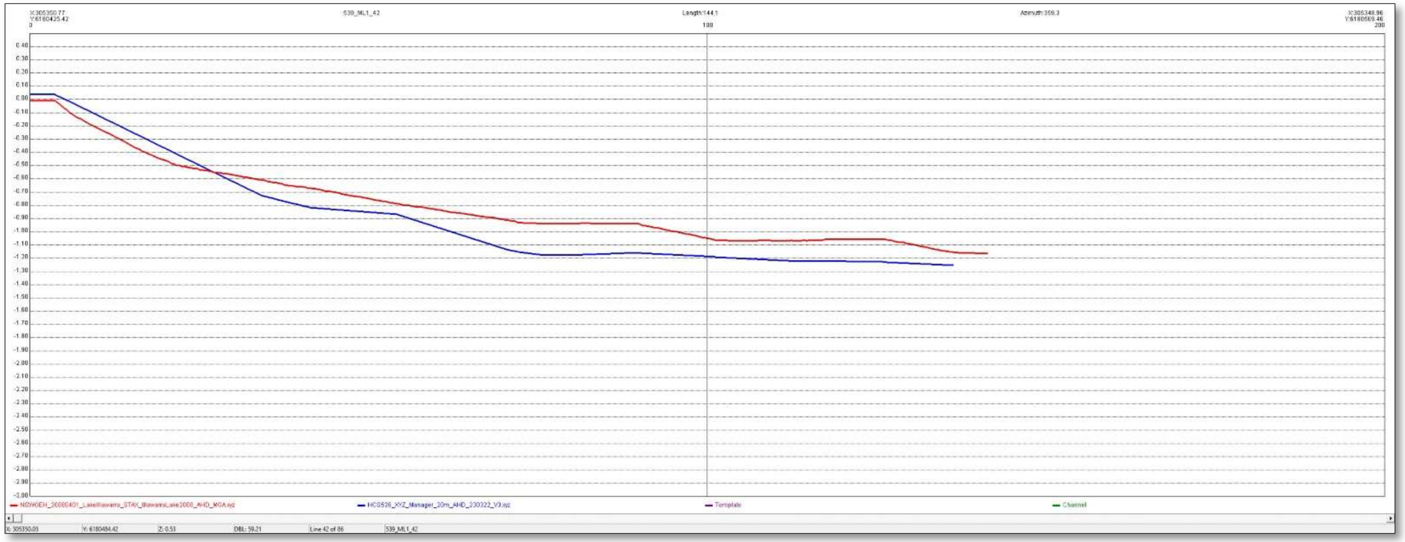


Figure 54: Lake 1 - profiles (red = 2008, blue = 2022/23) 41 and 42.

Figure 55: Lake 1 - profiles (red = 2008, blue = 2022/23) 43 and 44.

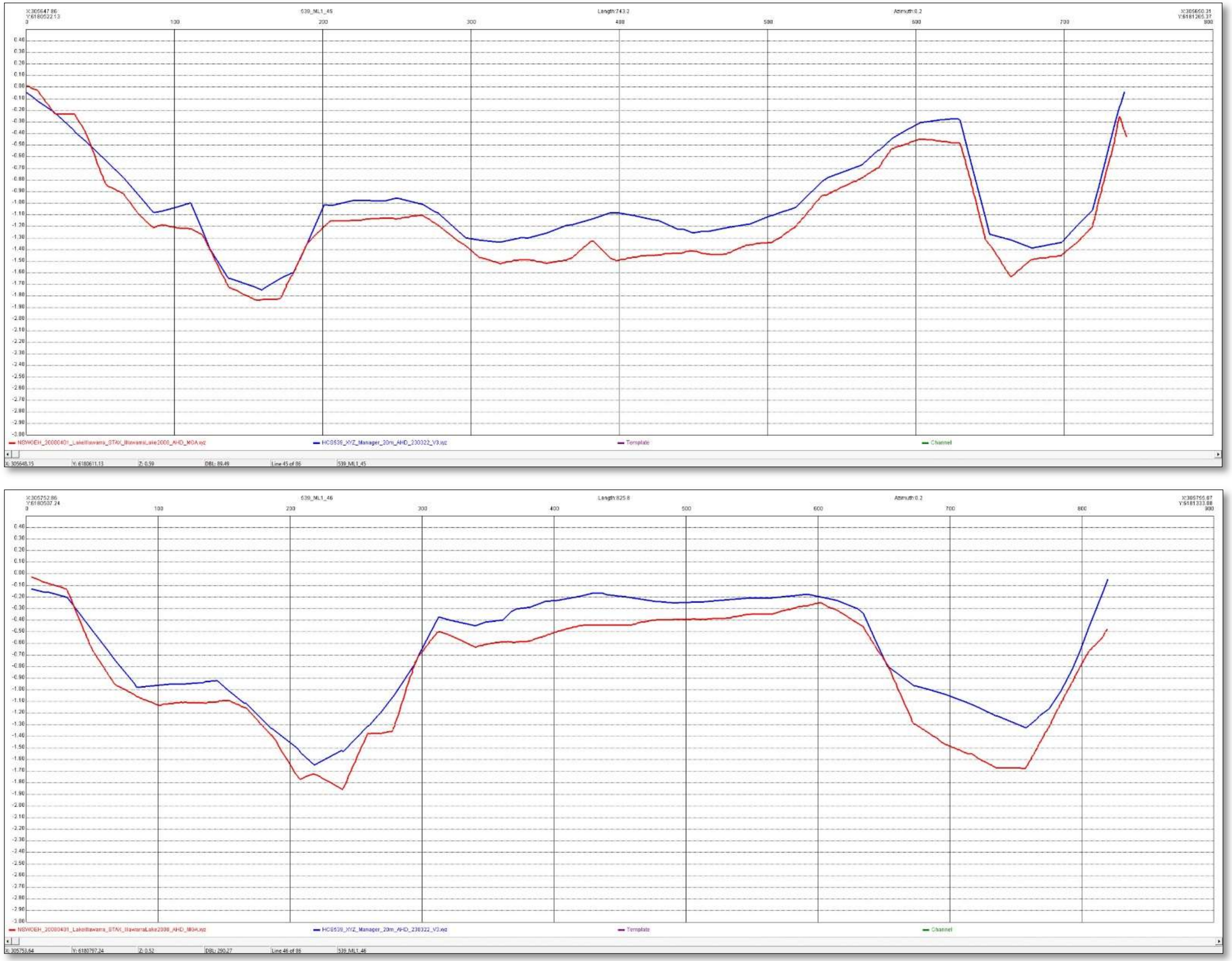
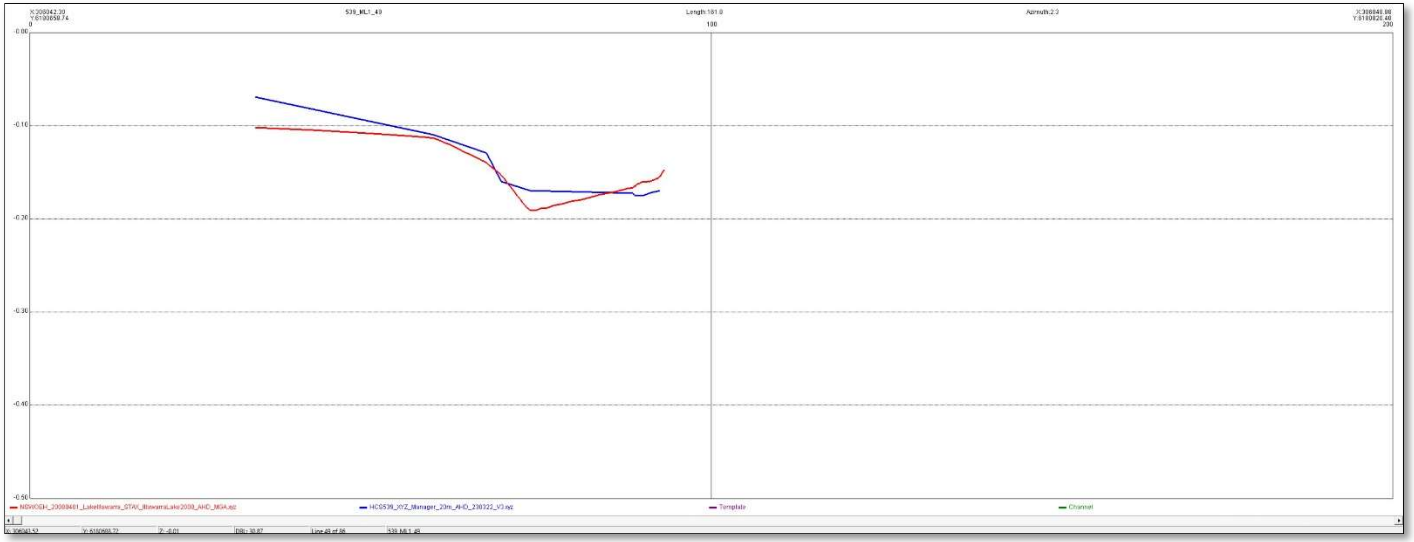


Figure 56: Lake 1 - profiles (red = 2008, blue = 2022/23) 45 and 46.

Figure 57: Lake 1 - profiles (red = 2008, blue = 2022/23) 47 and 48.



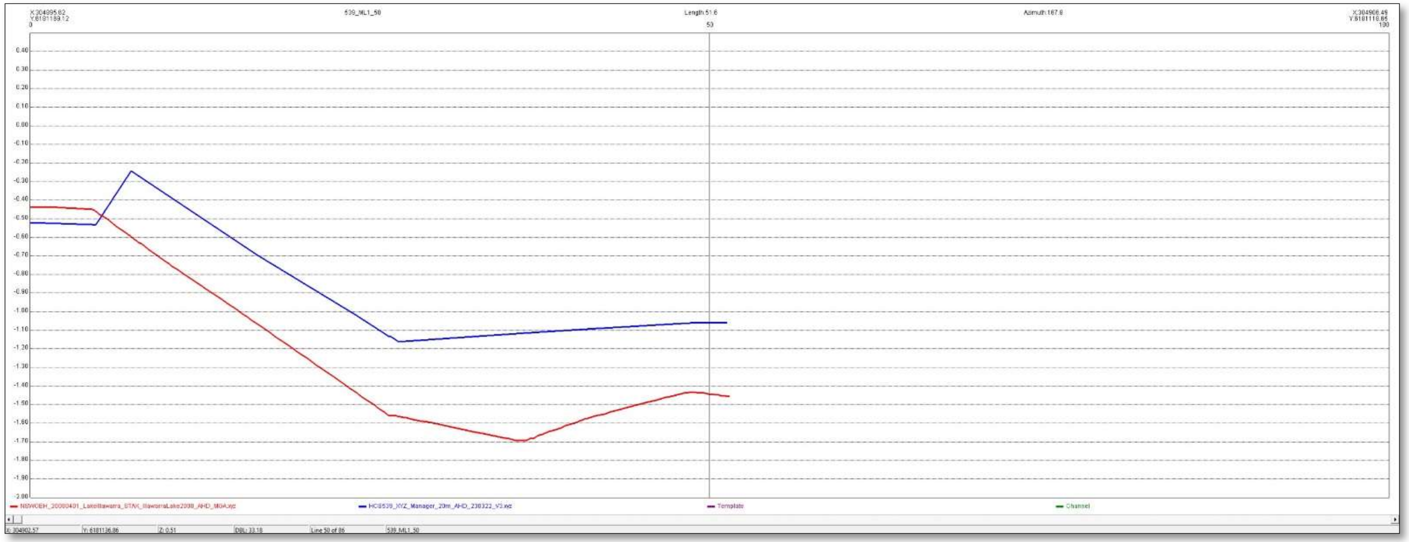
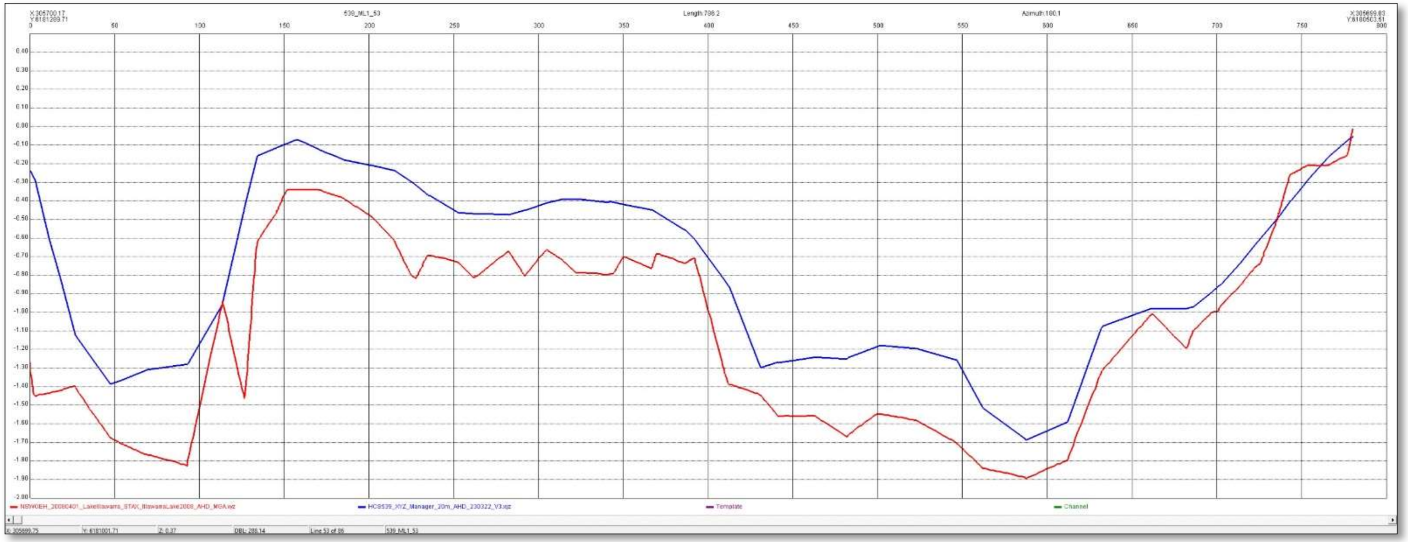


Figure 58: Lake 1 - profiles (red = 2008, blue = 2022/23) 49 and 50.

Figure 59: Lake 1 - profiles (red = 2008, blue = 2022/23) 51 and 52.



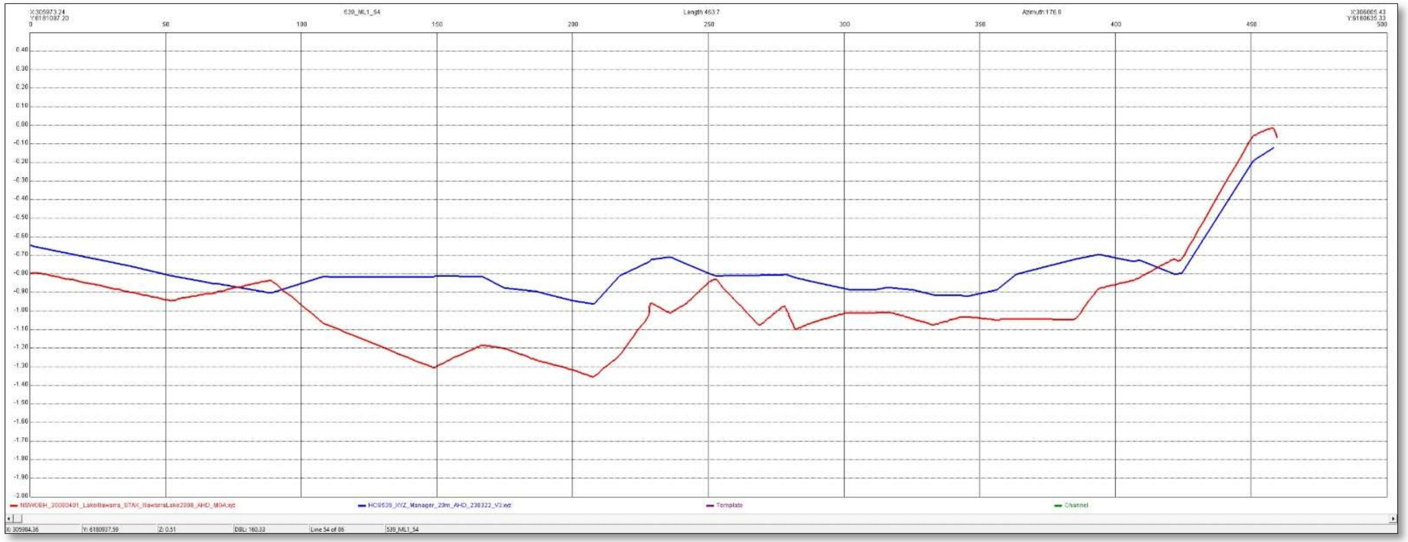
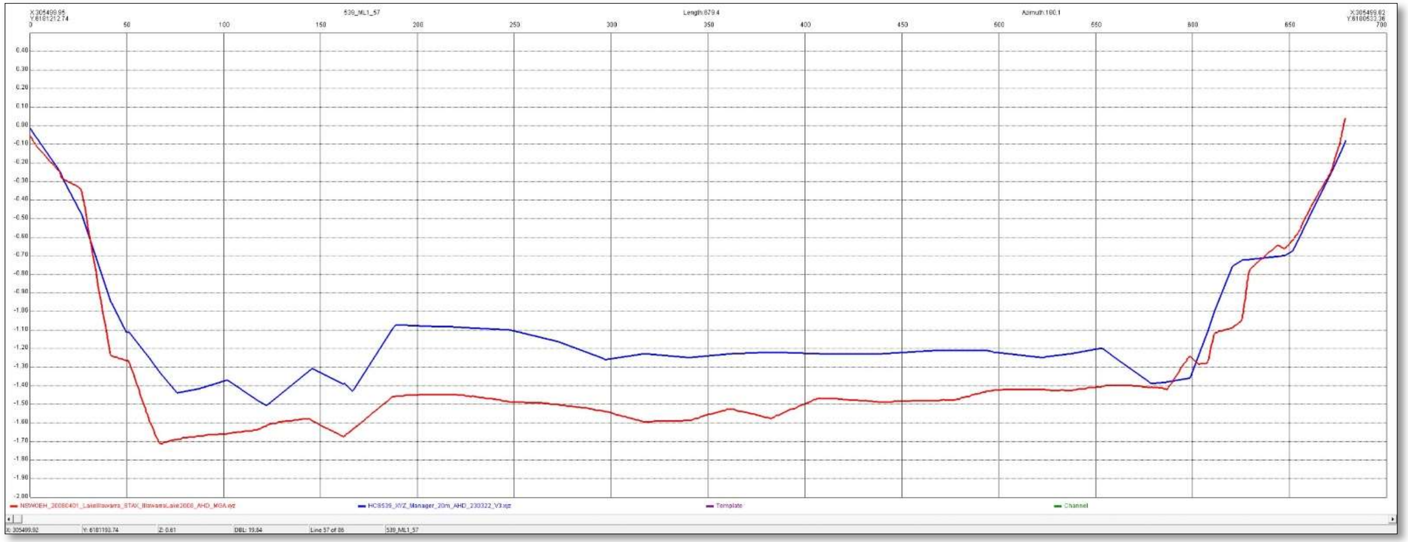


Figure 60: Lake 1 - profiles (red = 2008, blue = 2022/23) 53 and 54.

Figure 61: Lake 1 - profiles (red = 2008, blue = 2022/23) 55 and 56.



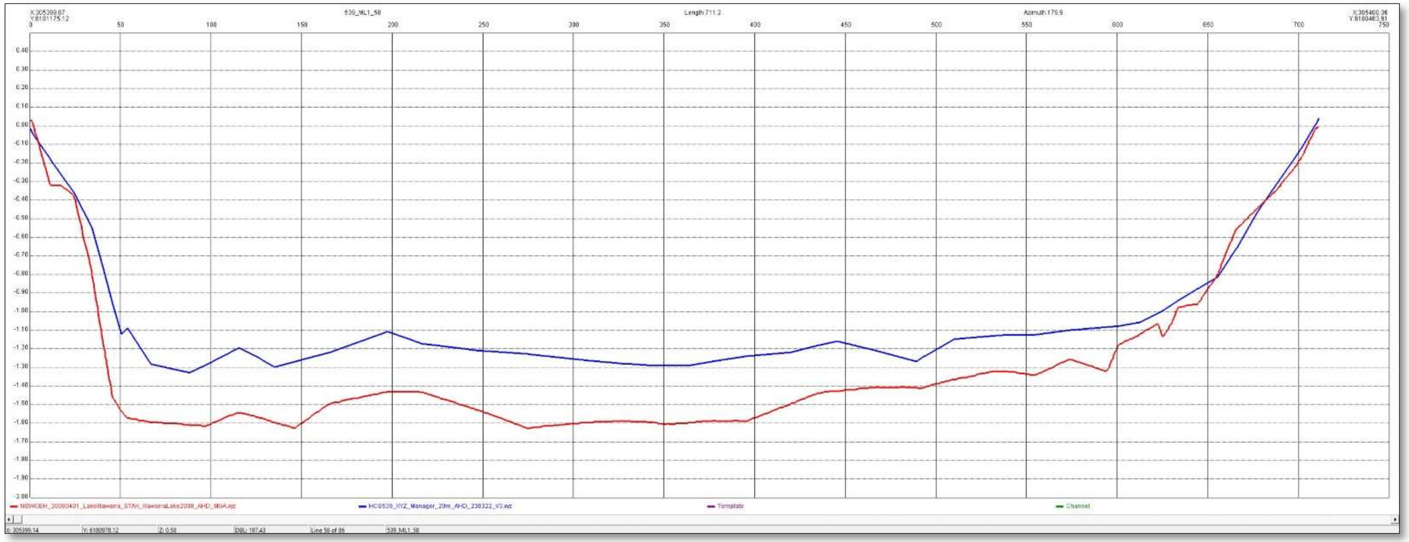


Figure 62: Lake 1 - profiles (red = 2008, blue = 2022/23) 57 and 58.

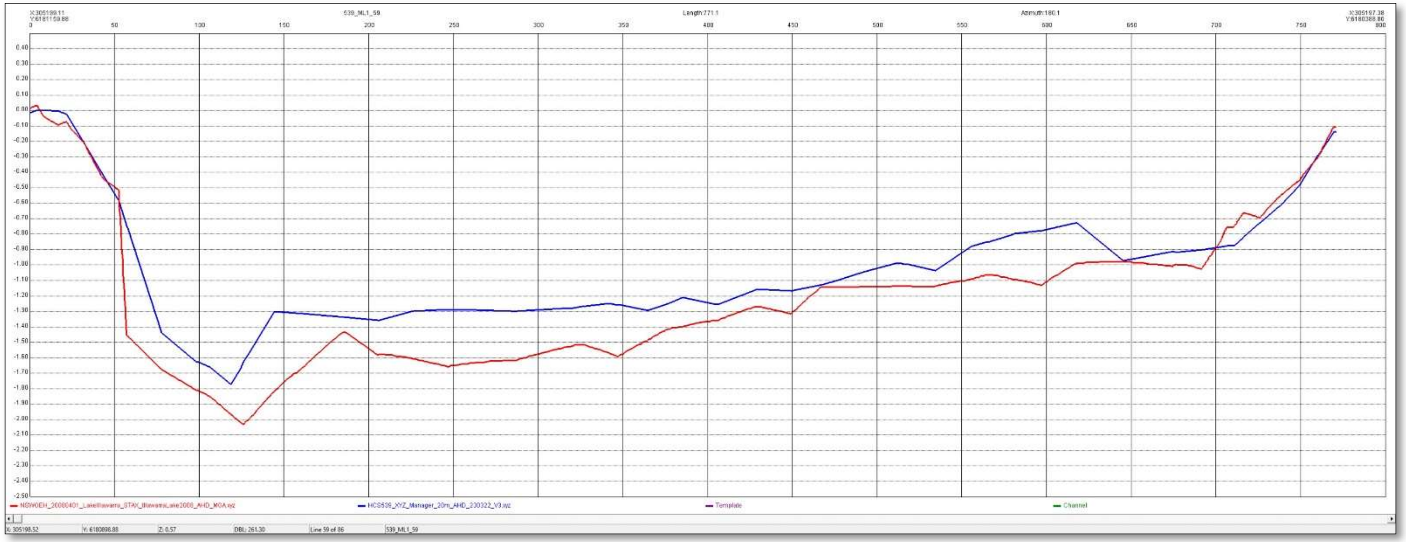


Figure 63: Lake 1 - profiles (red = 2008, blue = 2022/23) 59 and 60.

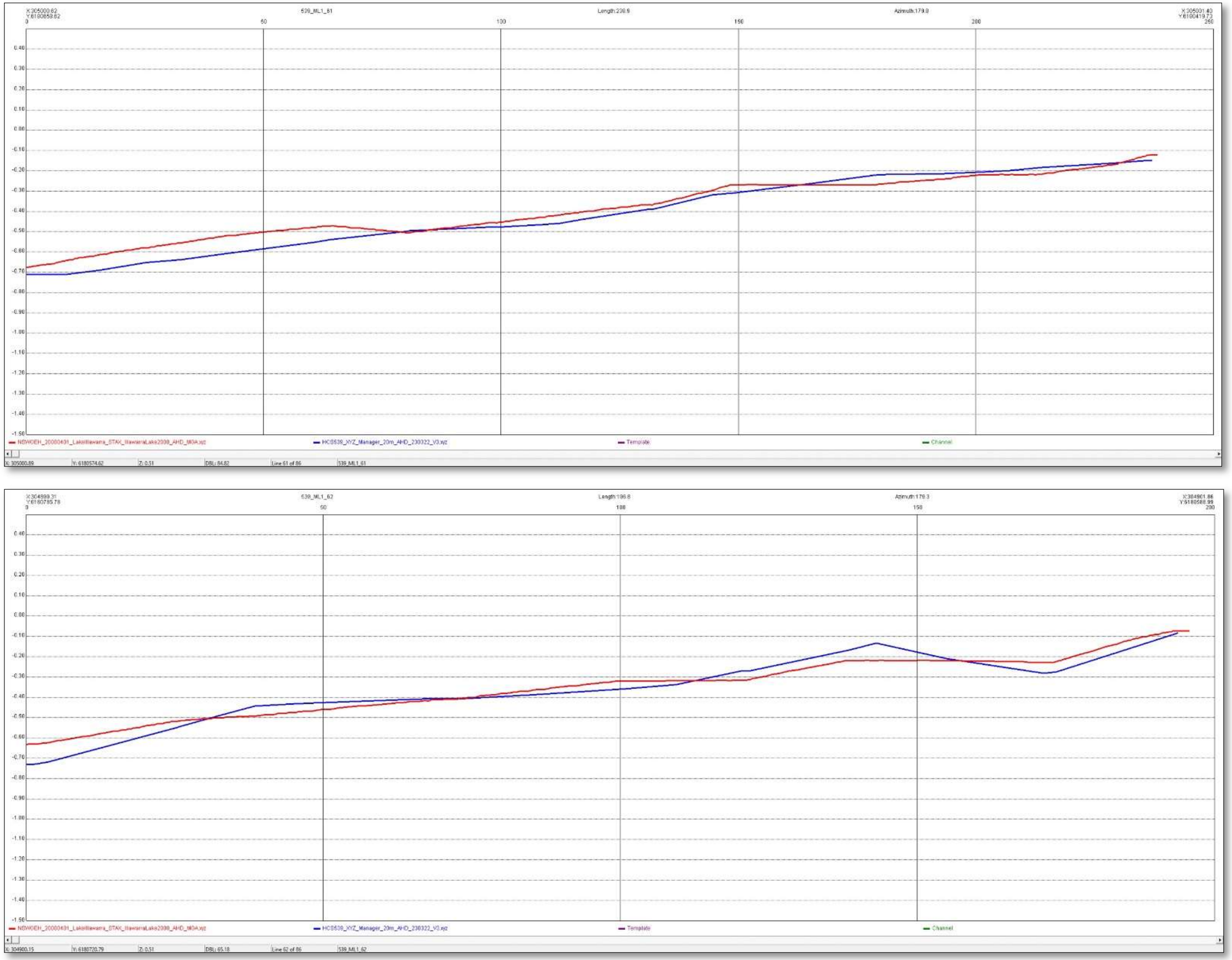


Figure 64: Lake 1 - profiles (red = 2008, blue = 2022/23) 61 and 62.

Figure 65: Lake 1 - profiles (red = 2008, blue = 2022/23) 63 and 64.

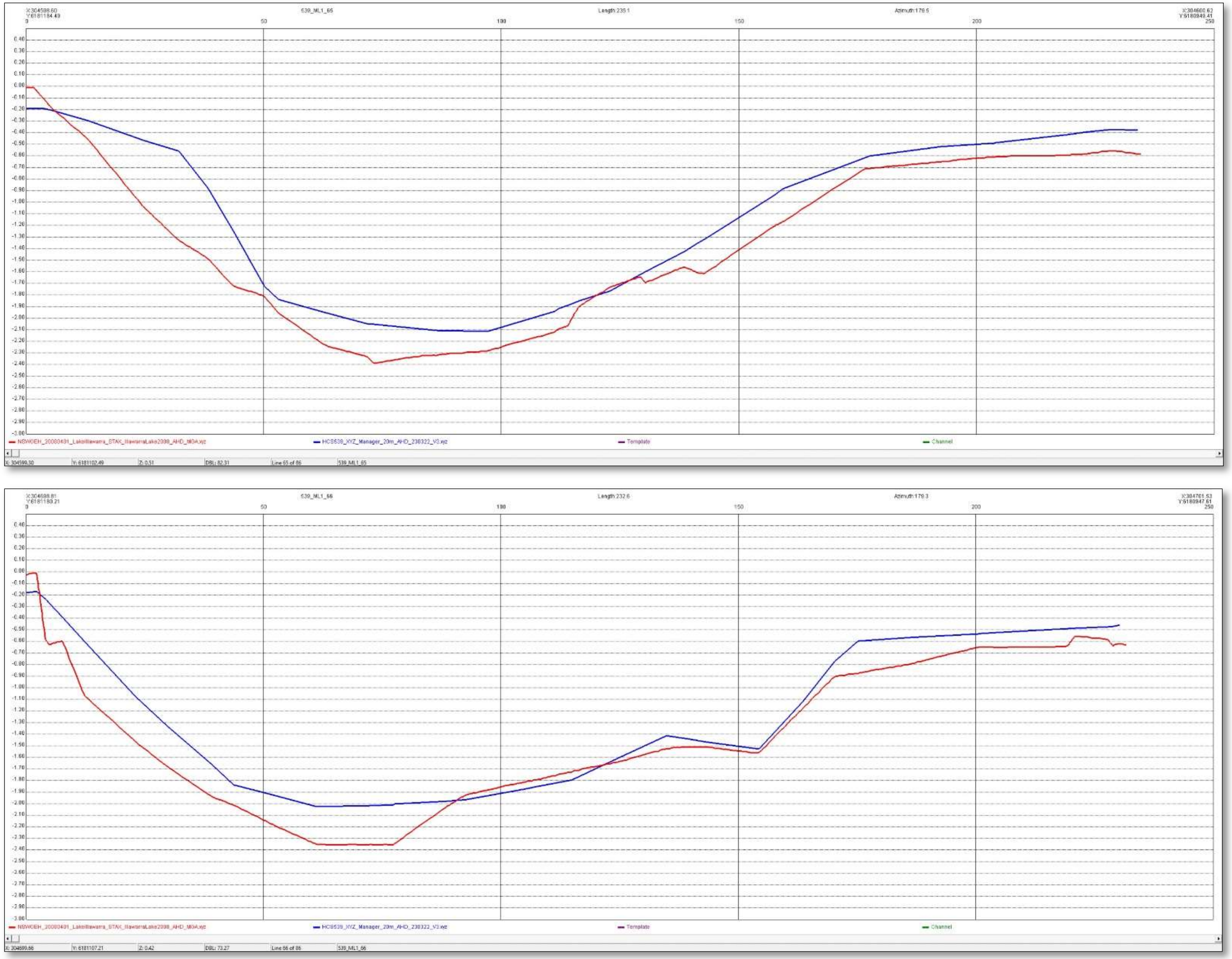
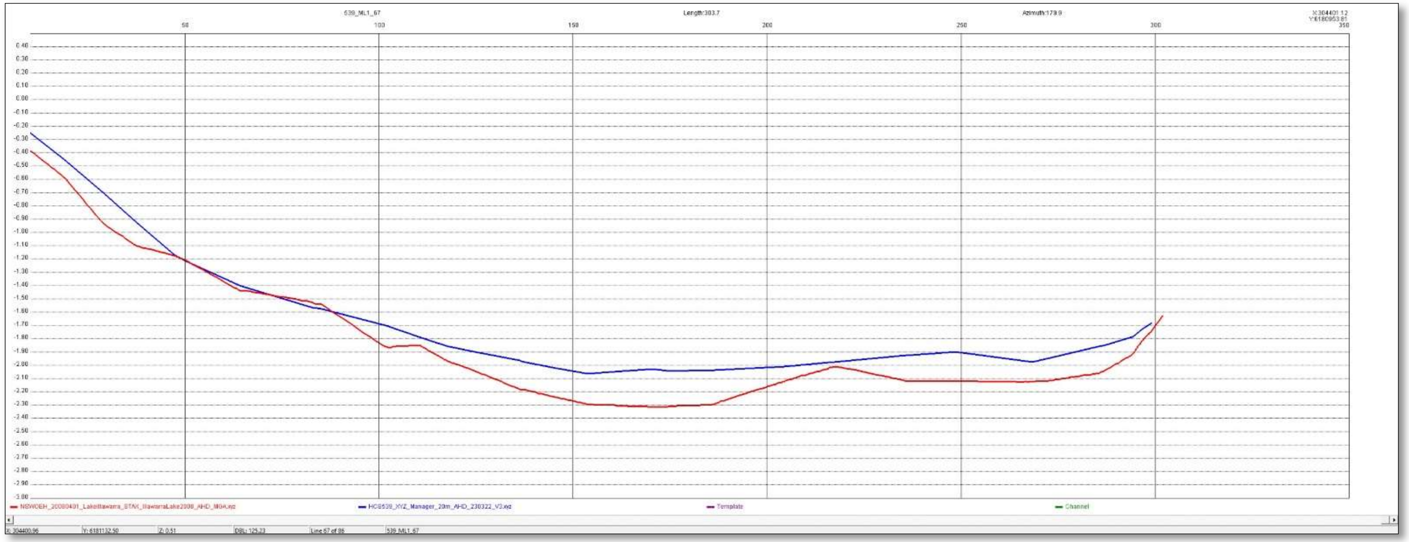


Figure 66: Lake 1 - profiles (red = 2008, blue = 2022/23) 65 and 66.



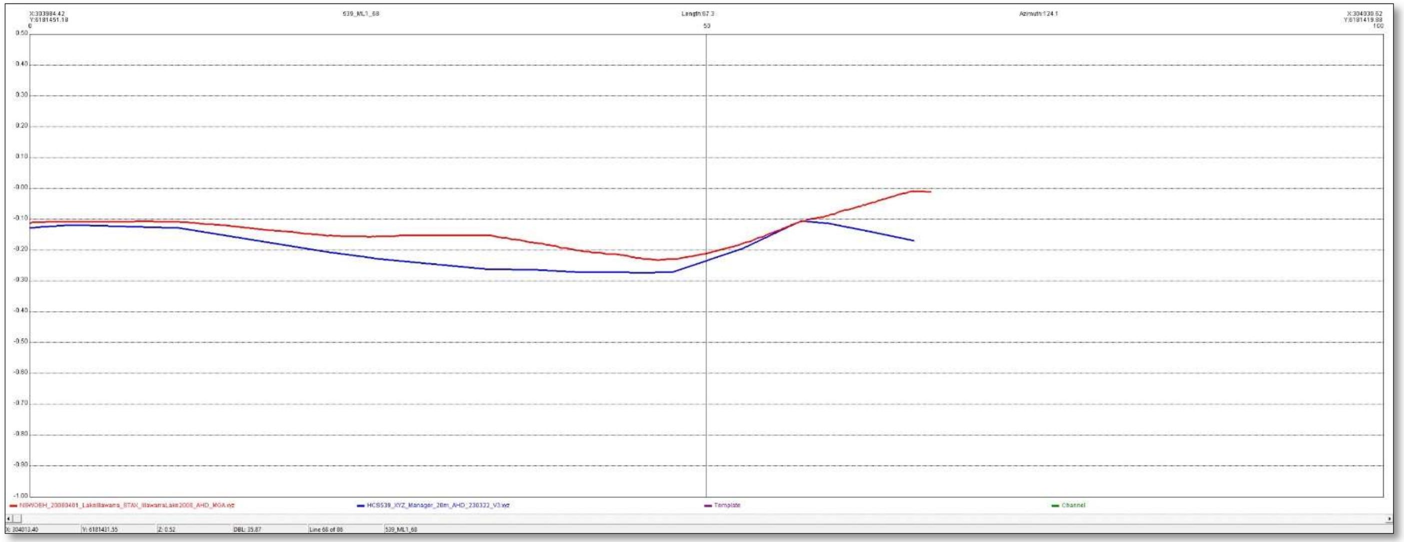
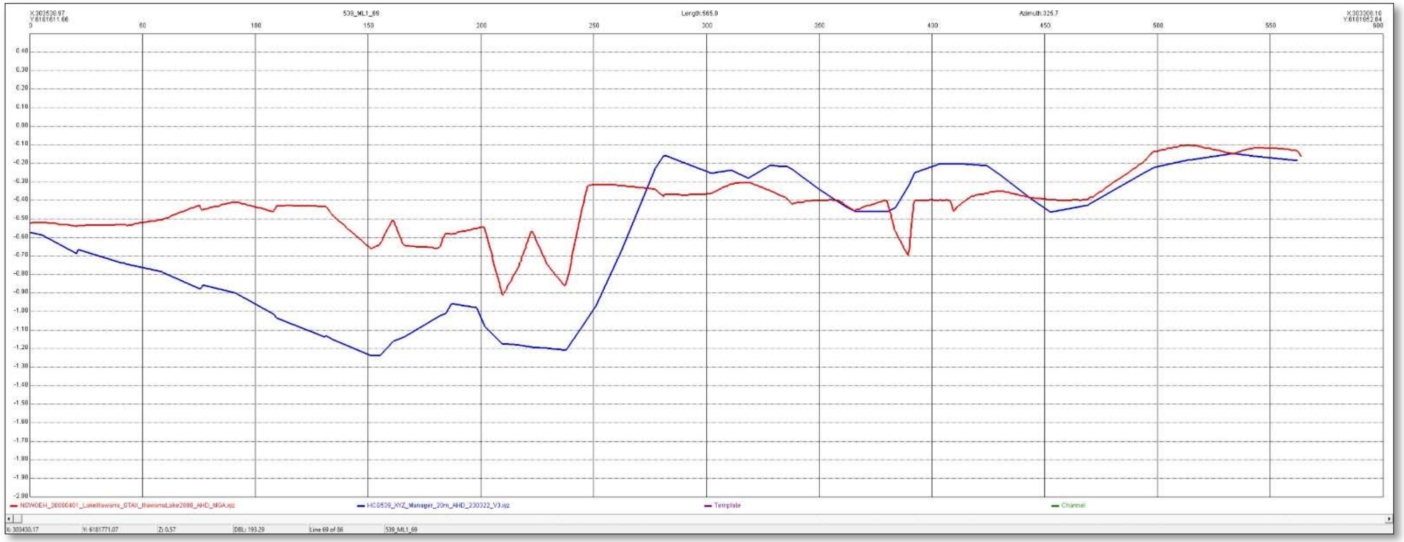


Figure 67: Lake 1 - profiles (red = 2008, blue = 2022/23) 67 and 68.



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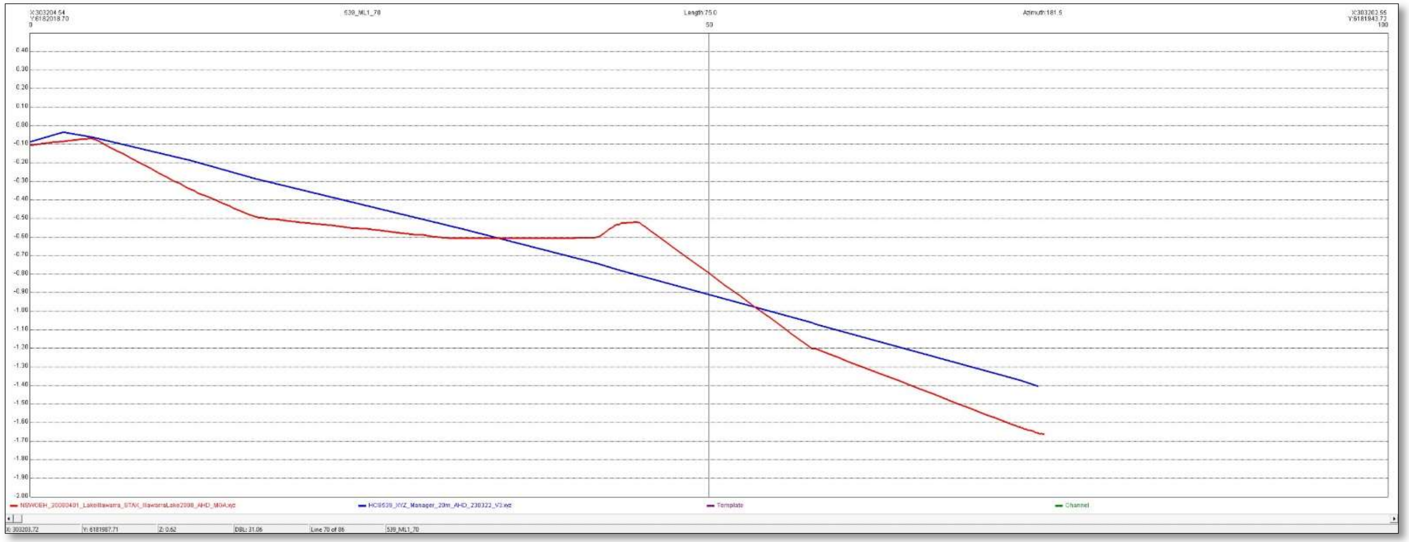


Figure 68: Lake 1 - profiles (red = 2008, blue = 2022/23) 69 and 70.

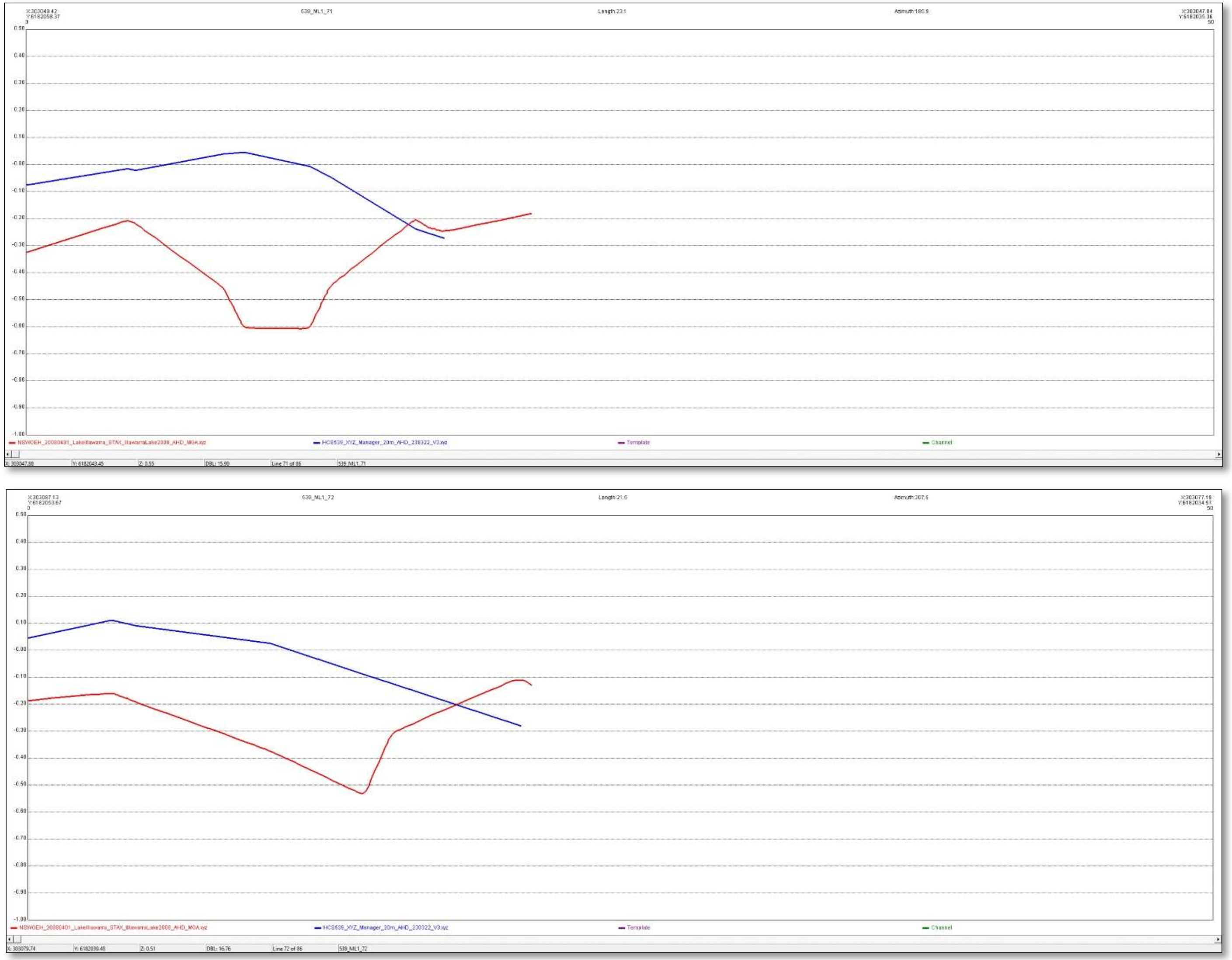


Figure 69: Lake 1 - profiles (red = 2008, blue = 2022/23) 71 and 72.

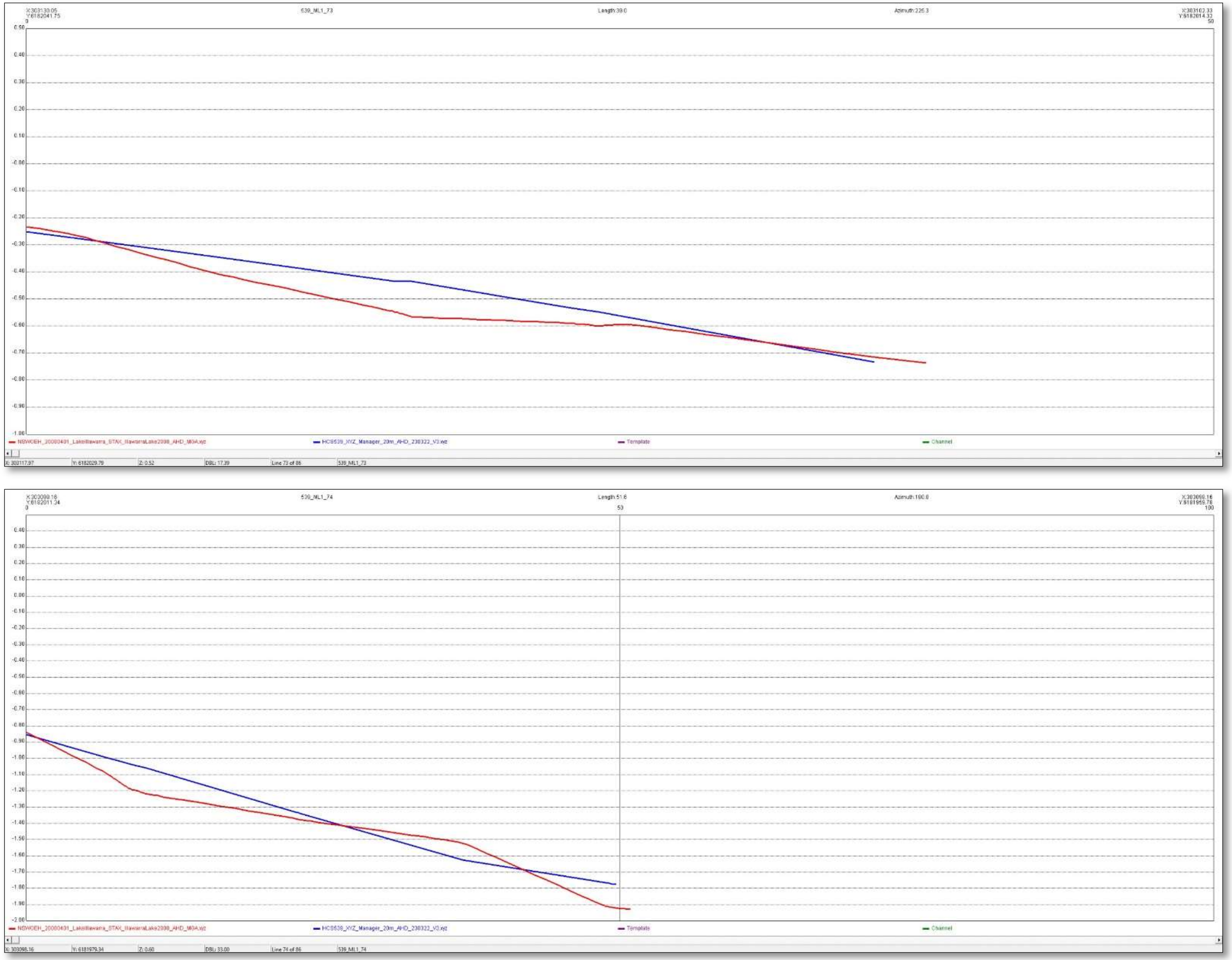
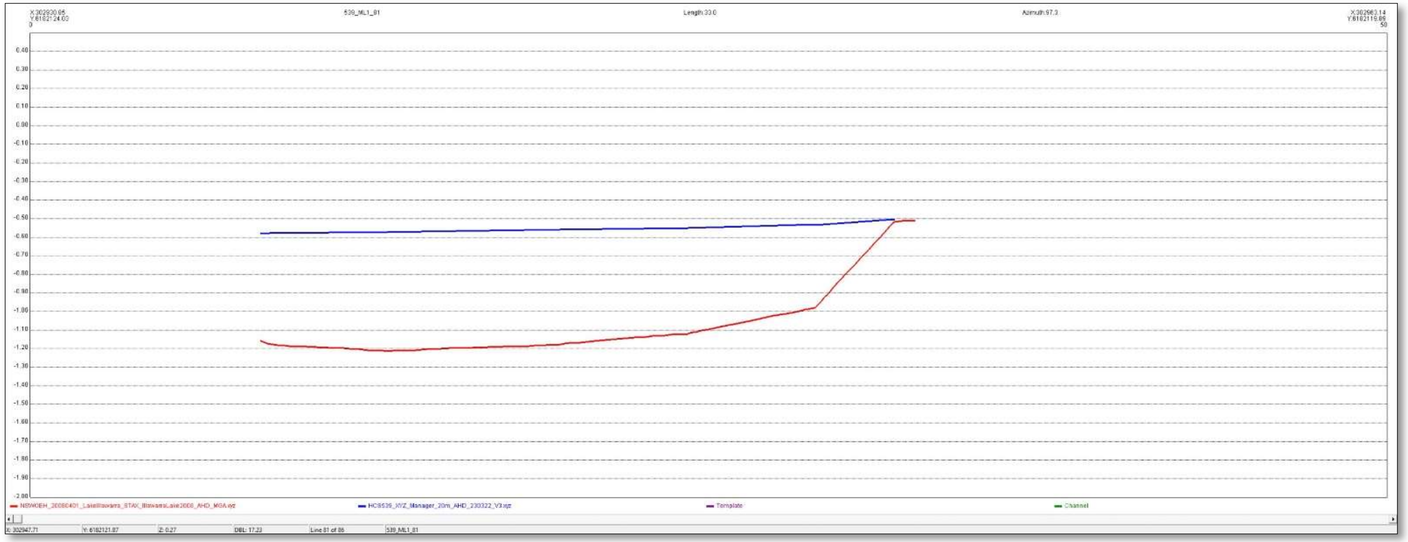


Figure 70: Lake 1 - profiles (red = 2008, blue = 2022/23) 73 and 74.

Figure 71: Lake 1 - profiles (red = 2008, blue = 2022/23) 75 and 76.

Figure 72: Lake 1 - profiles (red = 2008, blue = 2022/23) 77 and 78.

Figure 73: Lake 1 - profiles (red = 2008, blue = 2022/23) 79 and 80.



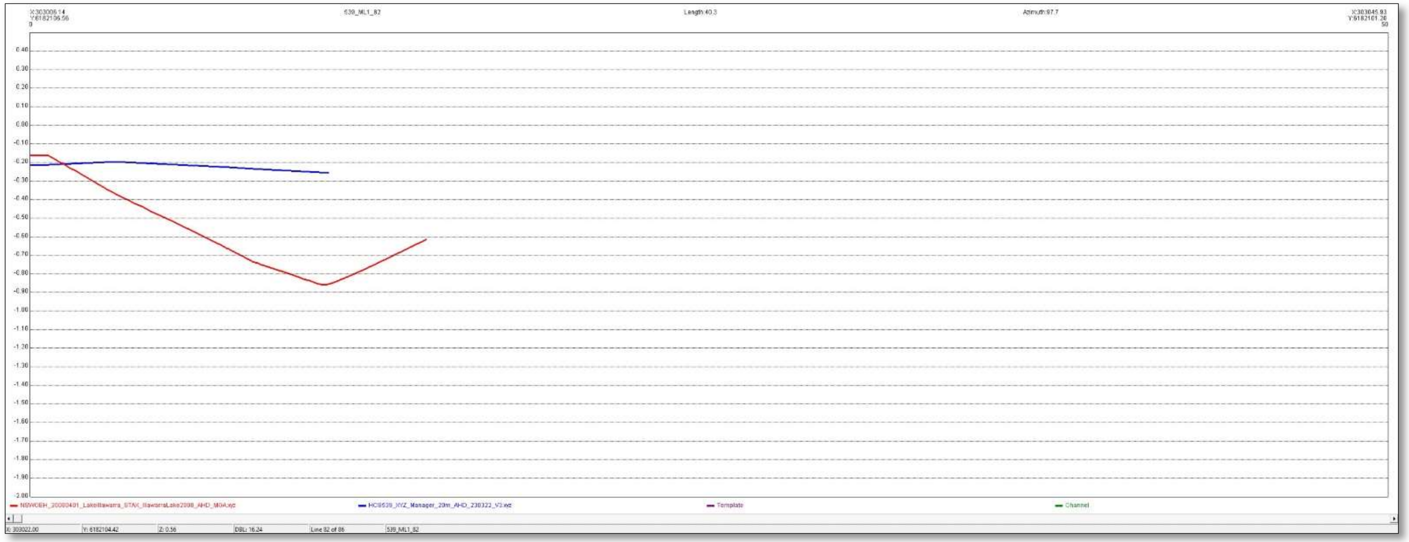


Figure 74: Lake 1 - profiles (red = 2008, blue = 2022/23) 81 and 82.

Figure 75: Lake 1 - profiles (red = 2008, blue = 2022/23) 83 and 84.

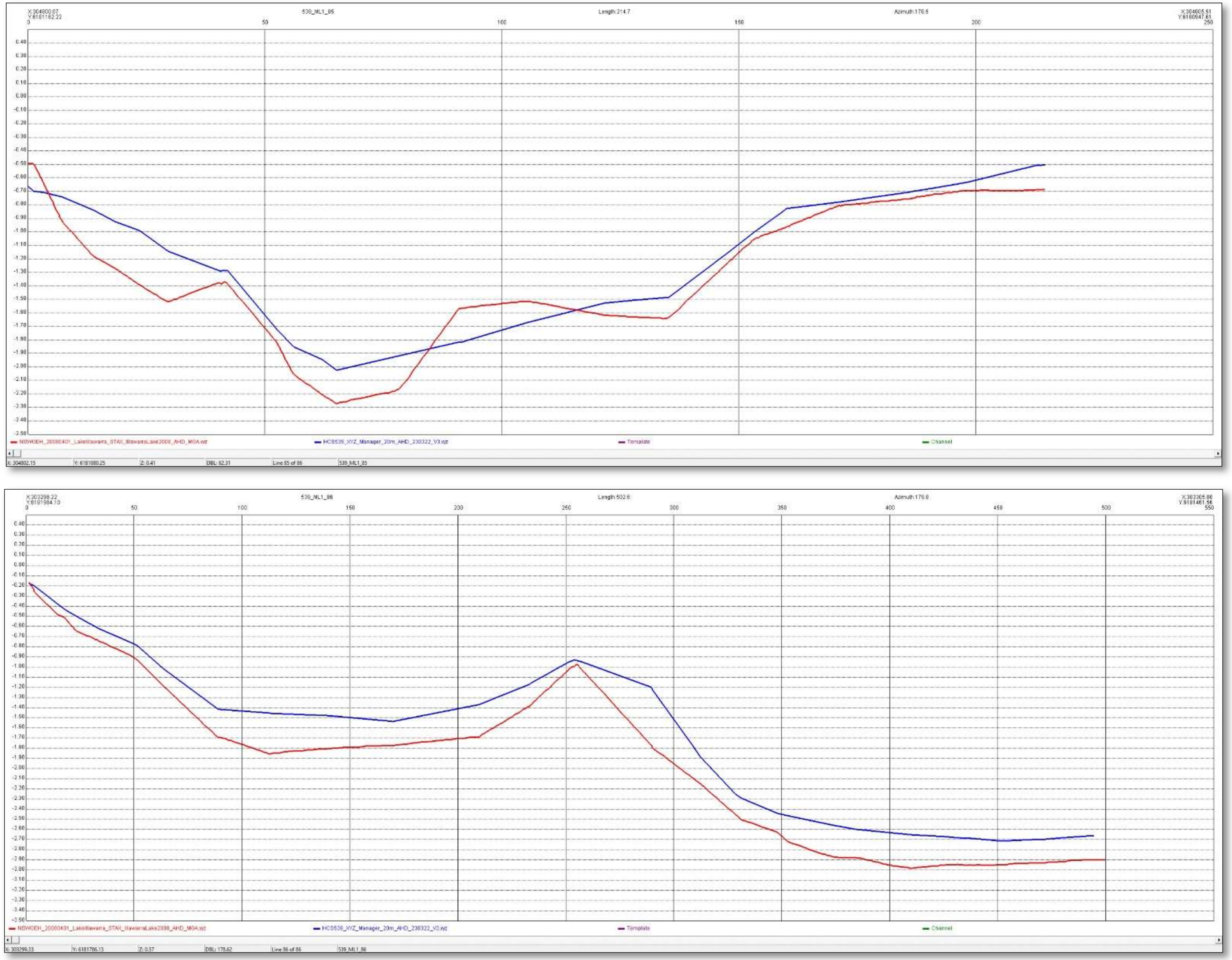


Figure 76: Lake 1 - profiles (red = 2008, blue = 2022/23) 85 and 86.

LAKE 2

Koona Bay

Figure 77: Lake 2 profiles utilised for analysis (data within Plan 539-1 Sheet 4).

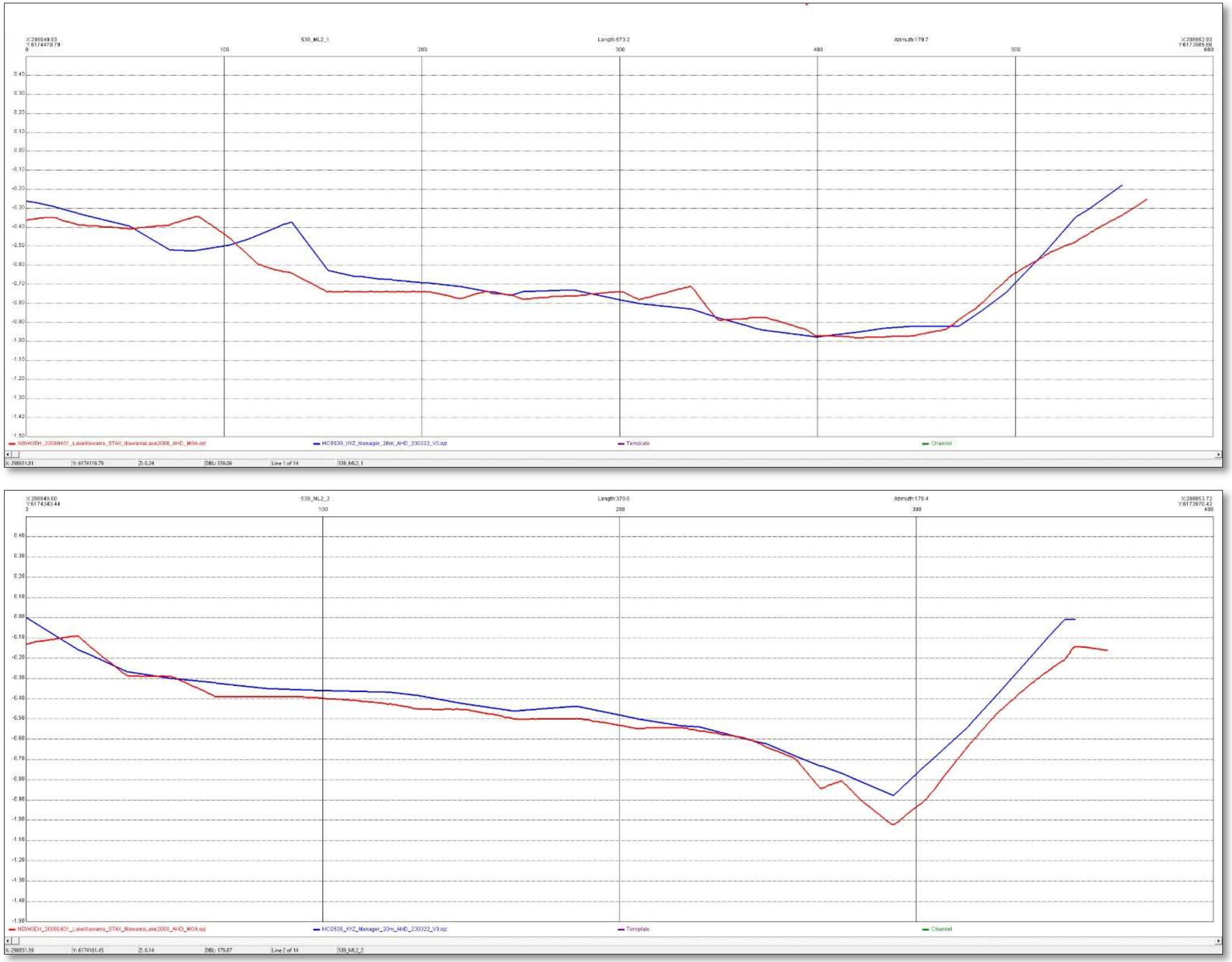
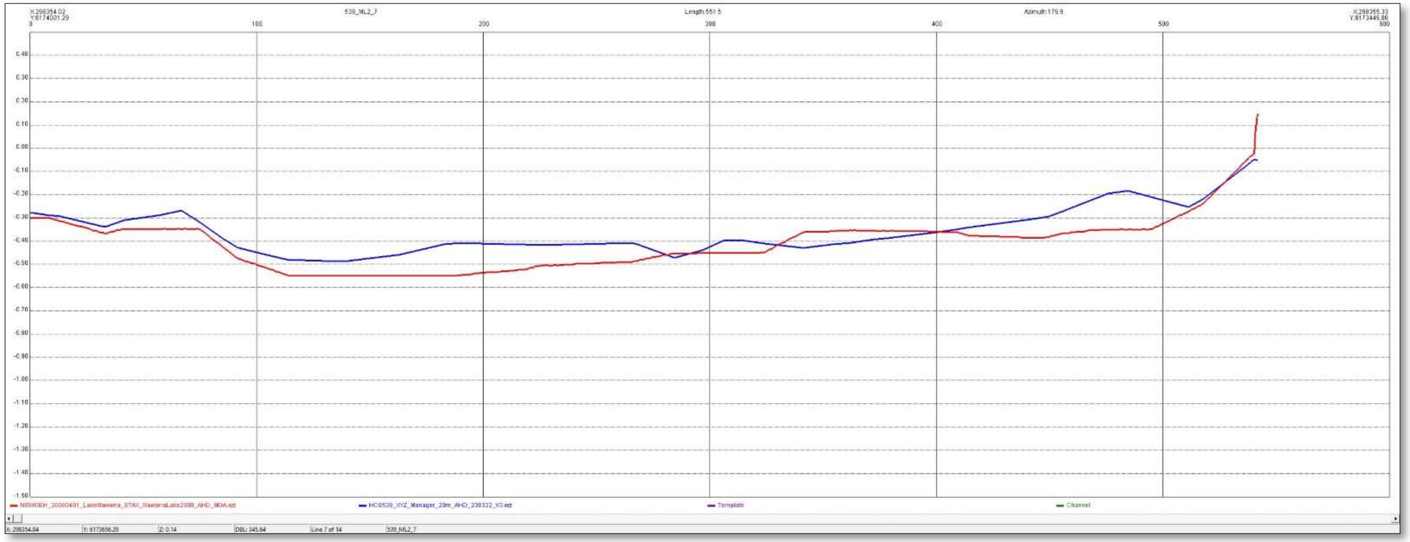


Figure 78: Lake 2 - profiles (red = 2008, blue = 2022/23) 1 and 2.

Figure 79: Lake 2 - profiles (red = 2008, blue = 2022/23) 3 and 4.

Figure 80: Lake 2 - profiles (red = 2008, blue = 2022/23) 5 and 6.



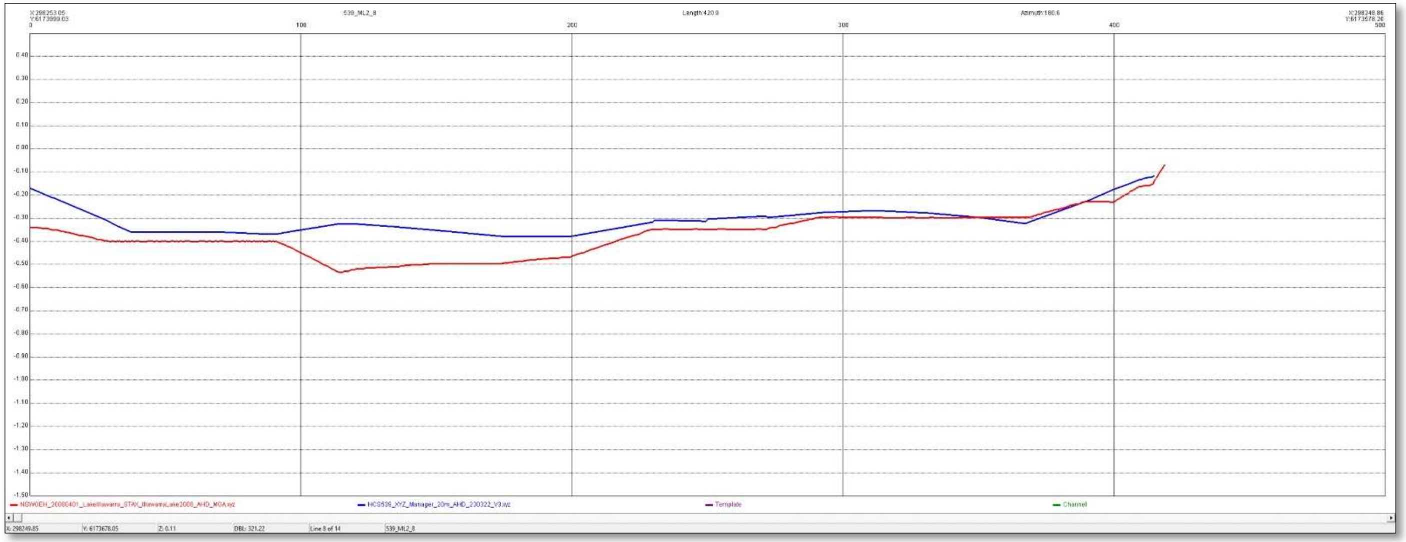


Figure 81: Lake 2 - profiles (red = 2008, blue = 2022/23) 7 and 8.

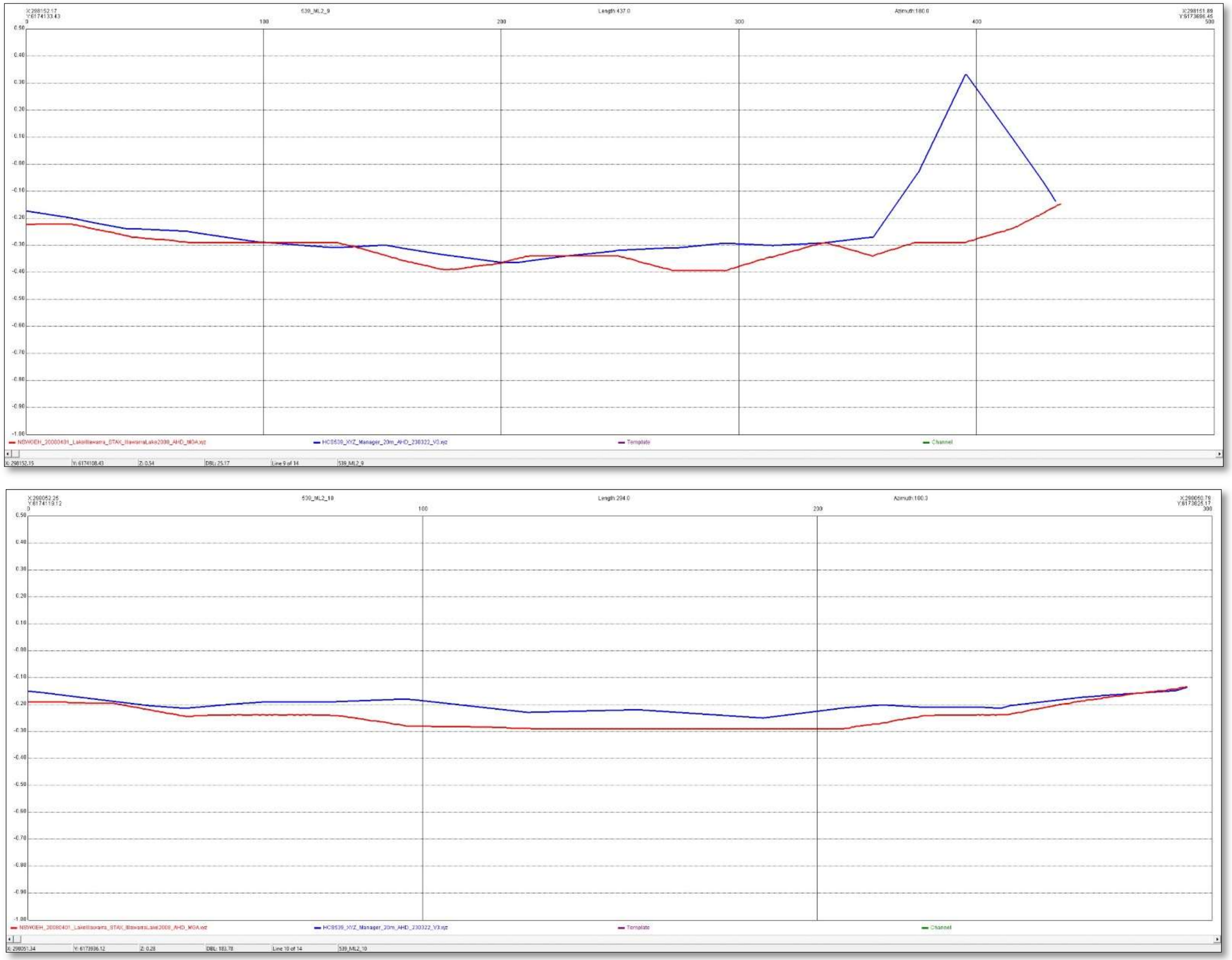


Figure 82: Lake 2 - profiles (red = 2008, blue = 2022/23) 9 and 10.

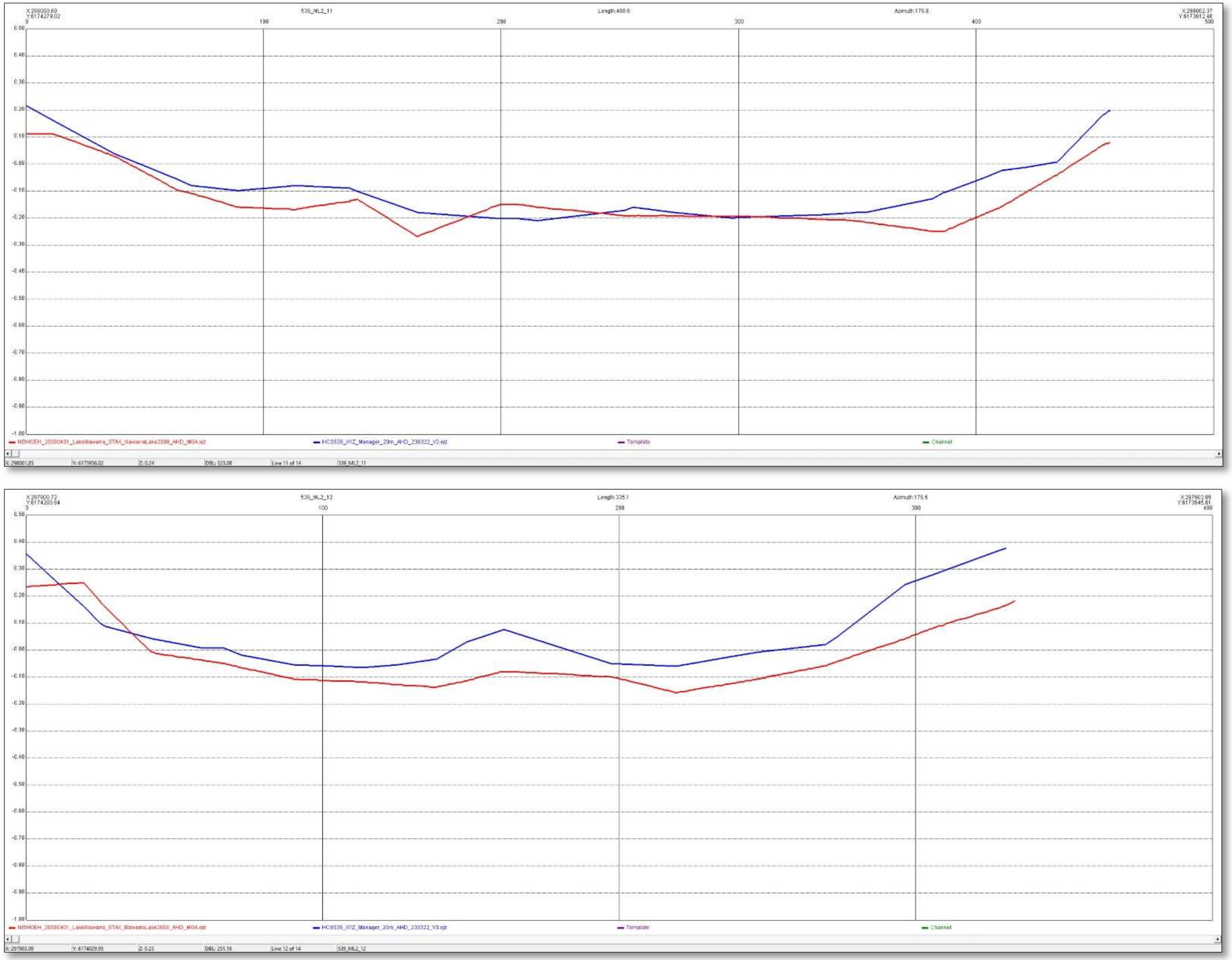
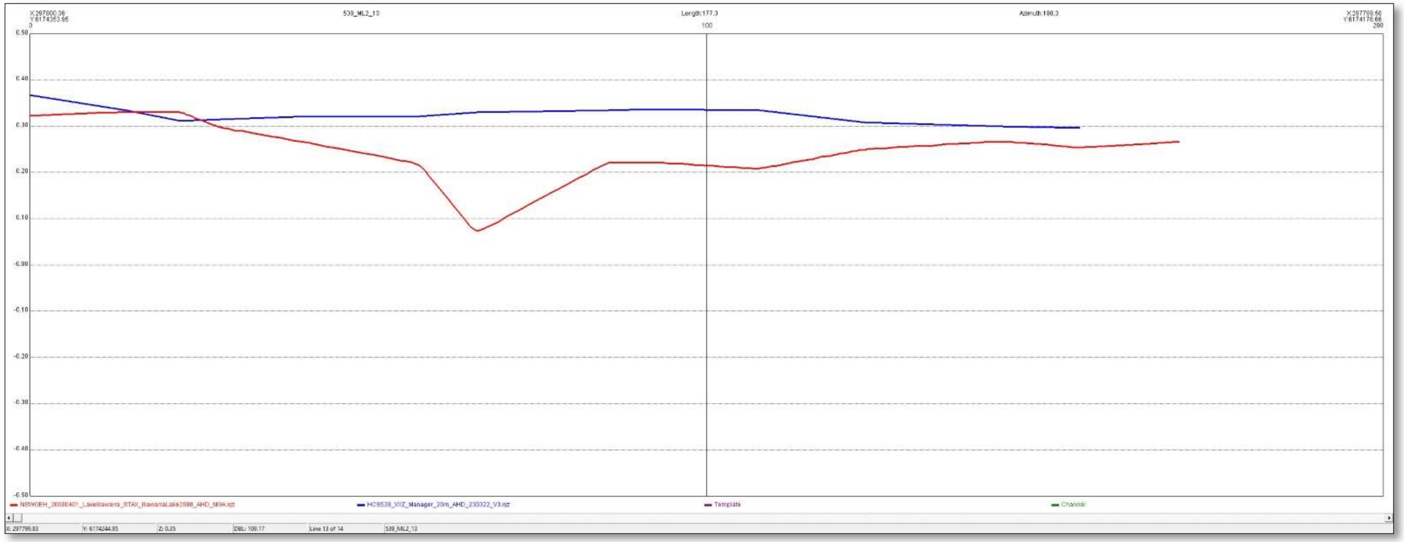


Figure 83: Lake 2 - profiles (red = 2008, blue = 2022/23) 11 and 12.



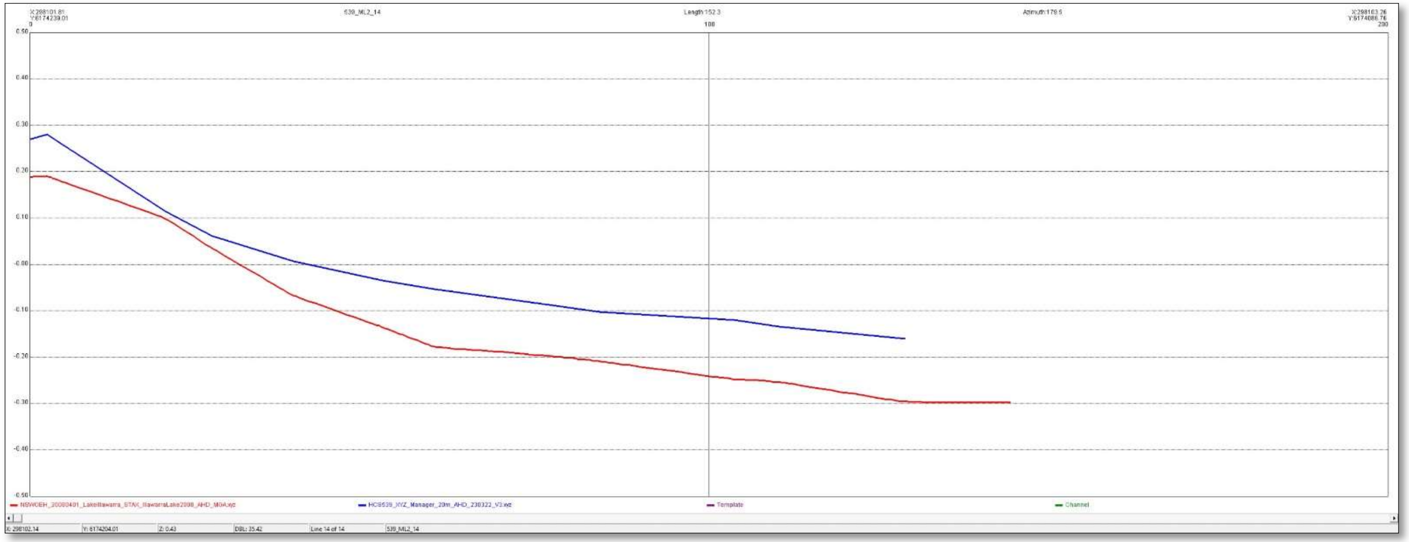
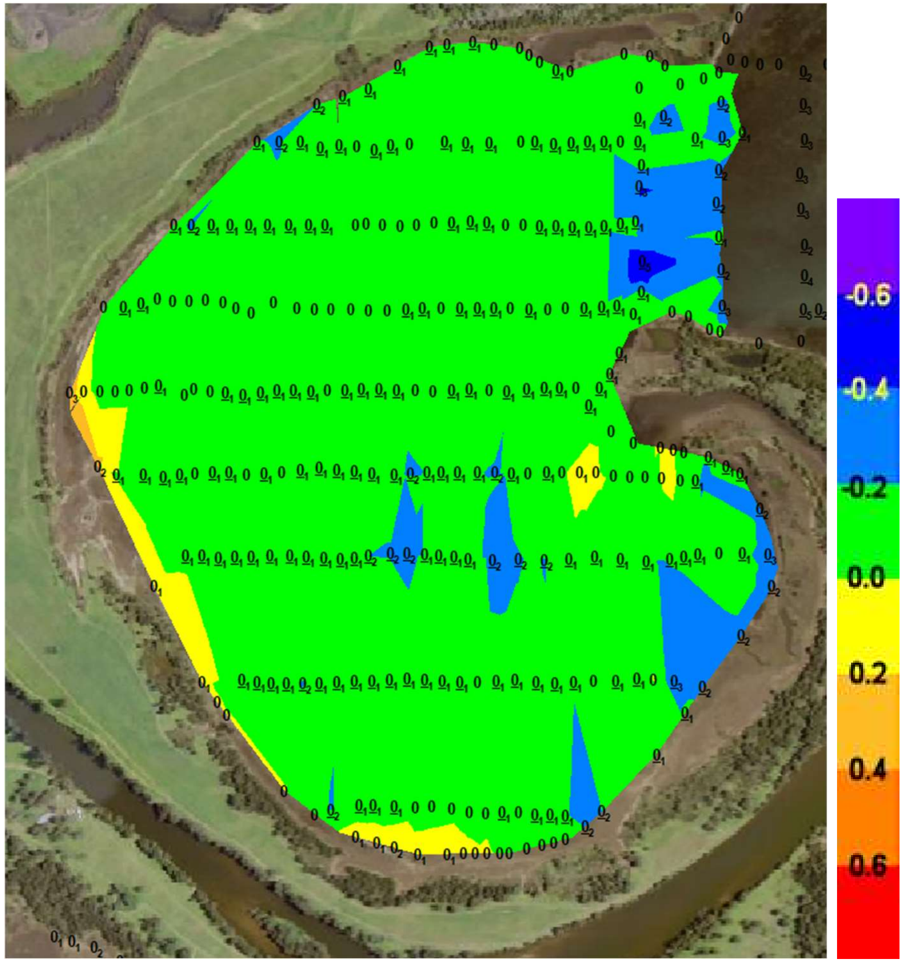


Figure 84: Lake 2 - profiles (red = 2008, blue = 2022/23) 13 and 14.

LAKE 3

Haywards Bay



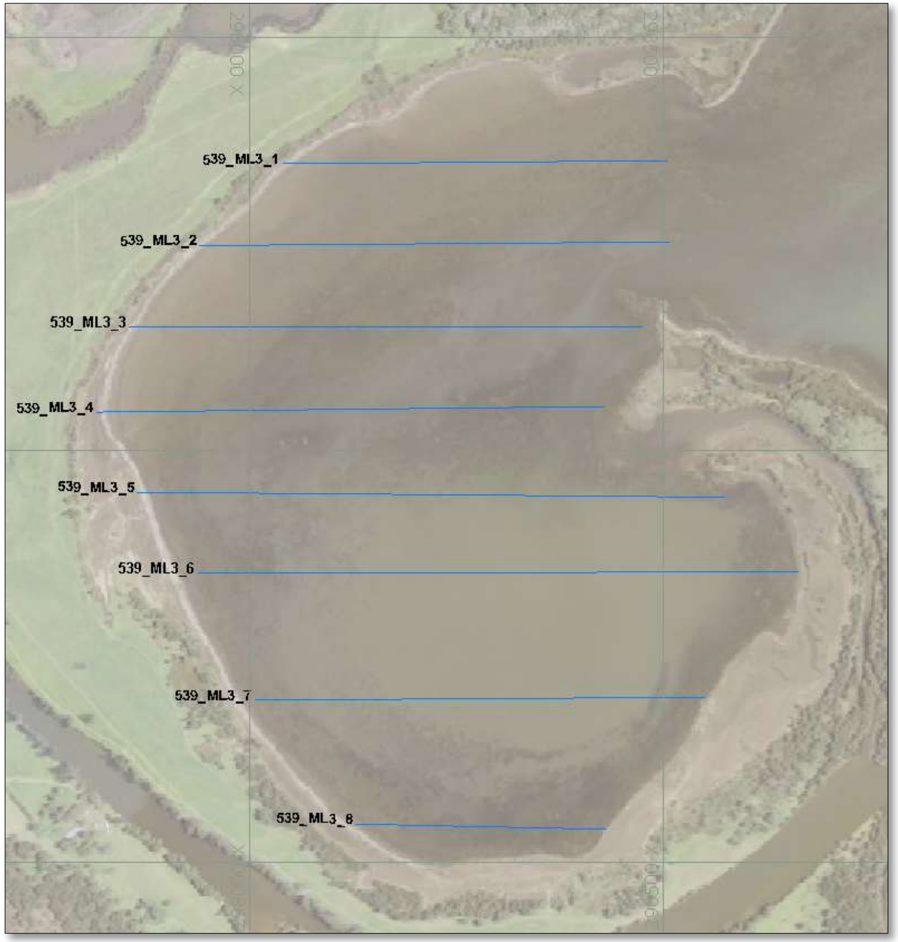


Figure 85: Lake 3 profiles utilised for analysis (data within Plan 539-1 Sheet 4).

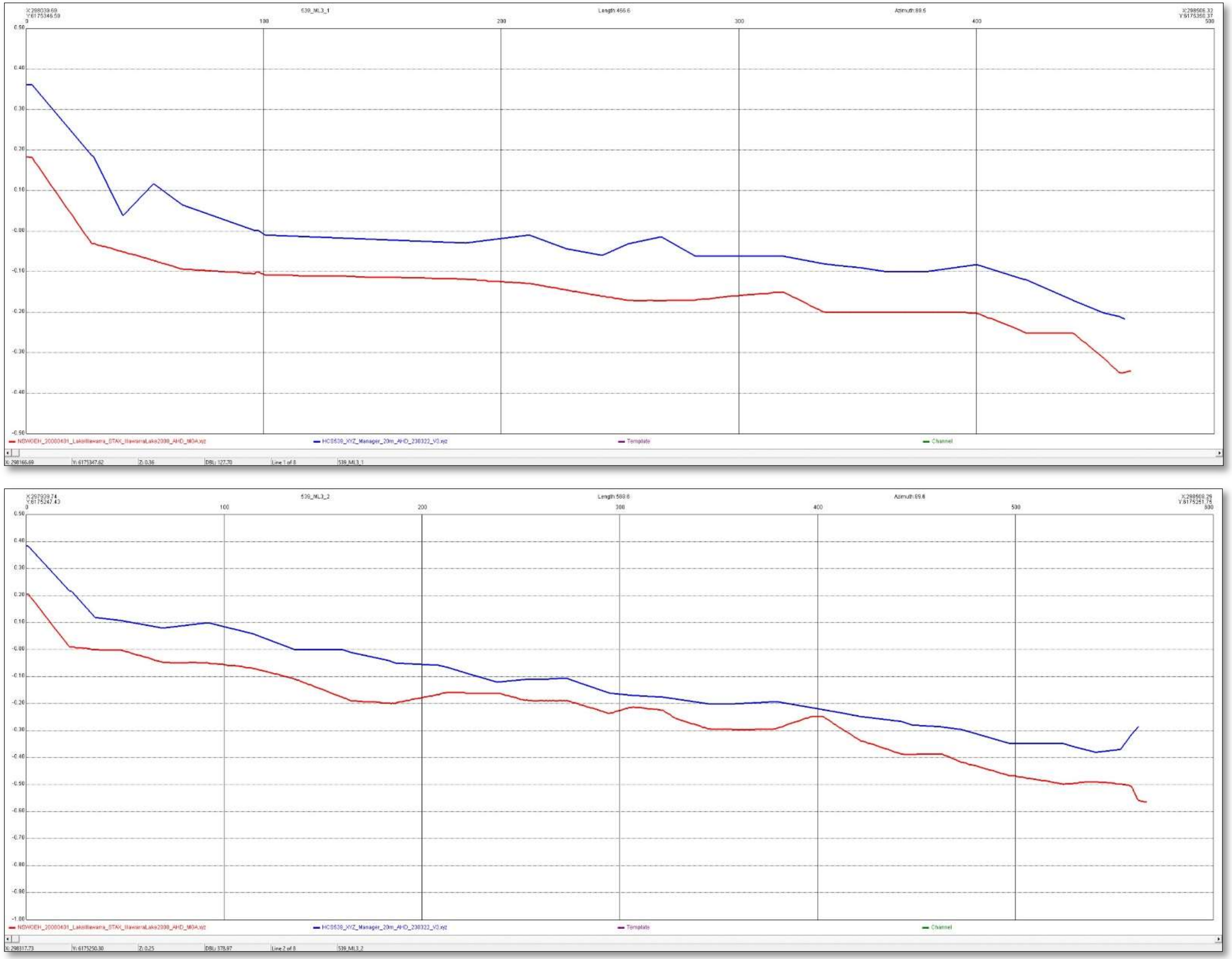
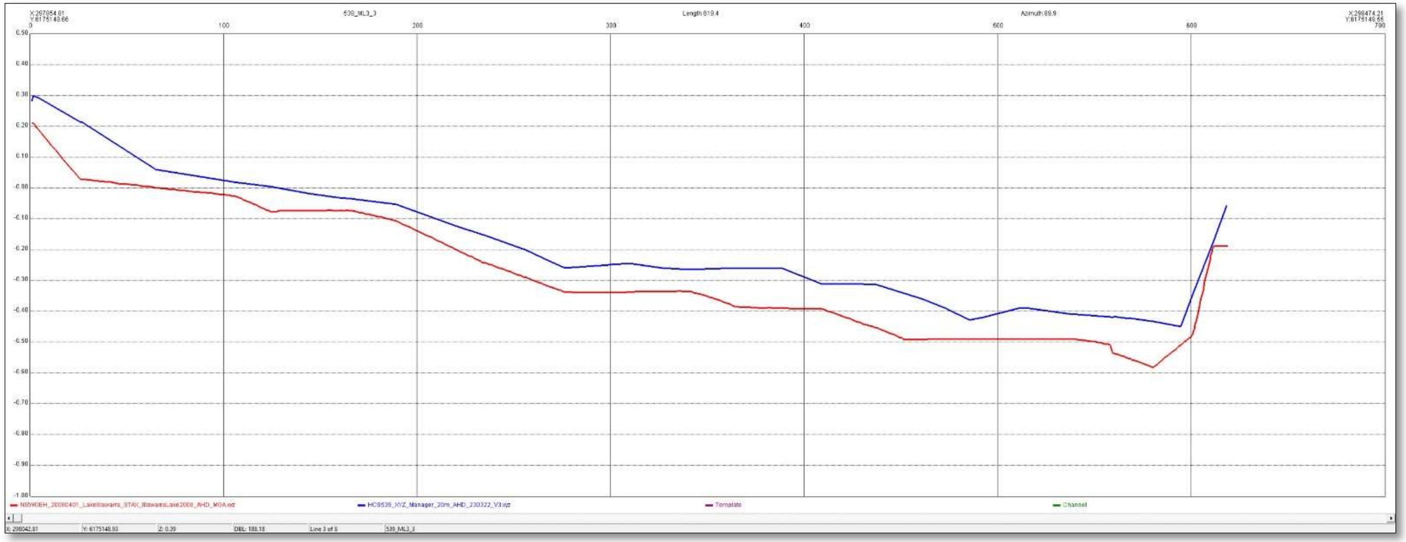


Figure 86: Lake 3 - profiles (red = 2008, blue = 2022/23) 1 and 2.



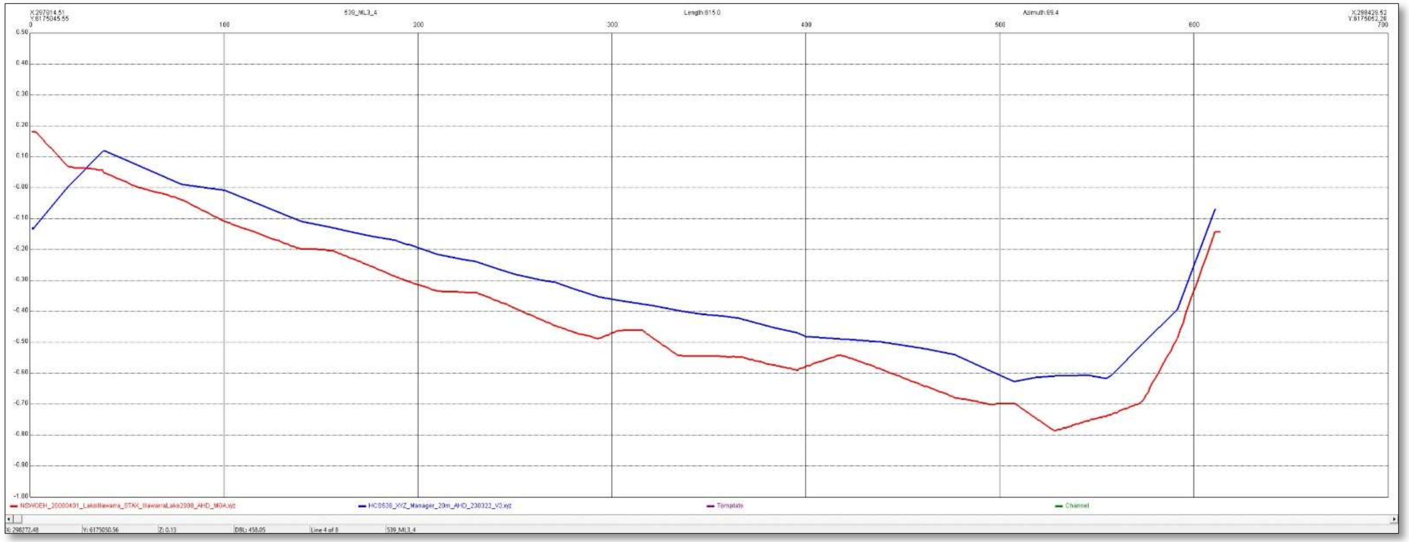


Figure 87: Lake 3 - profiles (red = 2008, blue = 2022/23) 3 and 4.

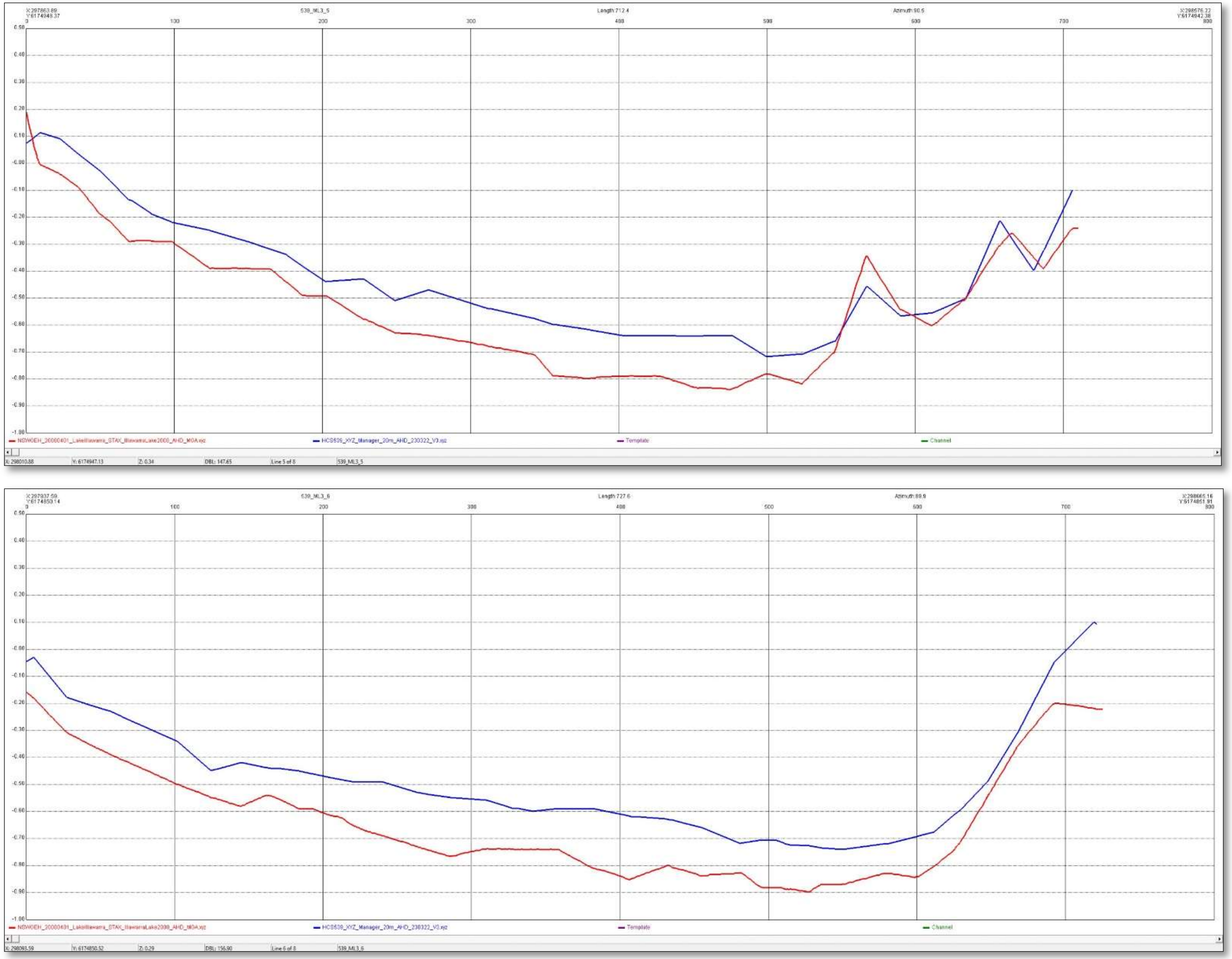


Figure 88: Lake 3 - profiles (red = 2008, blue = 2022/23) 5 and 6.

Figure 89: Lake 3 - profiles (red = 2008, blue = 2022/23) 7 and 8.

LAKE 4

Muddy Bay North

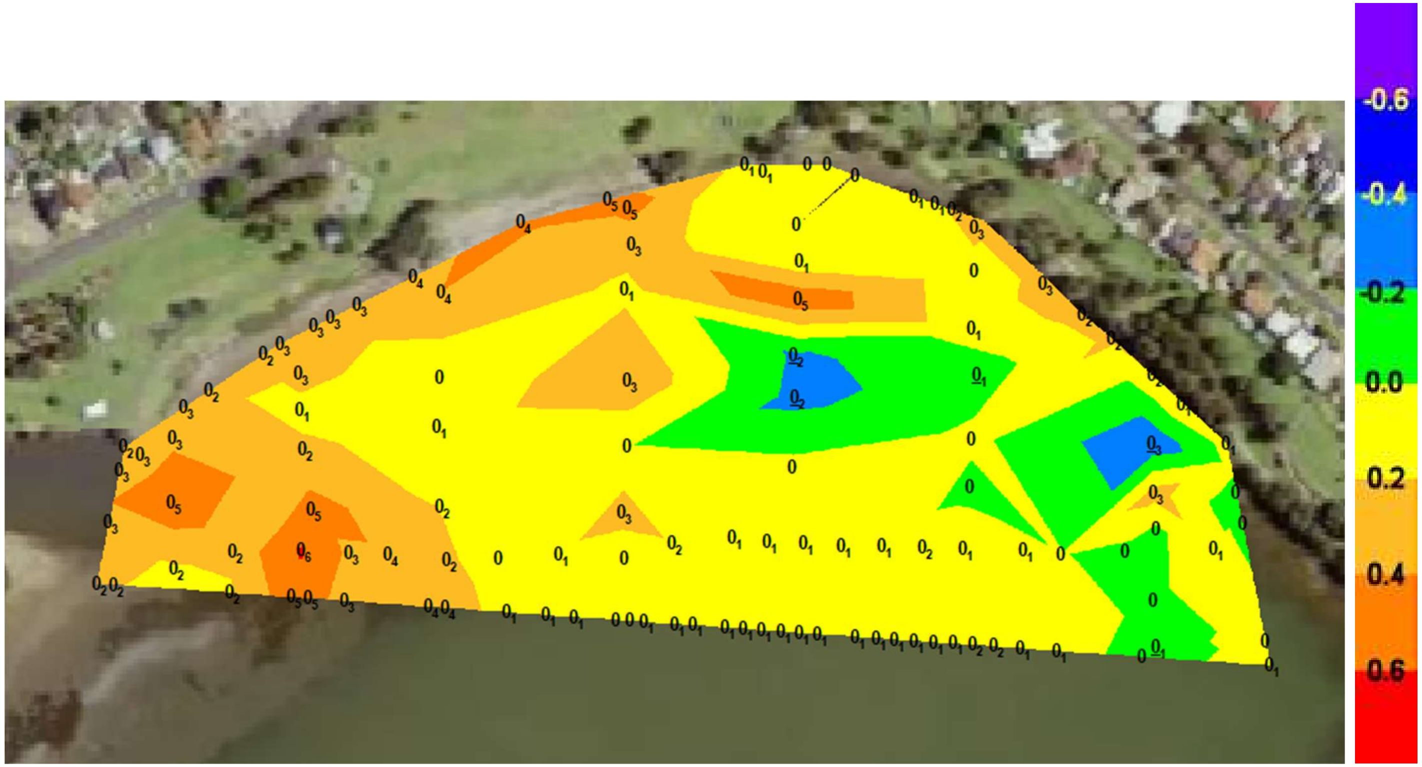


Figure 90: Lake 4 profiles utilised for analysis (data within Plan 539-1 Sheet 2).

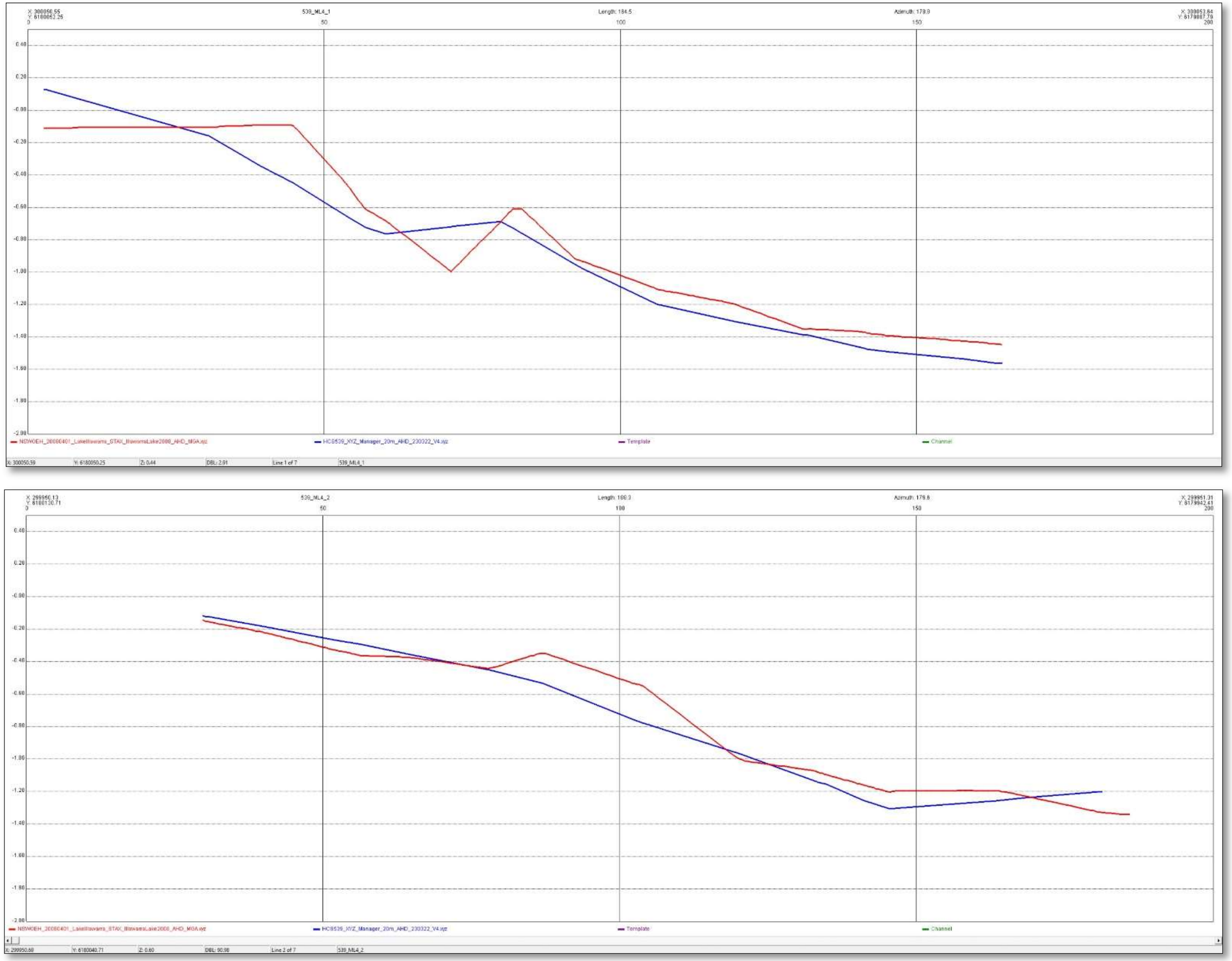


Figure 91: Lake 4 - profiles (red = 2008, blue = 2022/23) 1 and 2.

Figure 92: Lake 4 - profiles (red = 2008, blue = 2022/23) 3 and 4.

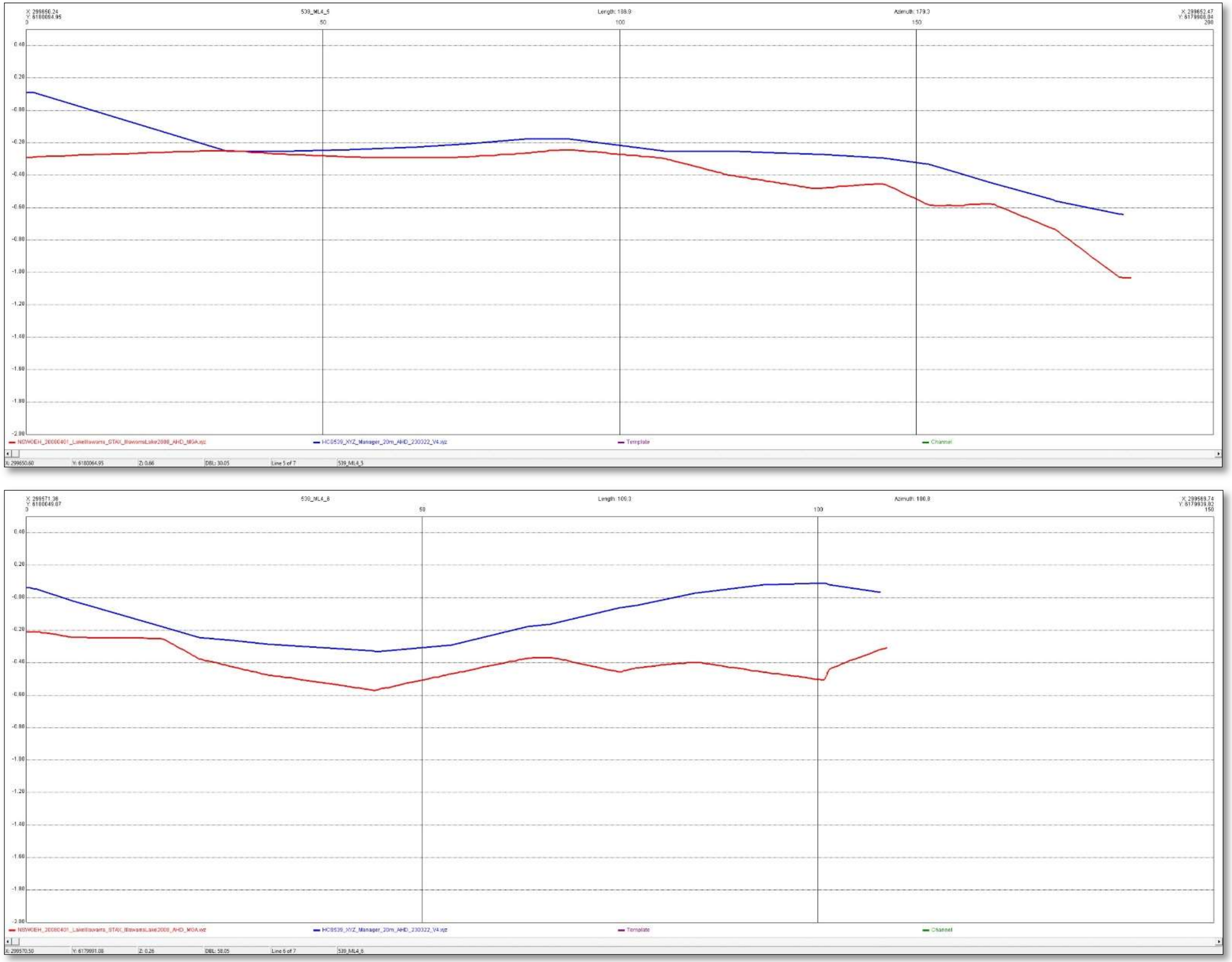


Figure 93: Lake 4 - profiles (red = 2008, blue = 2022/23) 5 and 6.

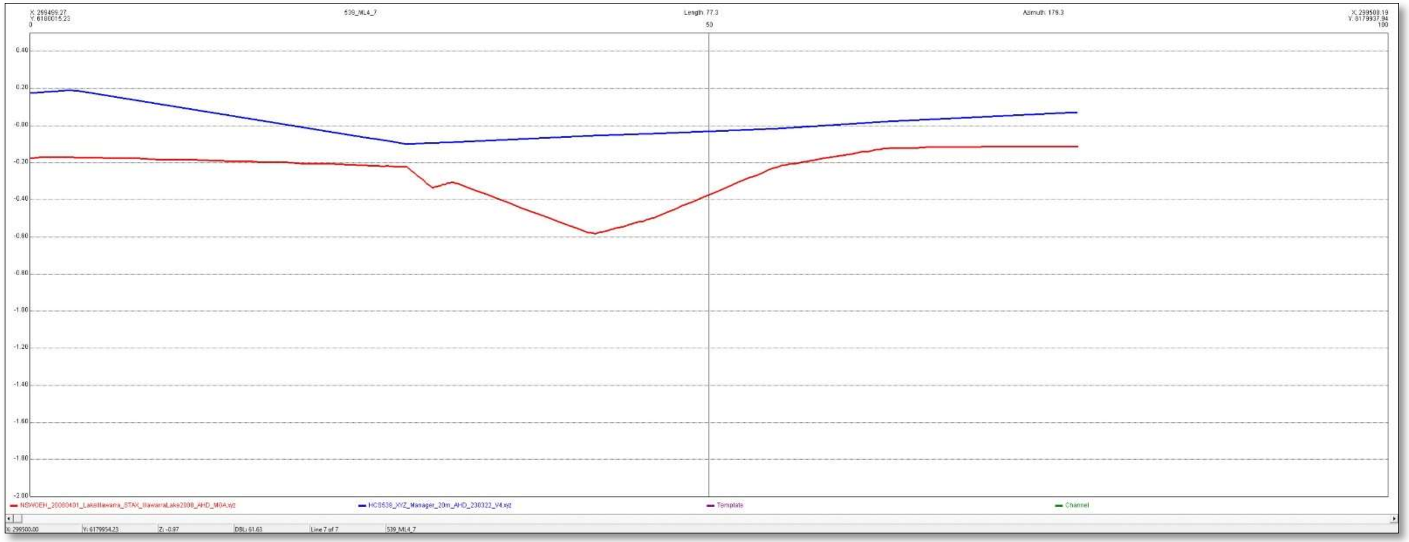


Figure 94: Lake 4 – profile (red = 2008, blue = 2022/23) 7.

LAKE 5

Main Lake

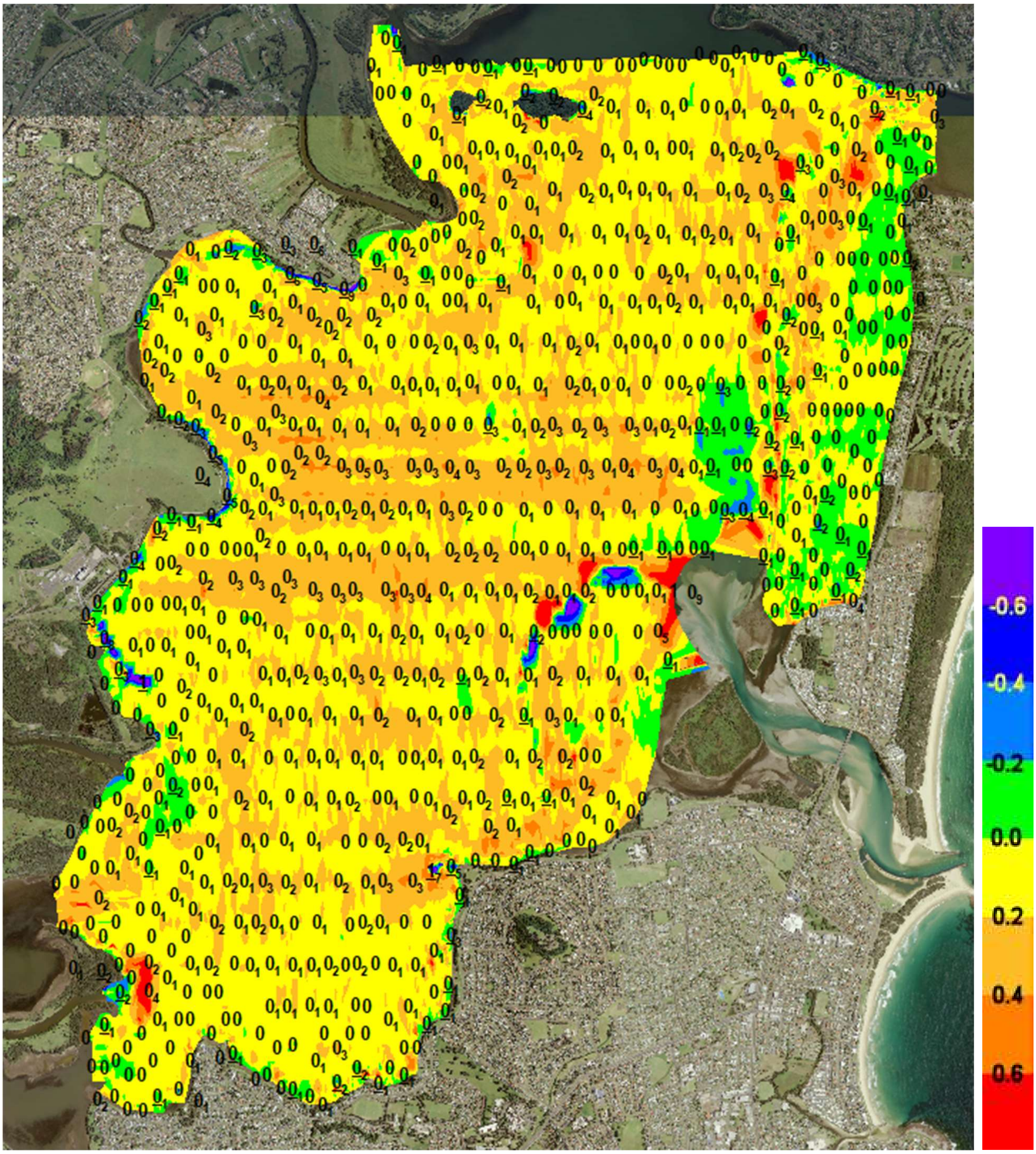


Figure 95: Lake 5 profiles utilised for analysis (data within Plan 539-1 Sheets 1 - 5).

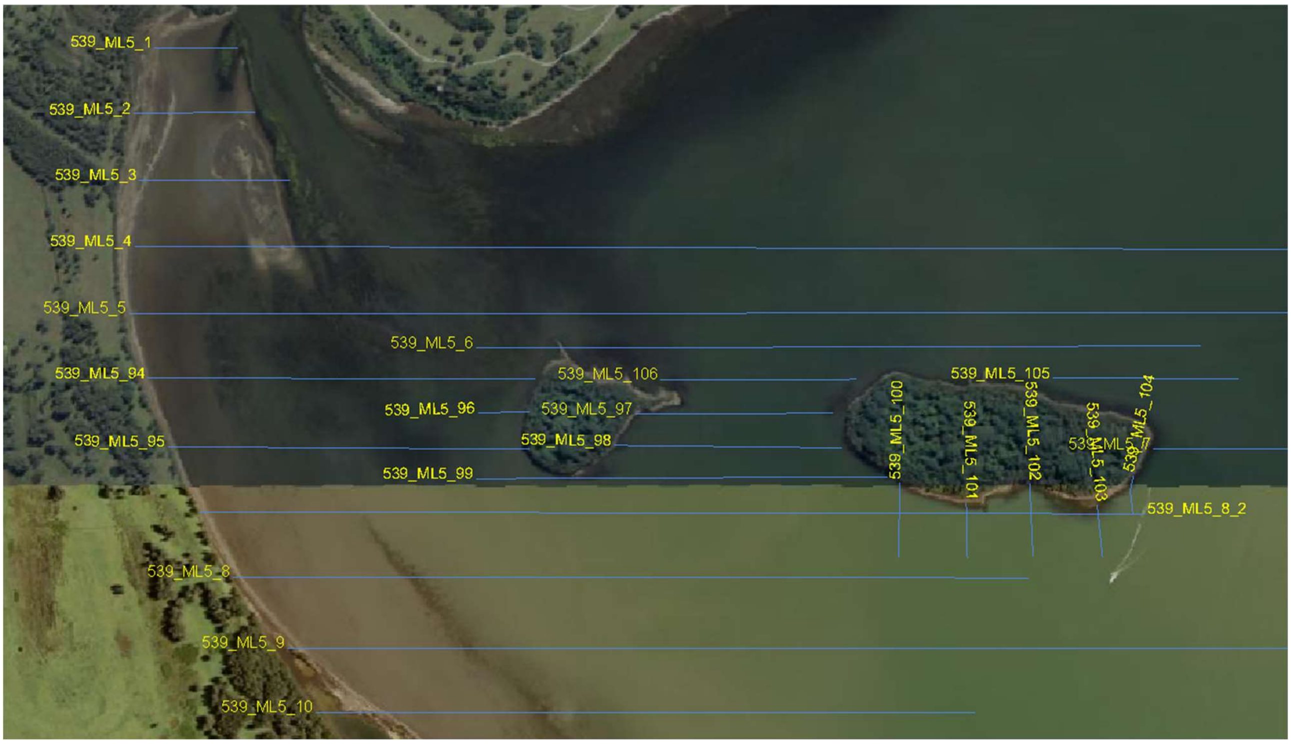


Figure 96: Lake 5 profiles – Inset 1 (data within Plan 539-1 Sheets 1 - 5).

Figure 97: Lake 5 profiles – Inset 2 (data within Plan 539-1 Sheets 1 - 5).

Figure 98: Lake 5 profiles – Inset 3 (data within Plan 539-1 Sheets 1 - 5).

Figure 99: Lake 5 profiles – Inset 4 (data within Plan 539-1 Sheets 1 - 5).

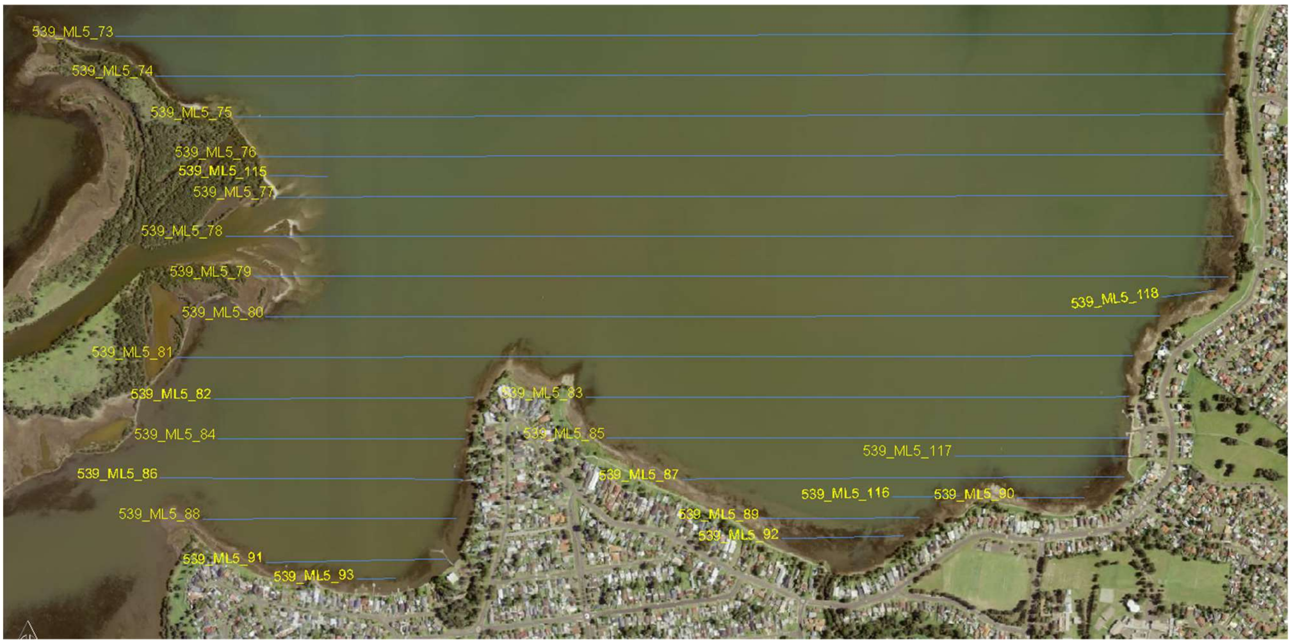


Figure 100: Lake 5 profiles – Inset 5 (data within Plan 539-1 Sheets 1 - 5).

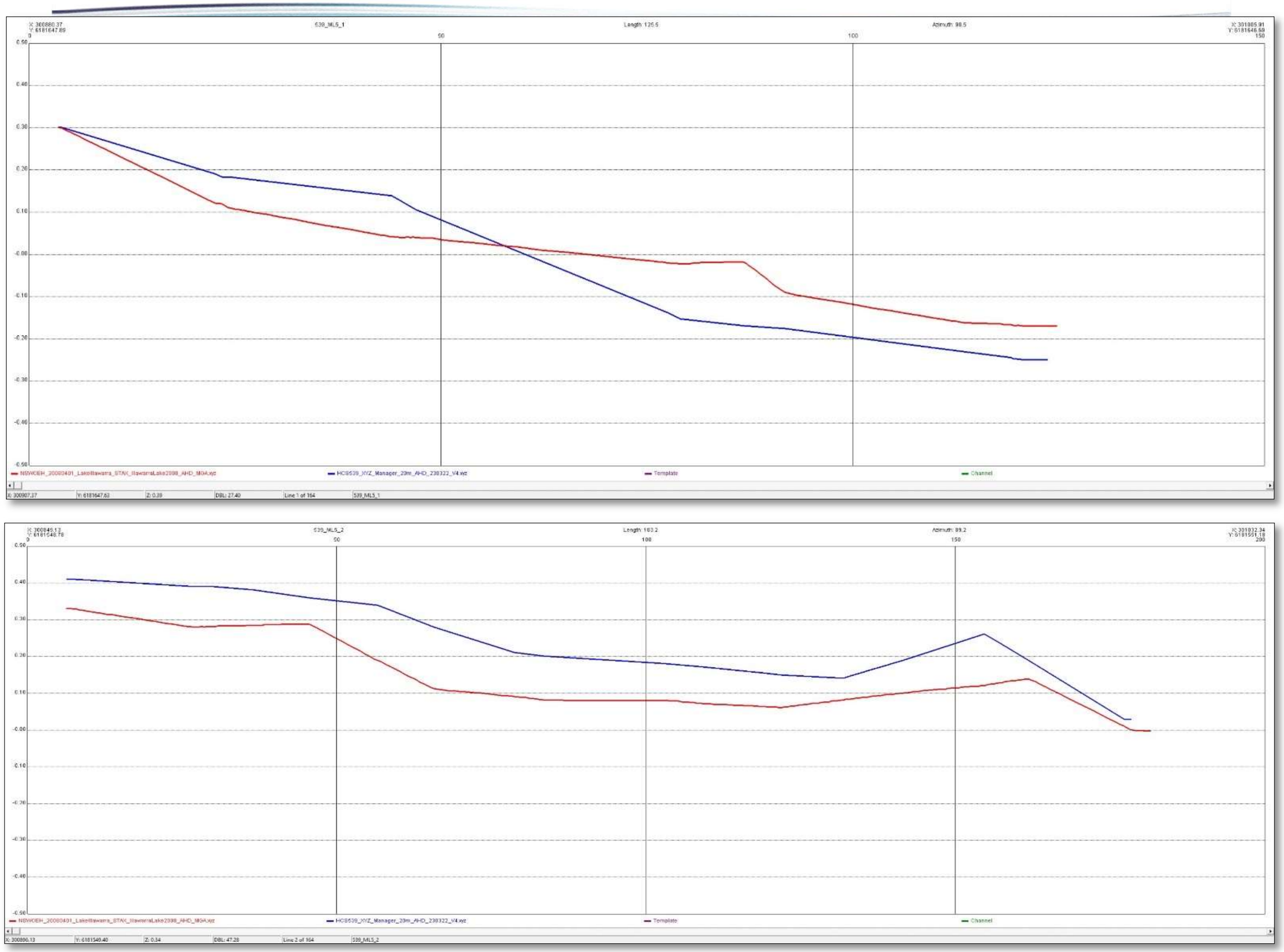


Figure 101: Lake 5 - profiles (red = 2008, blue = 2022/23) 1 and 2.

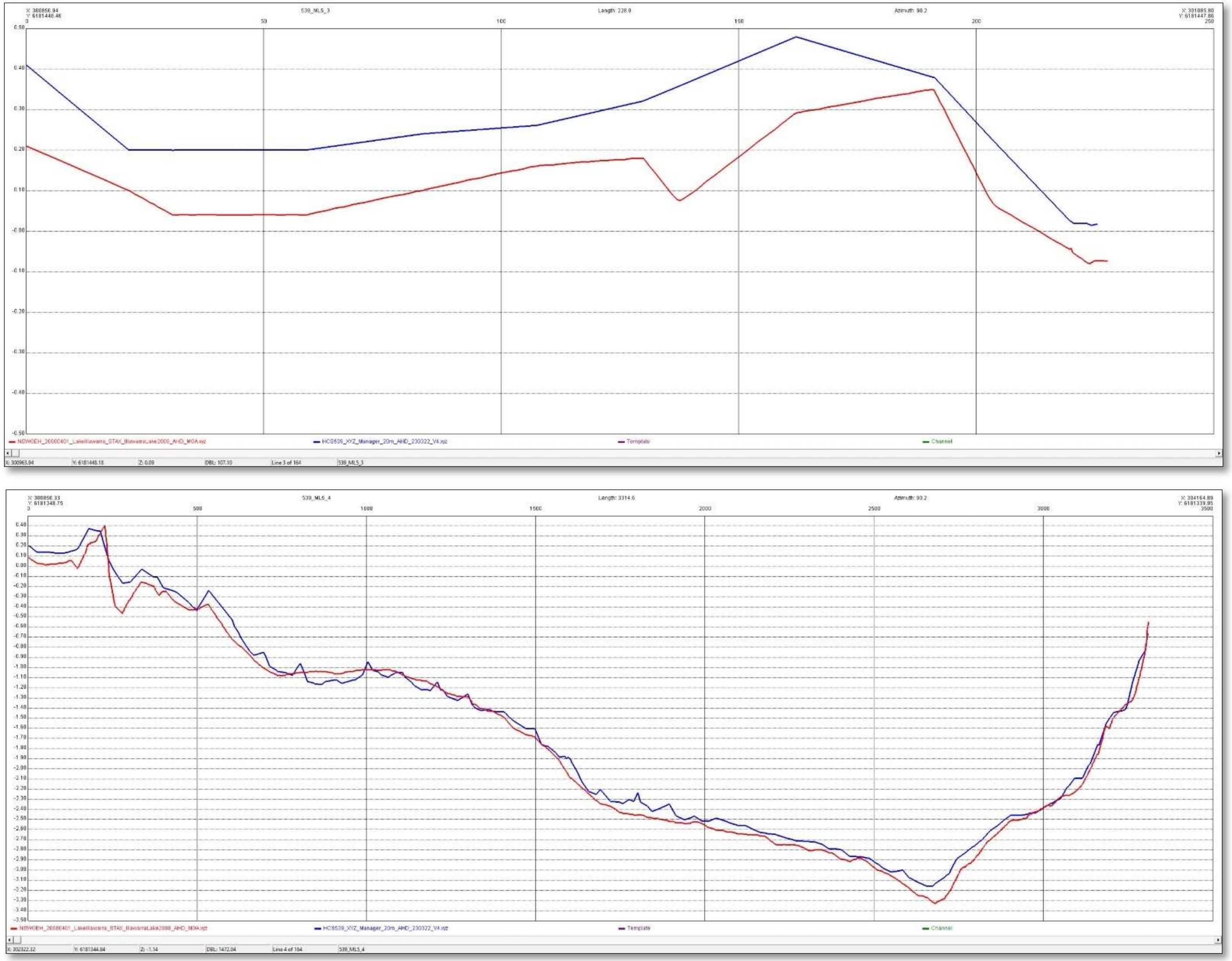
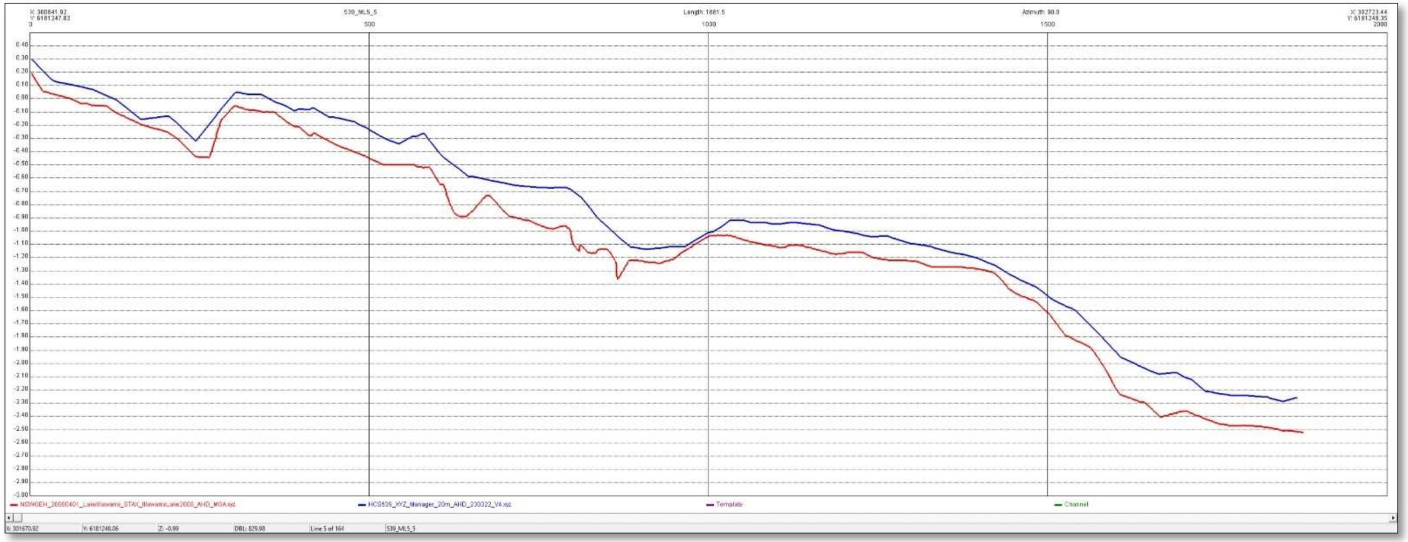


Figure 102: Lake 5 - profiles (red = 2008, blue = 2022/23) 3 and 4.



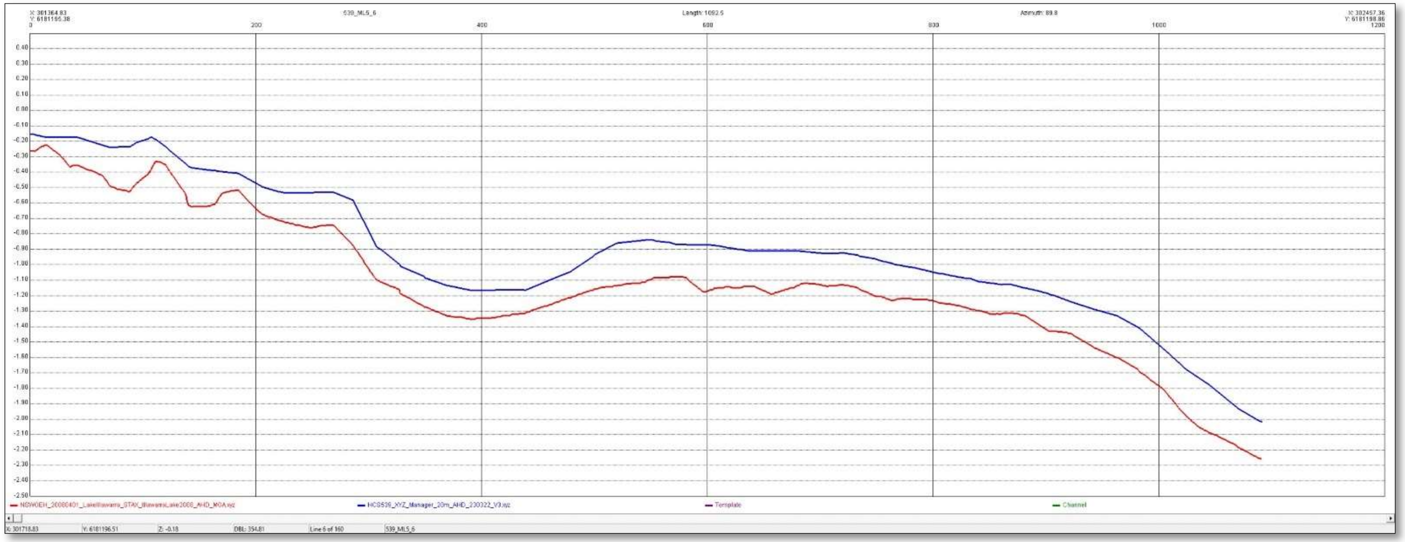


Figure 103: Lake 5 - profiles (red = 2008, blue = 2022/23) 5 and 6.

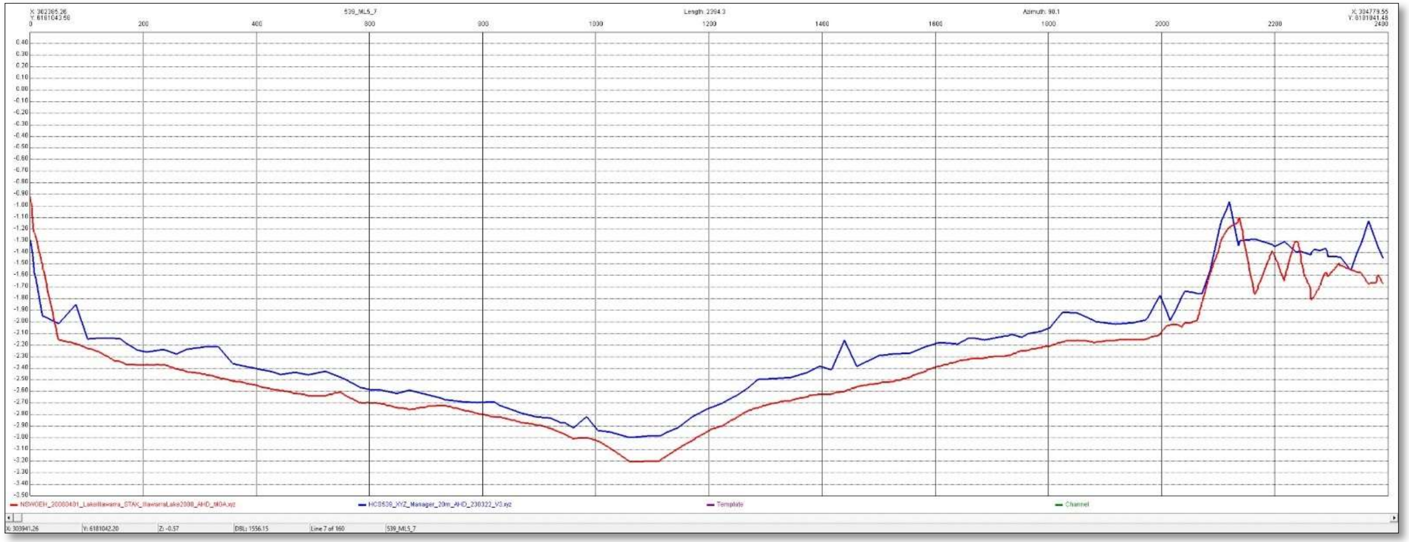


Figure 104: Lake 5 - profiles (red = 2008, blue = 2022/23) 7 and 8.

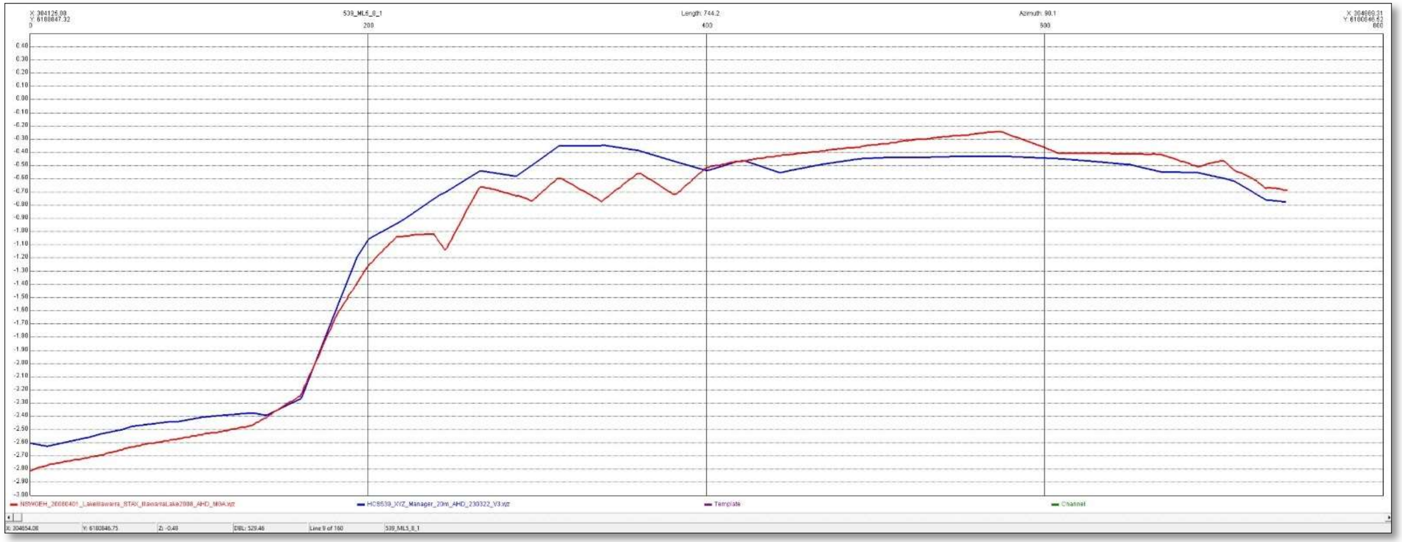


Figure 105: Lake 5 - profiles (red = 2008, blue = 2022/23) 8_1 and 8_2.

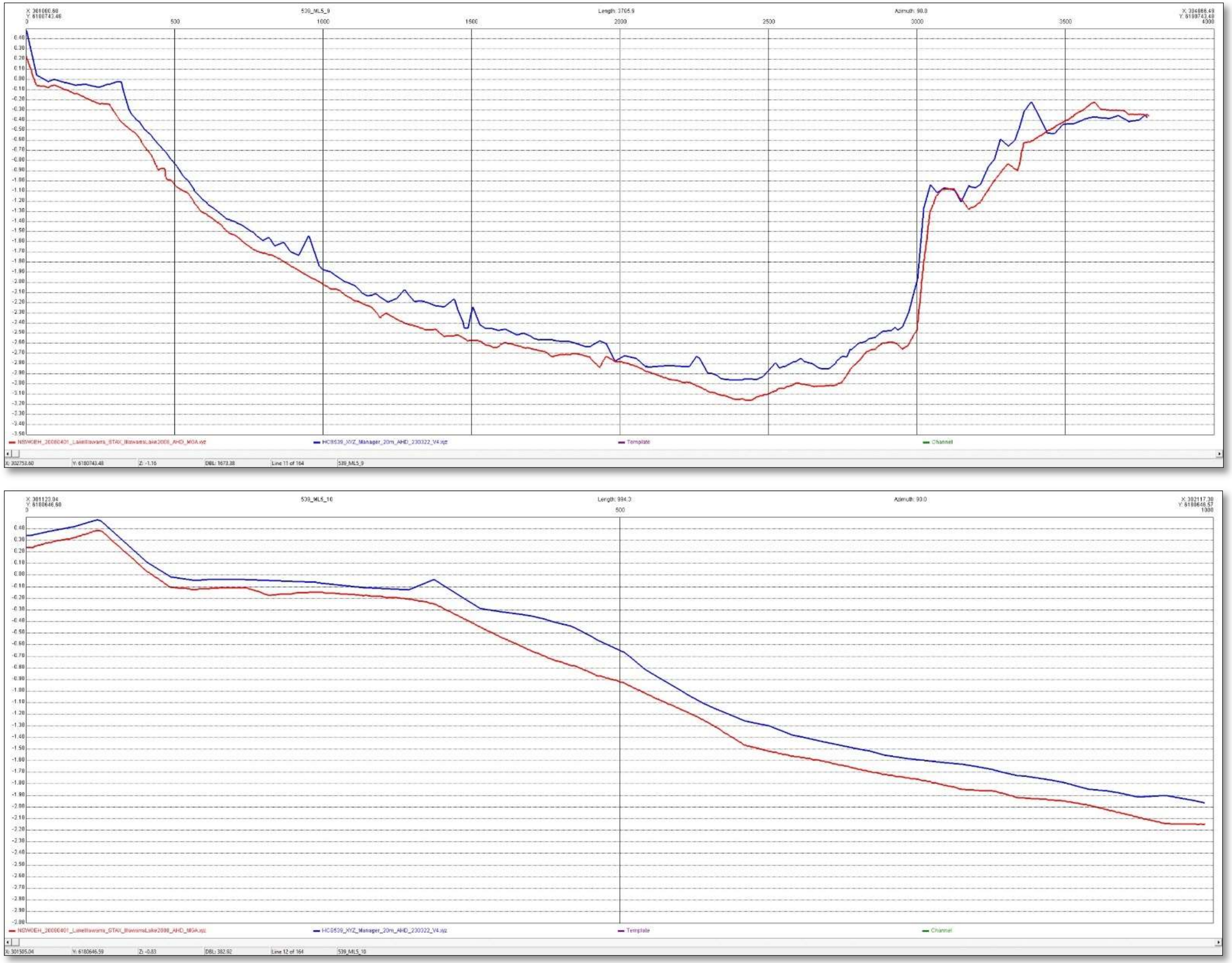


Figure 106: Lake 5 - profiles (red = 2008, blue = 2022/23) 9 and 10.

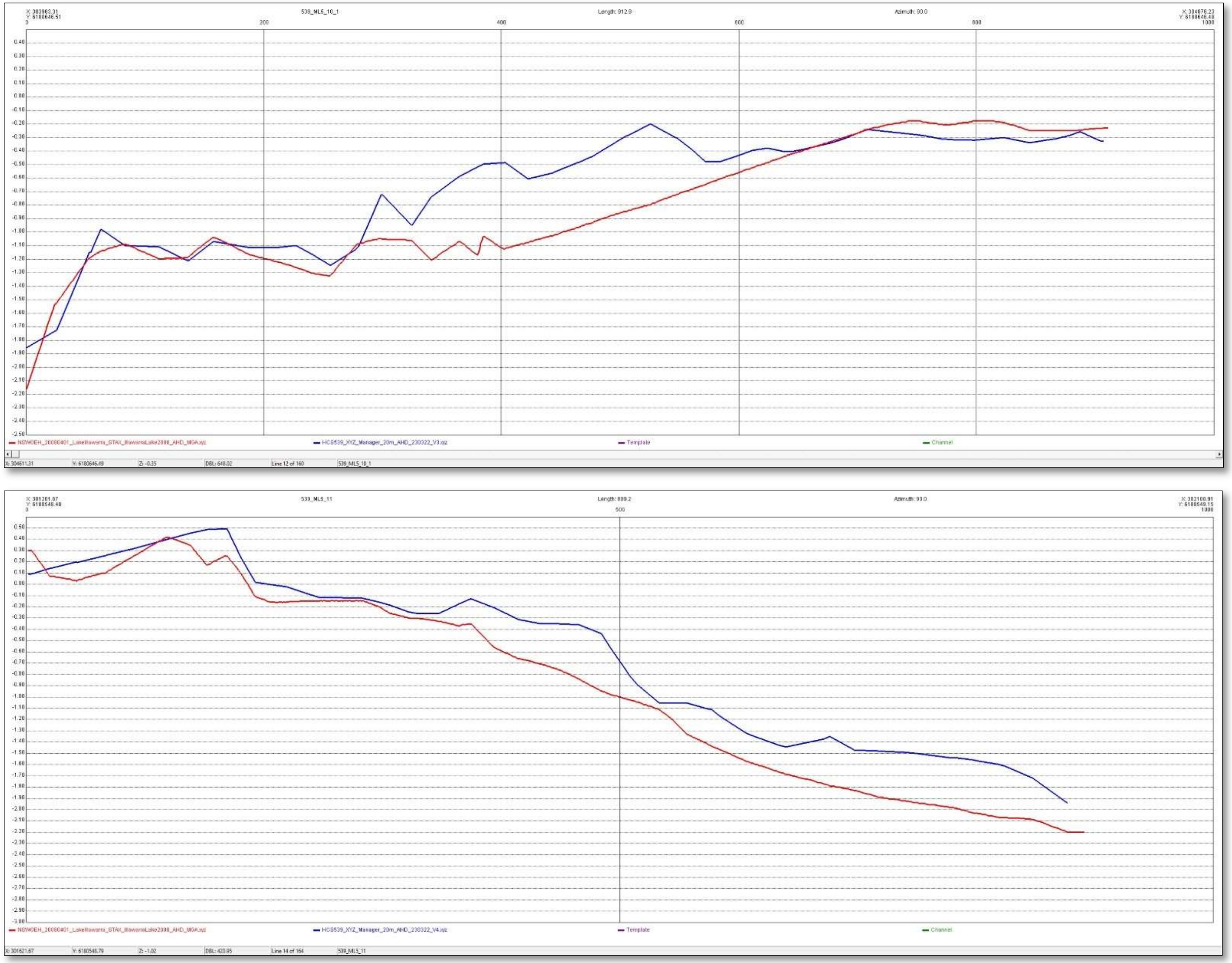


Figure 107: Lake 5 - profiles (red = 2008, blue = 2022/23) 10_1 and 11.

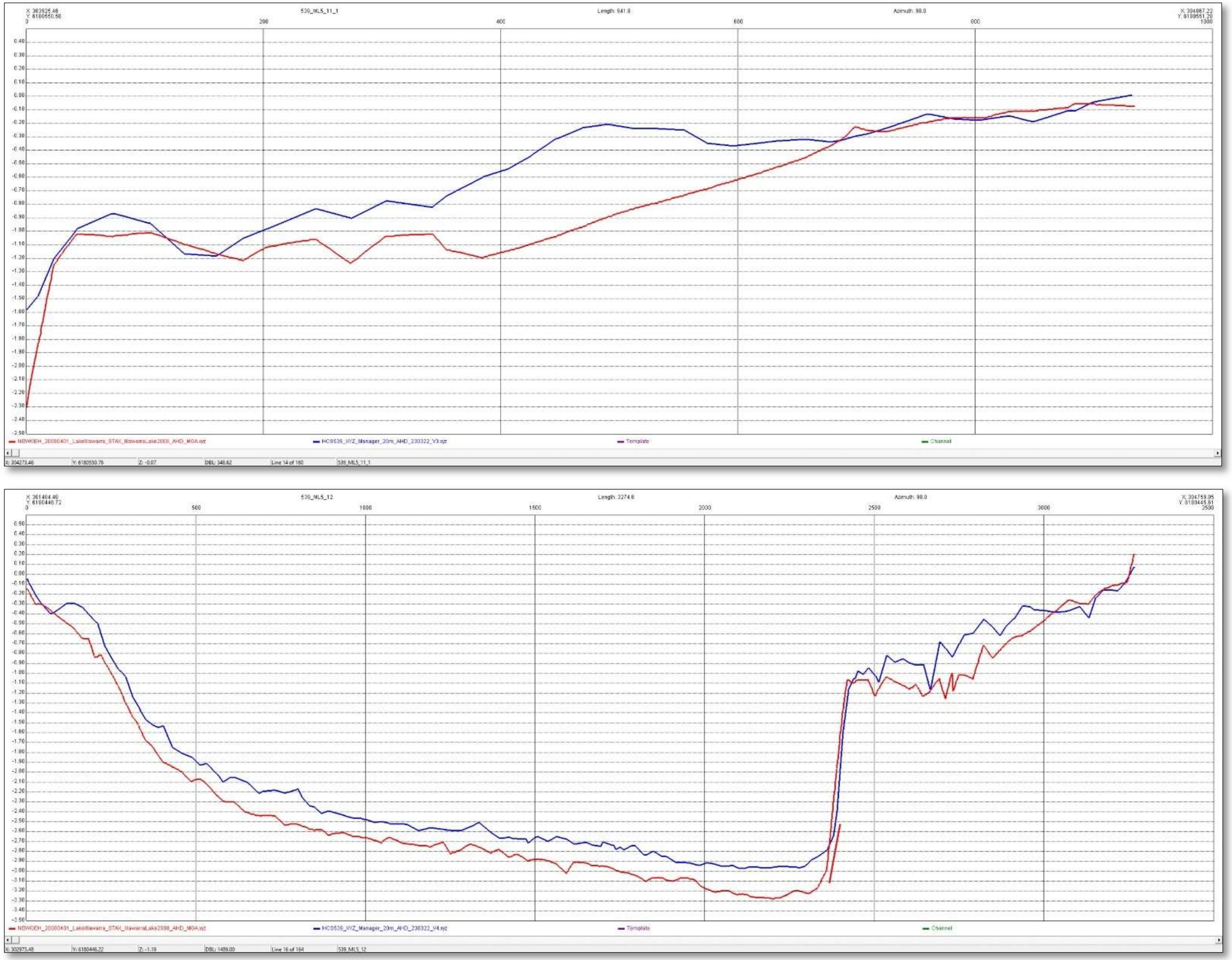
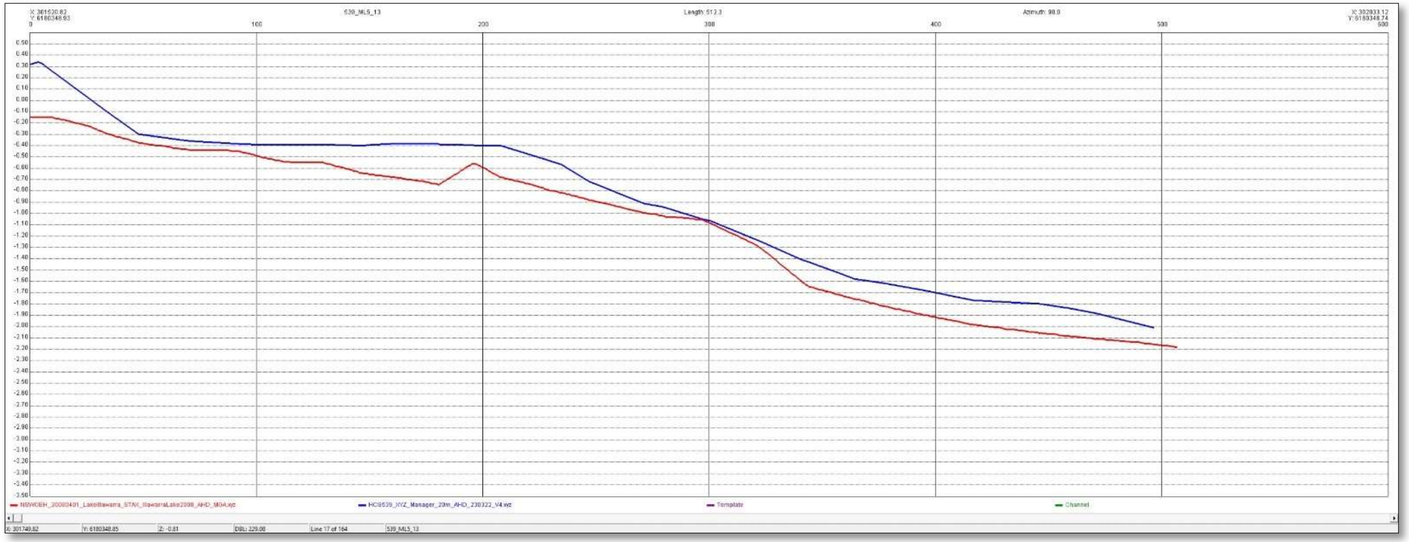


Figure 108: Lake 5 - profiles (red = 2008, blue = 2022/23) 11_1 and 12.



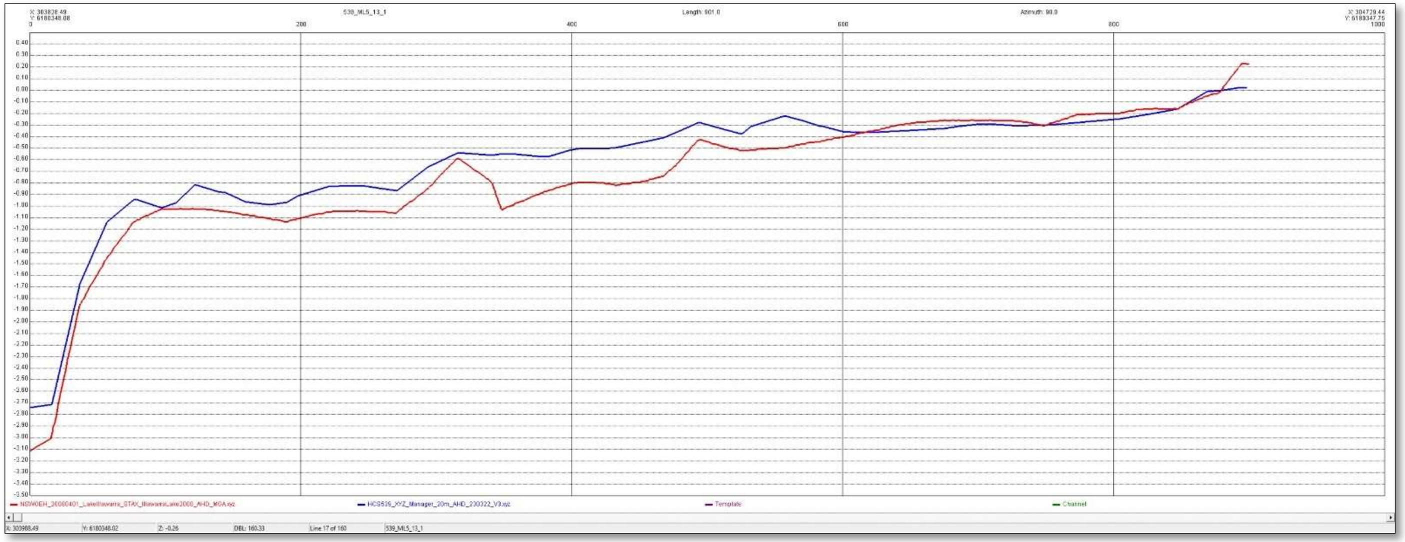


Figure 109: Lake 5 - profiles (red = 2008, blue = 2022/23) 13 and 13_1.

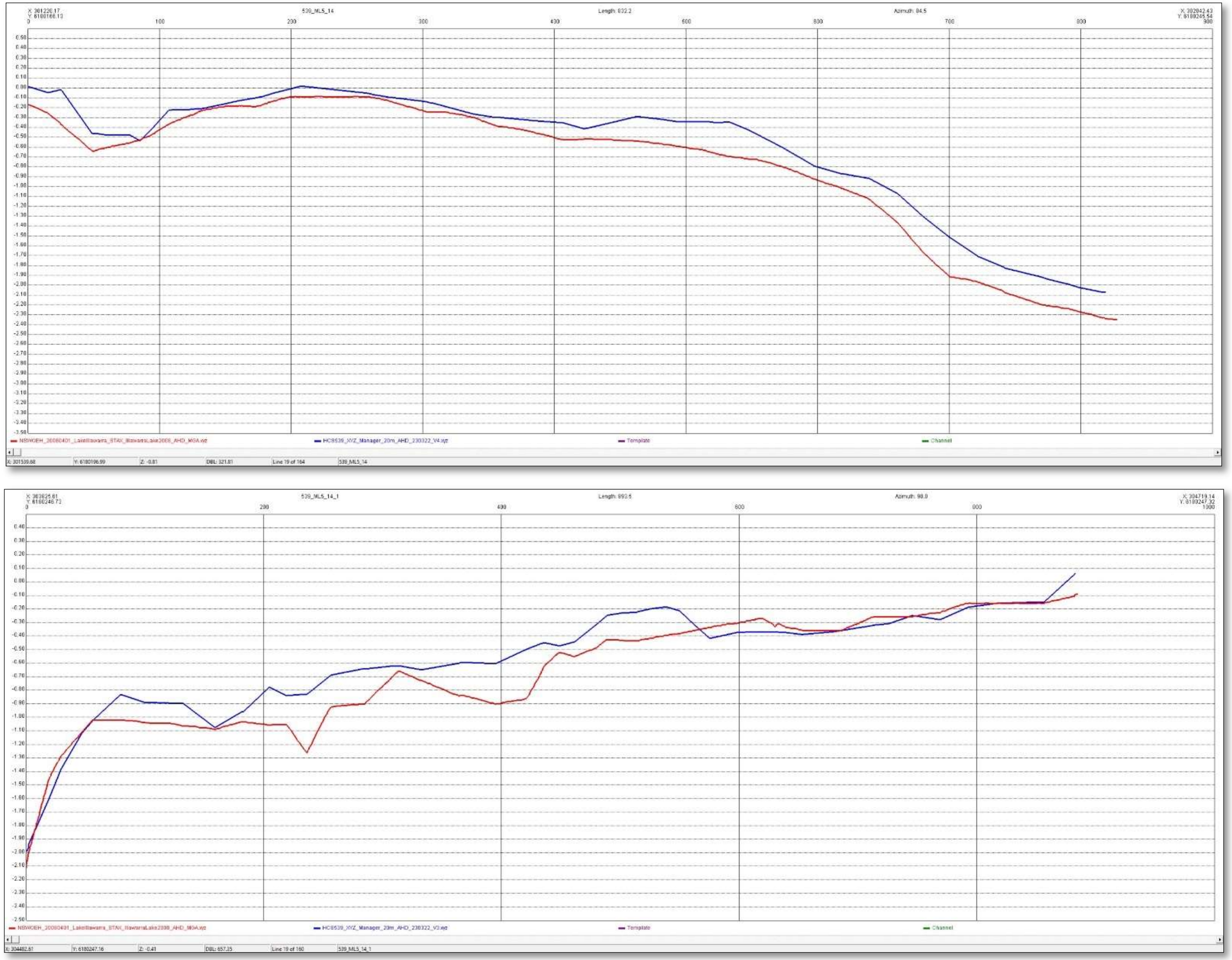


Figure 110: Lake 5 - profiles (red = 2008, blue = 2022/23) 14 and 14_1.

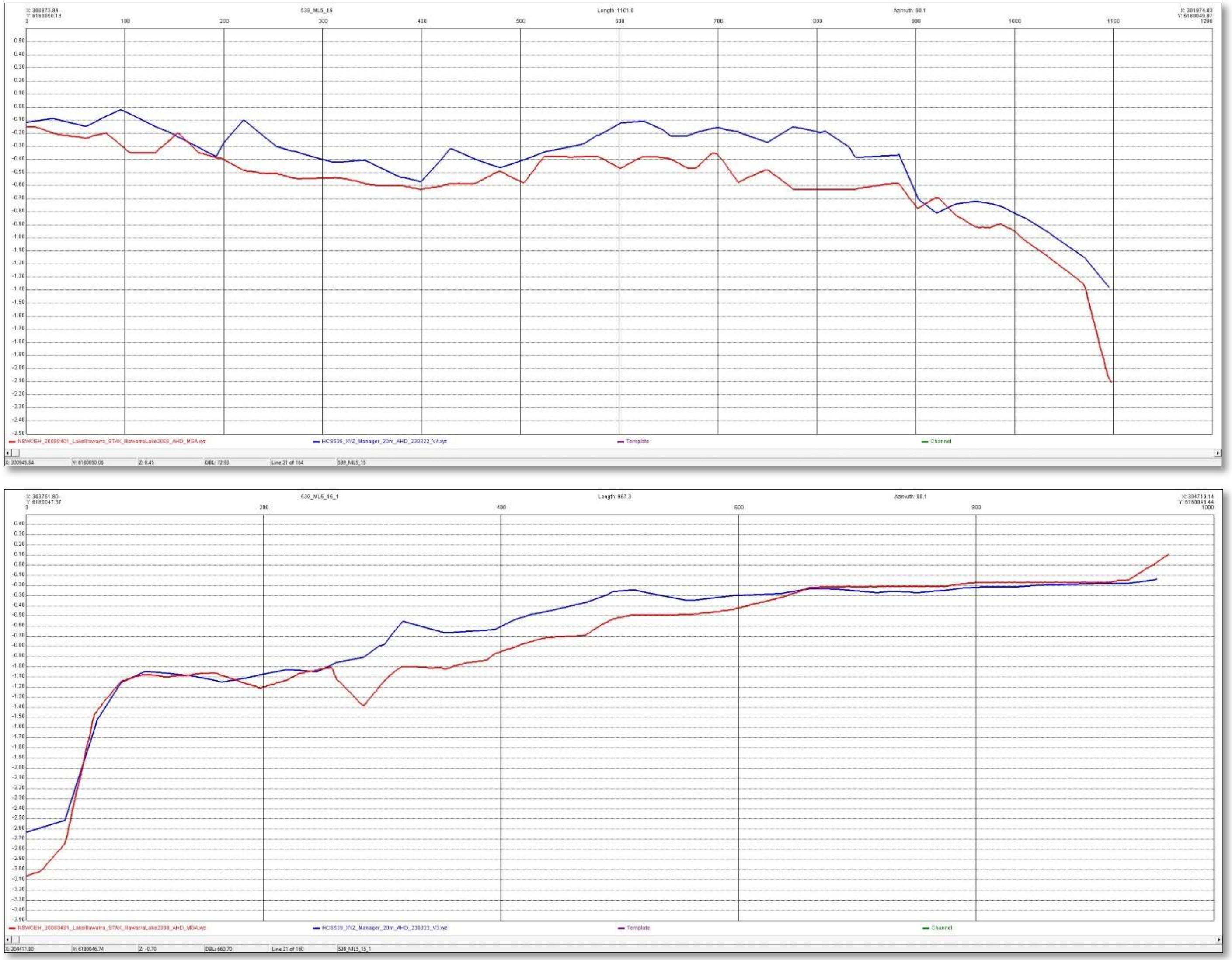


Figure 111: Lake 5 - profiles (red = 2008, blue = 2022/23) 15 and 15_1.

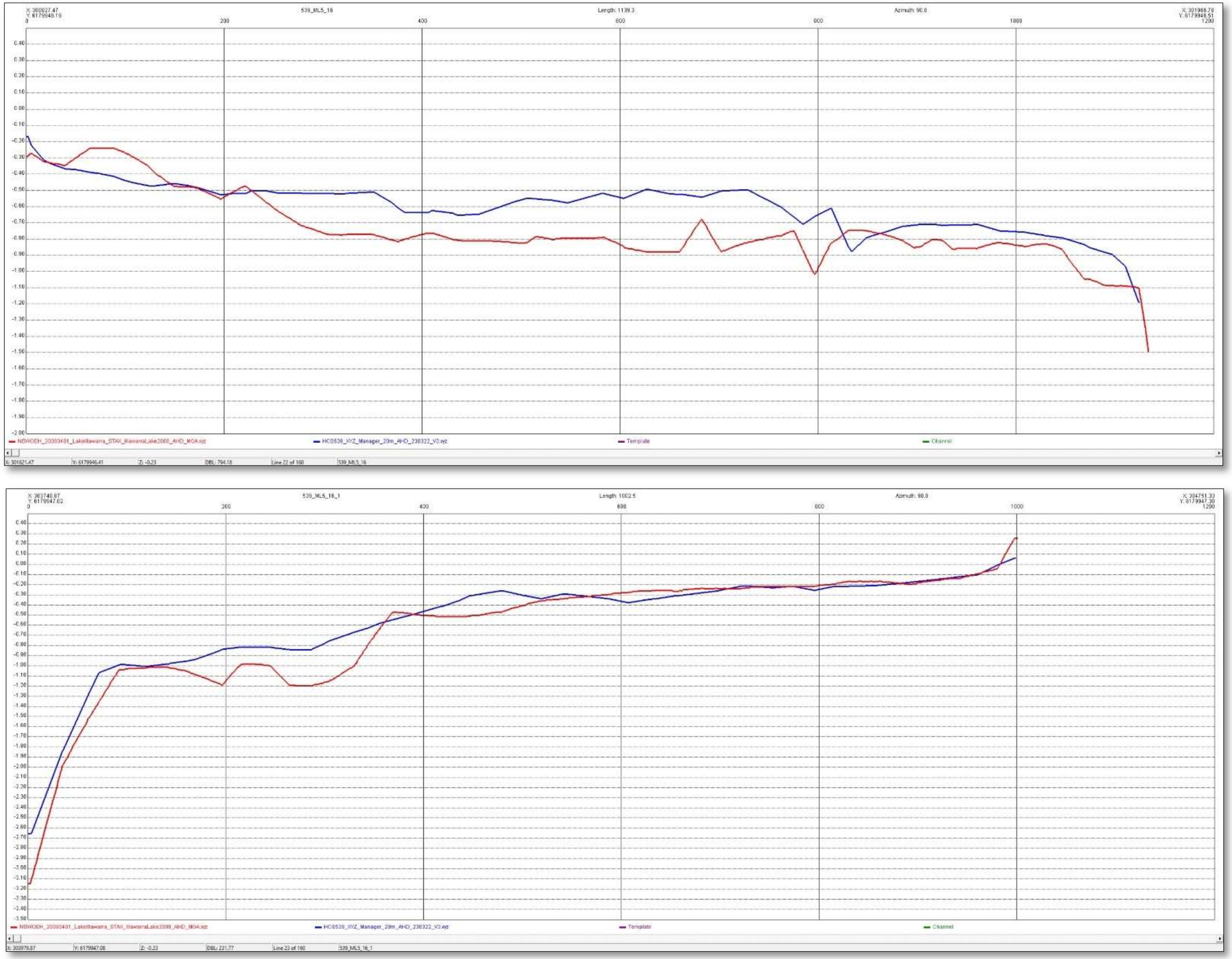
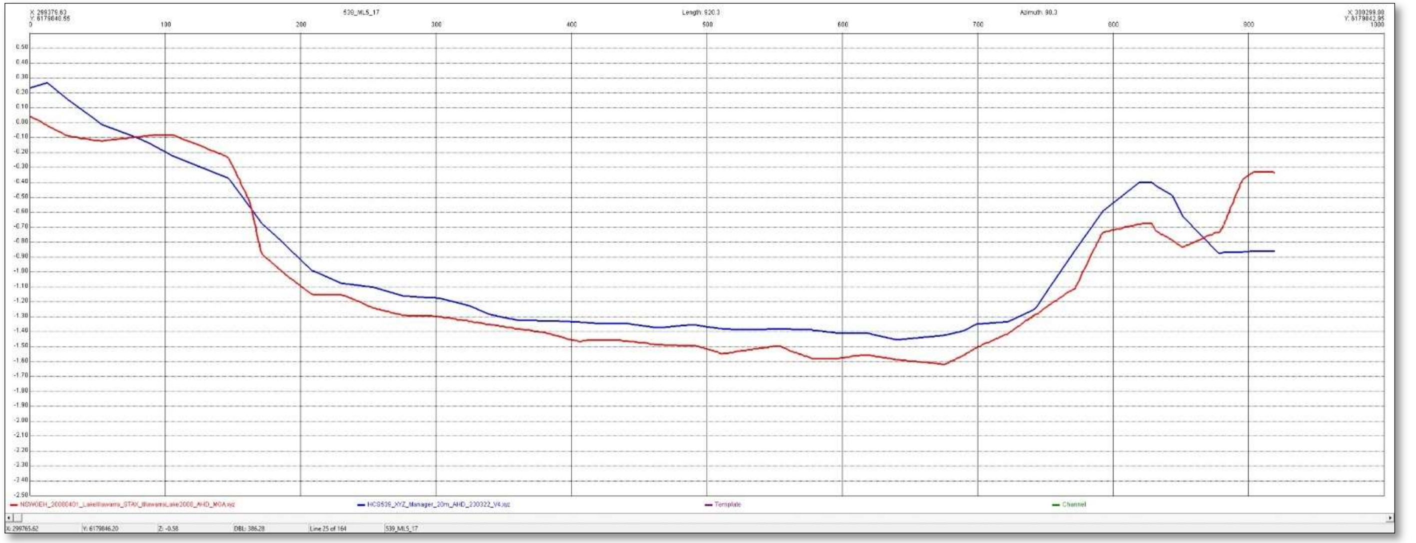


Figure 112: Lake 5 - profiles (red = 2008, blue = 2022/23) 16 and 16_1.



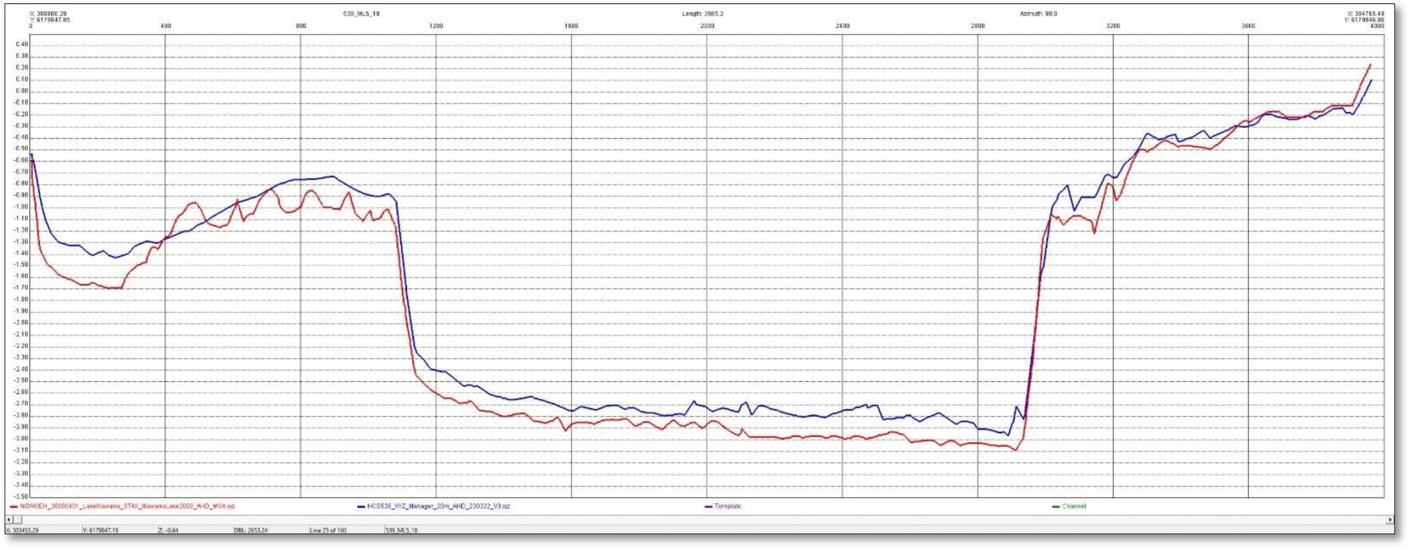
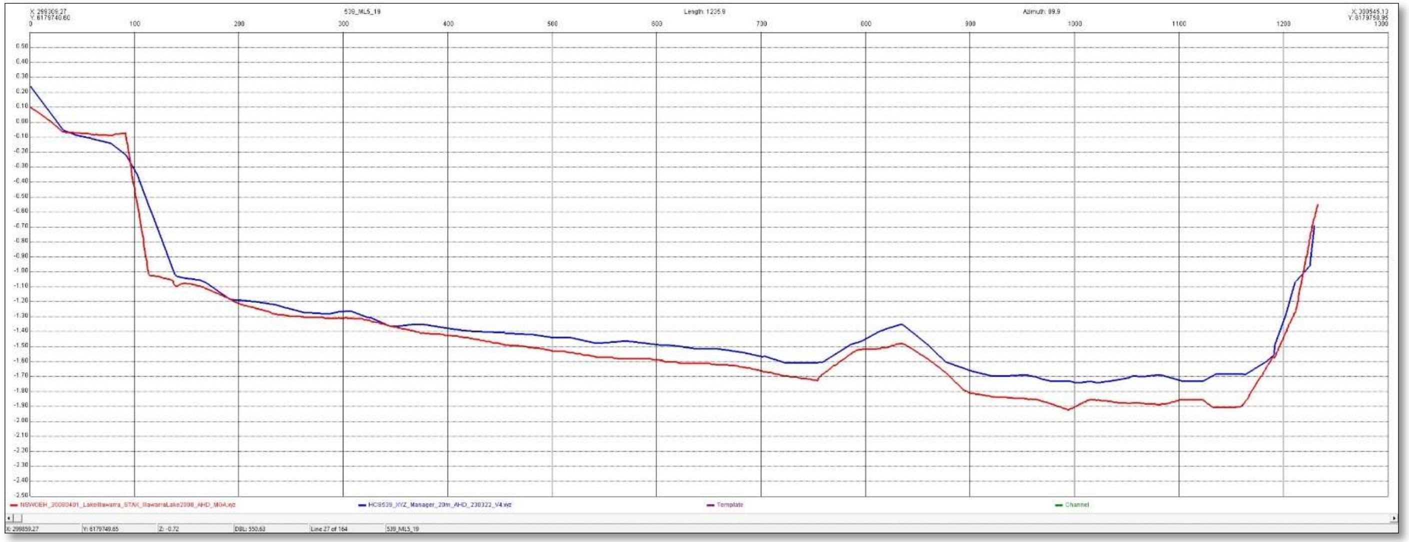


Figure 113: Lake 5 - profiles (red = 2008, blue = 2022/23) 17 and 18.



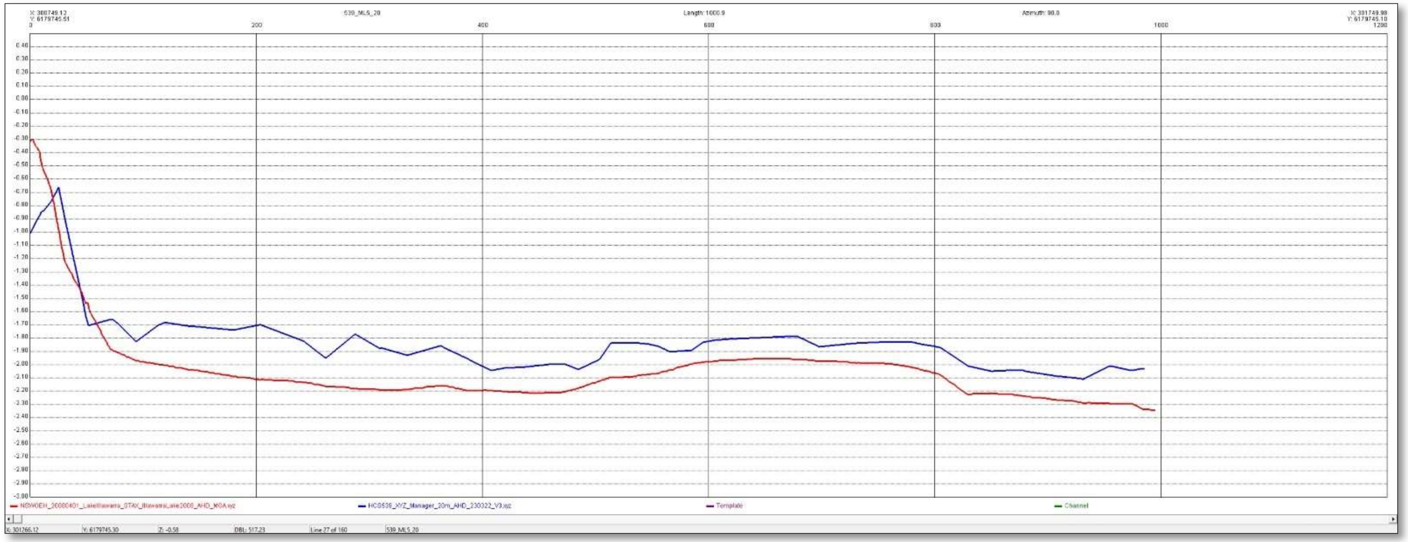


Figure 114: Lake 5 - profiles (red = 2008, blue = 2022/23) 19 and 20.

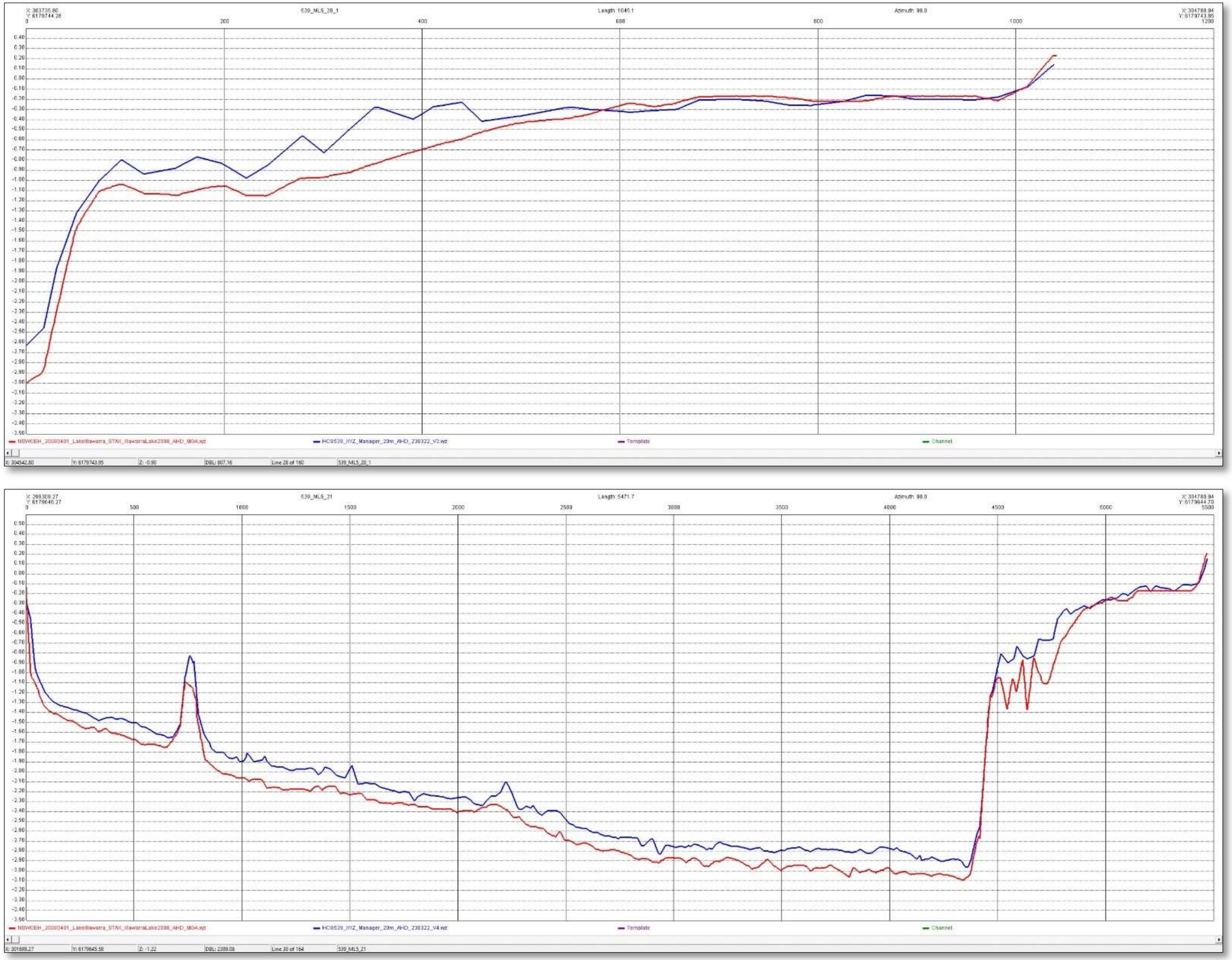
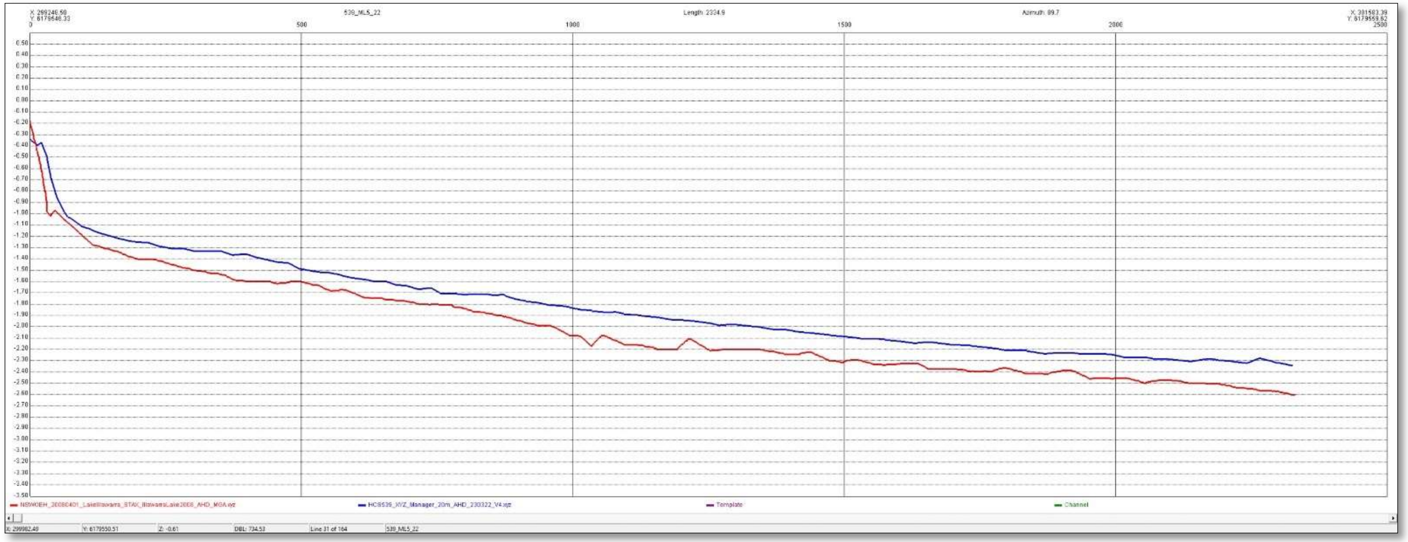


Figure 115: Lake 5 - profiles (red = 2008, blue = 2022/23) 20_1 and 21.



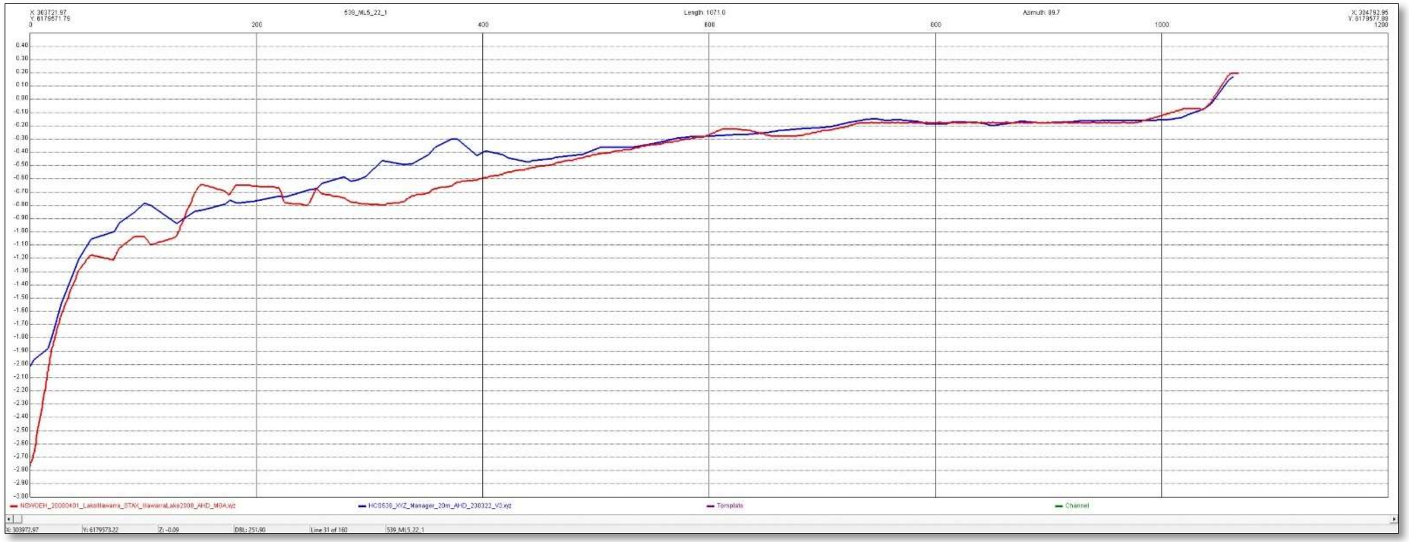
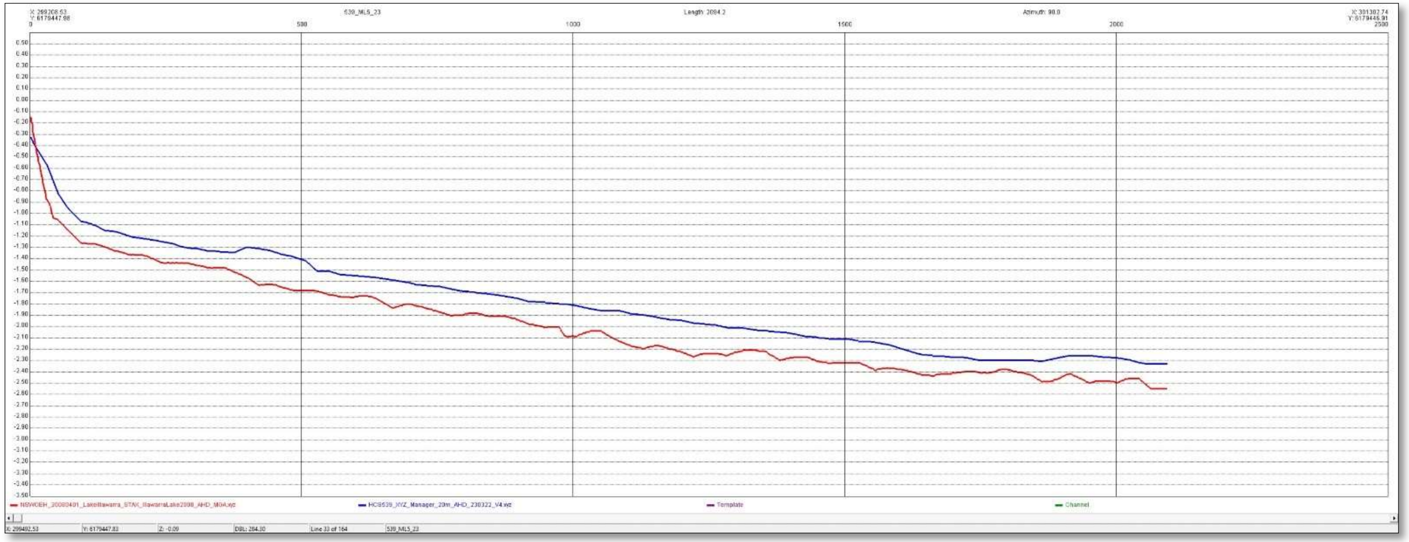


Figure 116: Lake 5 - profiles (red = 2008, blue = 2022/23) 22 and 22_1.



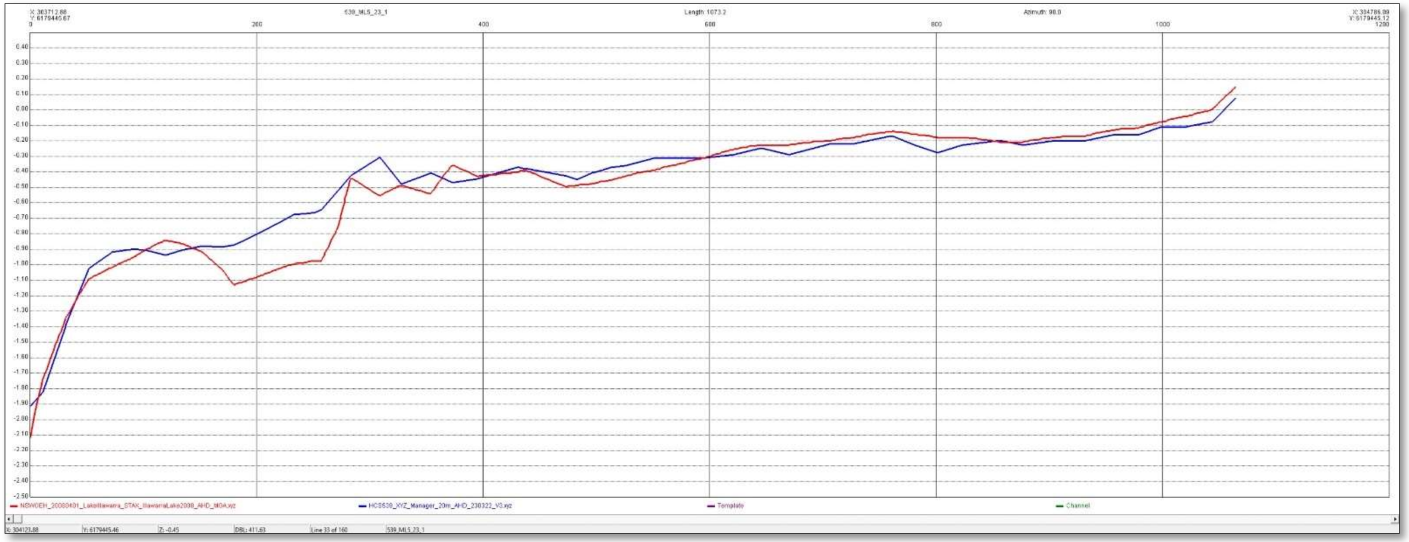


Figure 117: Lake 5 - profiles (red = 2008, blue = 2022/23) 23 and 23_1.

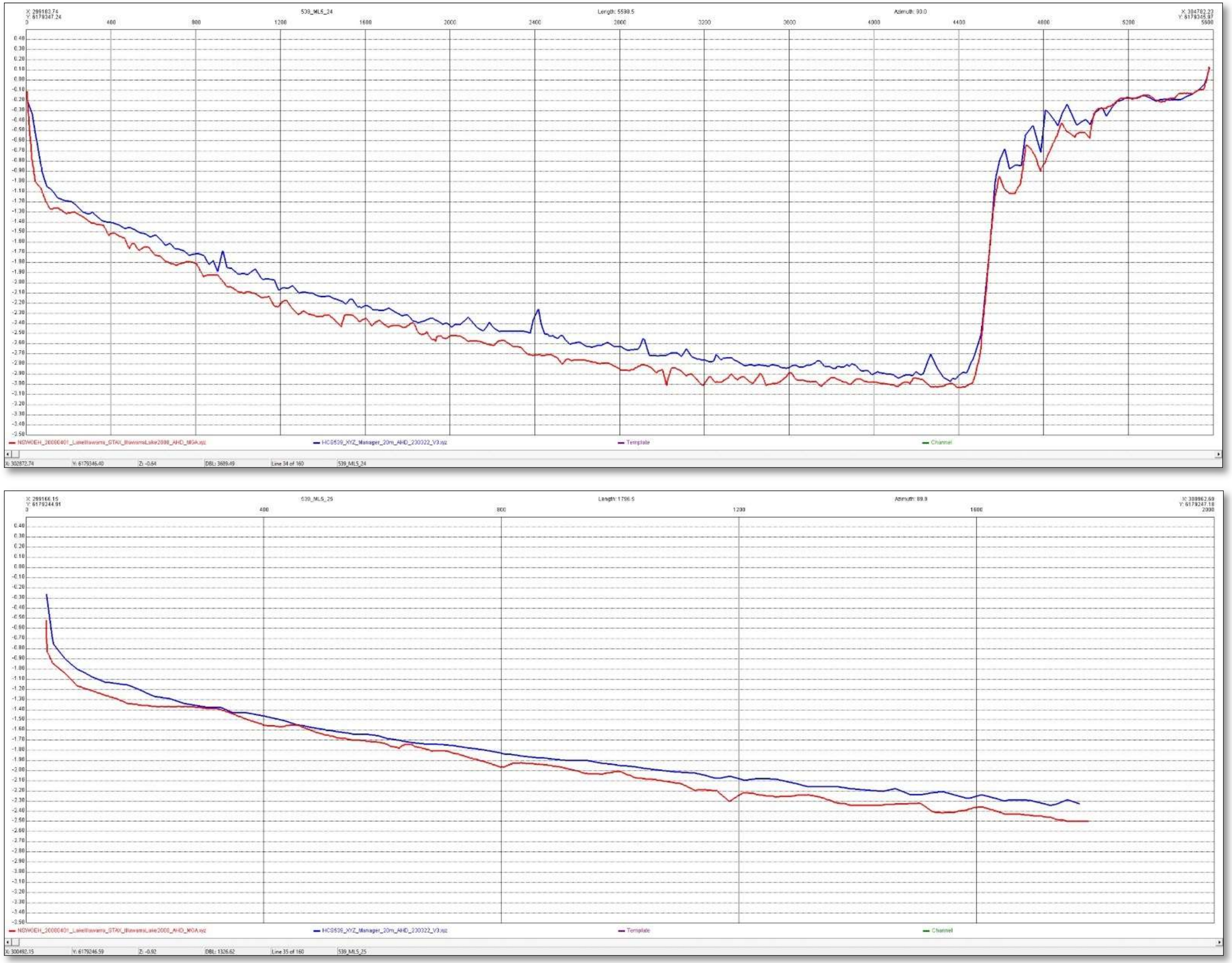
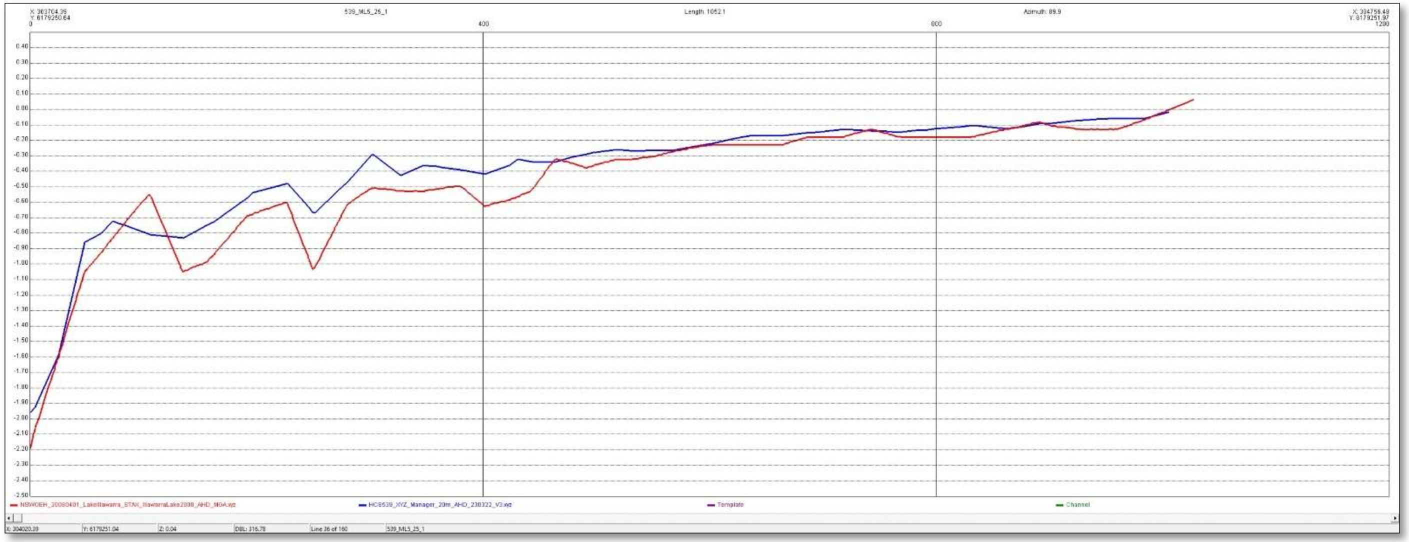


Figure 118: Lake 5 - profiles (red = 2008, blue = 2022/23) 24 and 25.



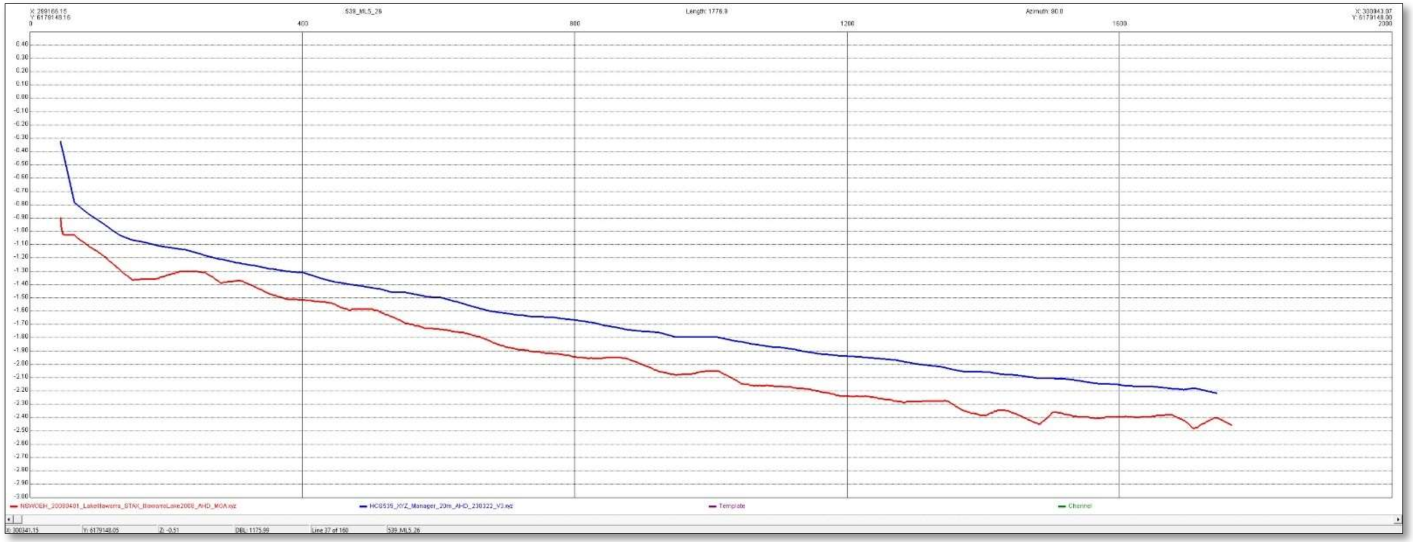


Figure 119: Lake 5 - profiles (red = 2008, blue = 2022/23) 25_1 and 26.

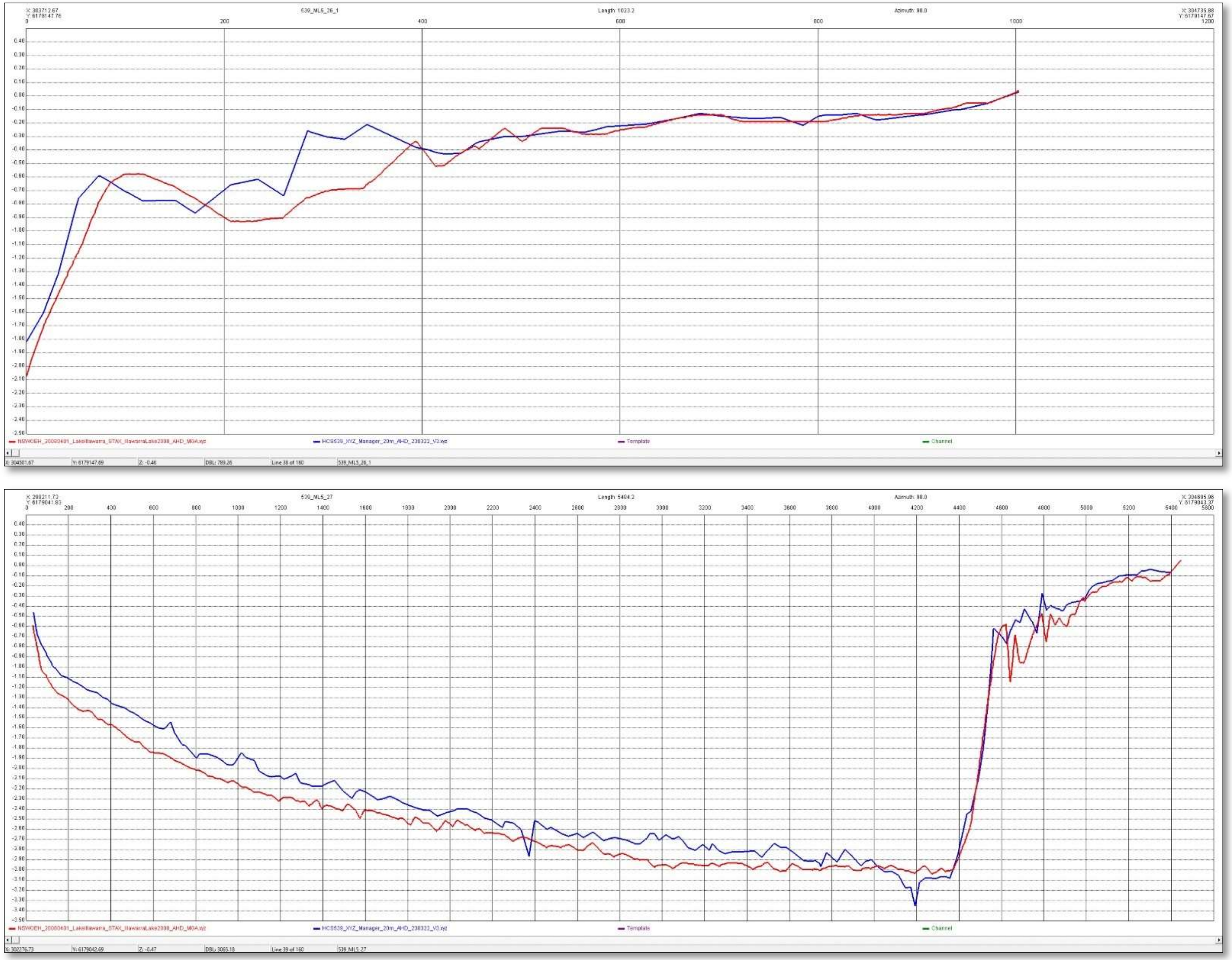
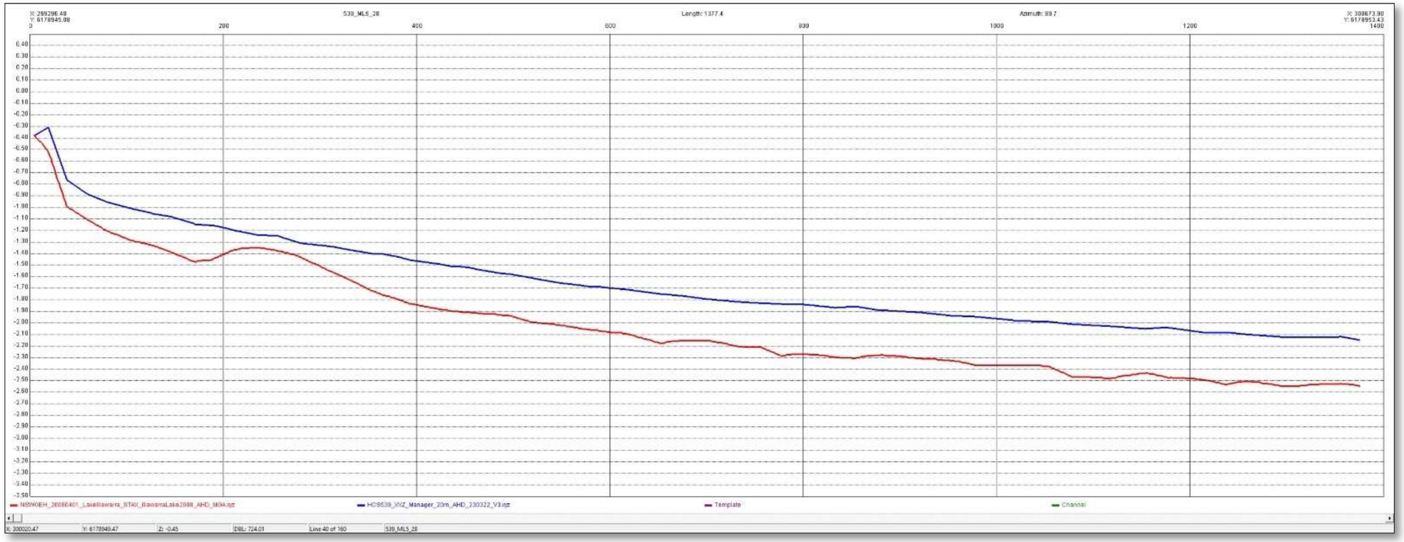


Figure 120: Lake 5 - profiles (red = 2008, blue = 2022/23) 26_1 and 27.



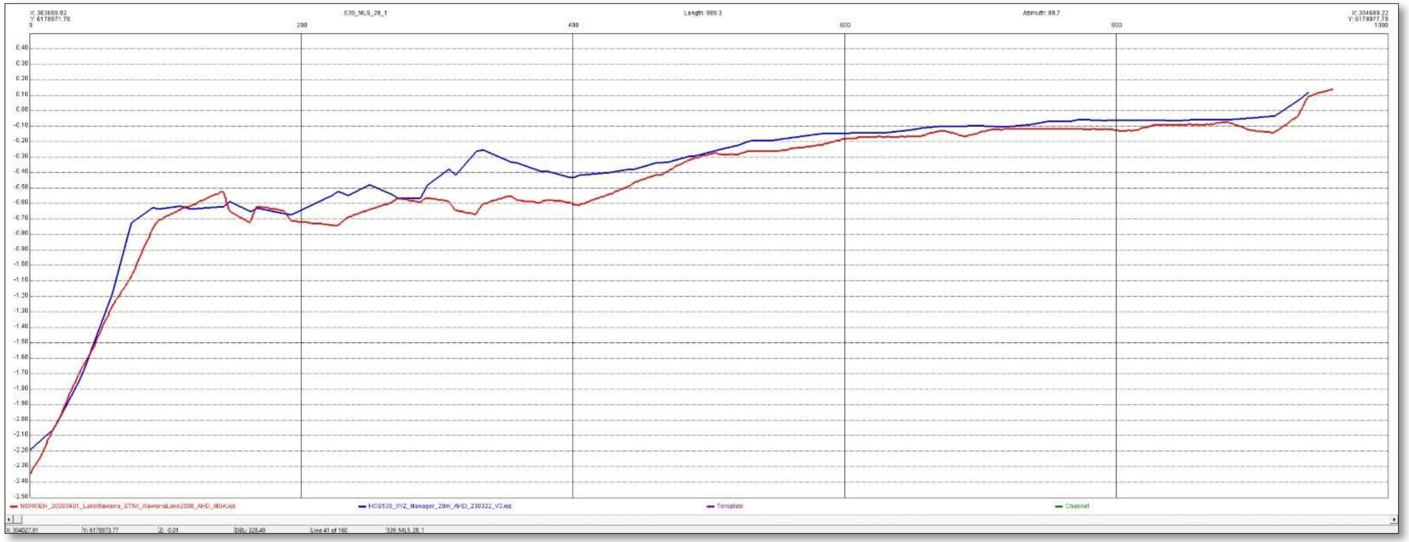


Figure 121: Lake 5 - profiles (red = 2008, blue = 2022/23) 28 and 28_1.

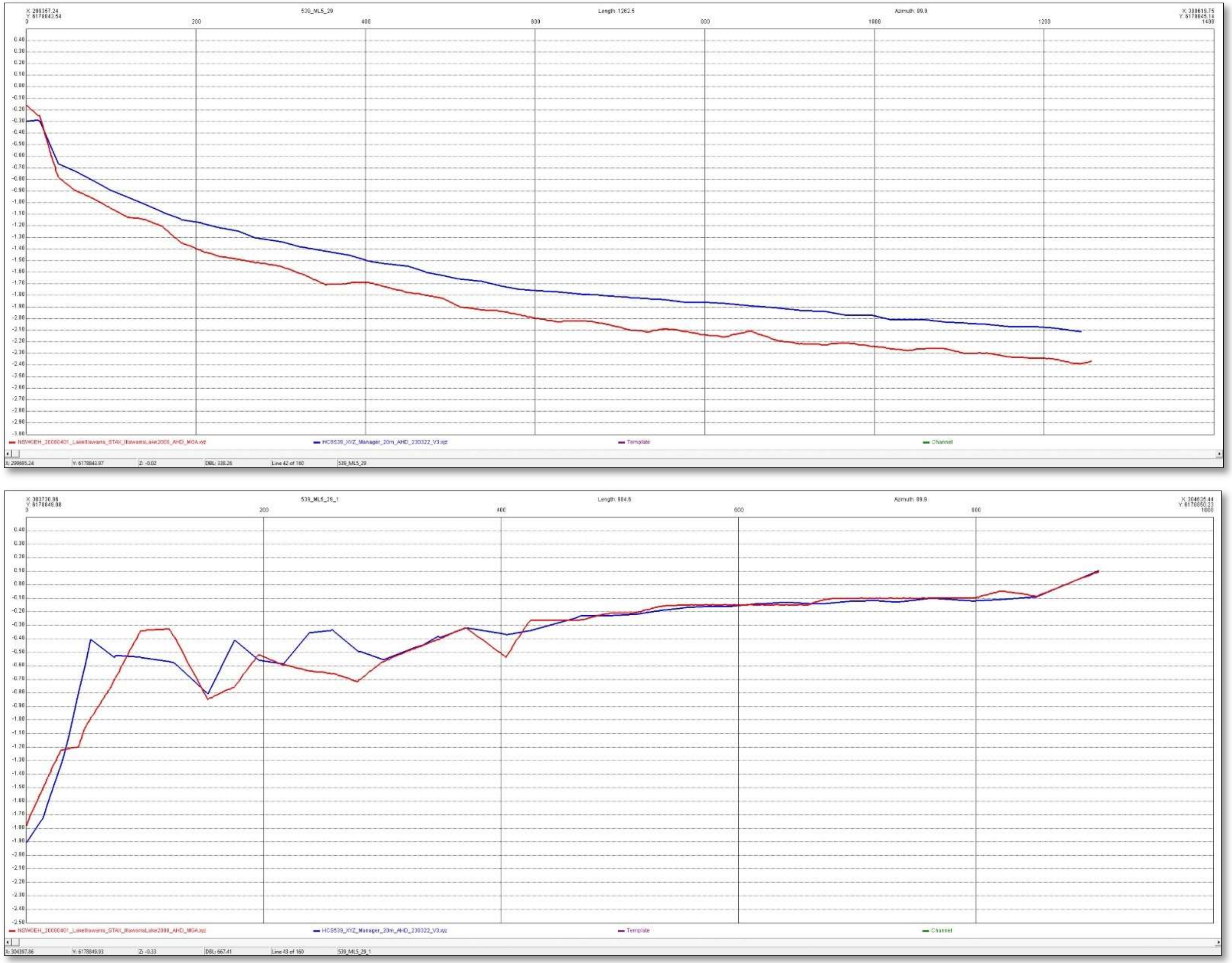
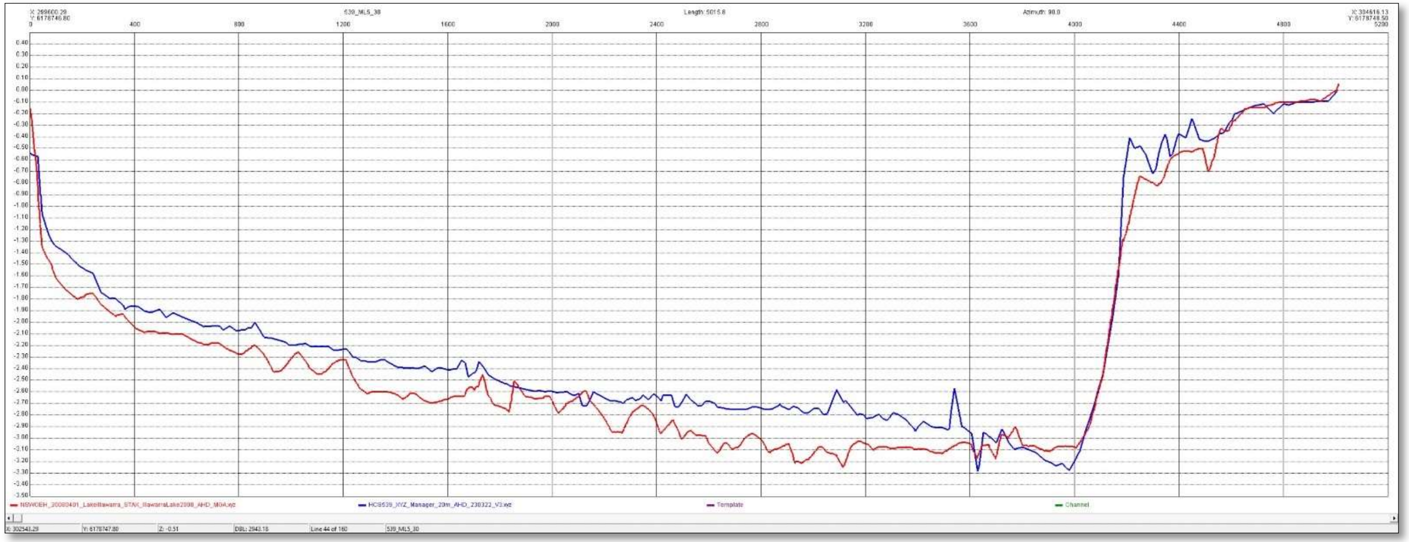


Figure 122: Lake 5 - profiles (red = 2008, blue = 2022/23) 29 and 29_1.



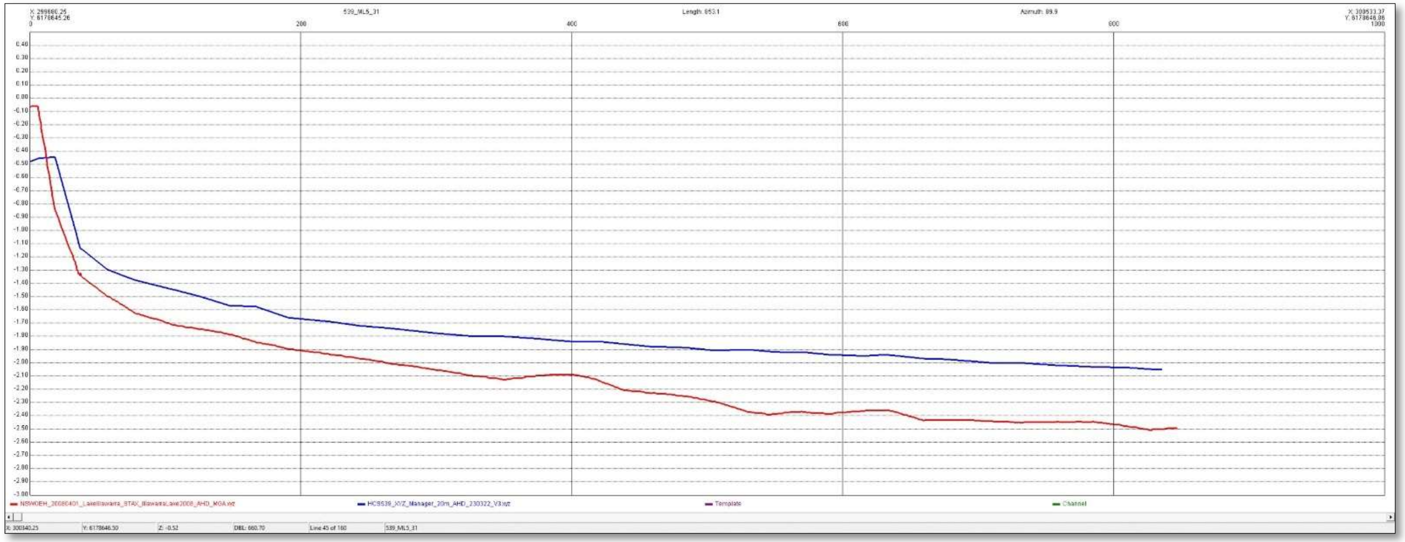
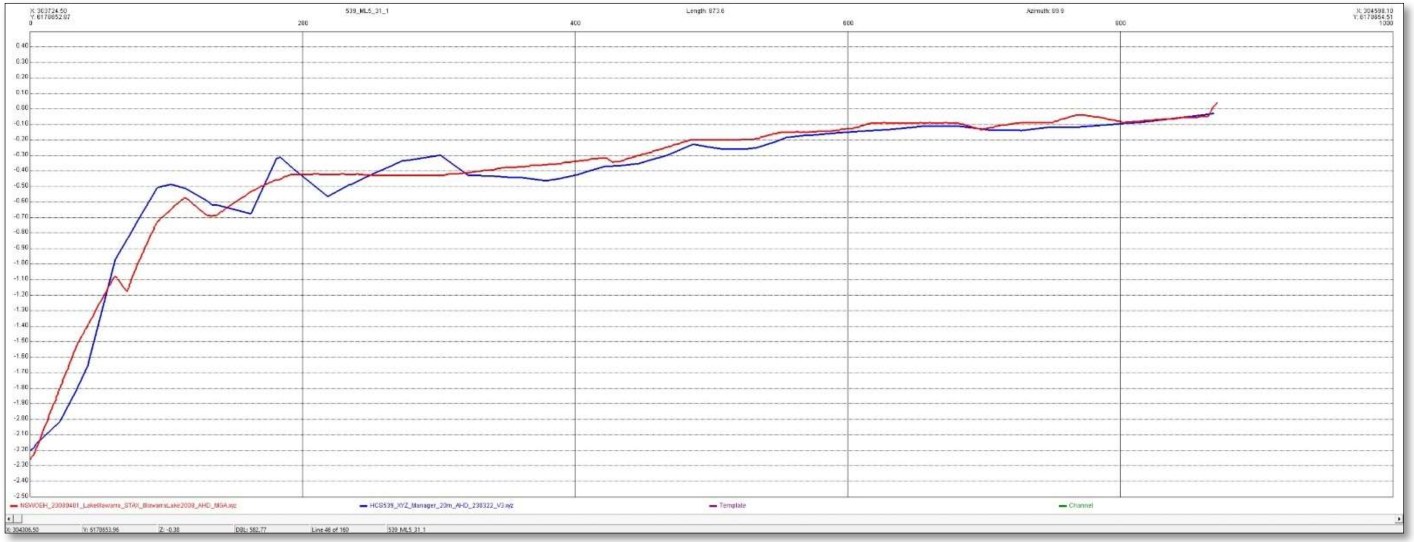


Figure 123: Lake 5 - profiles (red = 2008, blue = 2022/23) 30 and 31.



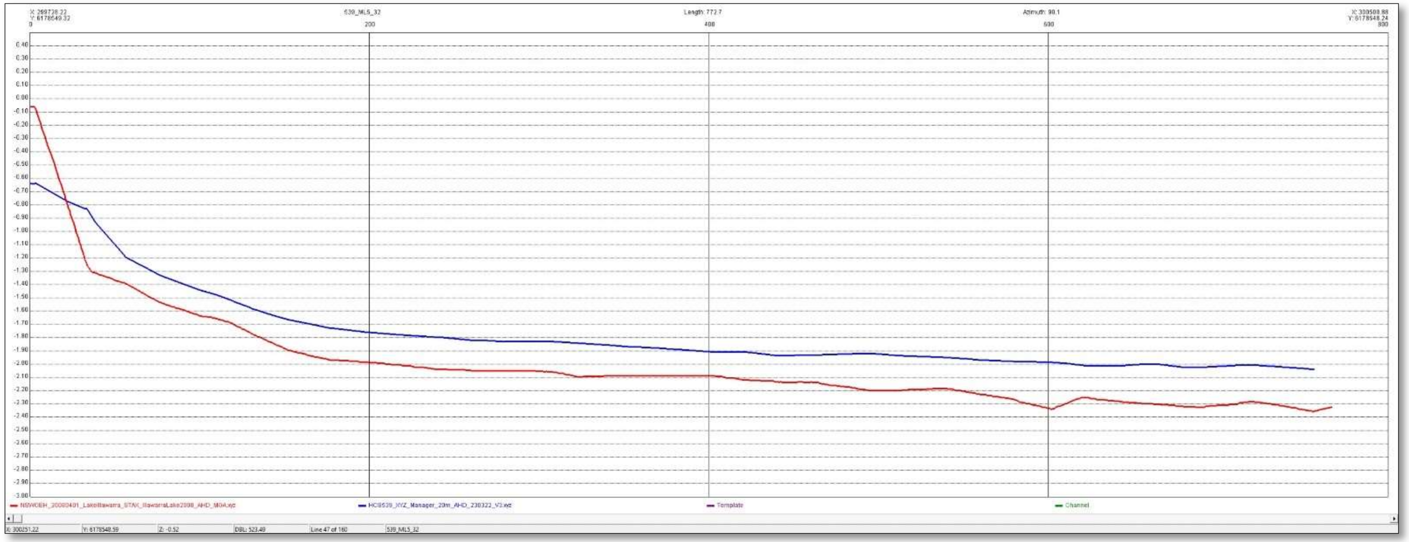


Figure 124: Lake 5 - profiles (red = 2008, blue = 2022/23) 31_1 and 32.

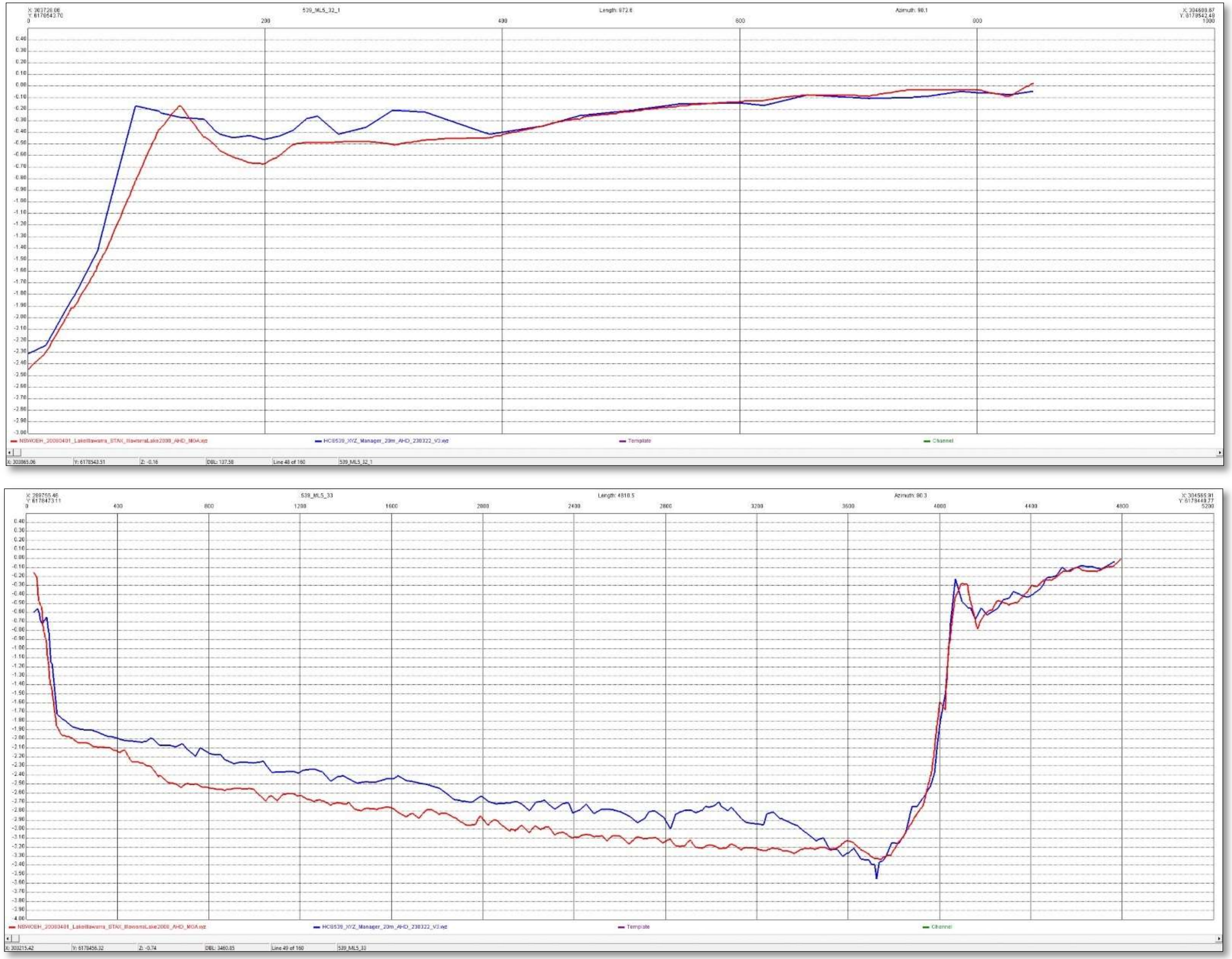


Figure 125: Lake 5 - profiles (red = 2008, blue = 2022/23) 32_1 and 33.

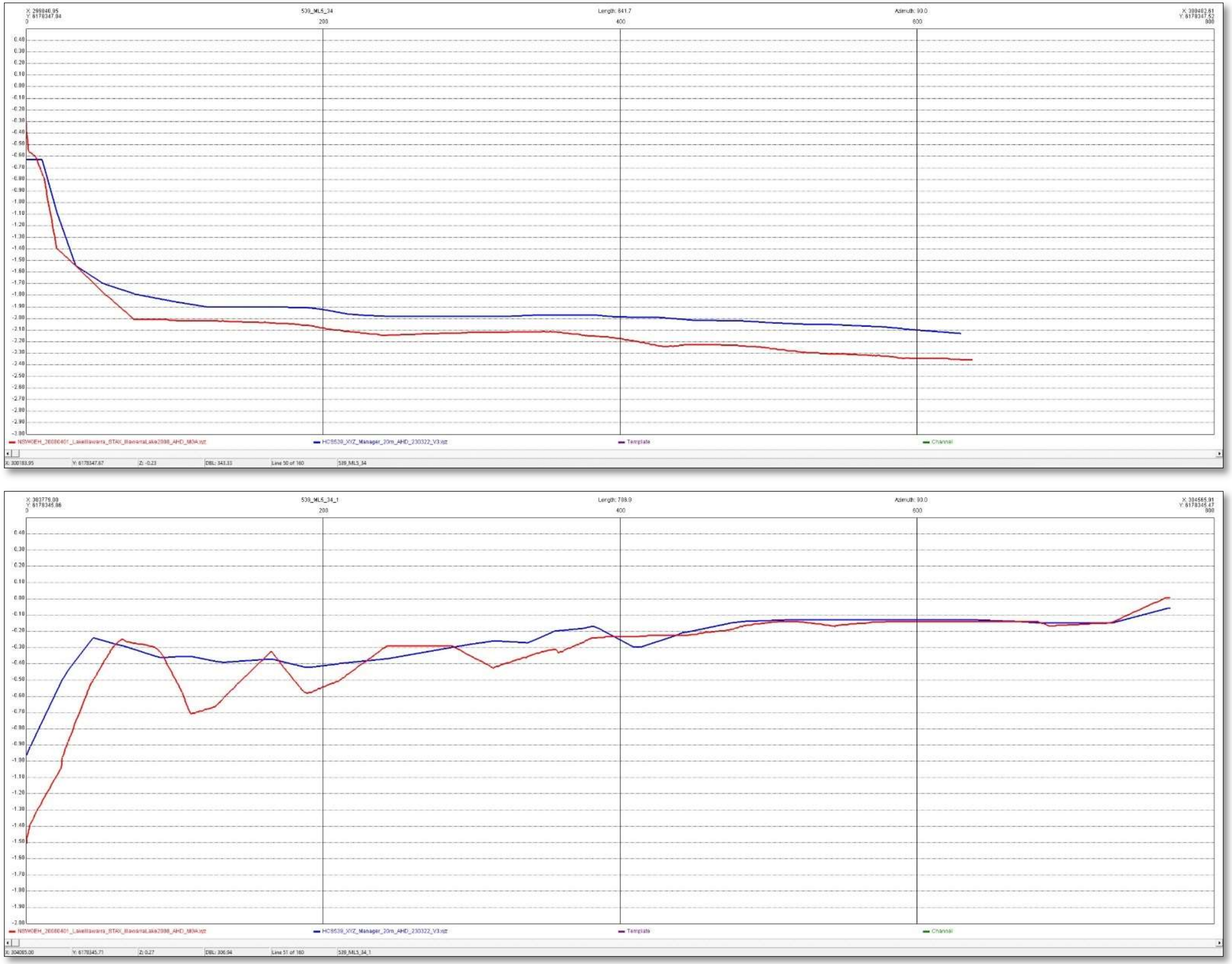


Figure 126: Lake 5 - profiles (red = 2008, blue = 2022/23) 34 and 34_1.

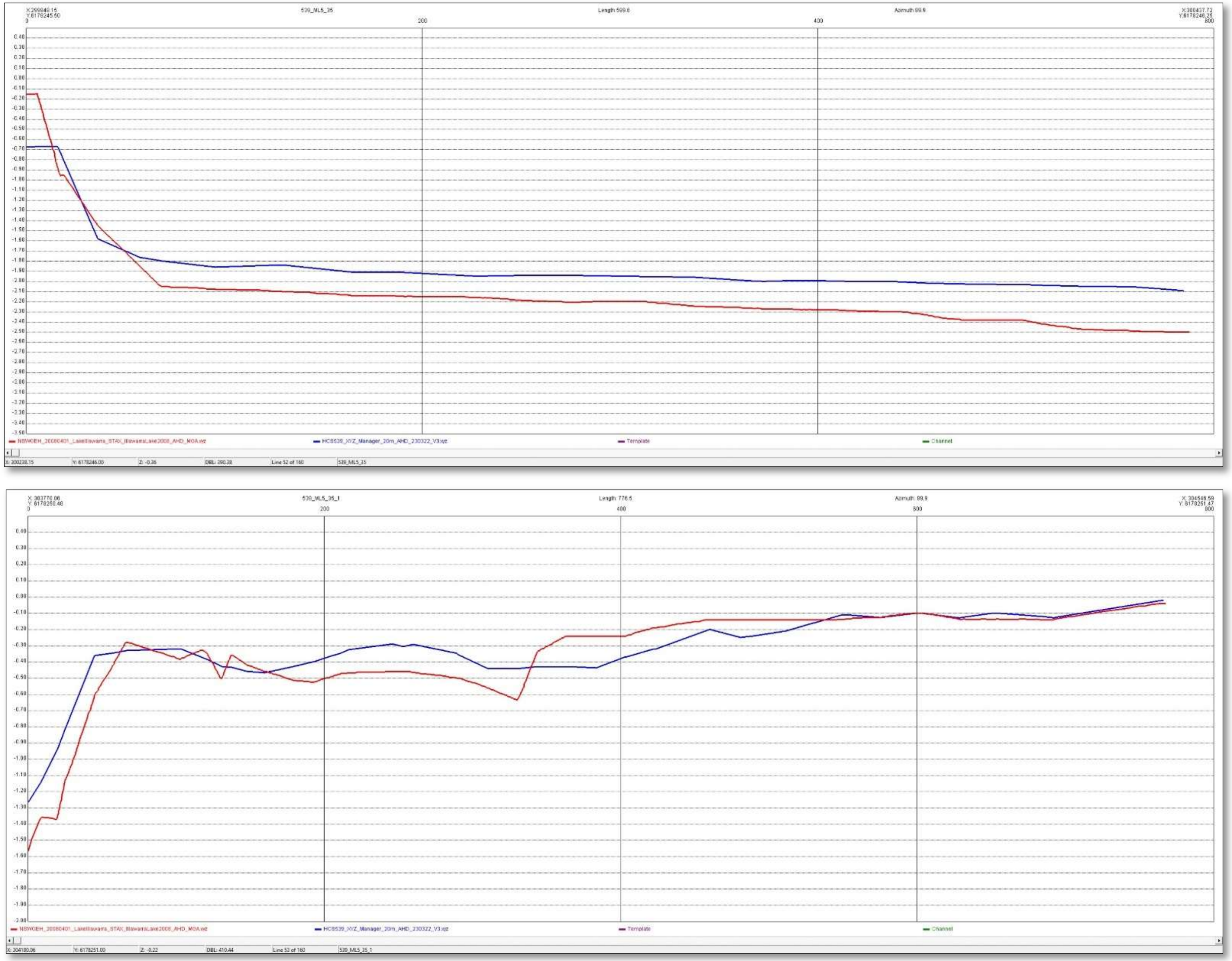


Figure 127: Lake 5 - profiles (red = 2008, blue = 2022/23) 35 and 35_1.

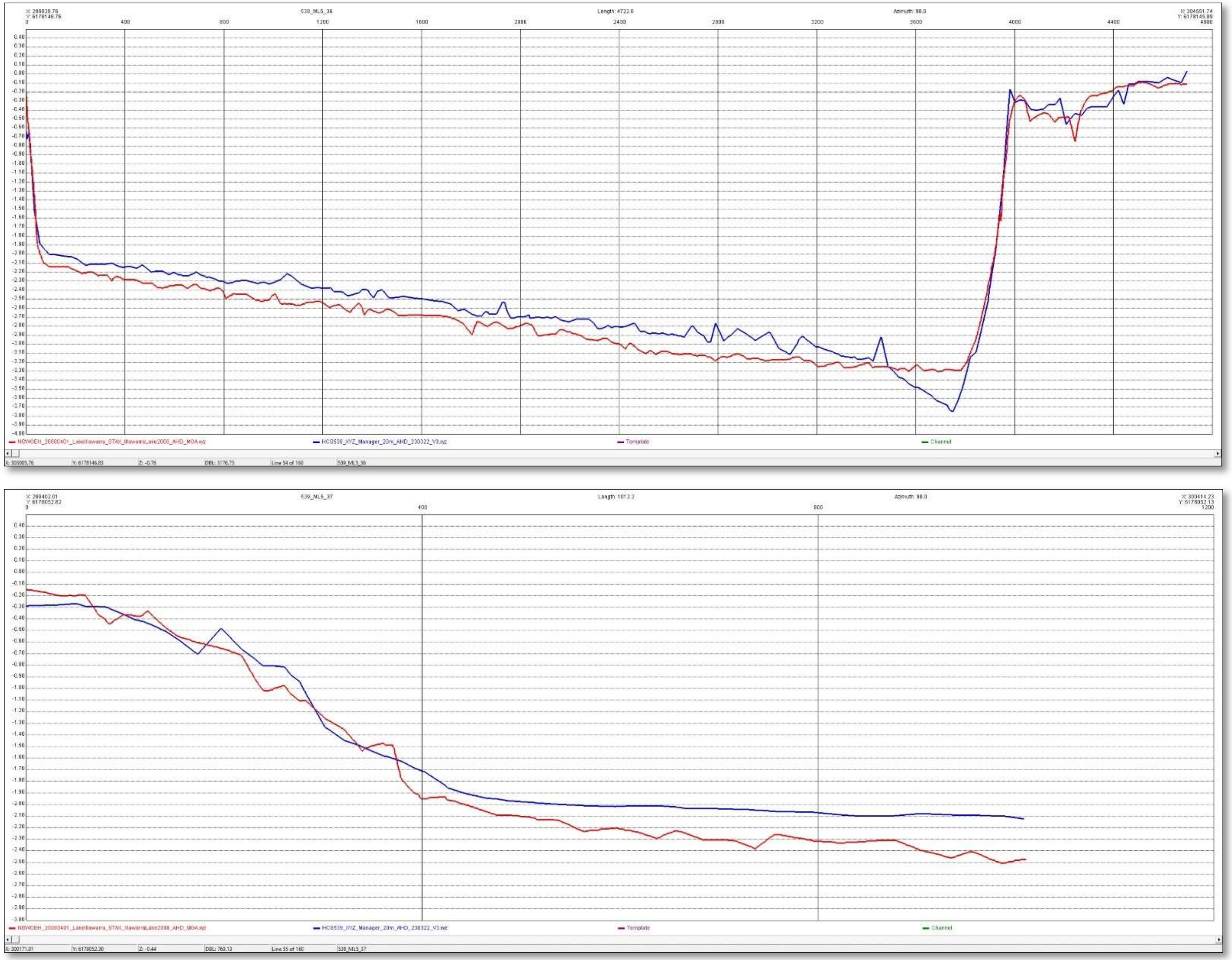


Figure 128: Lake 5 - profiles (red = 2008, blue = 2022/23) 36 and 37.

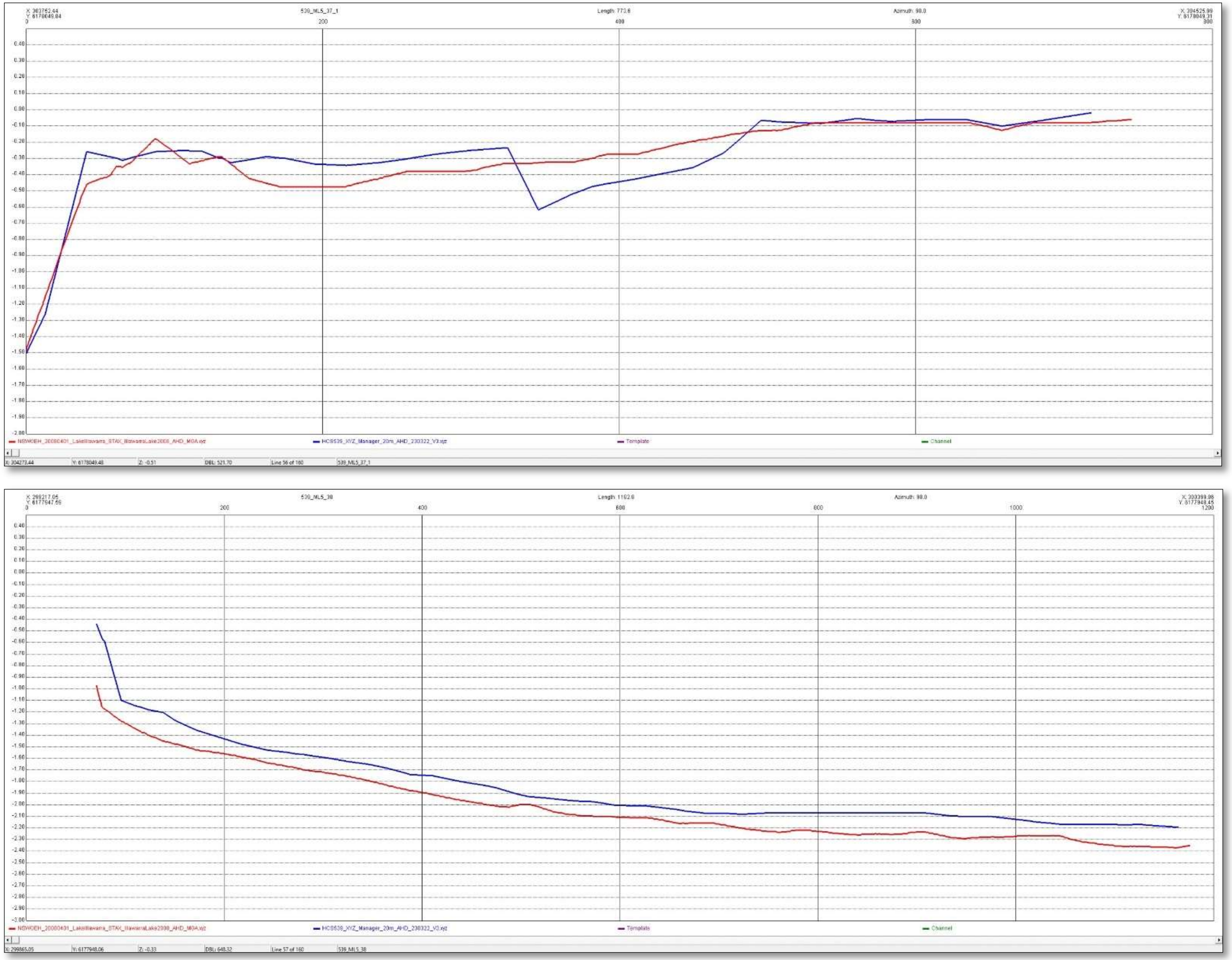


Figure 129: Lake 5 - profiles (red = 2008, blue = 2022/23) 37_1 and 38.

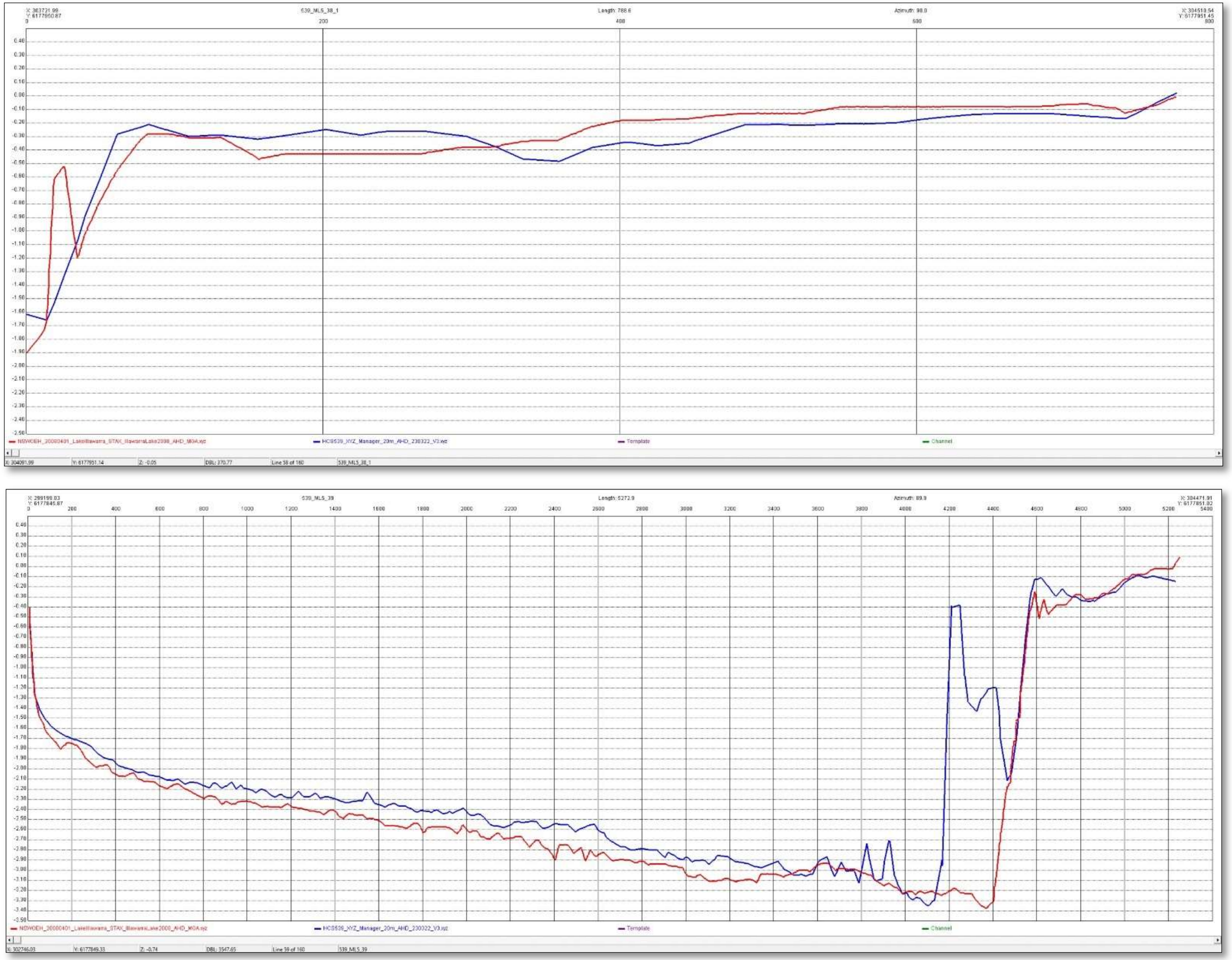
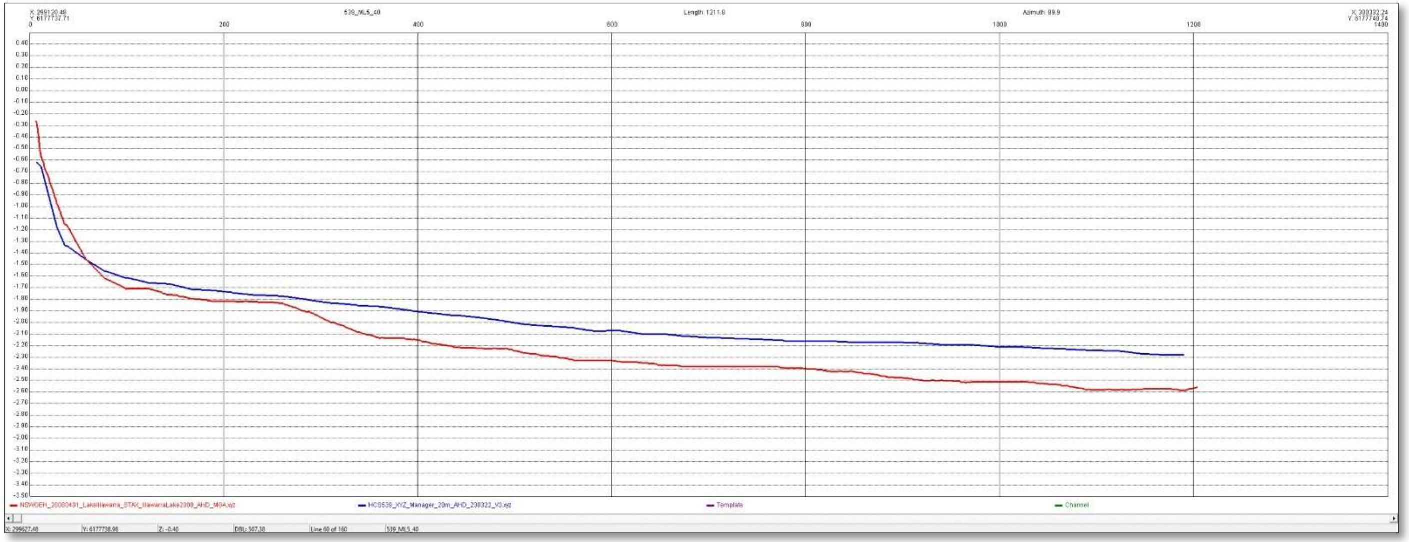


Figure 130: Lake 5 - profiles (red = 2008, blue = 2022/23) 38_1 and 39.



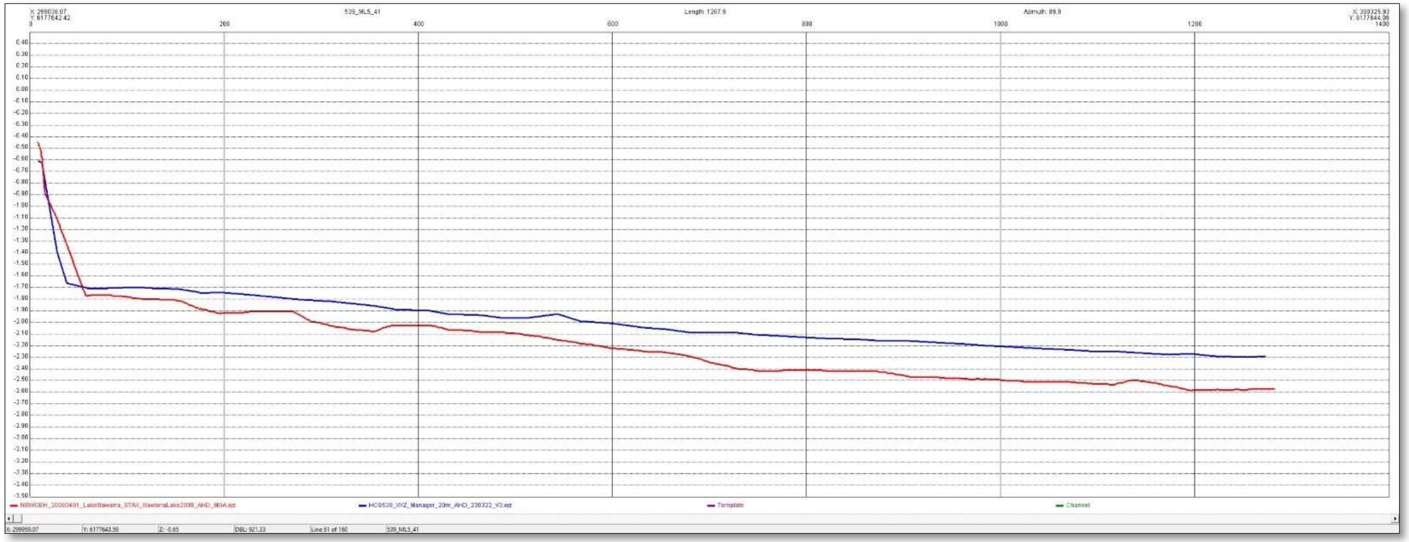
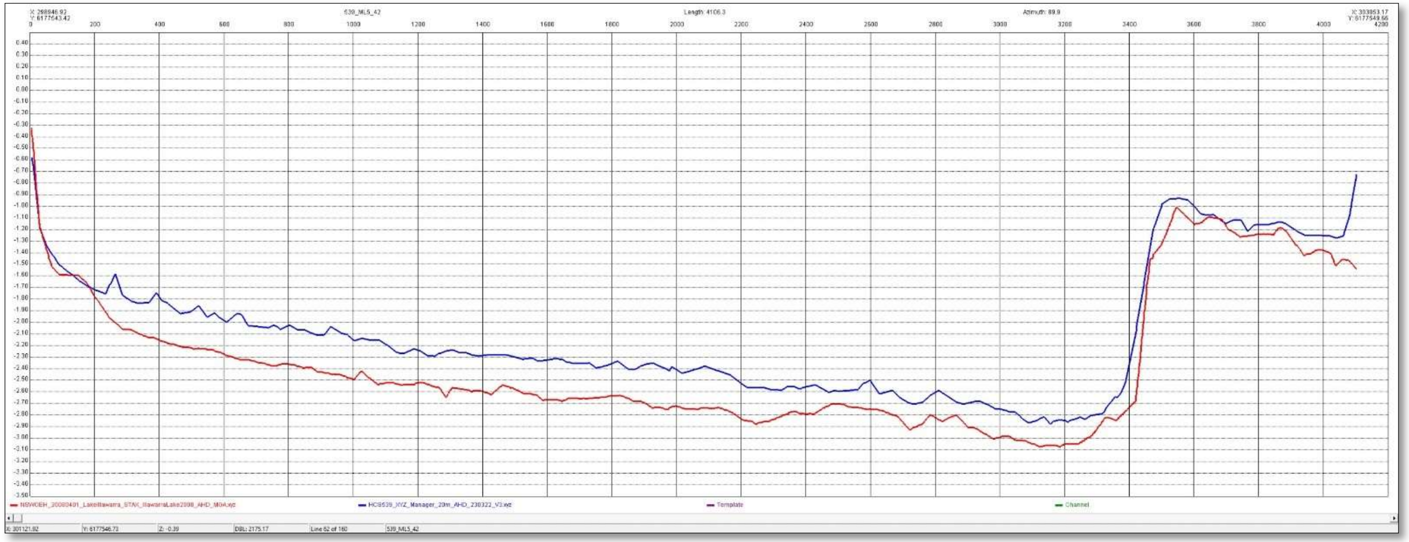


Figure 131: Lake 5 - profiles (red = 2008, blue = 2022/23) 40 and 40_1.



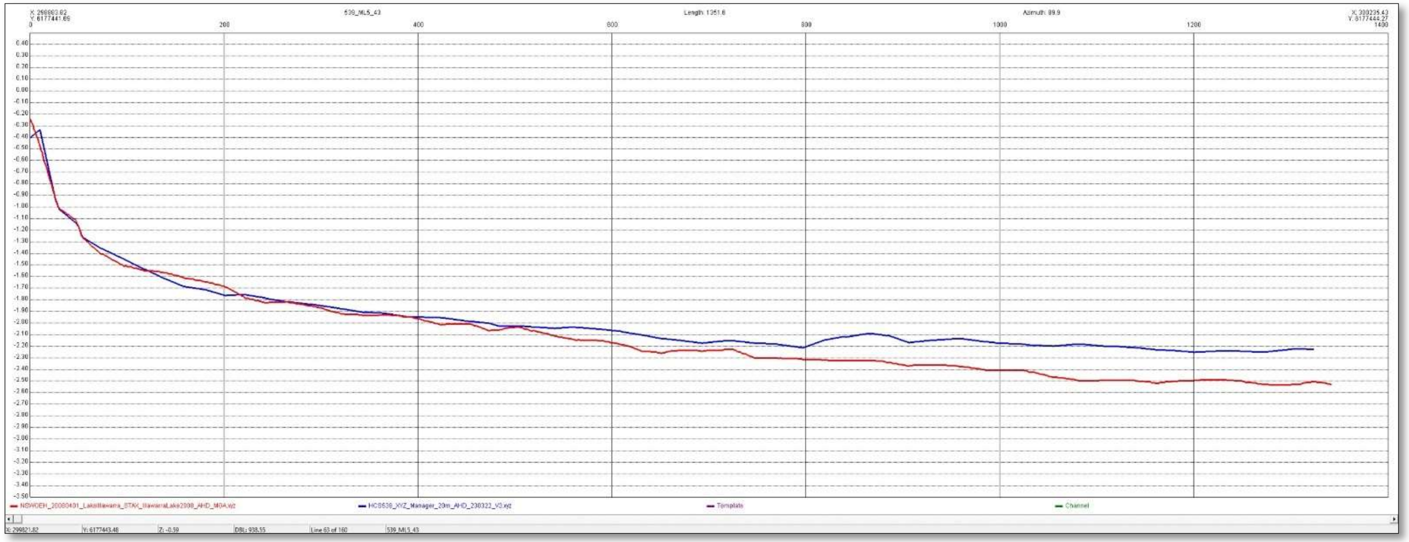


Figure 132: Lake 5 - profiles (red = 2008, blue = 2022/23) 42 and 43.

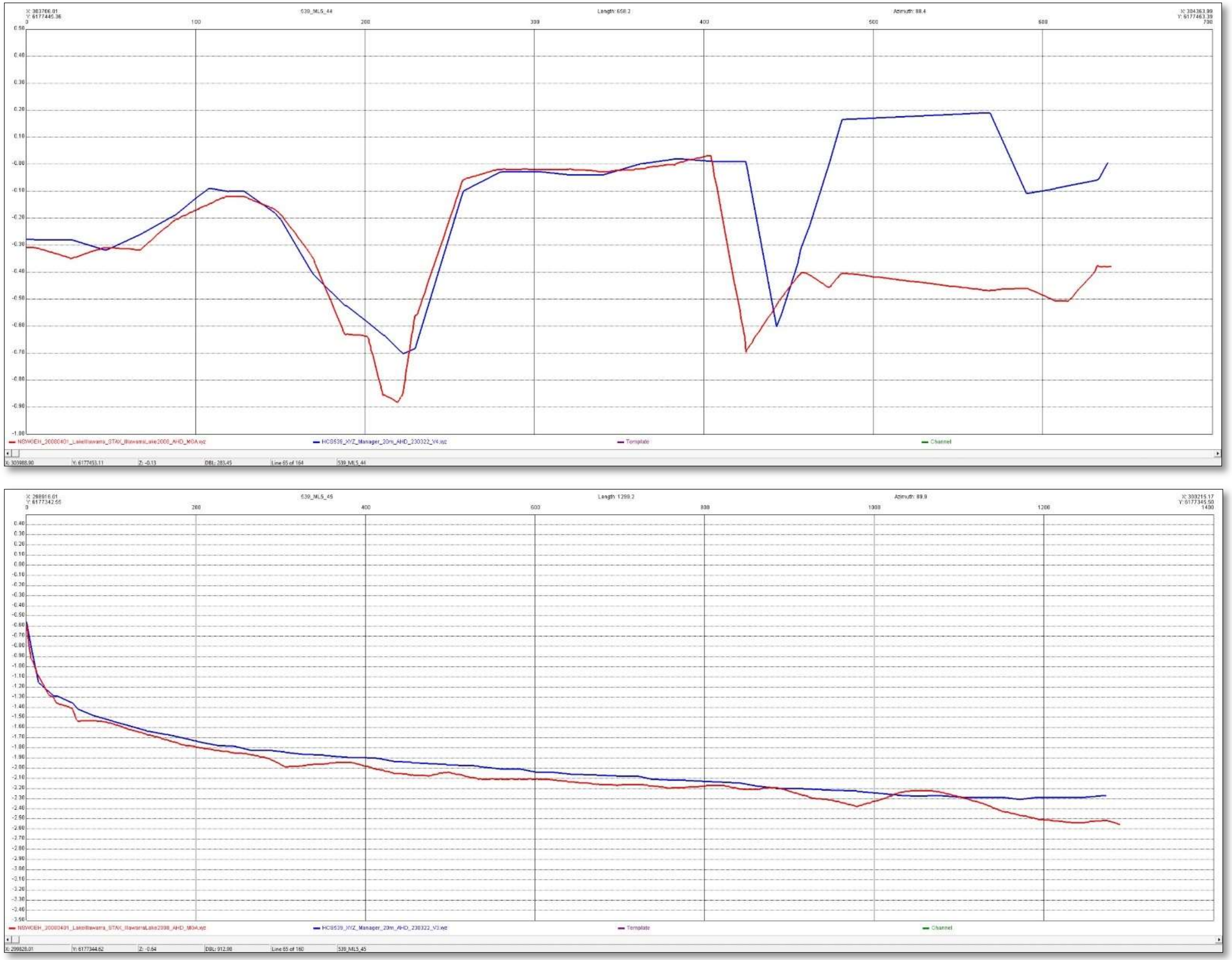


Figure 133: Lake 5 - profiles (red = 2008, blue = 2022/23) 44 and 45.

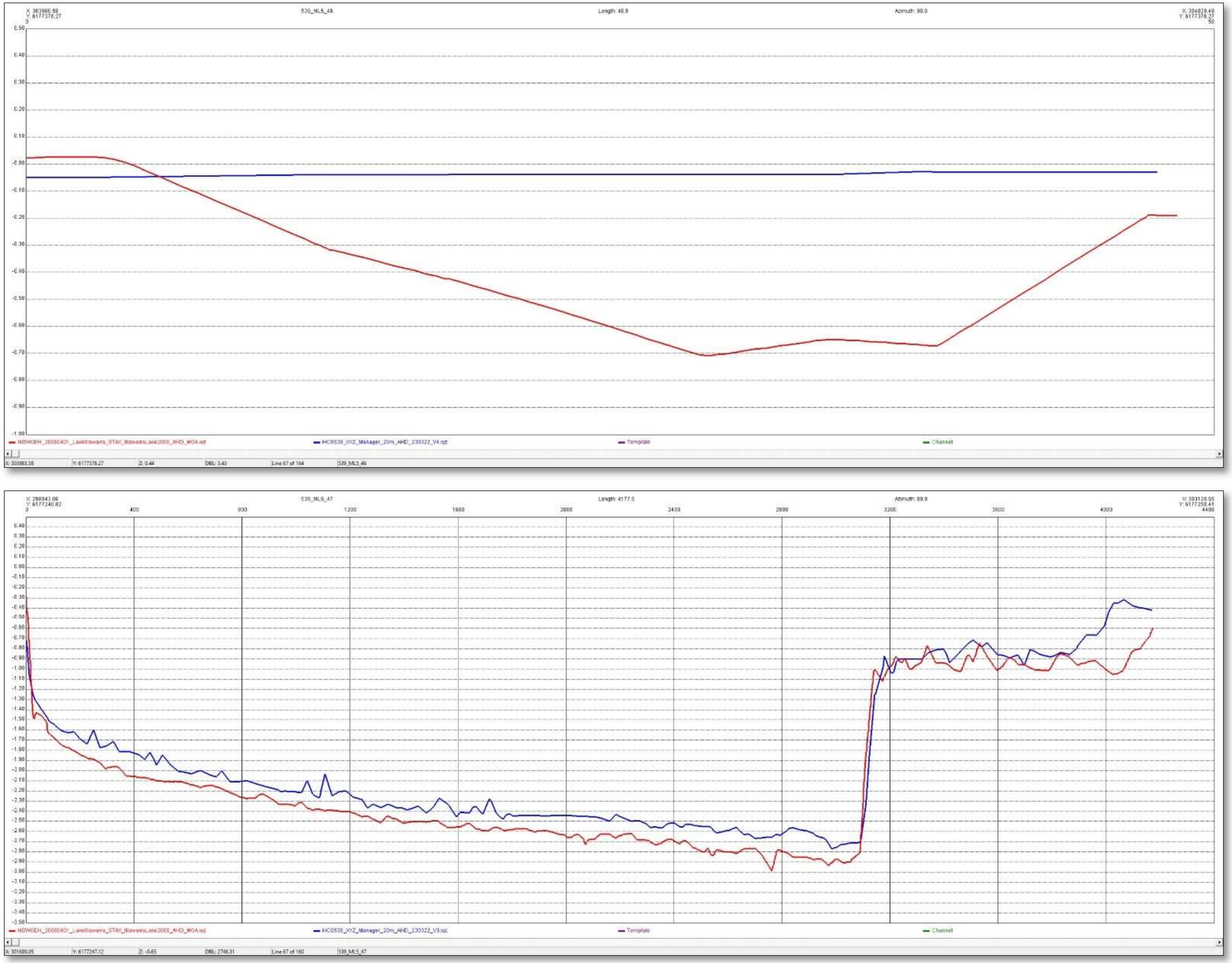
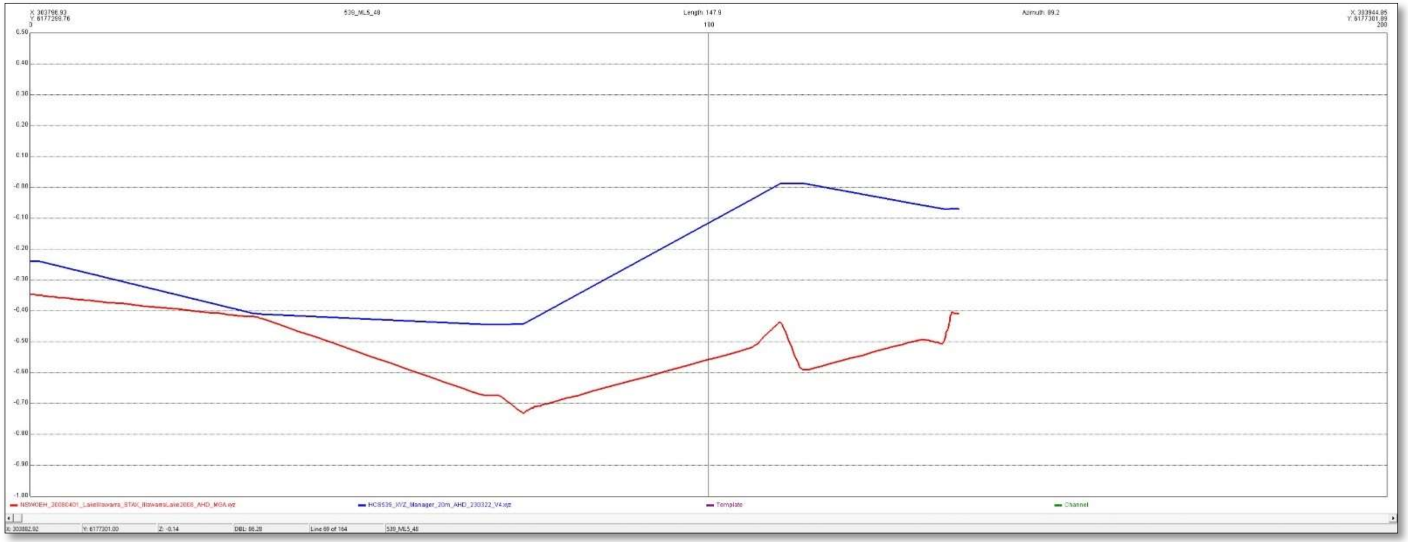


Figure 134: Lake 5 - profiles (red = 2008, blue = 2022/23) 46 and 47.



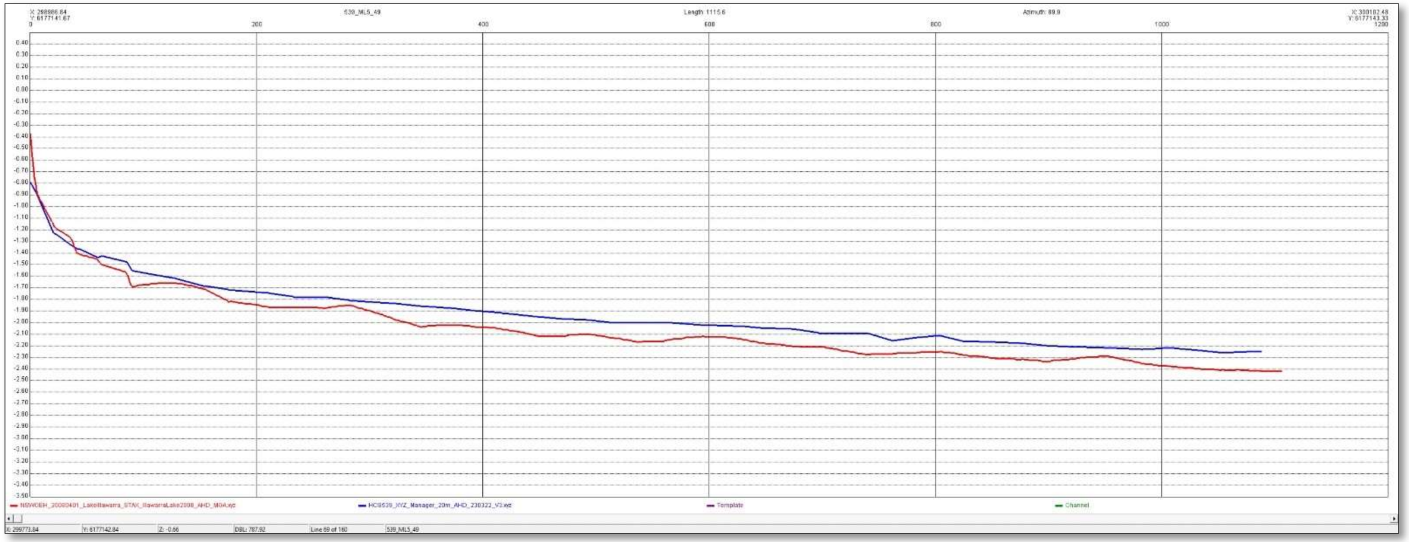


Figure 135: Lake 5 - profiles (red = 2008, blue = 2022/23) 48 and 49.

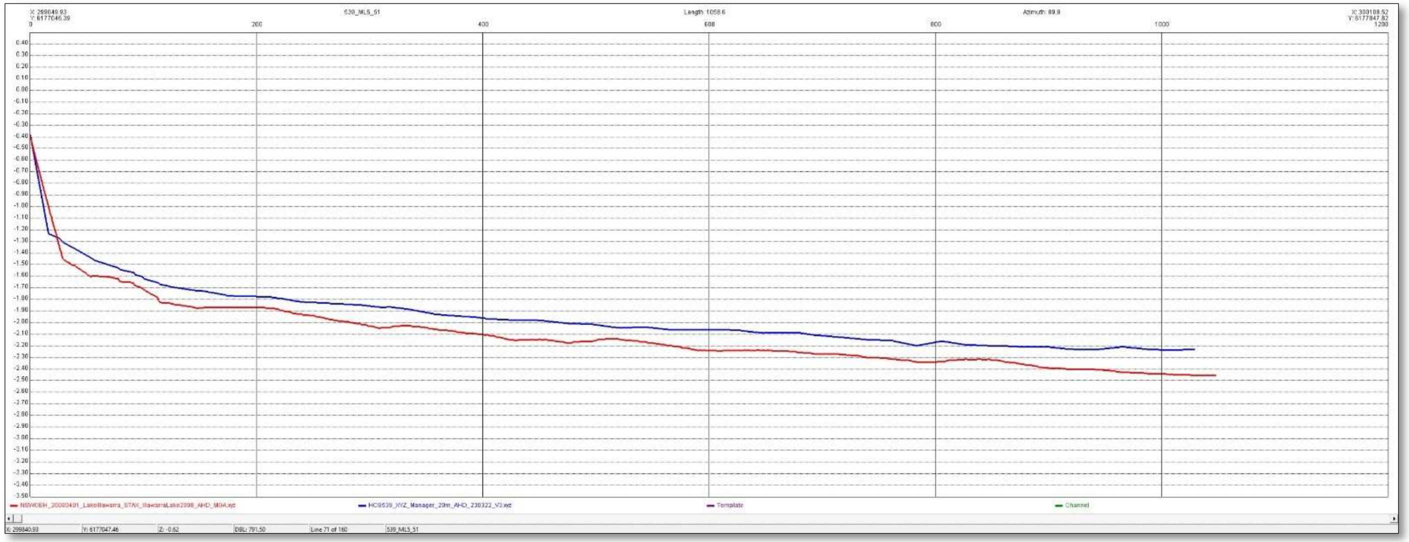


Figure 136: Lake 5 - profiles (red = 2008, blue = 2022/23) 50 and 51.

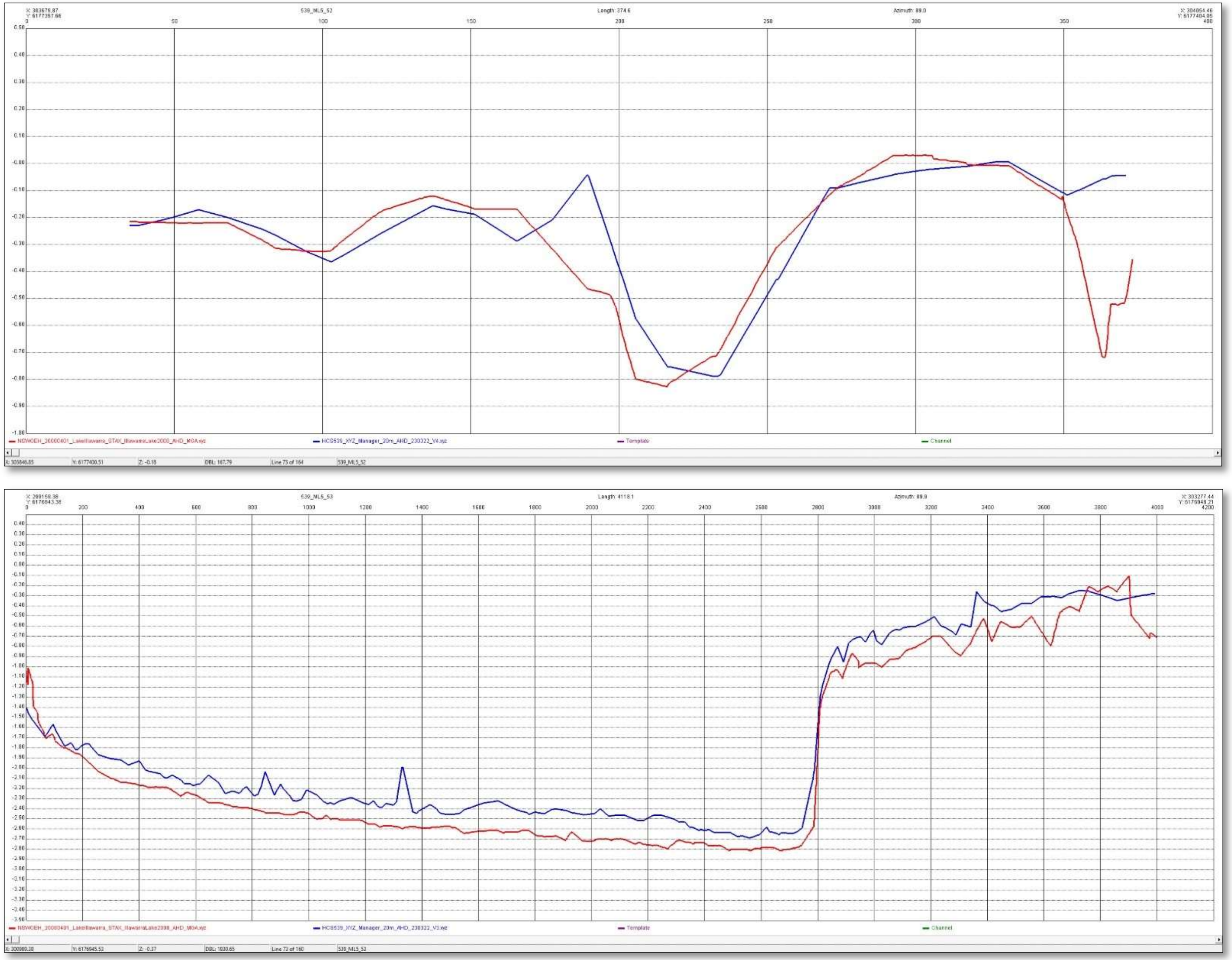
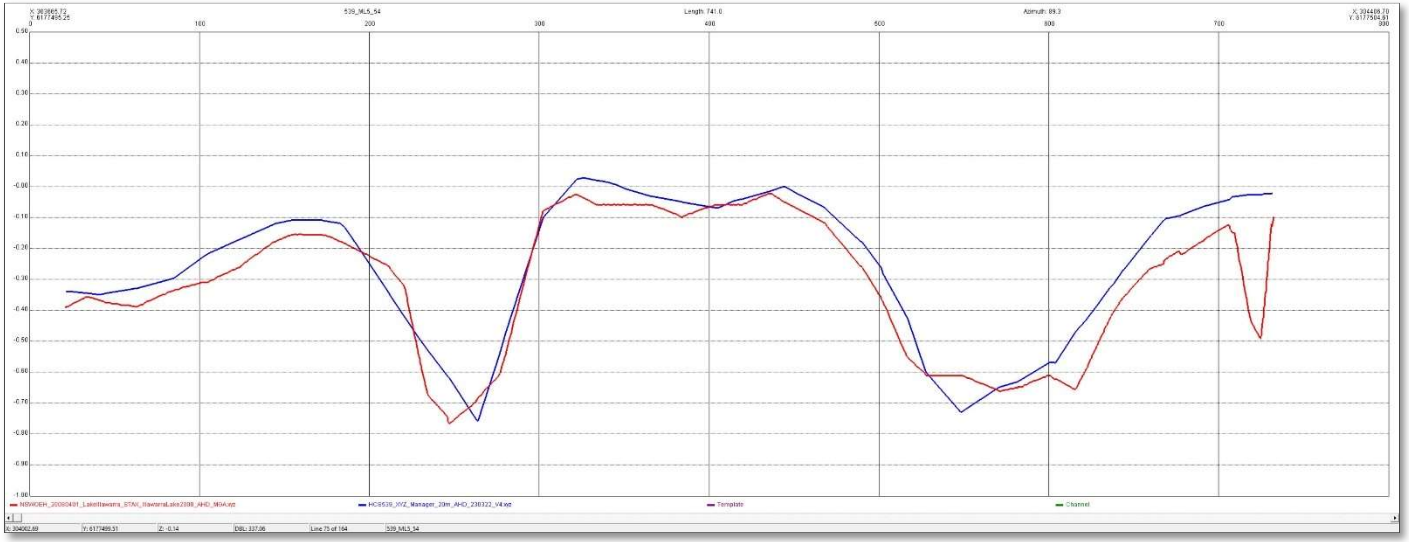


Figure 137: Lake 5 - profiles (red = 2008, blue = 2022/23) 52 and 53.



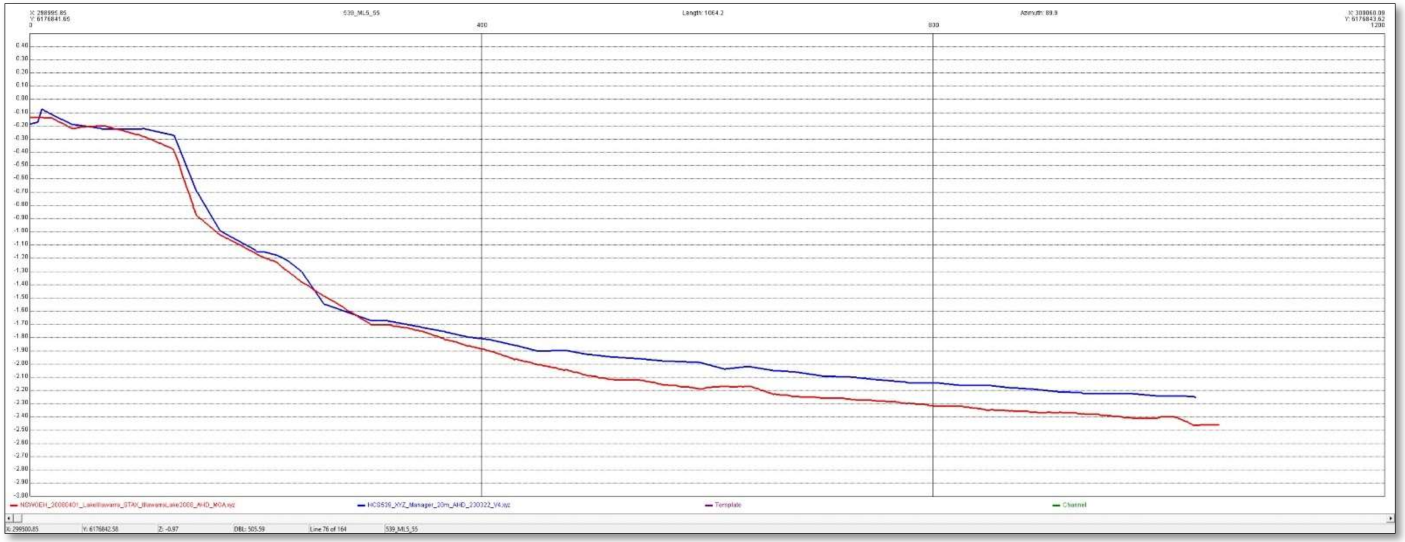
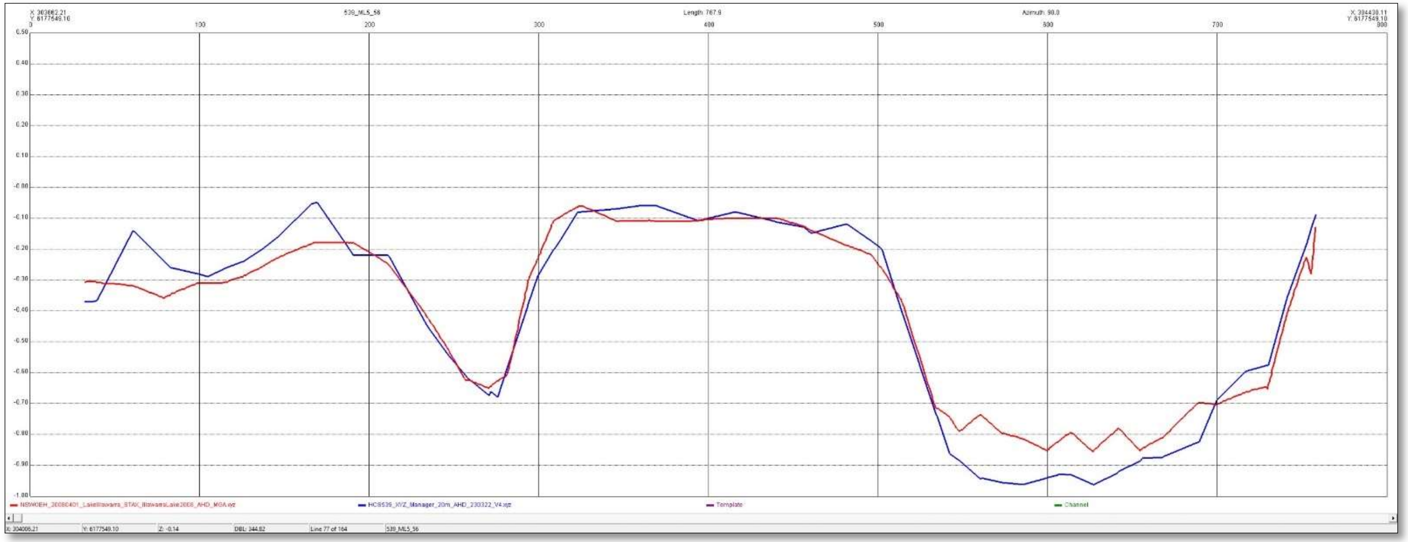


Figure 138: Lake 5 - profiles (red = 2008, blue = 2022/23) 54 and 55.



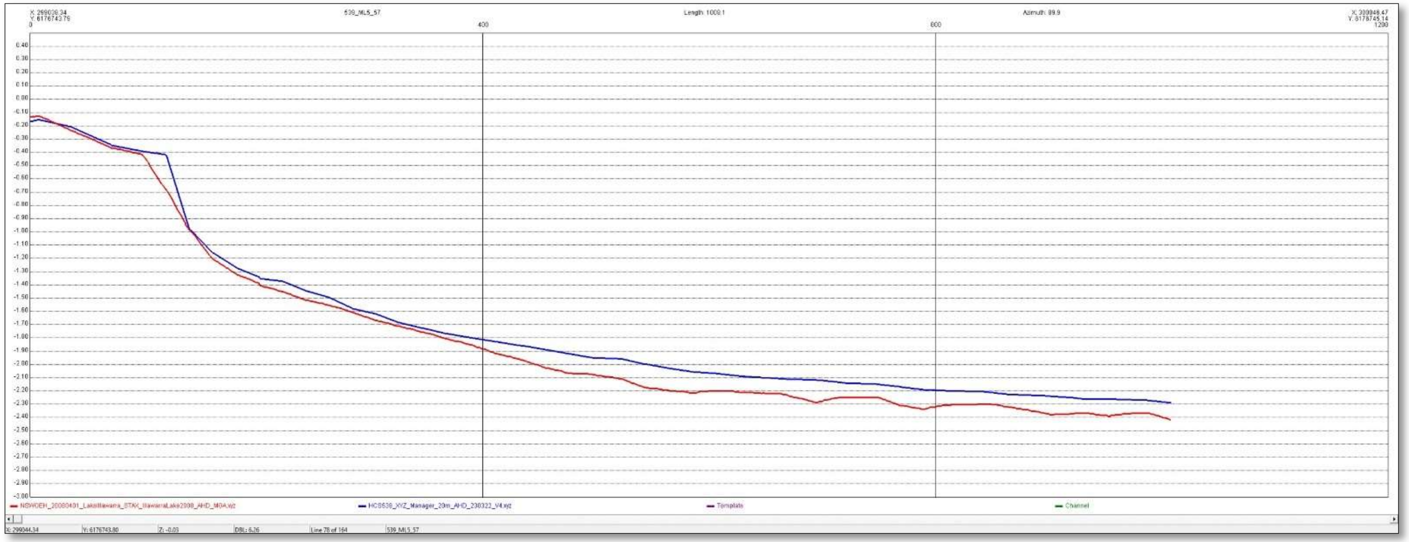
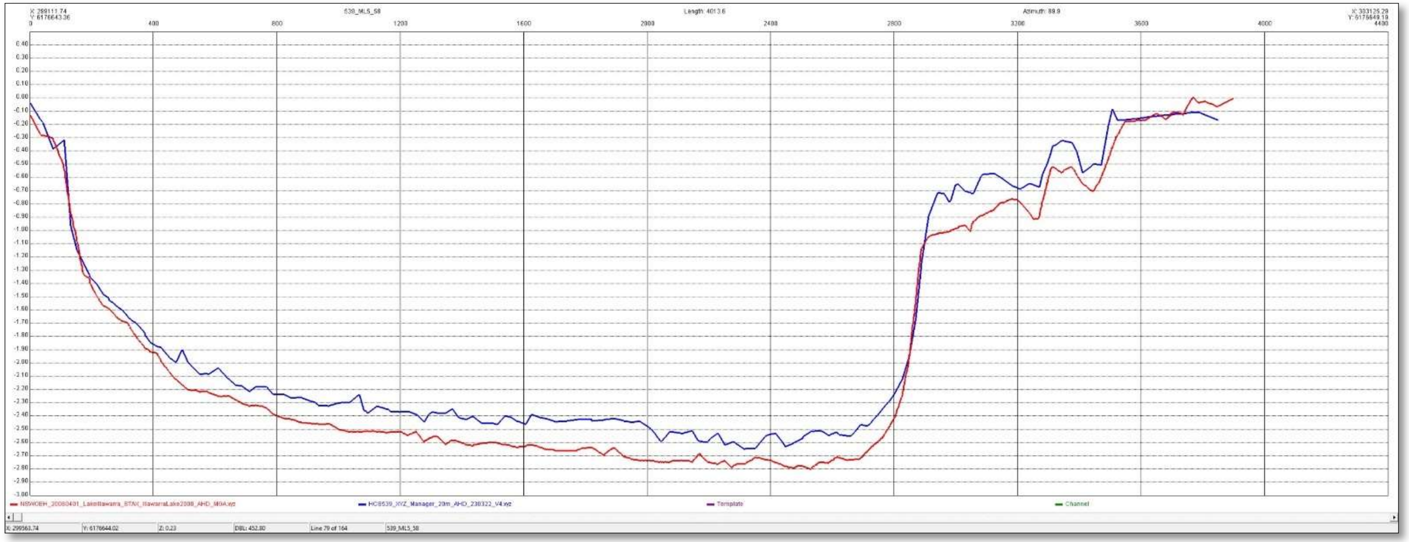


Figure 139: Lake 5 - profiles (red = 2008, blue = 2022/23) 56 and 57.



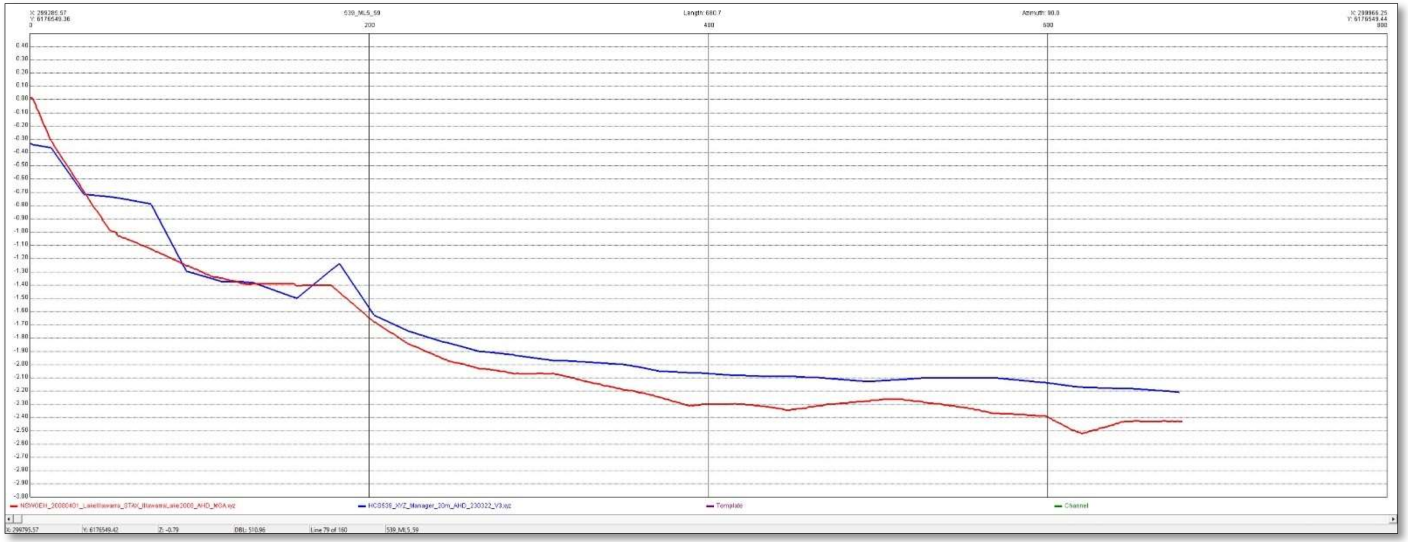


Figure 140: Lake 5 - profiles (red = 2008, blue = 2022/23) 58 and 59.

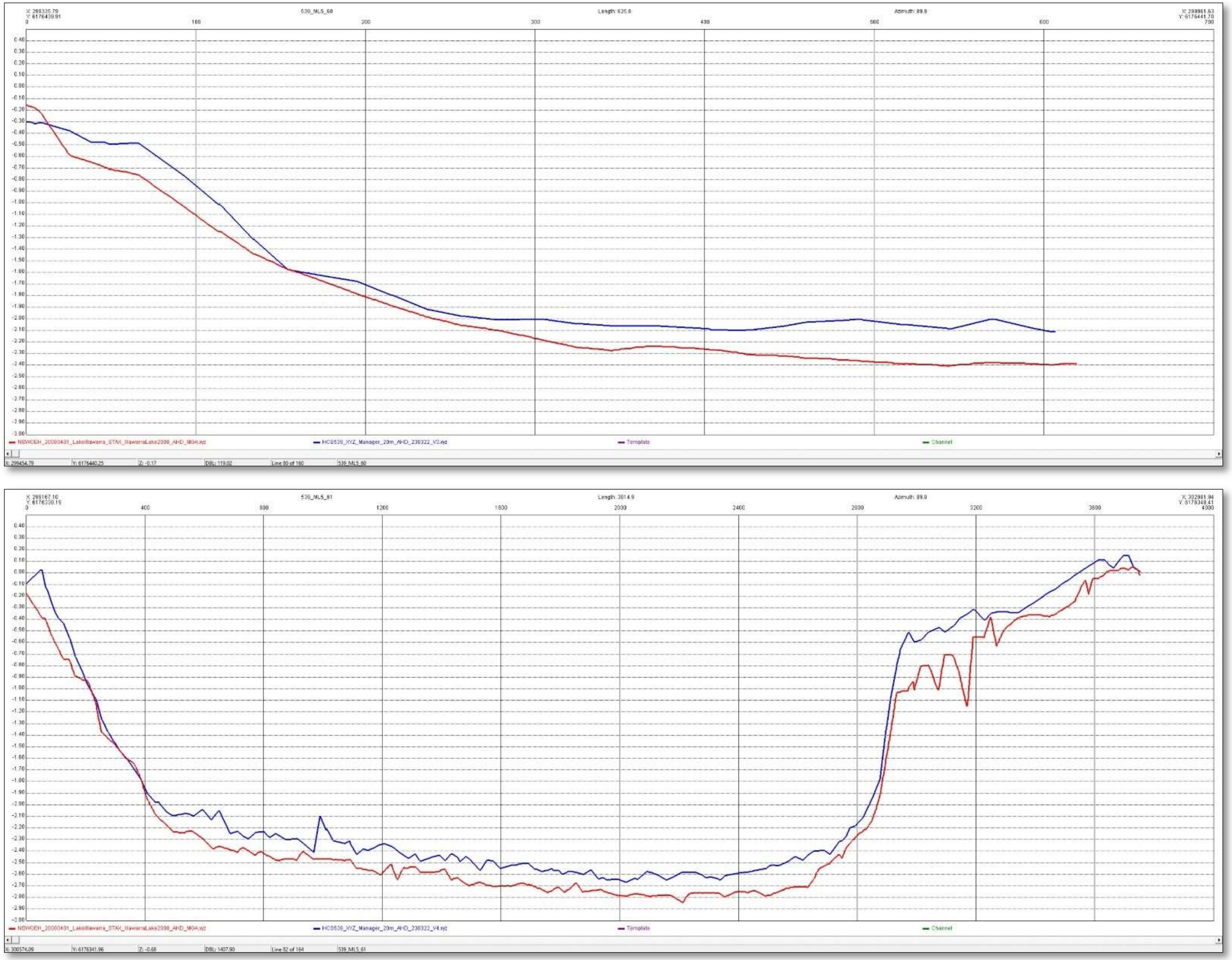
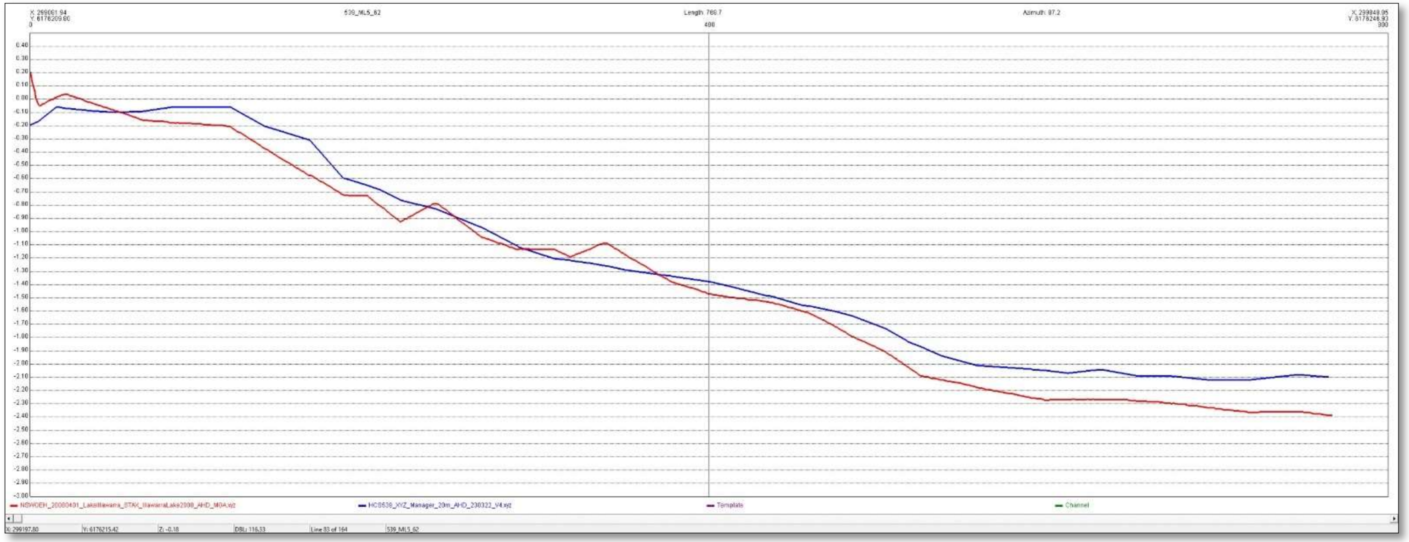


Figure 141: Lake 5 - profiles (red = 2008, blue = 2022/23) 60 and 61.



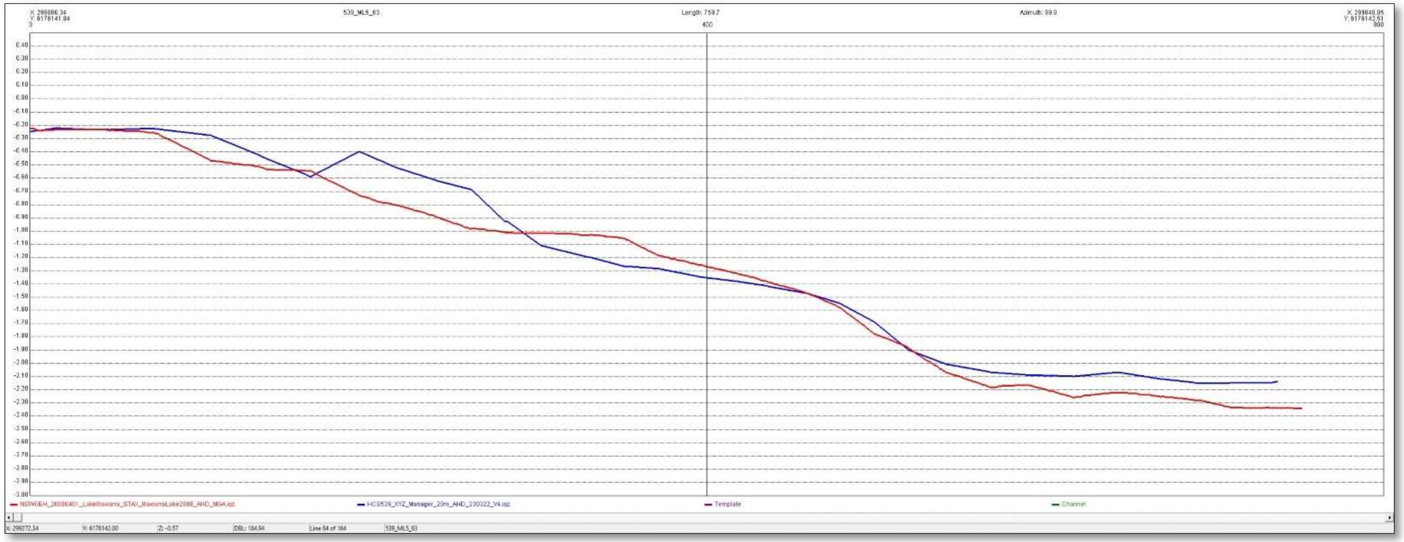


Figure 142: Lake 5 - profiles (red = 2008, blue = 2022/23) 62 and 63.

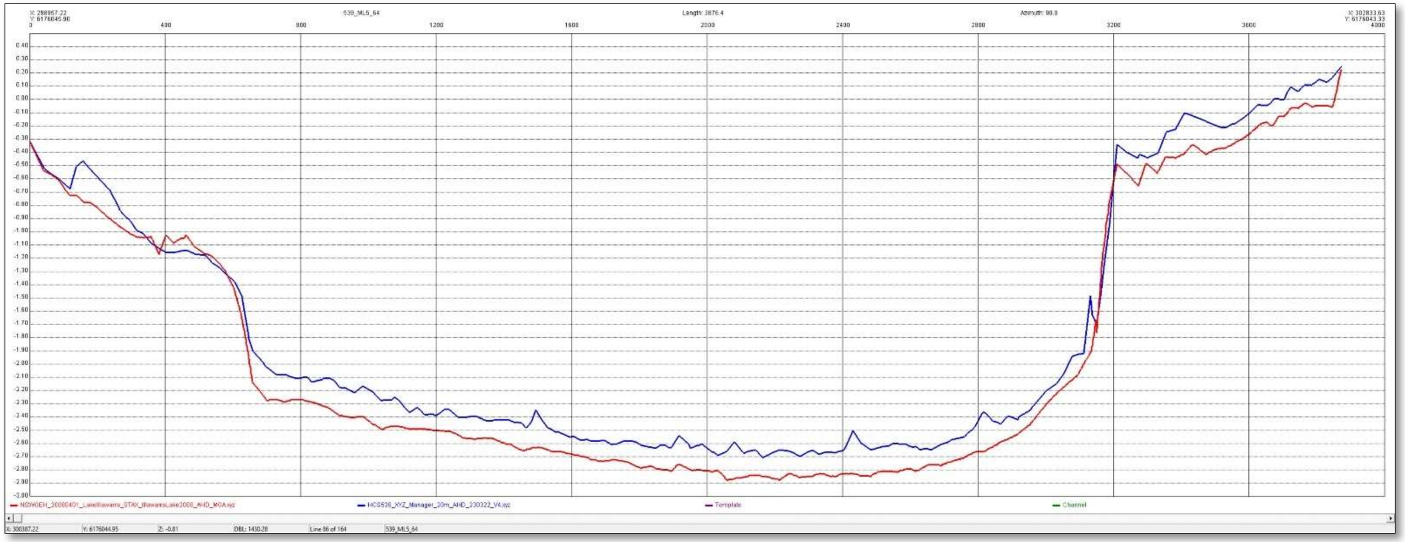
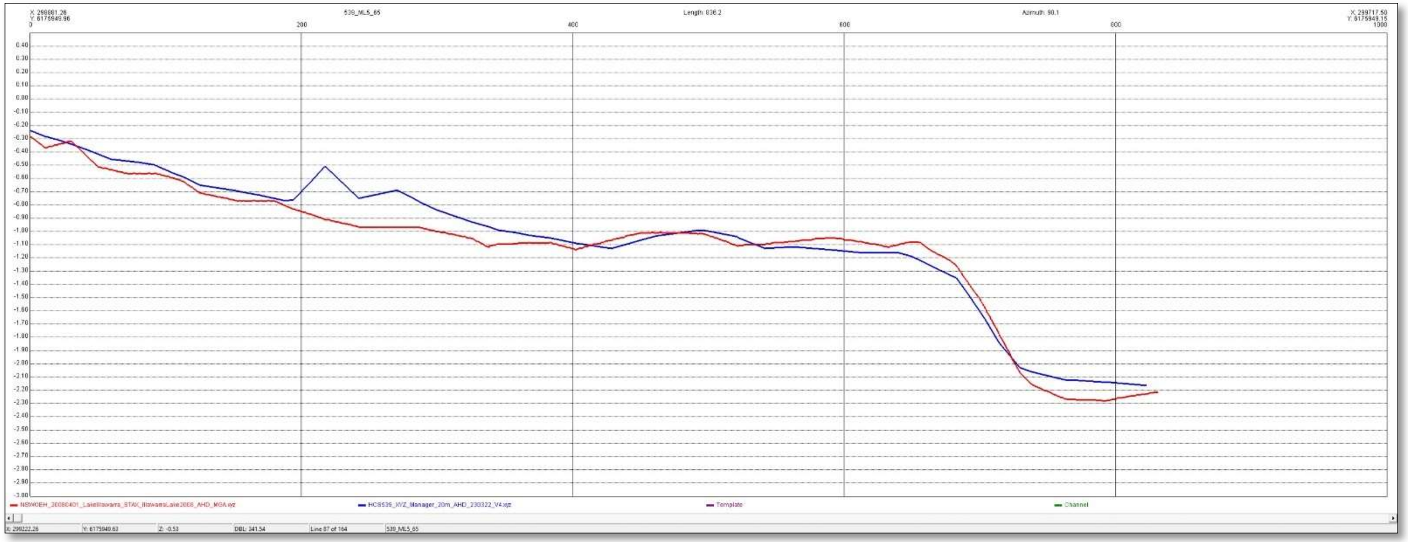


Figure 143: Lake 5 - profiles (red = 2008, blue = 2022/23) 63_1 and 64.



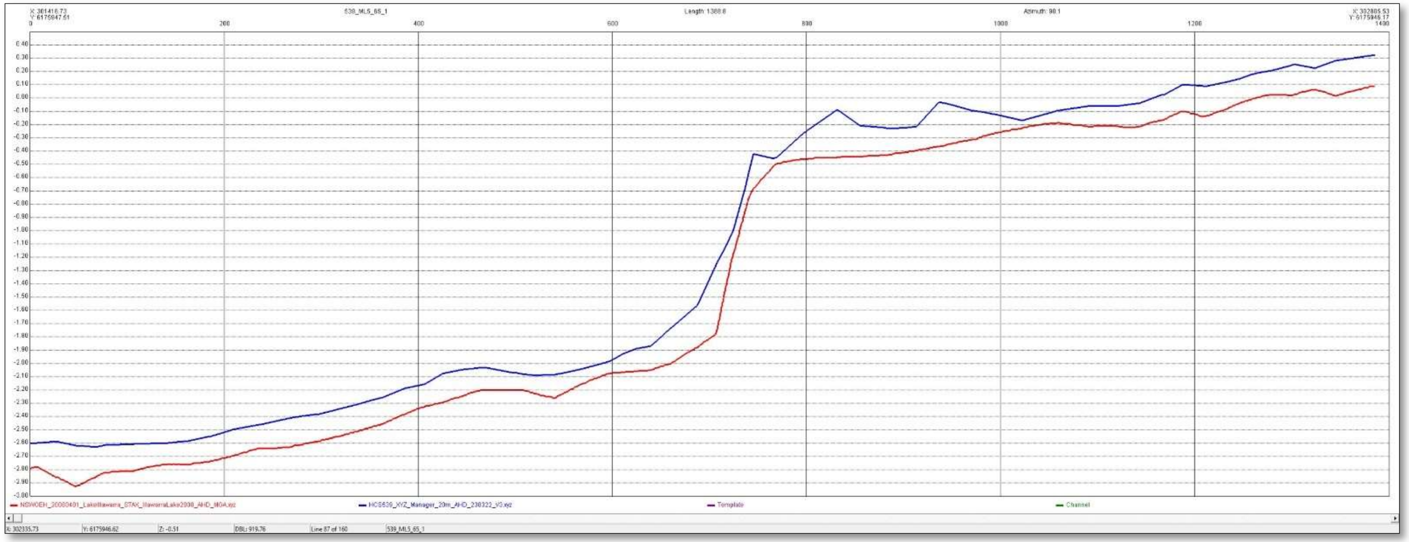


Figure 144: Lake 5 - profiles (red = 2008, blue = 2022/23) 65 and 65_1.

Figure 145: Lake 5 - profiles (red = 2008, blue = 2022/23) 66 and 66_1.

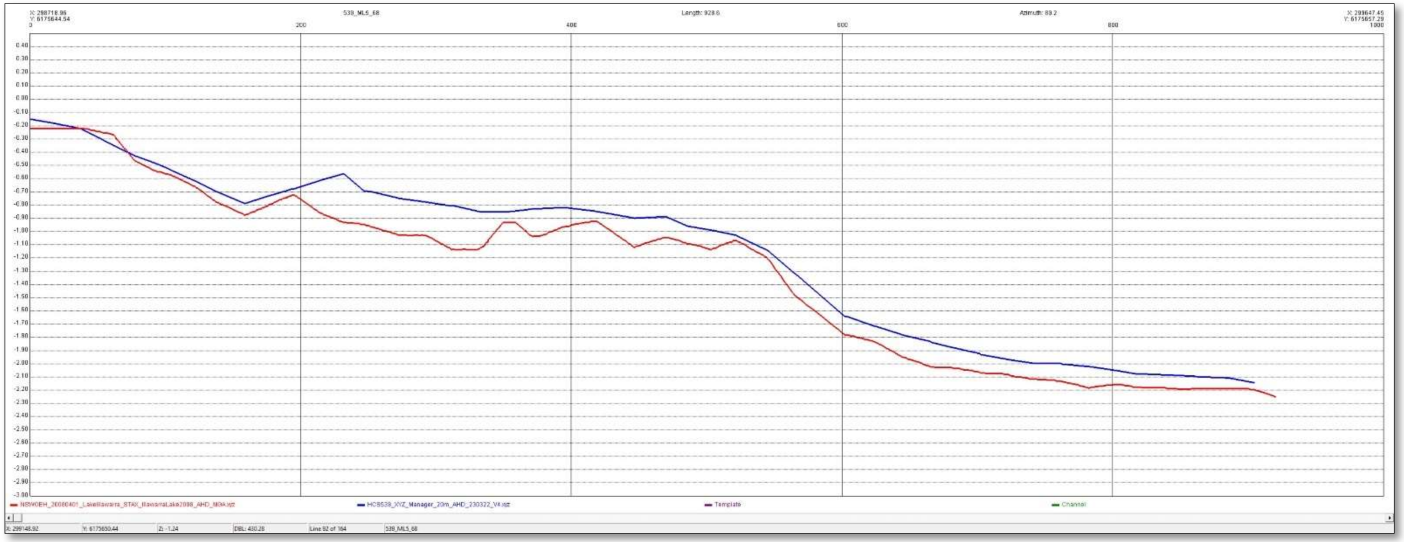


Figure 146: Lake 5 - profiles (red = 2008, blue = 2022/23) 67 and 68.

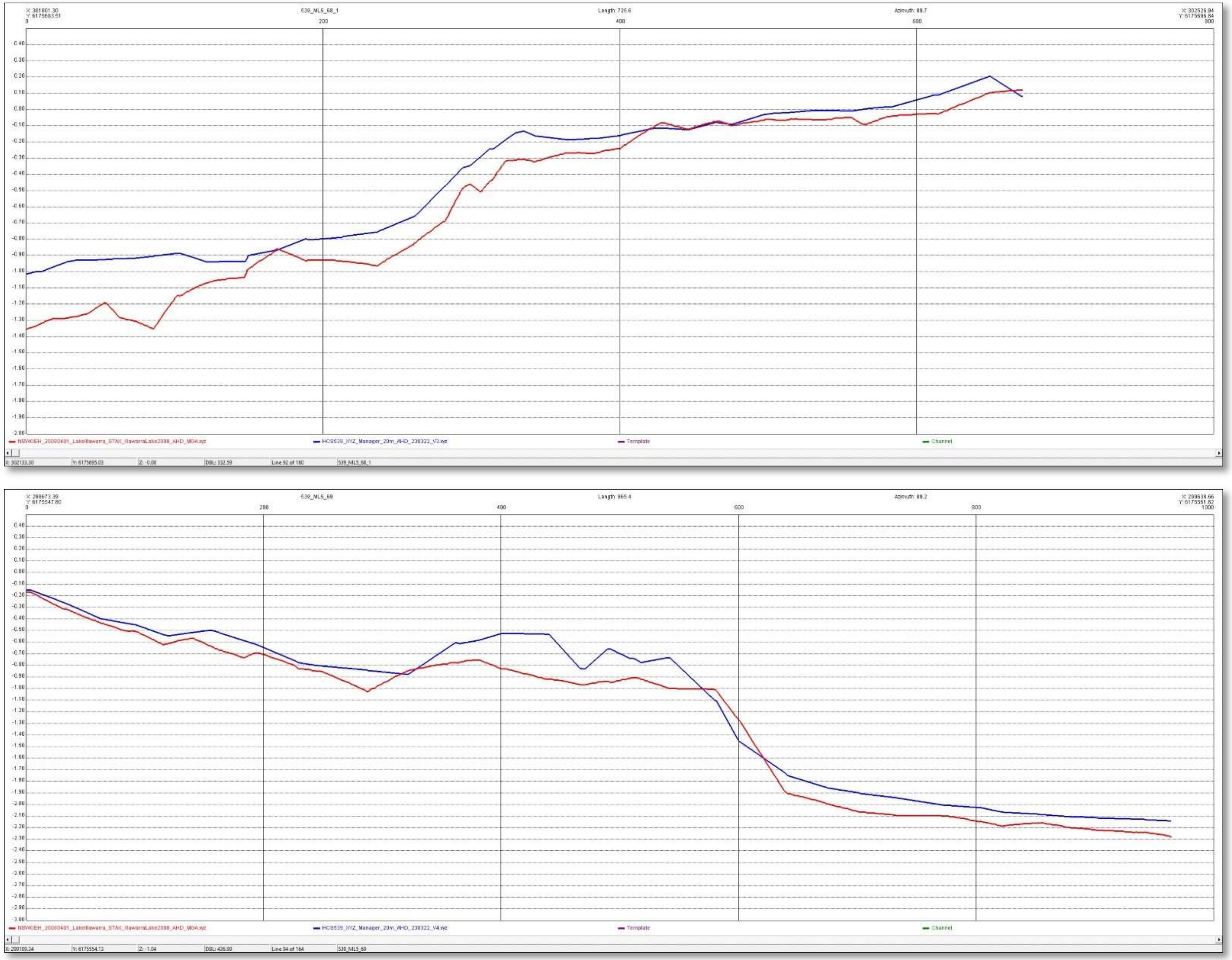
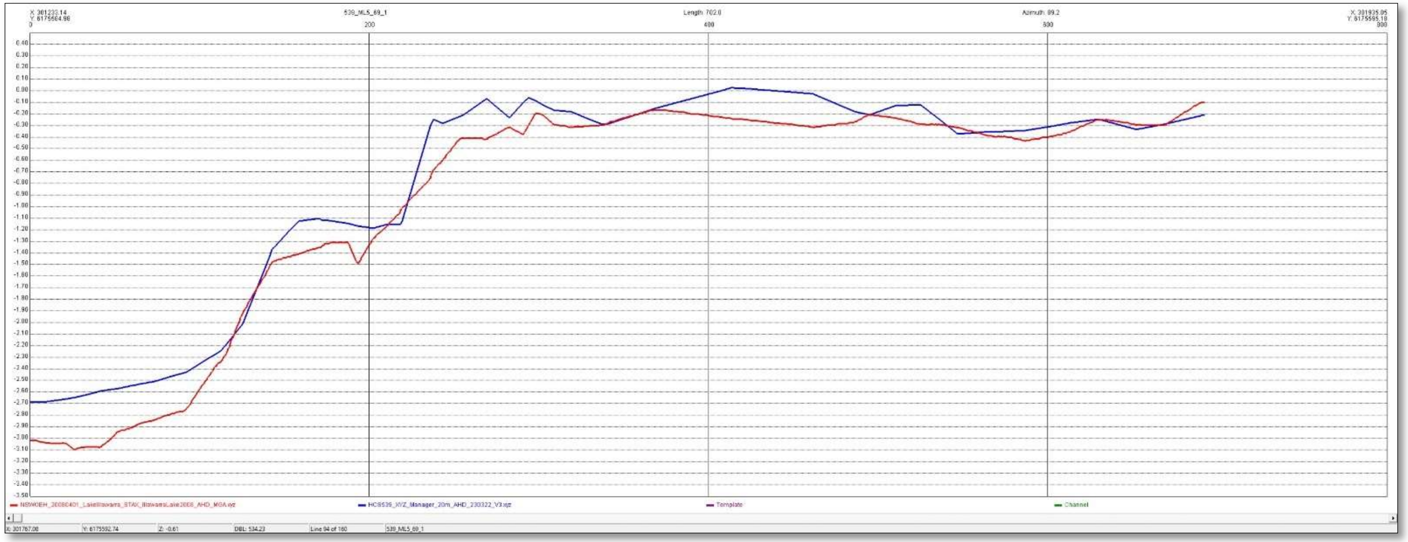


Figure 147: Lake 5 - profiles (red = 2008, blue = 2022/23) 68_1 and 69.



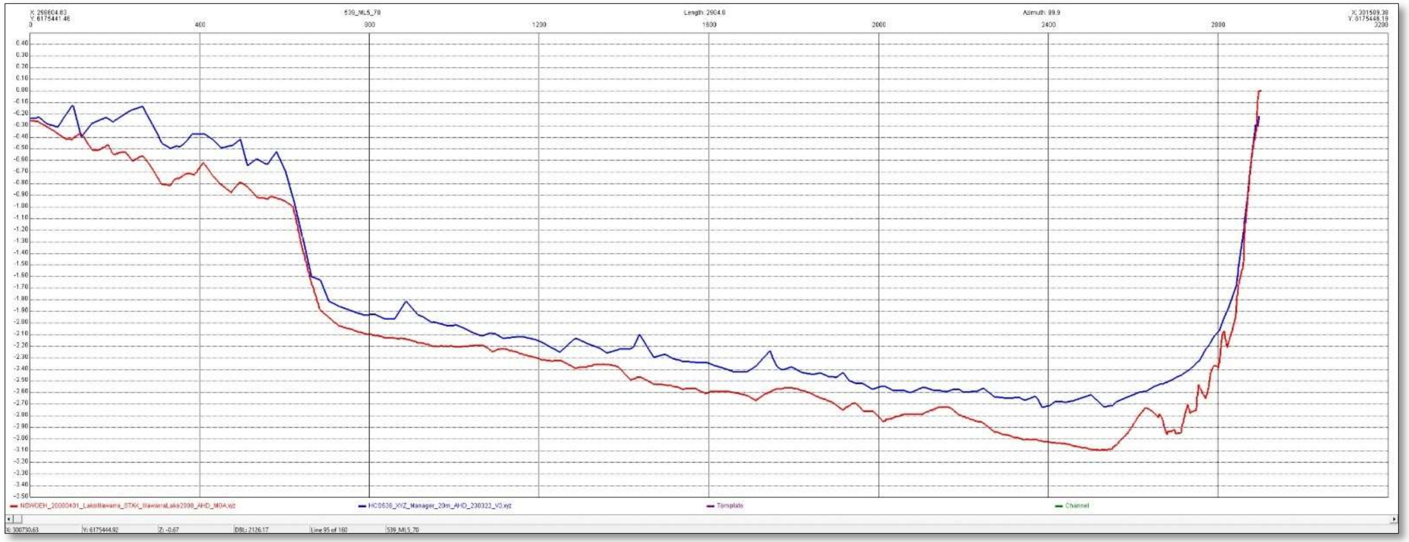


Figure 148: Lake 5 - profiles (red = 2008, blue = 2022/23) 69_1 and 70.

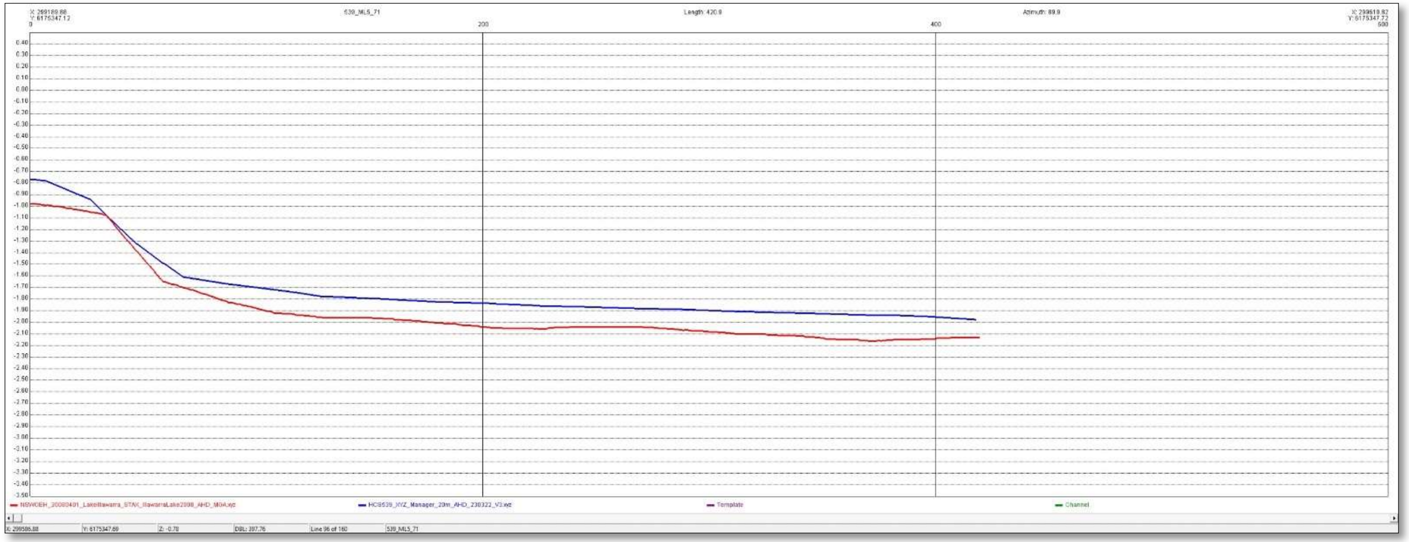
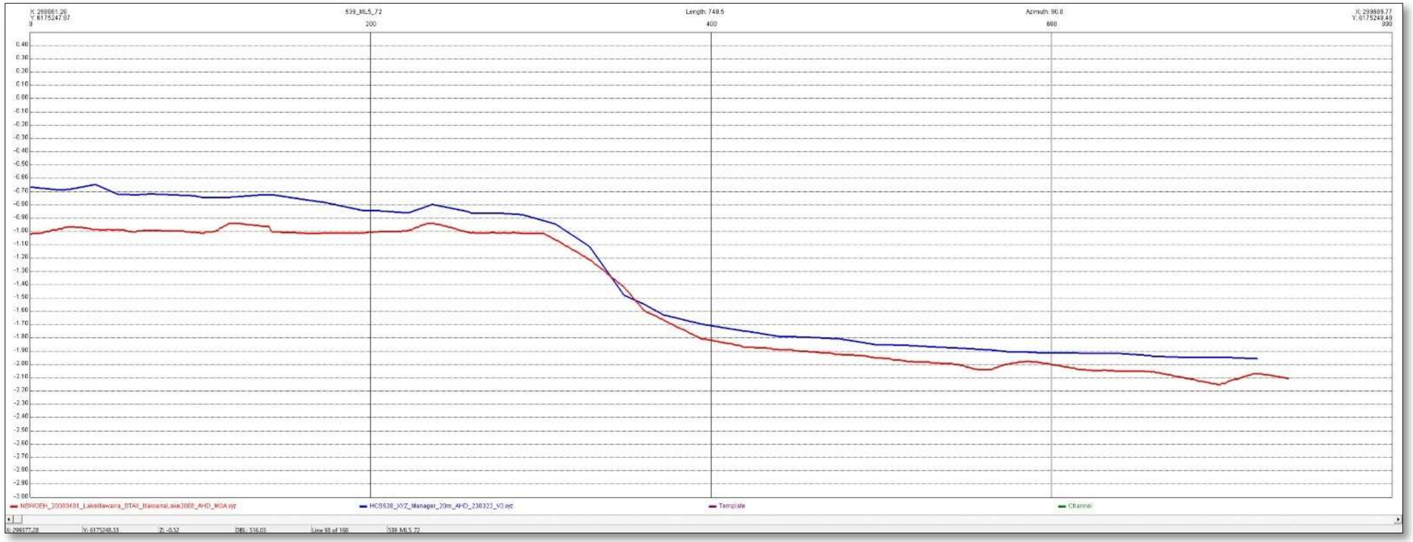


Figure 149: Lake 5 - profiles (red = 2008, blue = 2022/23) 71 and 71_1.



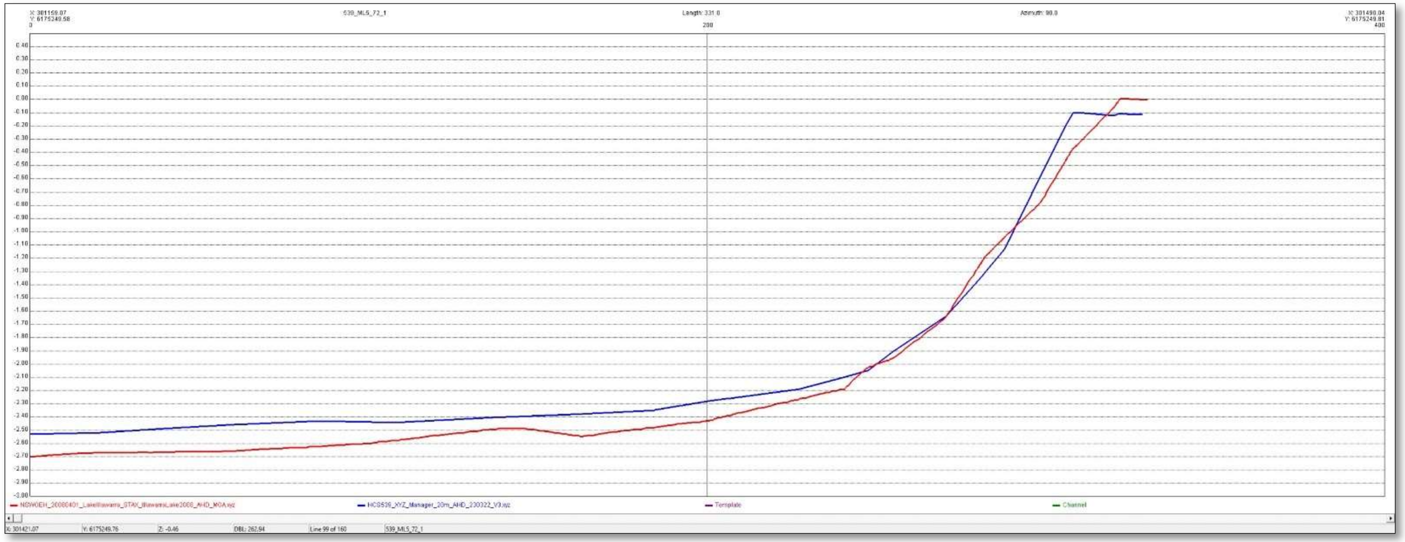


Figure 150: Lake 5 - profiles (red = 2008, blue = 2022/23) 72 and 72_1.

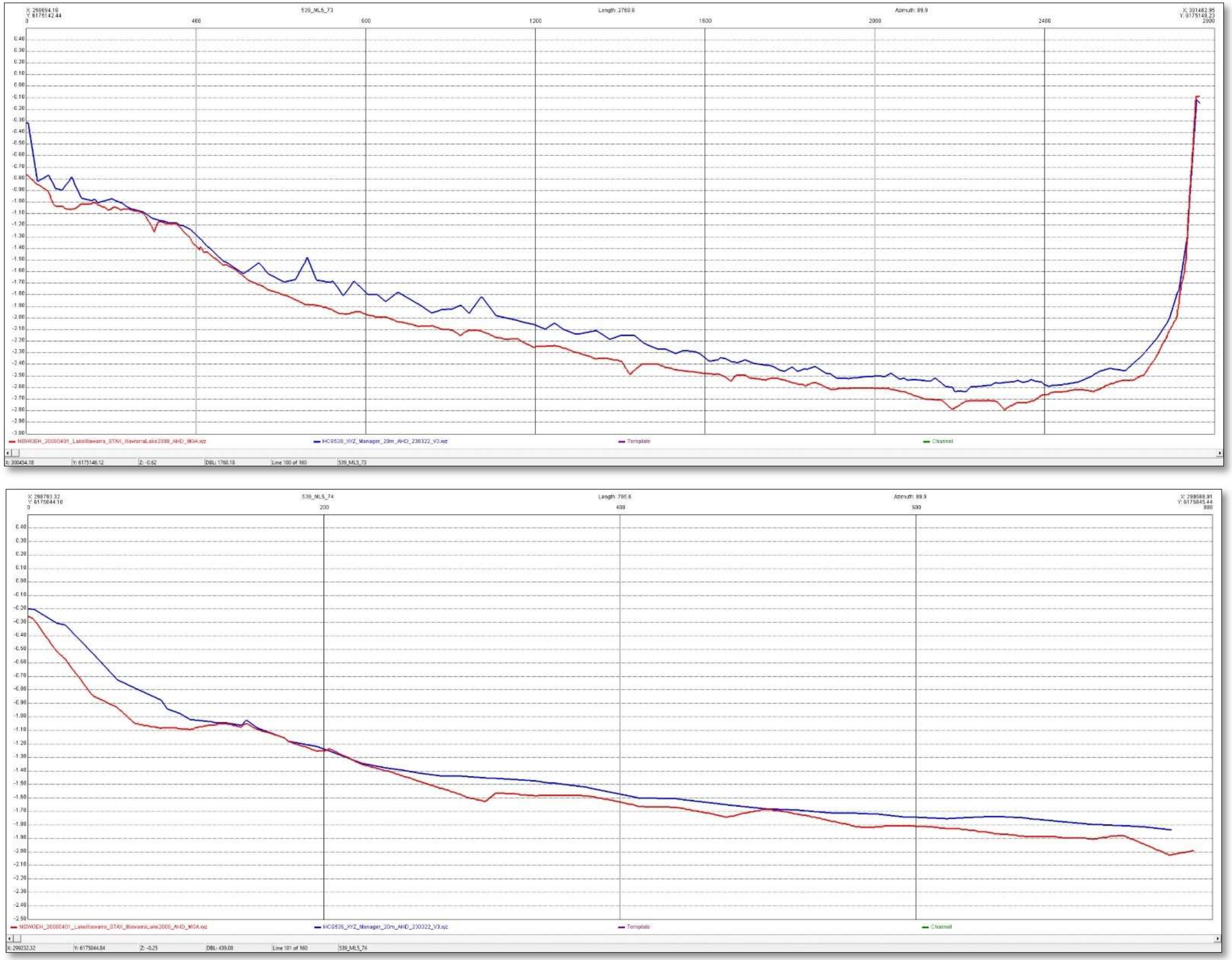


Figure 151: Lake 5 - profiles (red = 2008, blue = 2022/23) 73 and 74.

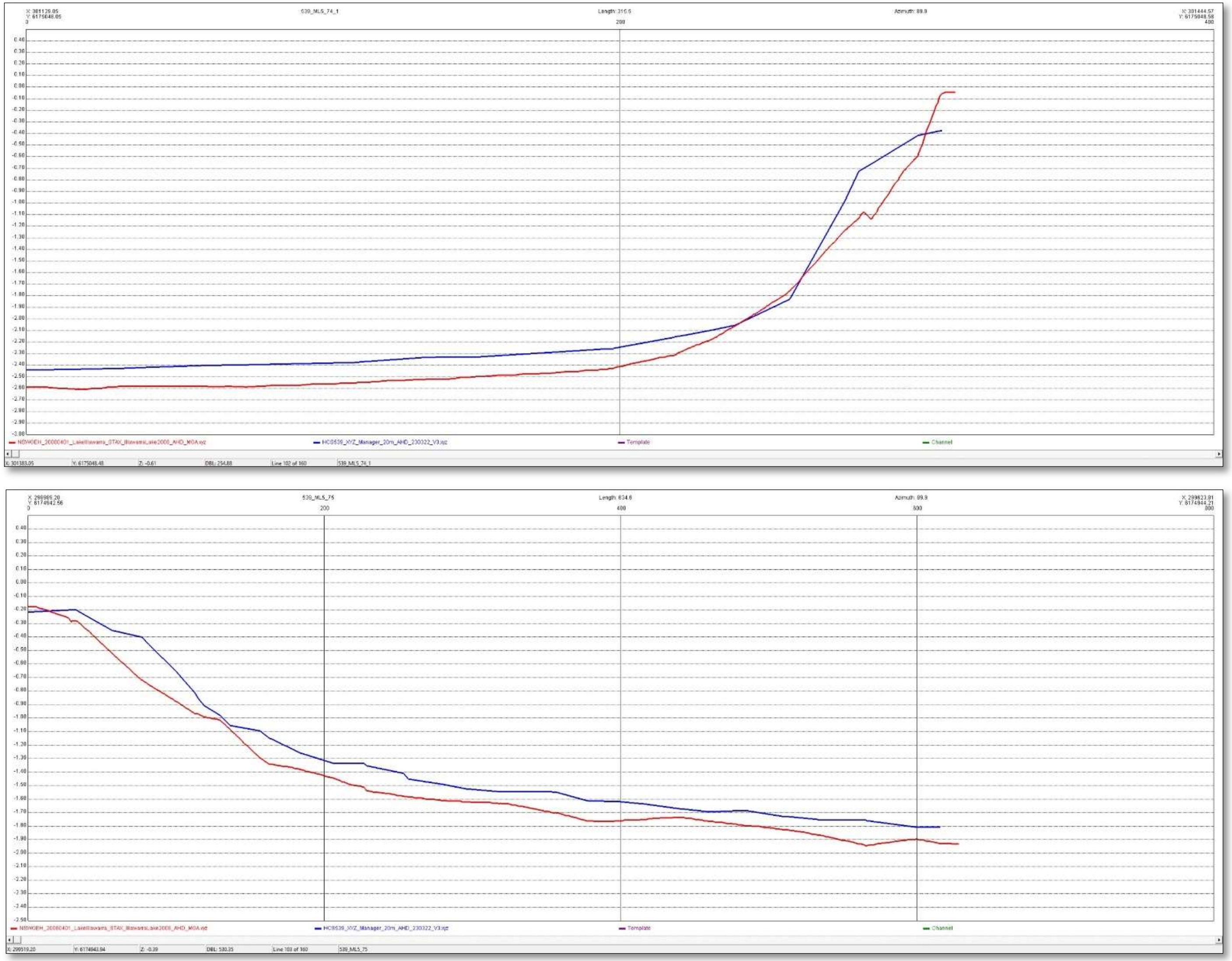
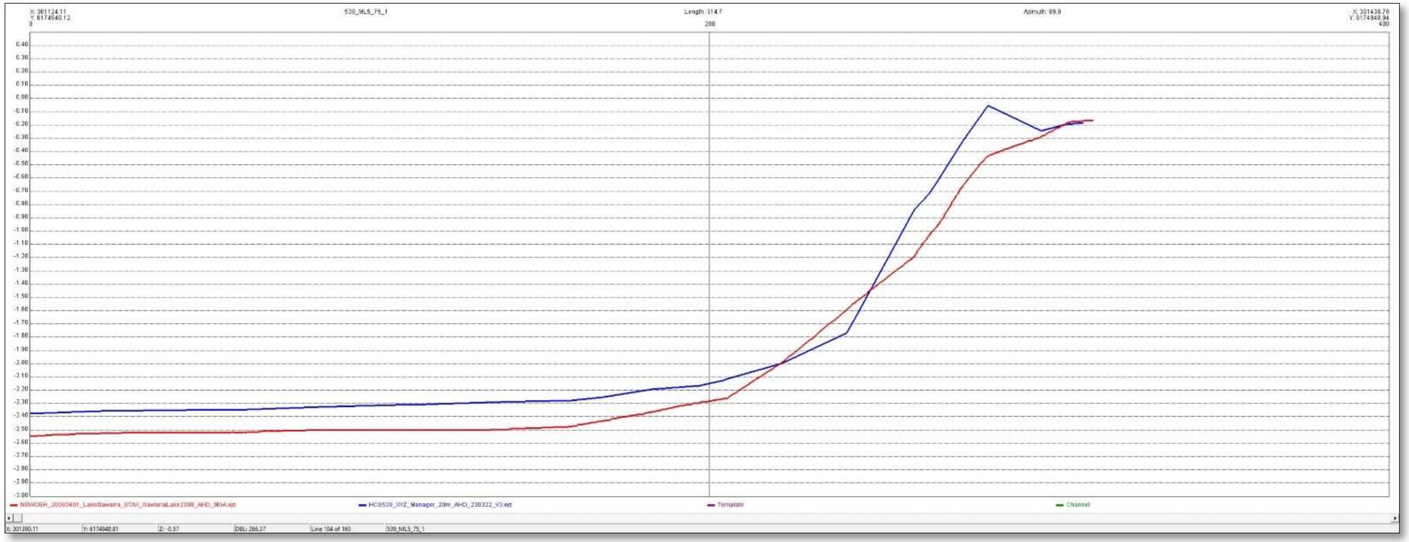


Figure 152: Lake 5 - profiles (red = 2008, blue = 2022/23) 74_1 and 75.



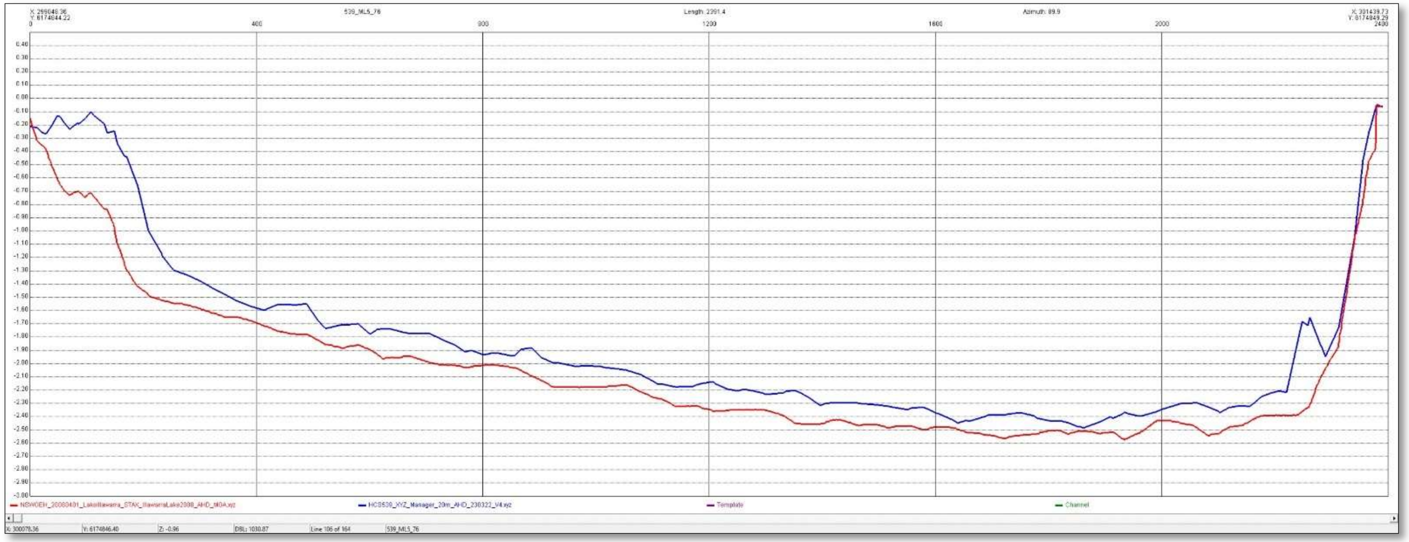


Figure 153: Lake 5 - profiles (red = 2008, blue = 2022/23) 75_1 and 76.

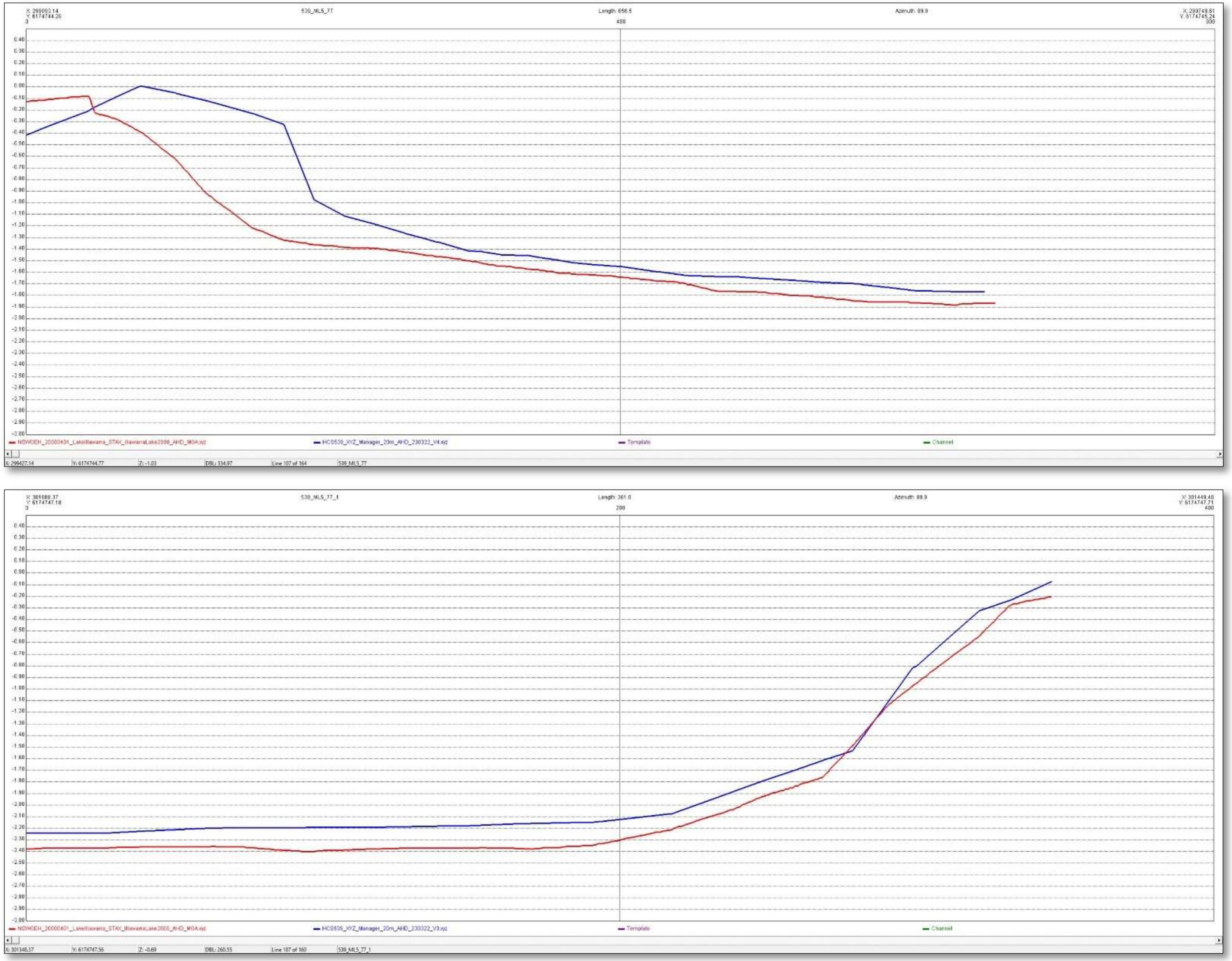


Figure 154: Lake 5 - profiles (red = 2008, blue = 2022/23) 77 and 77_1.

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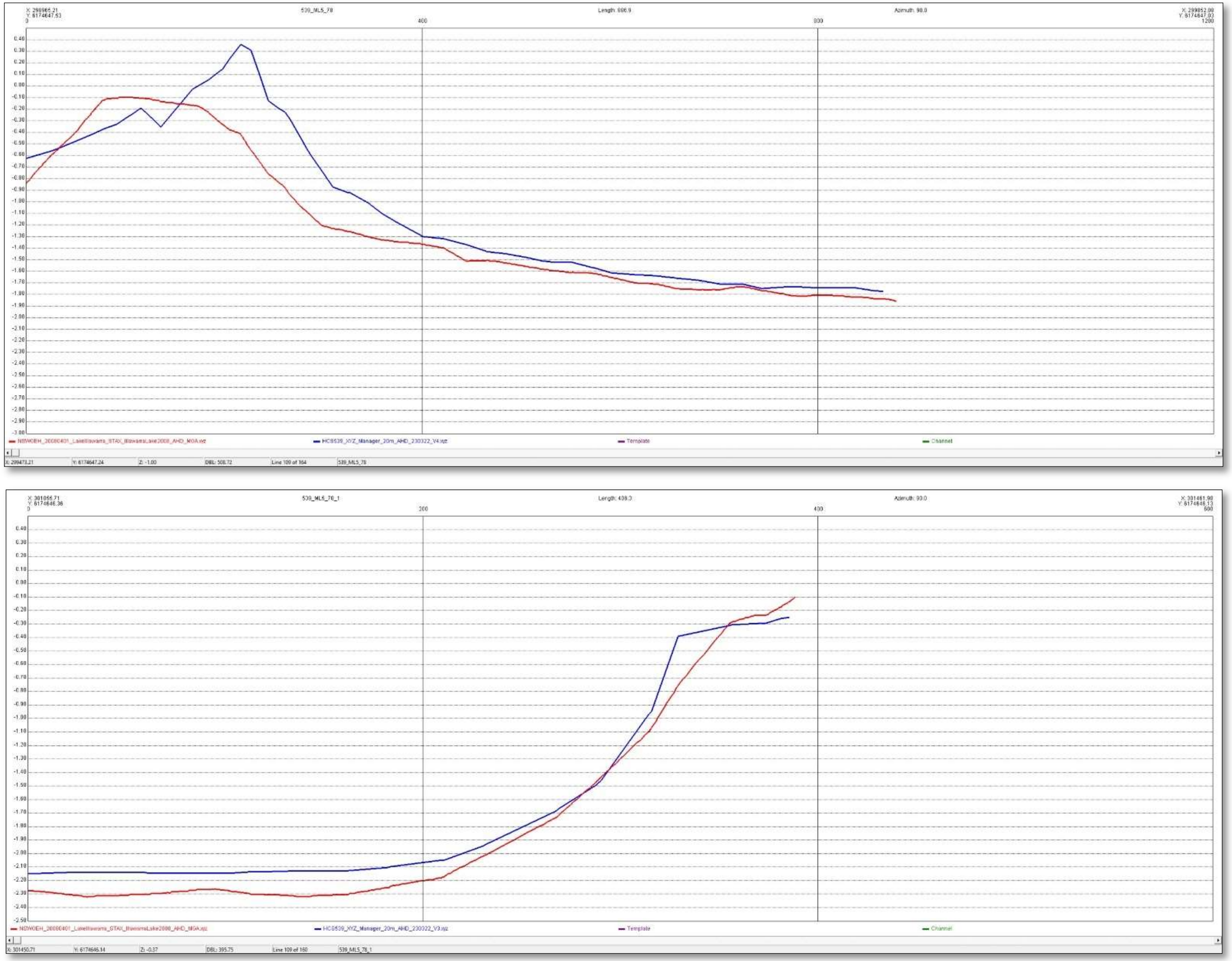


Figure 155: Lake 5 - profiles (red = 2008, blue = 2022/23) 78 and 78_1.

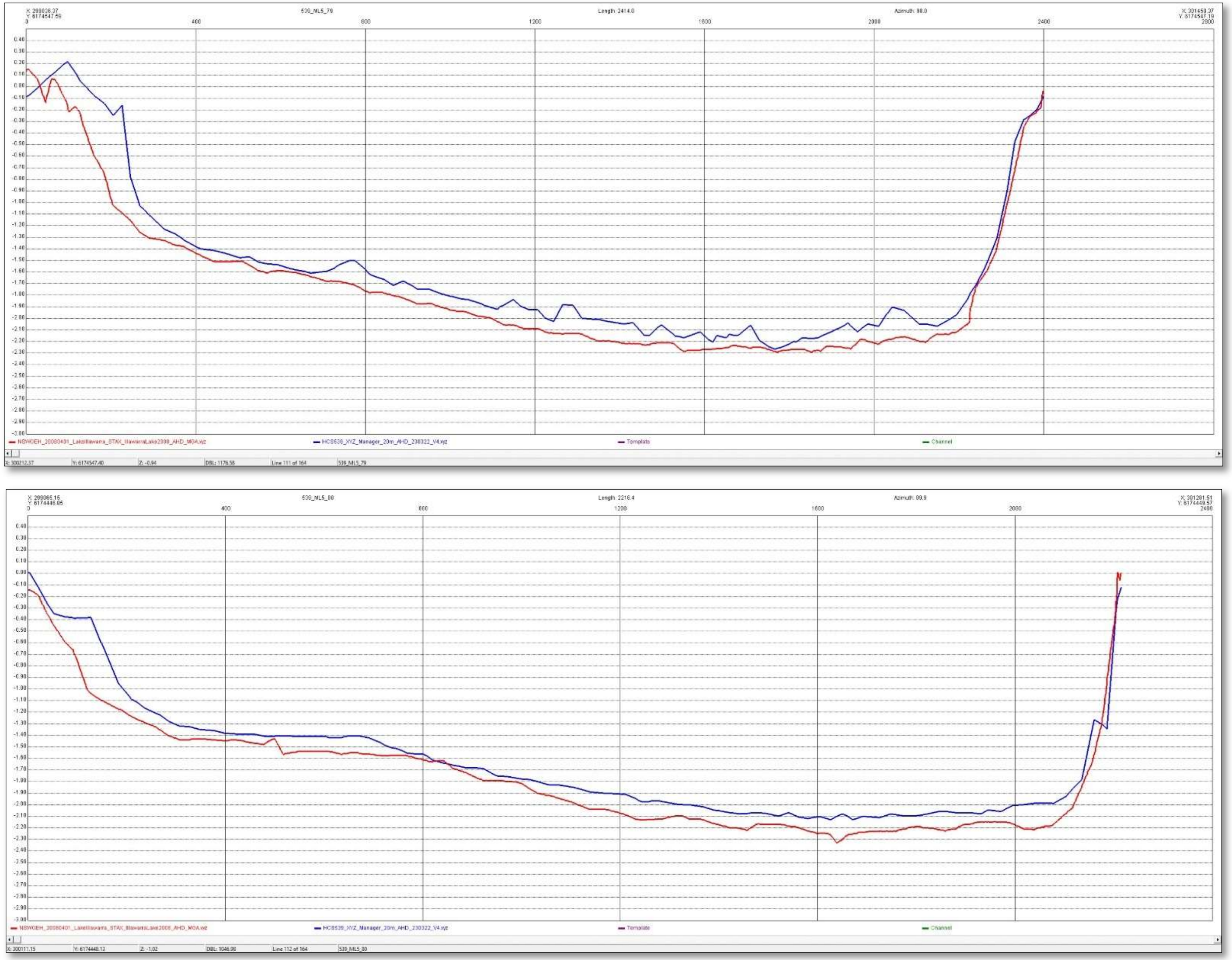
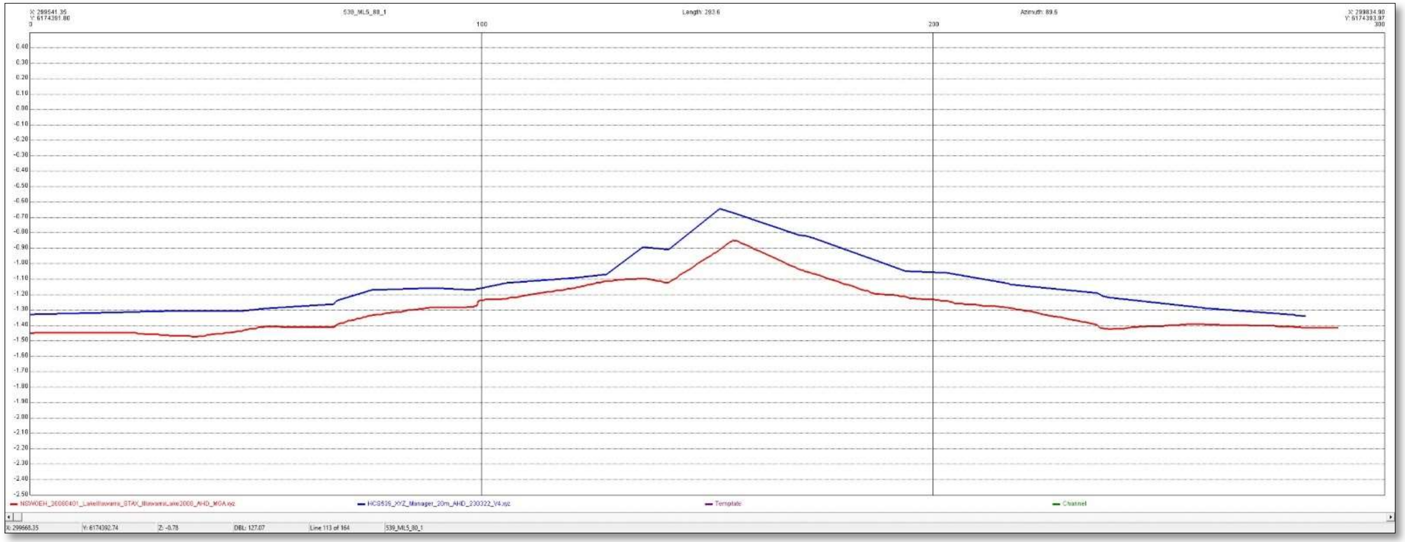


Figure 156: Lake 5 - profiles (red = 2008, blue = 2022/23) 79 and 80.



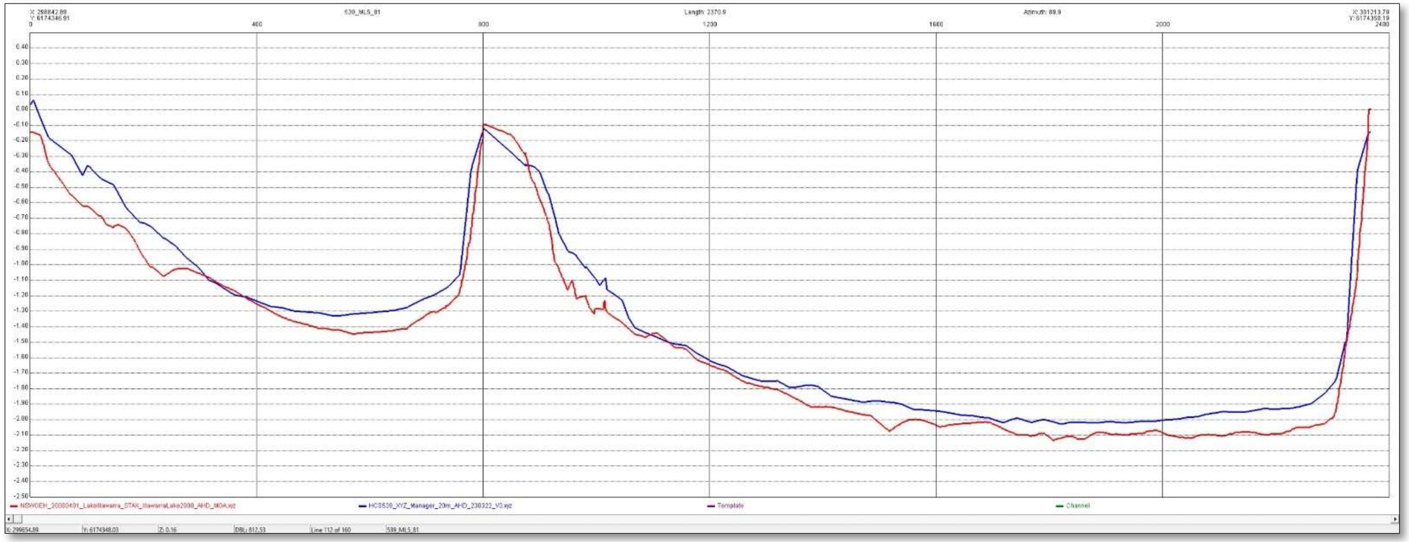
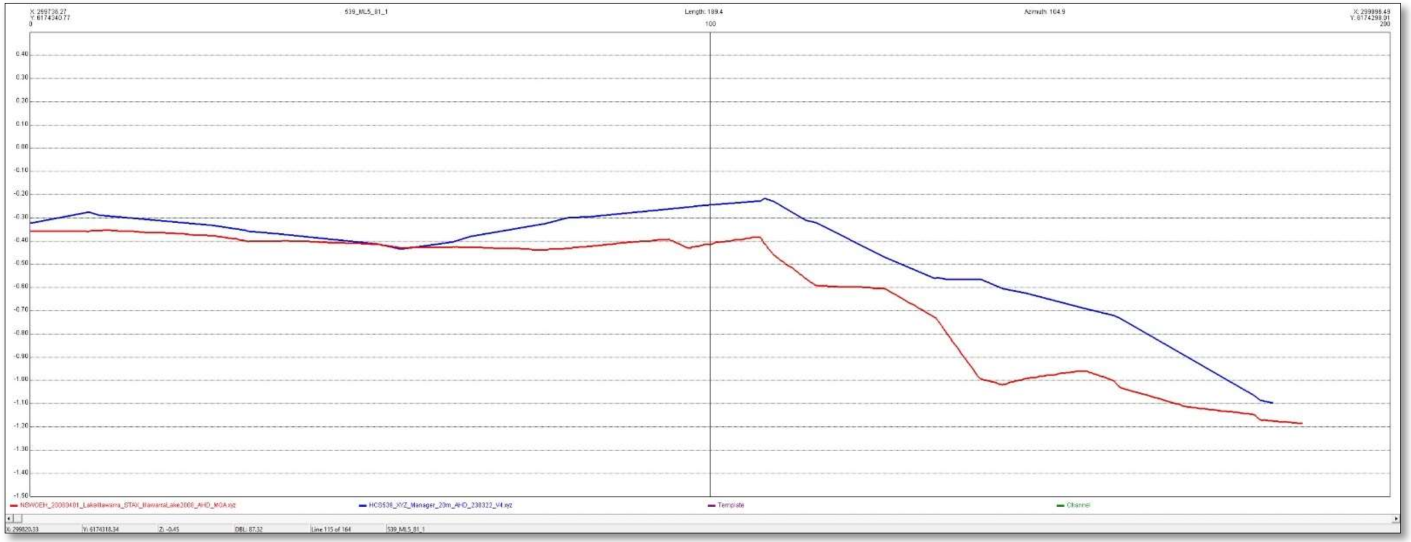


Figure 157: Lake 5 - profiles (red = 2008, blue = 2022/23) 80_1 and 81.



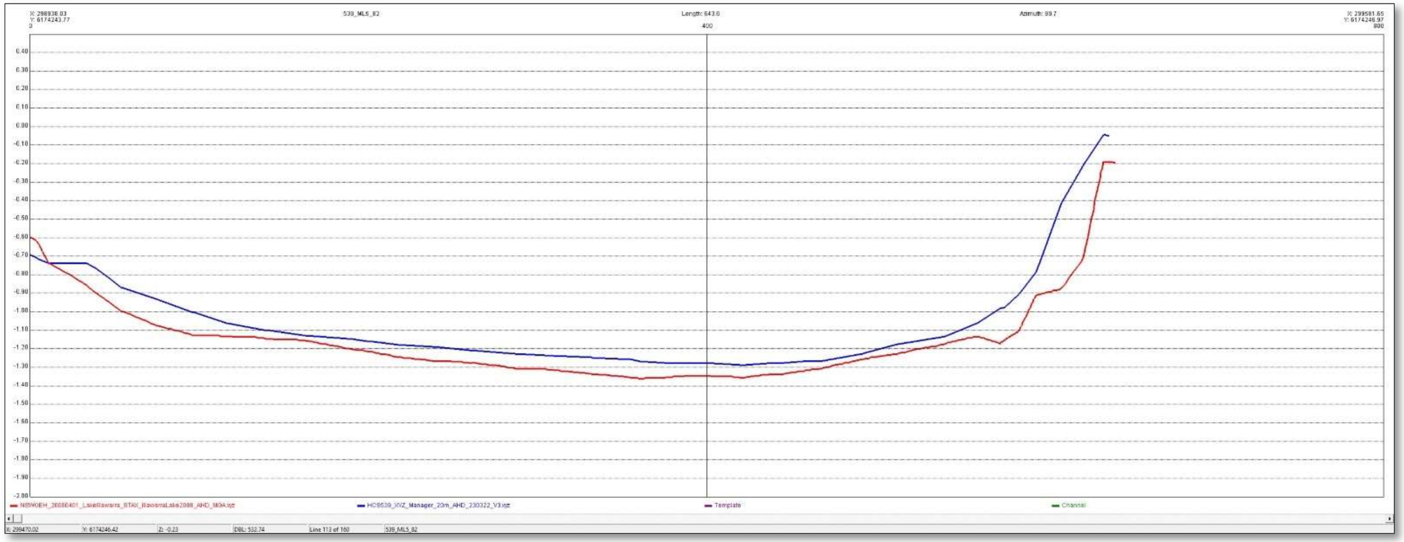


Figure 158: Lake 5 - profiles (red = 2008, blue = 2022/23) 81_1 and 82.

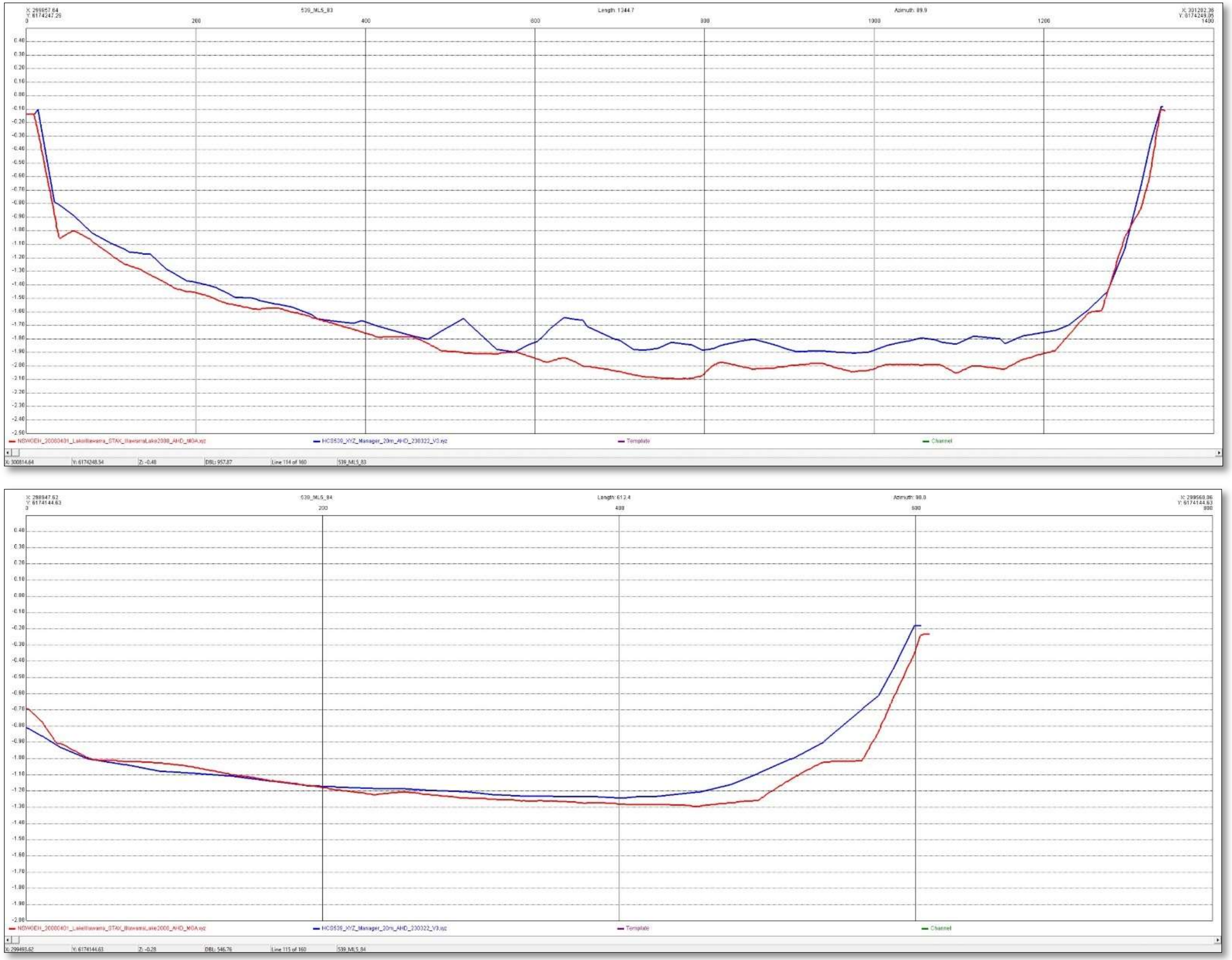
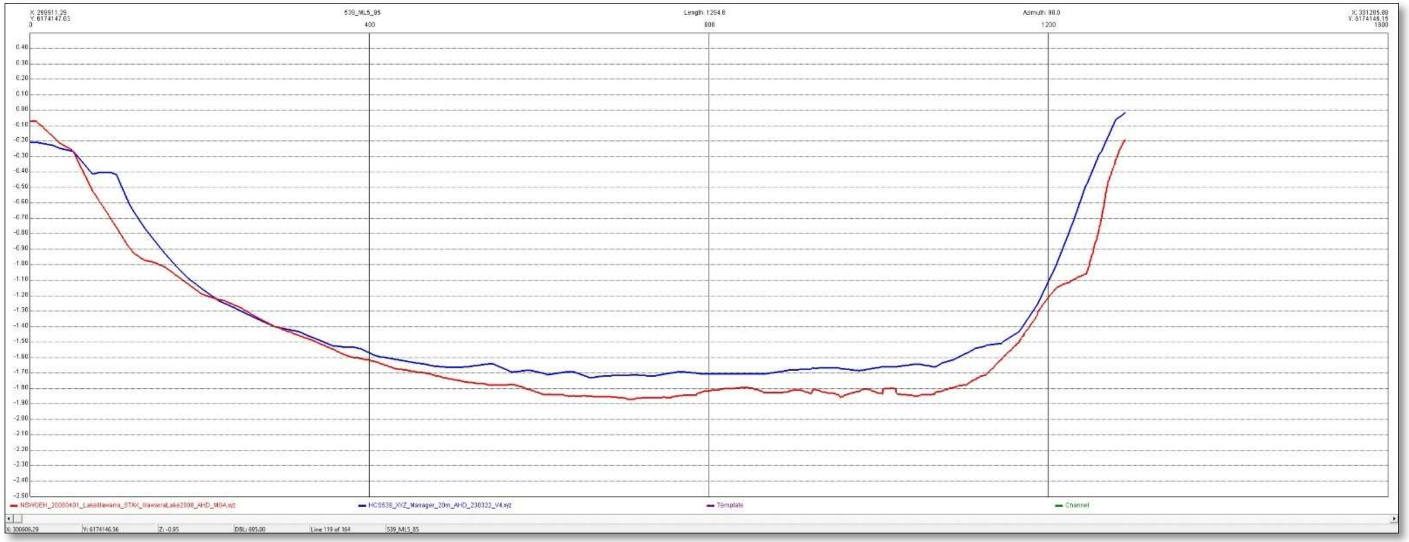


Figure 159: Lake 5 - profiles (red = 2008, blue = 2022/23) 83 and 84.



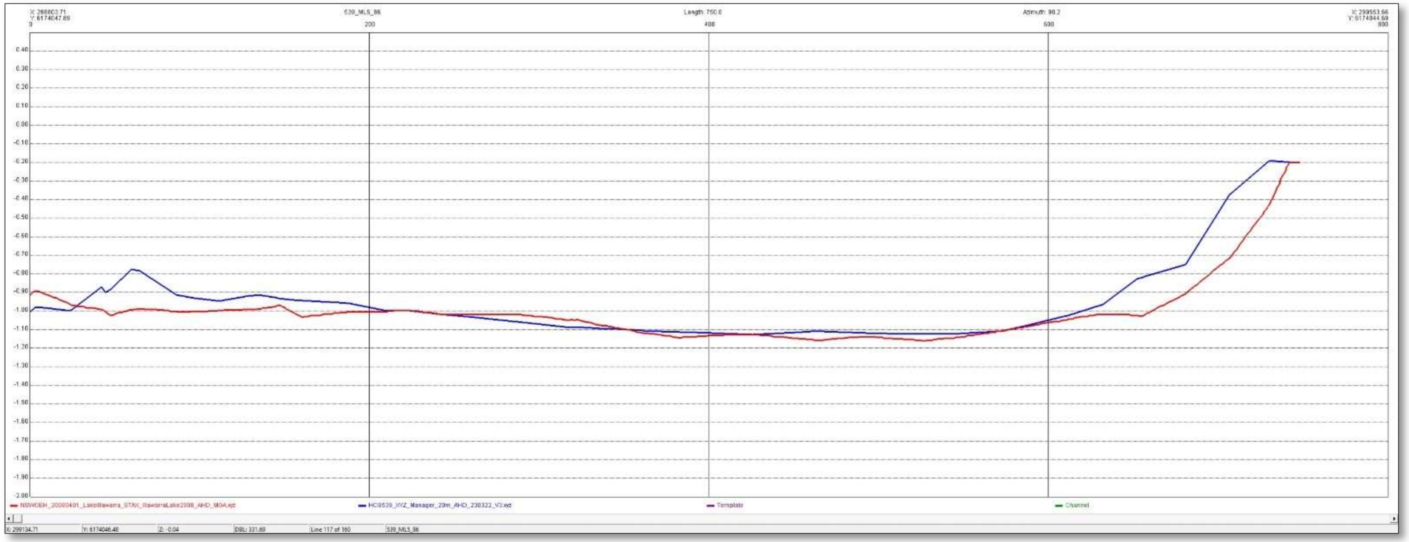


Figure 160: Lake 5 - profiles (red = 2008, blue = 2022/23) 85 and 86.

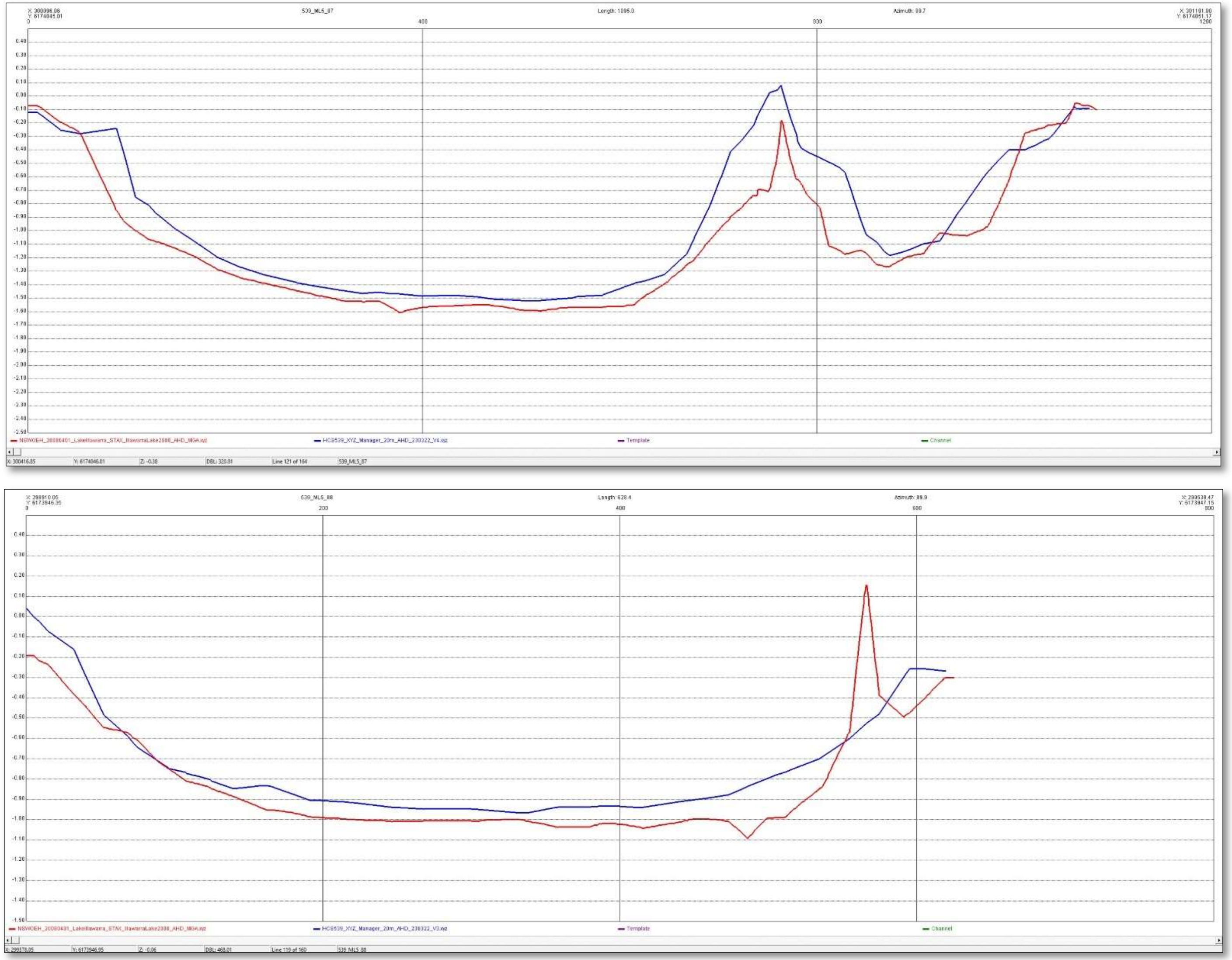


Figure 161: Lake 5 - profiles (red = 2008, blue = 2022/23) 87 and 88.

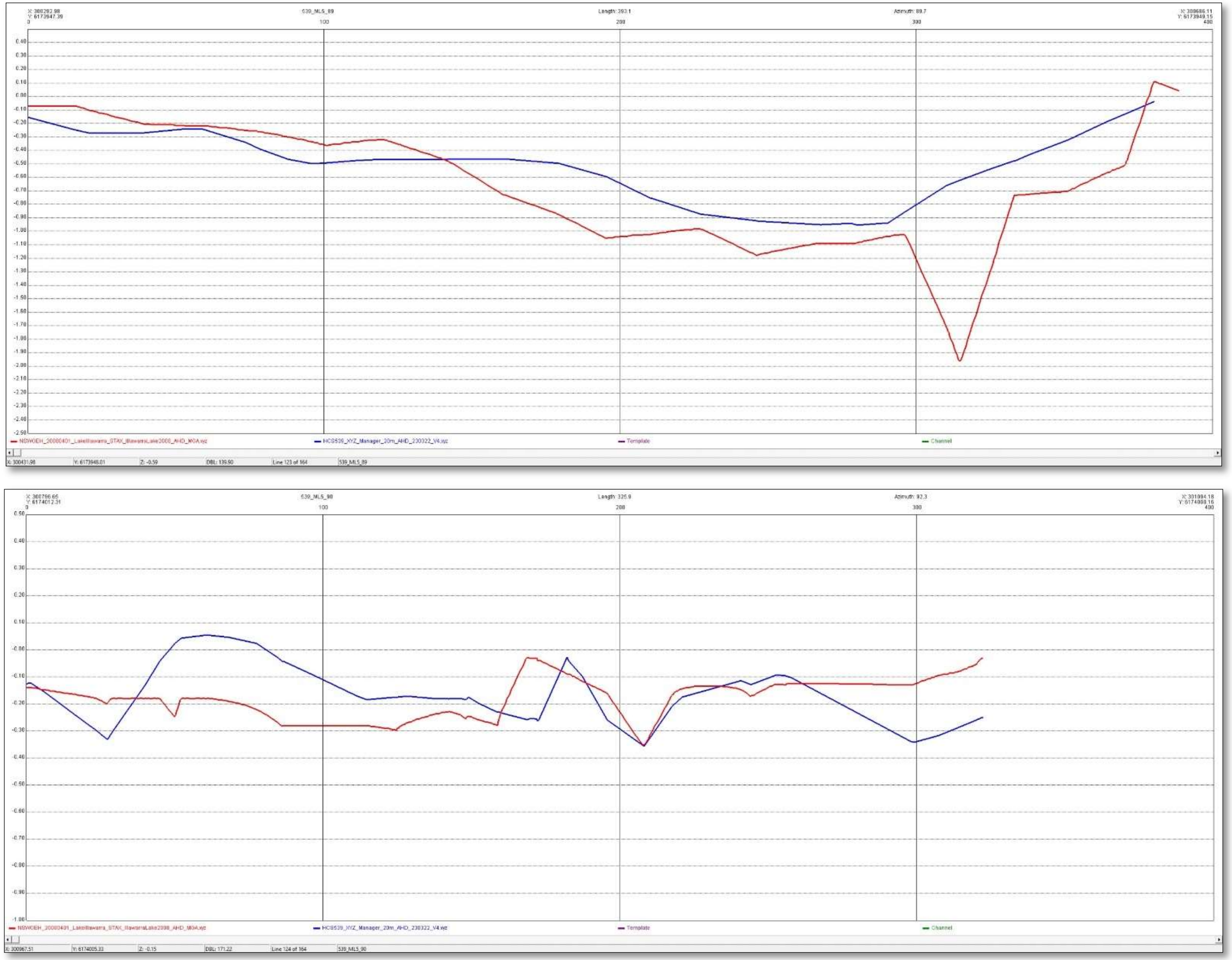


Figure 162: Lake 5 - profiles (red = 2008, blue = 2022/23) 89 and 90.

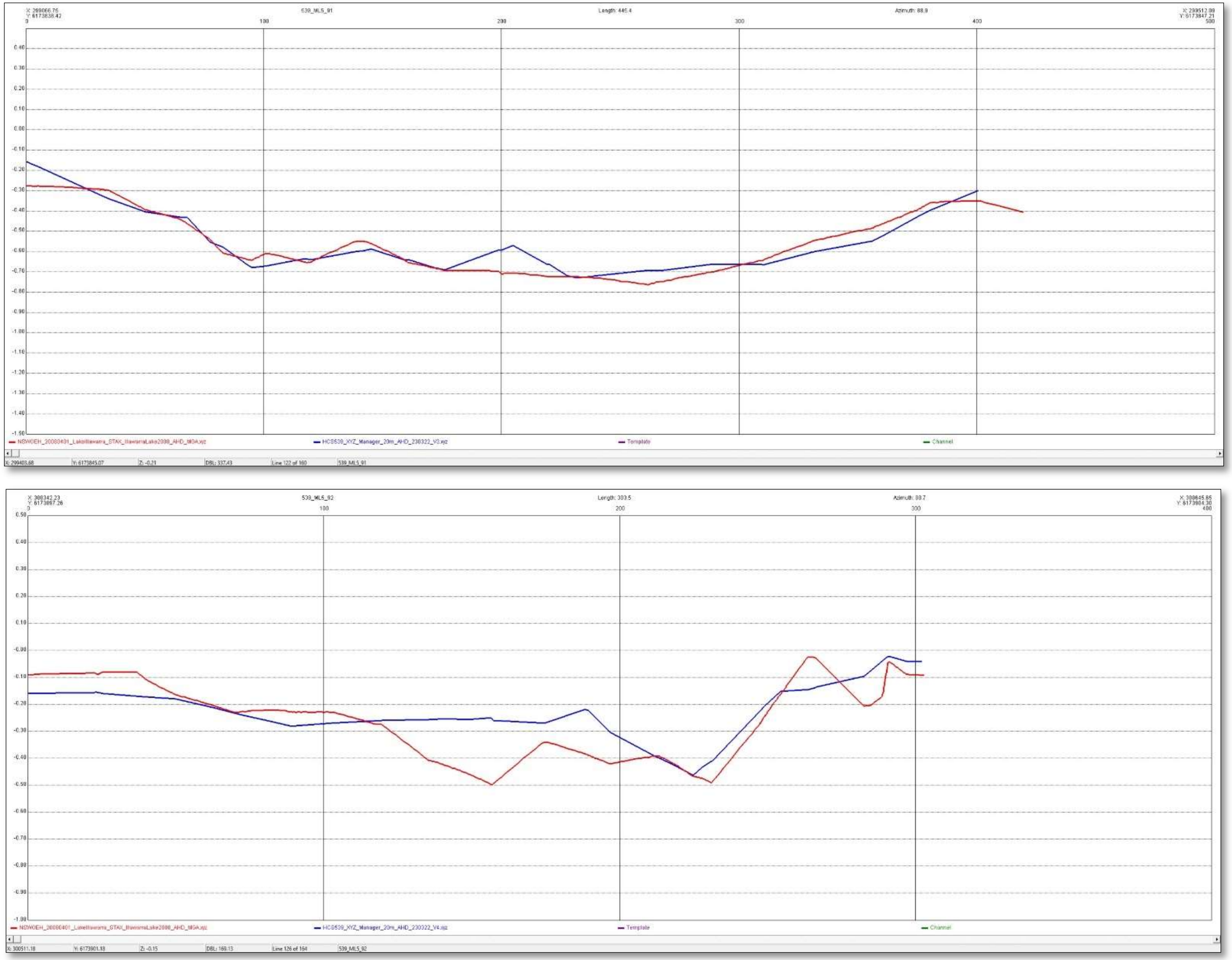
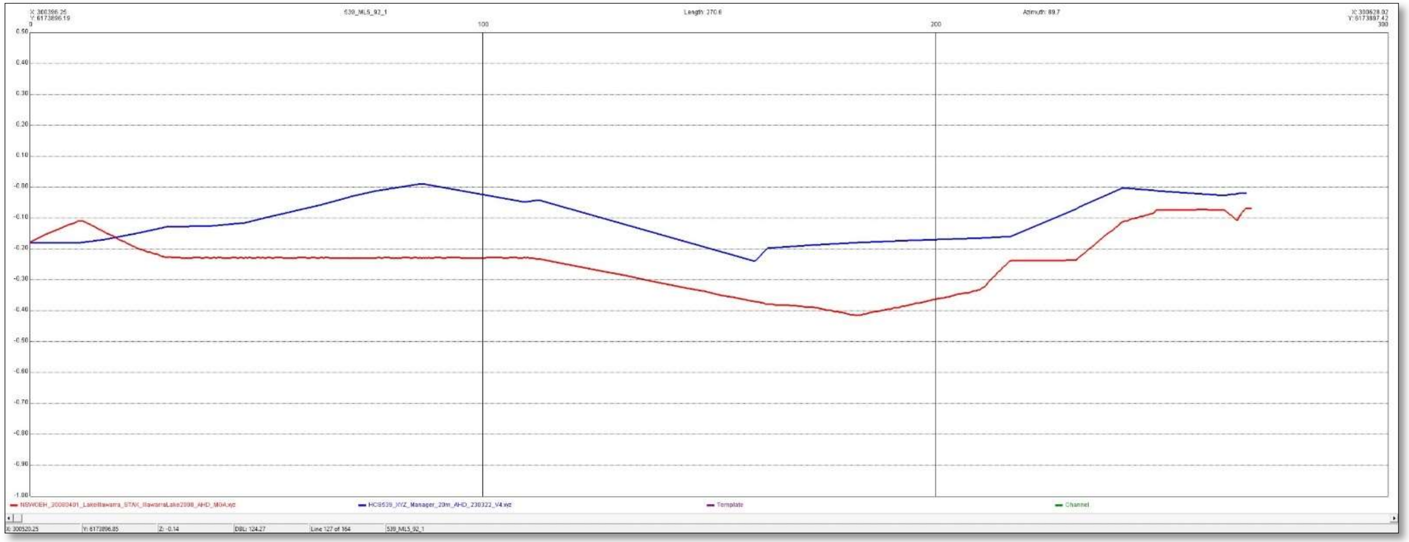


Figure 163: Lake 5 - profiles (red = 2008, blue = 2022/23) 91 and 92.



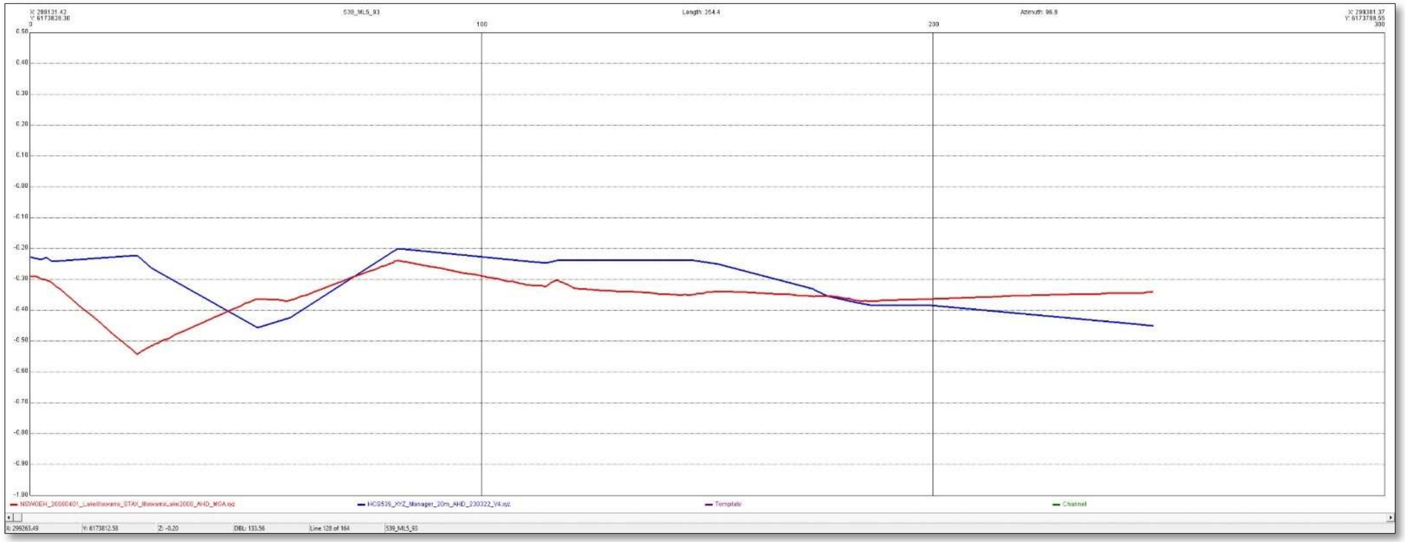


Figure 164: Lake 5 - profiles (red = 2008, blue = 2022/23) 92_1 and 93.

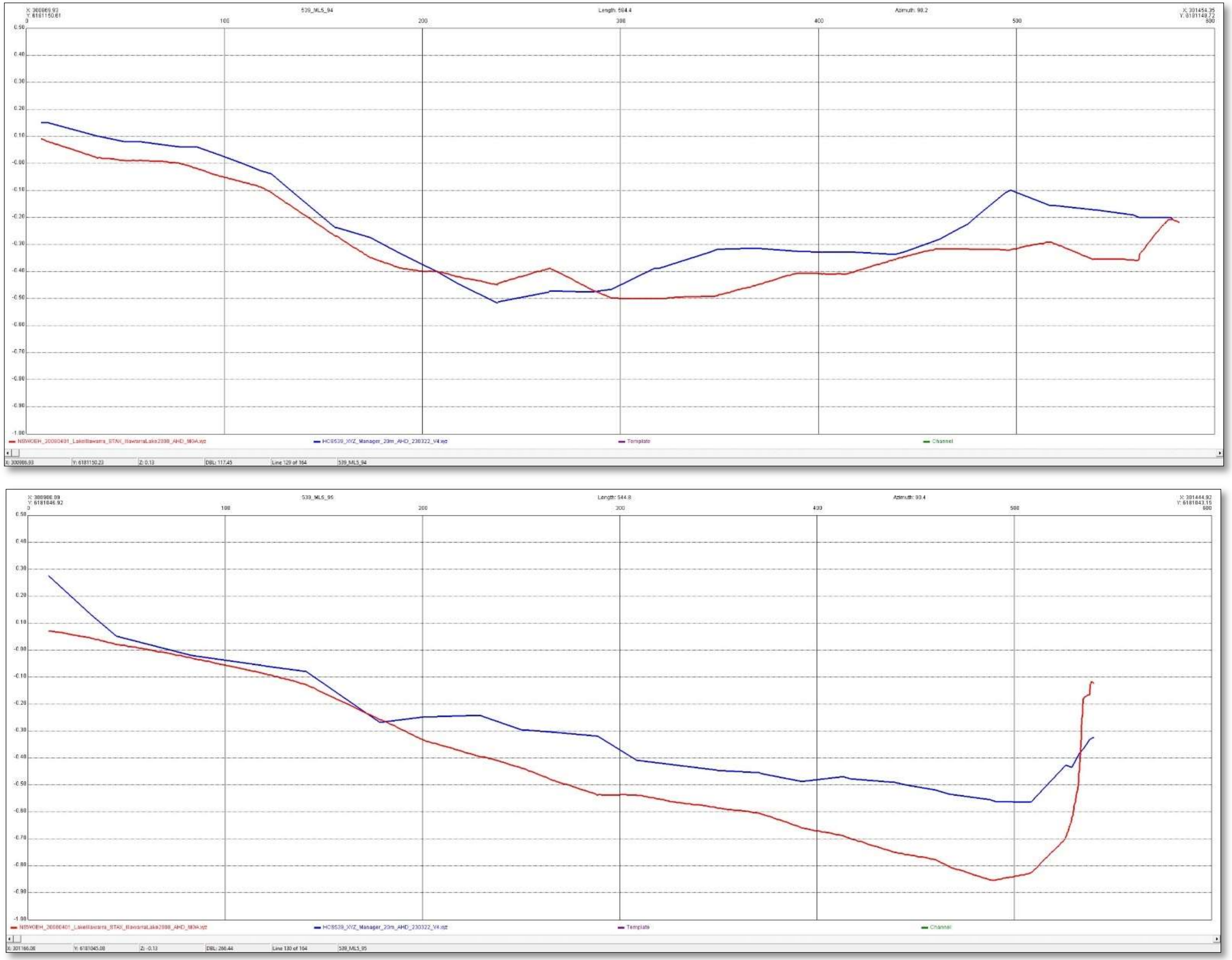


Figure 165: Lake 5 - profiles (red = 2008, blue = 2022/23) 94 and 95.

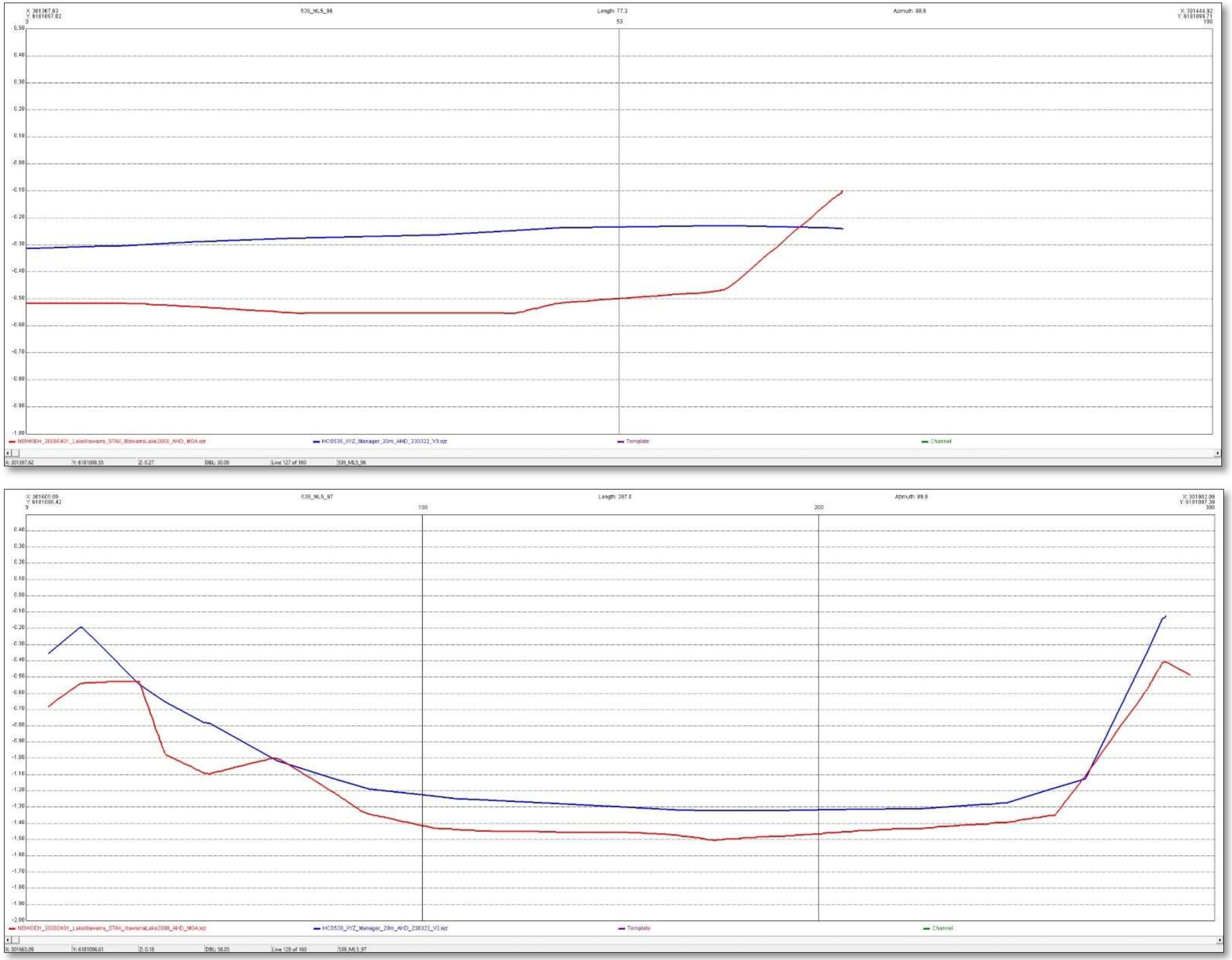


Figure 166: Lake 5 - profiles (red = 2008, blue = 2022/23) 96 and 97.

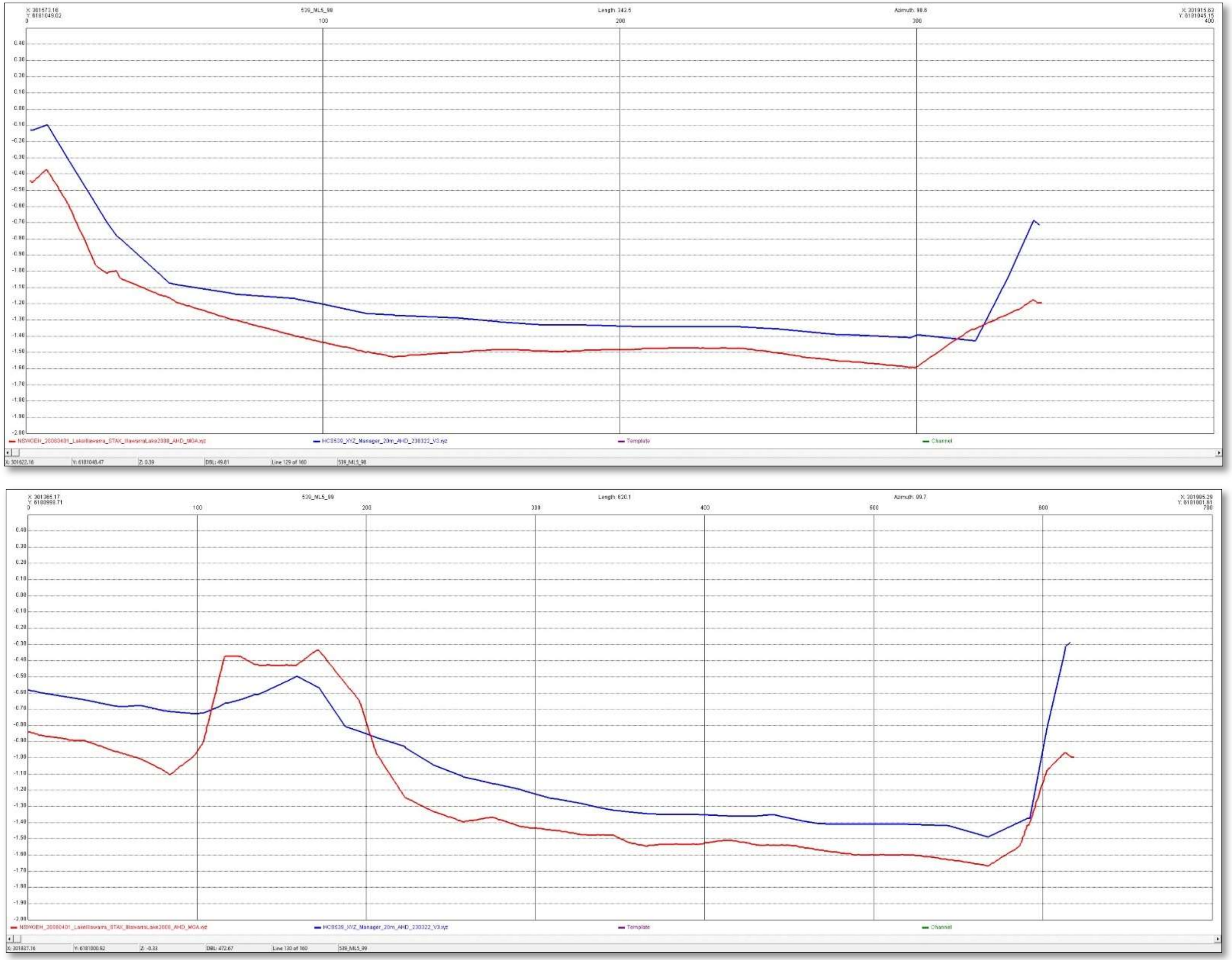


Figure 167: Lake 5 - profiles (red = 2008, blue = 2022/23) 98 and 99.

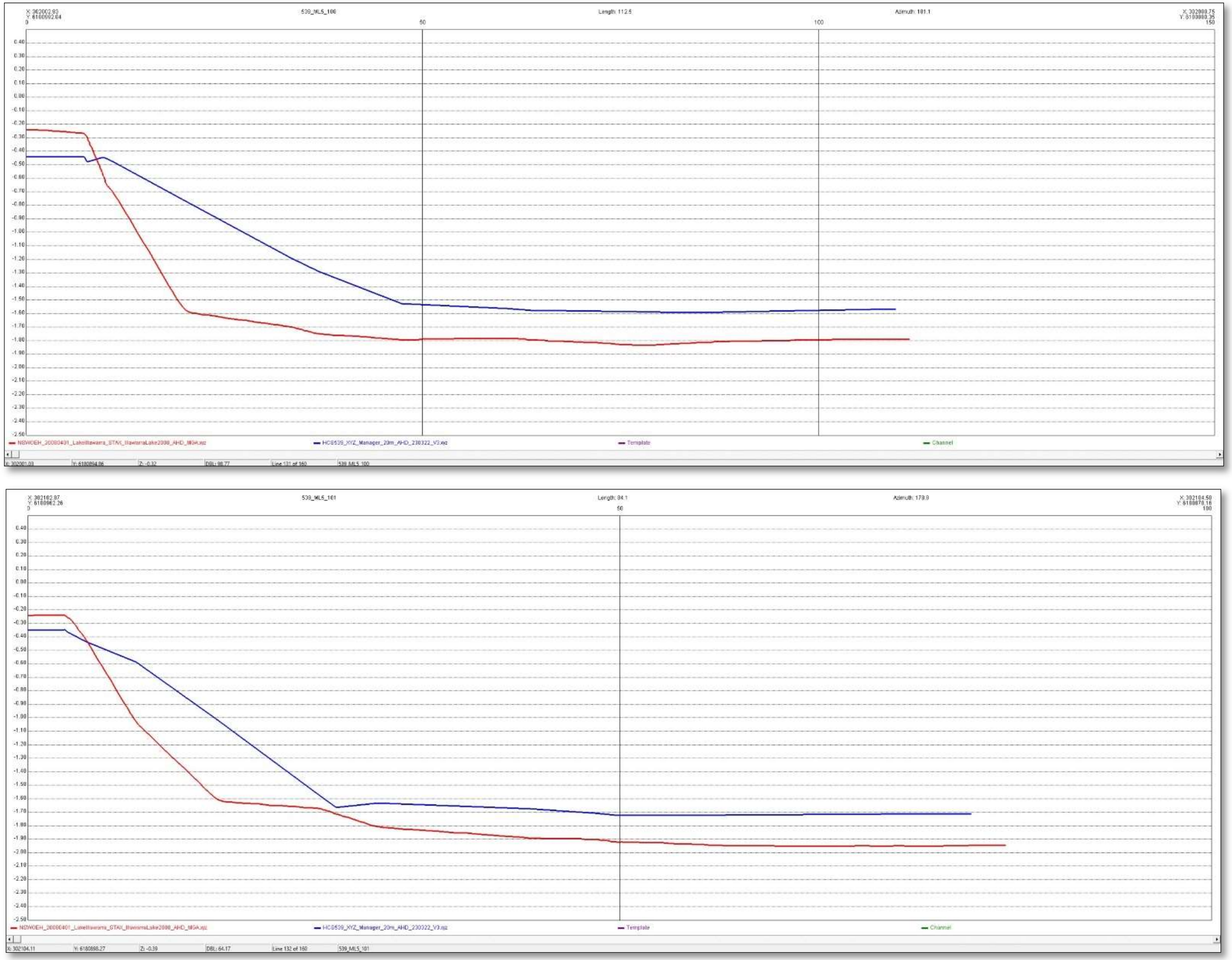
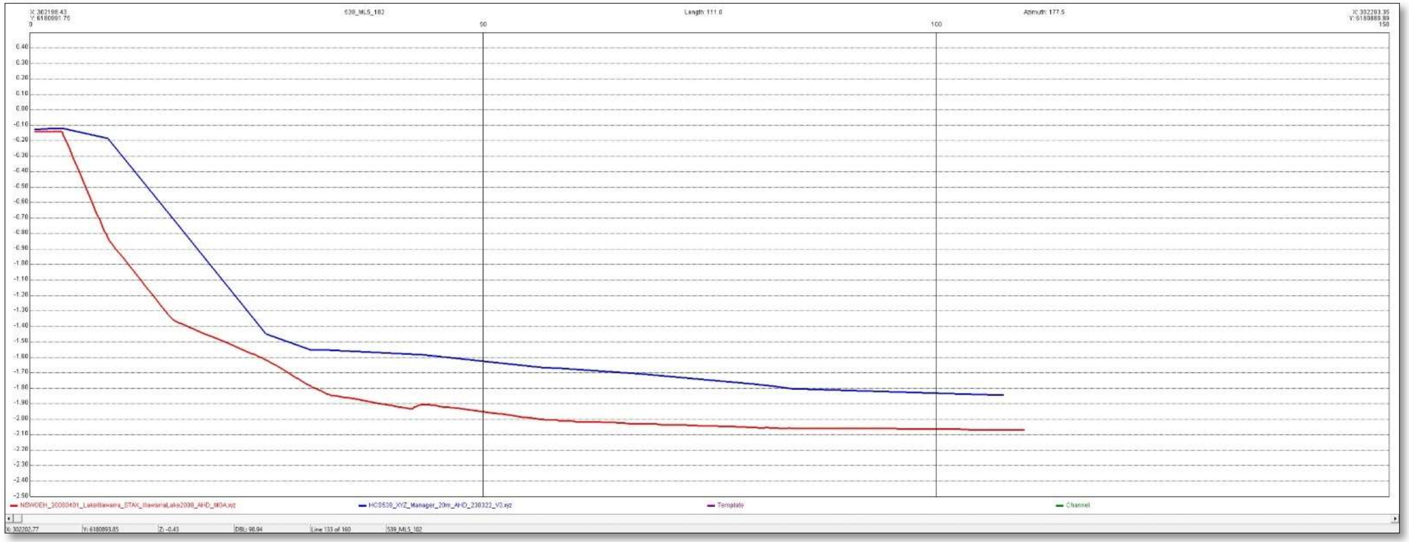


Figure 168: Lake 5 - profiles (red = 2008, blue = 2022/23) 100 and 101.



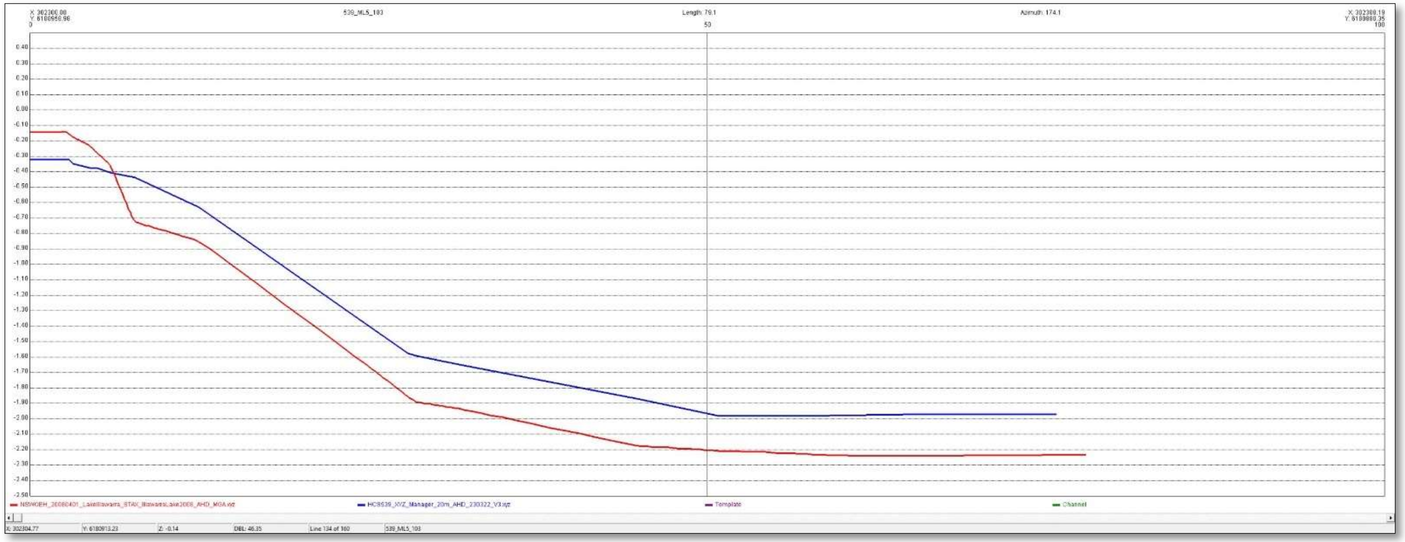
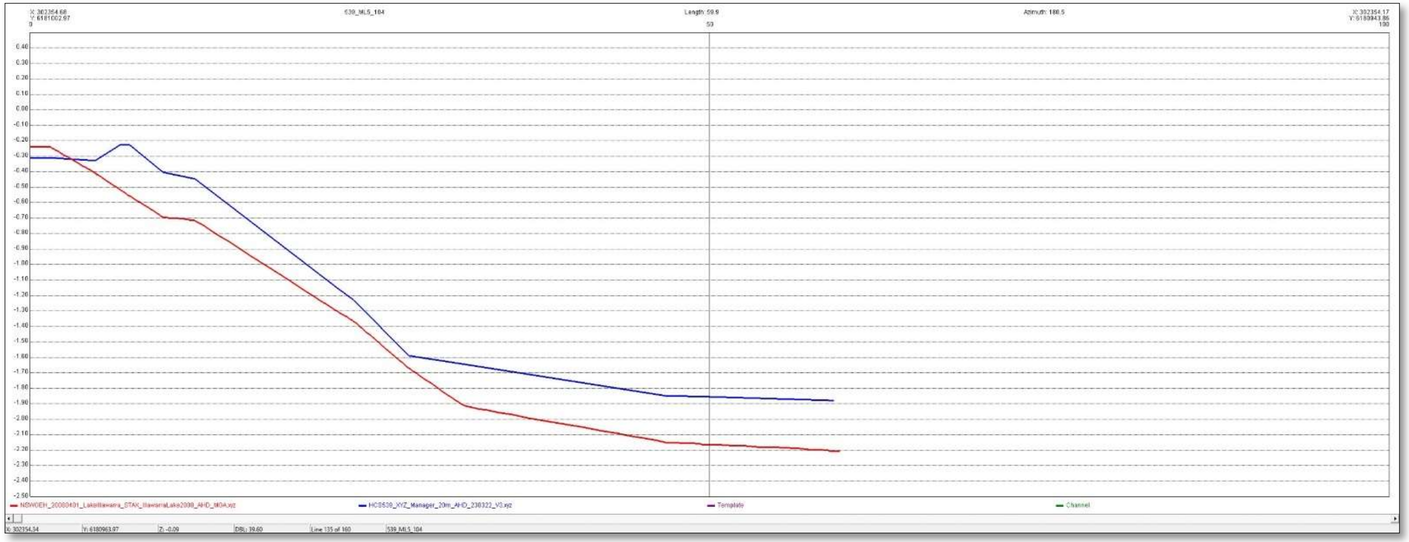


Figure 169: Lake 5 - profiles (red = 2008, blue = 2022/23) 102 and 103.



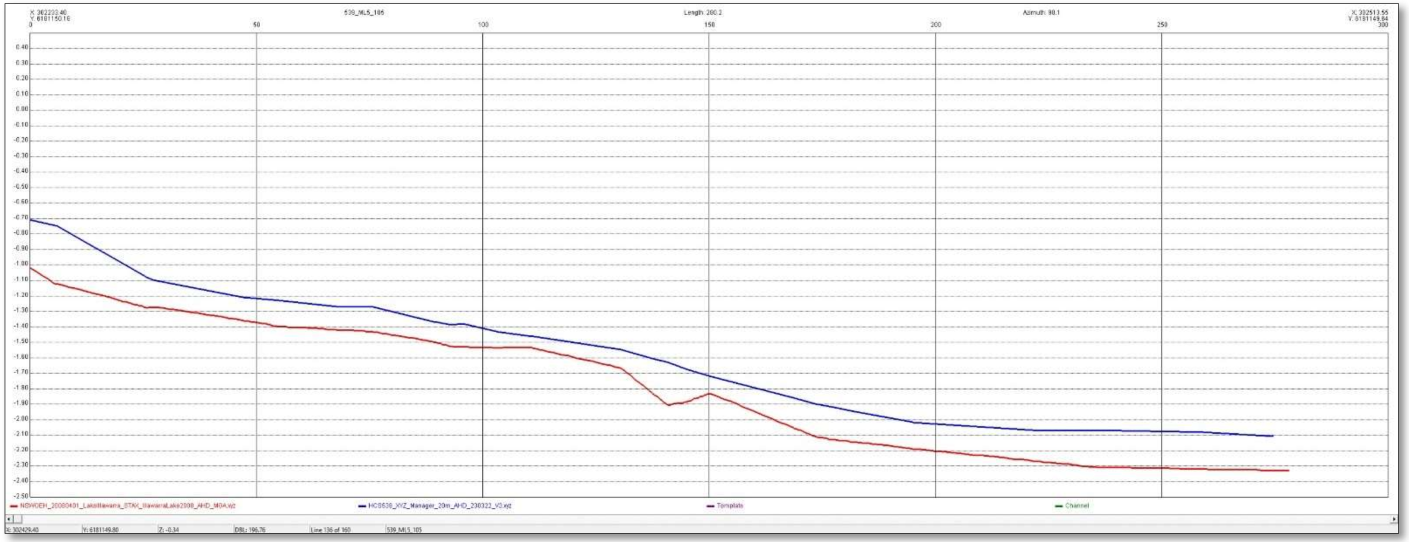
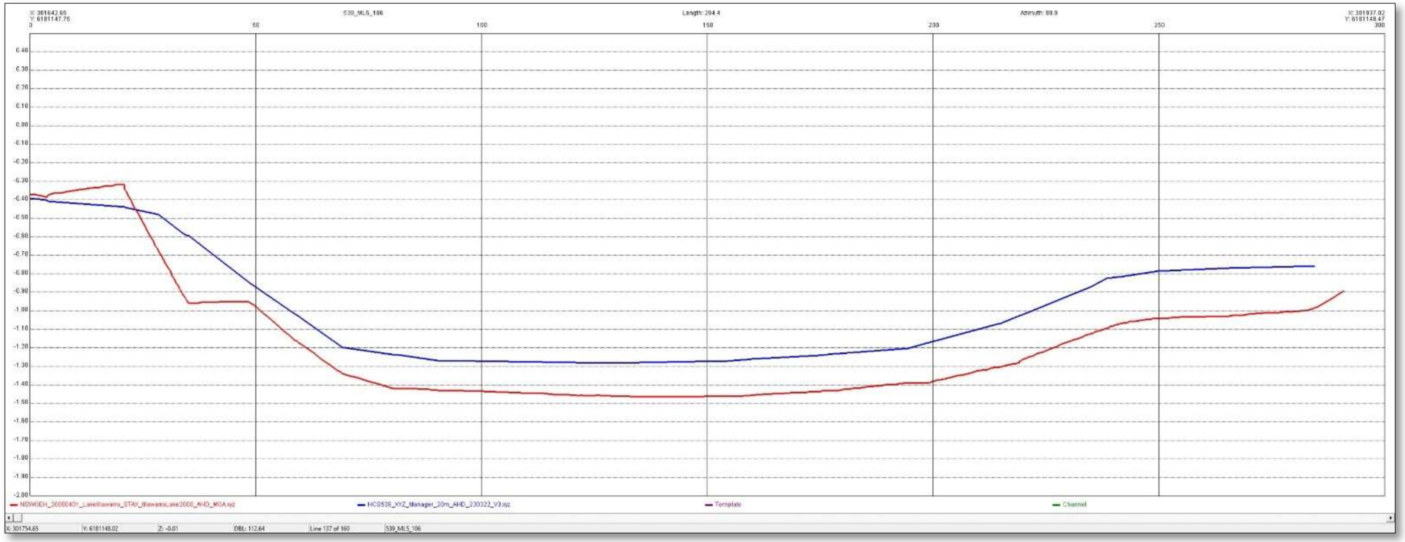


Figure 170: Lake 5 - profiles (red = 2008, blue = 2022/23) 104 and 105.



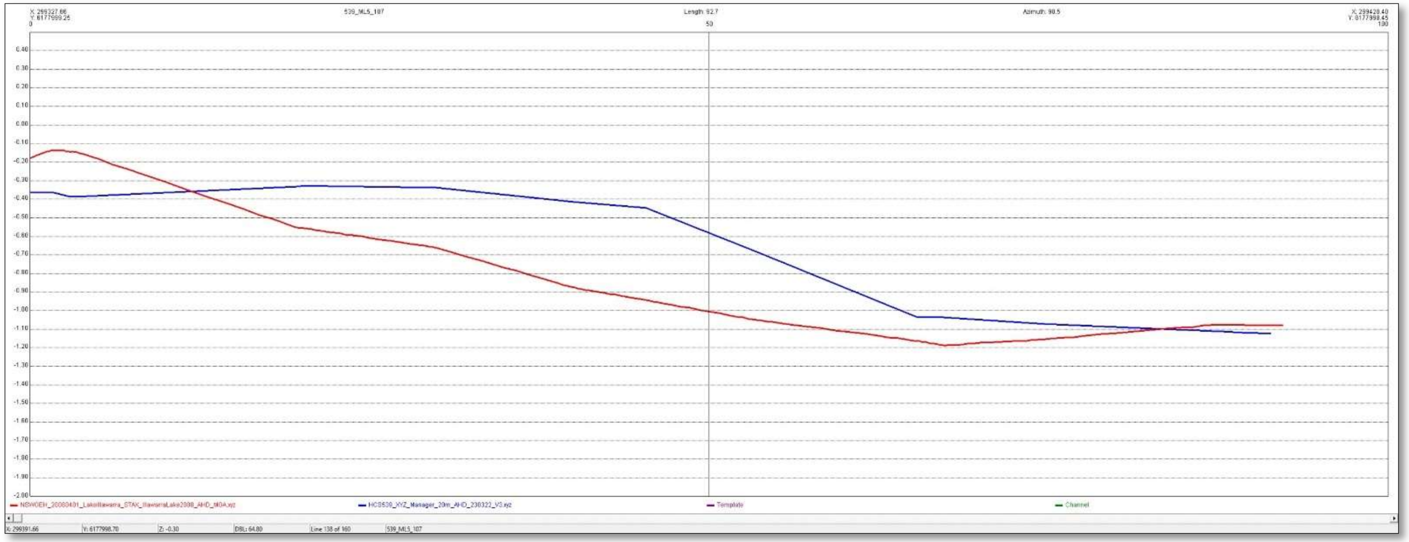


Figure 171: Lake 5 - profiles (red = 2008, blue = 2022/23) 106 and 107.

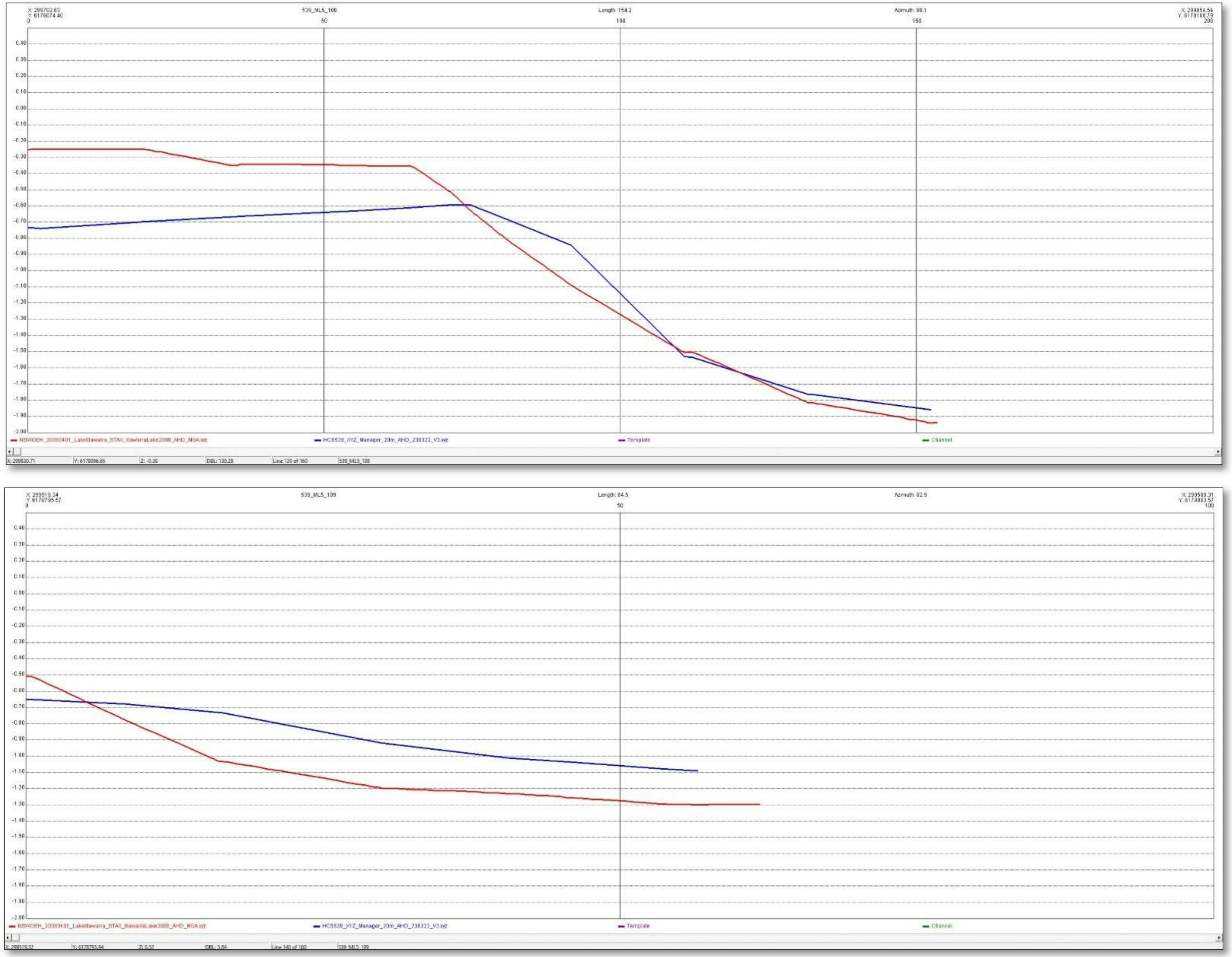


Figure 172: Lake 5 - profiles (red = 2008, blue = 2022/23) 108 and 109.

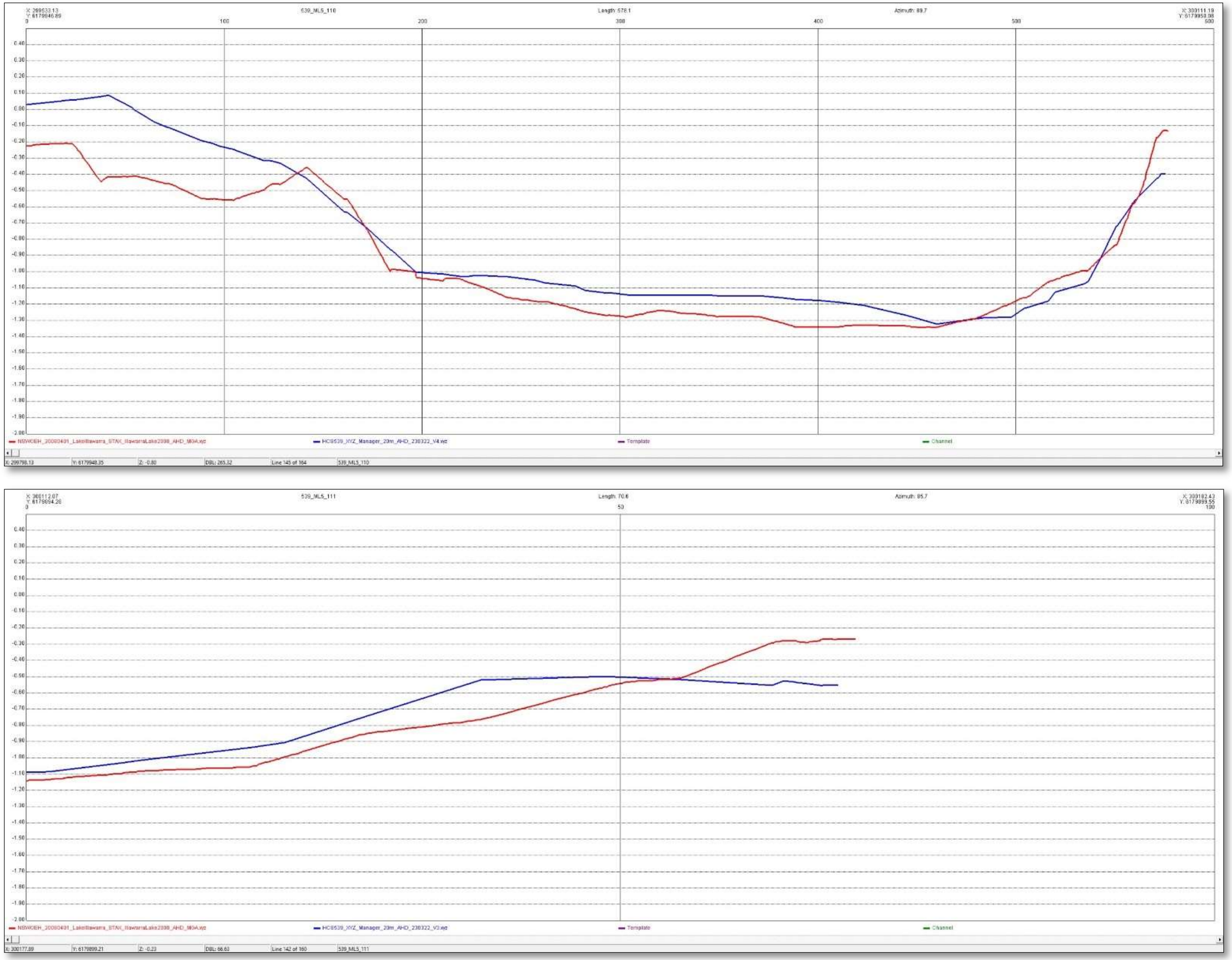


Figure 173: Lake 5 - profiles (red = 2008, blue = 2022/23) 110 and 111.

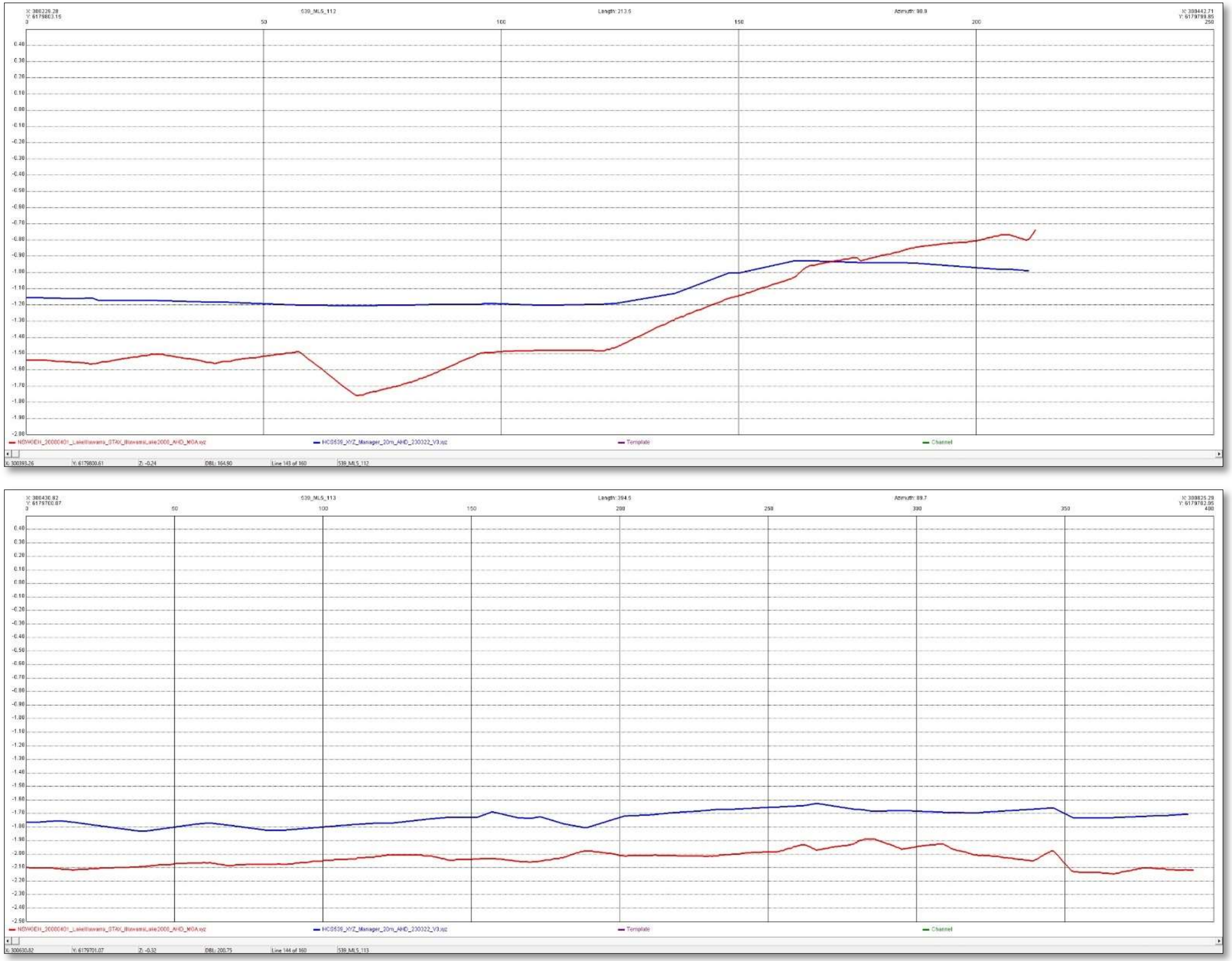


Figure 174: Lake 5 - profiles (red = 2008, blue = 2022/23) 112 and 113.

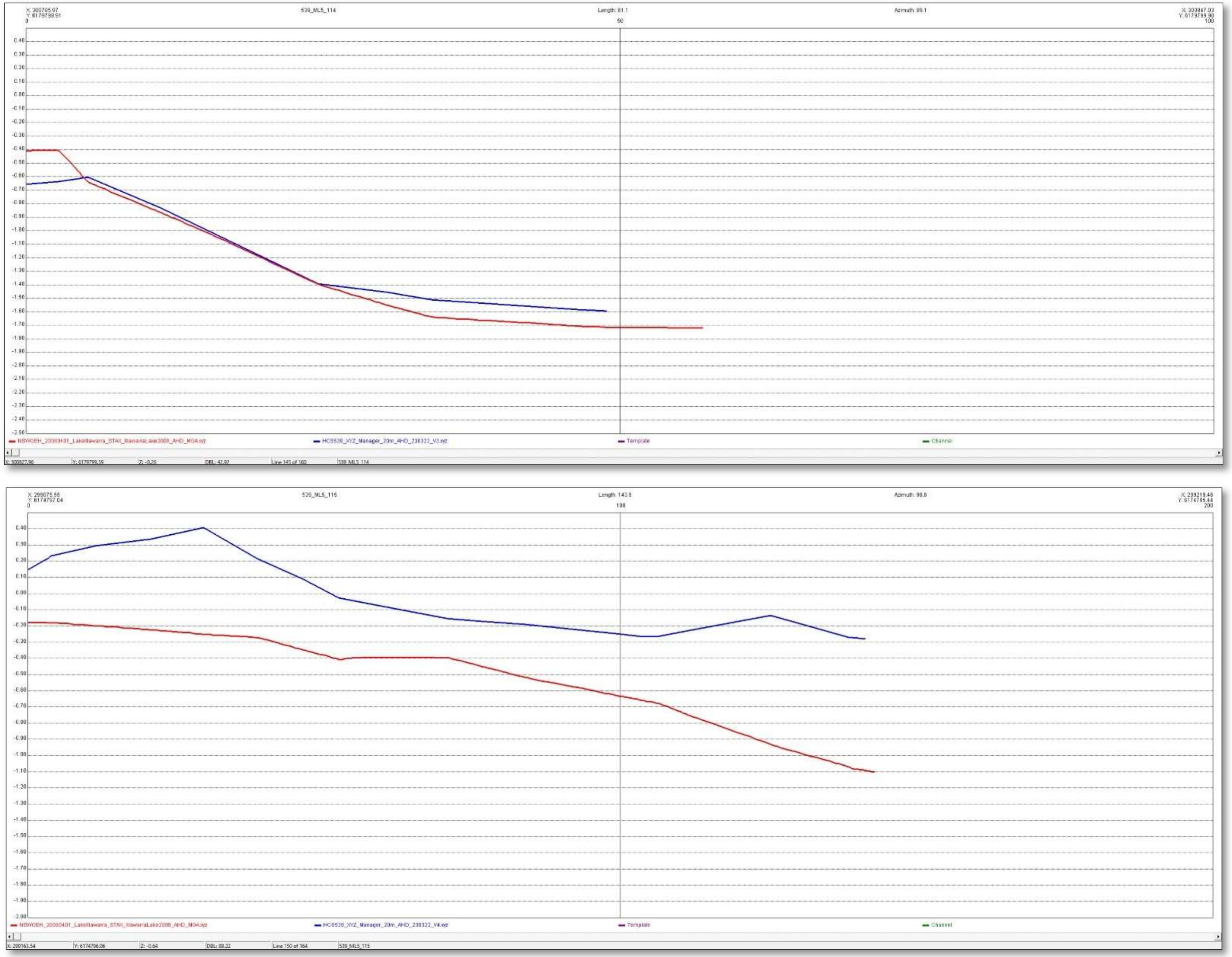


Figure 175: Lake 5 - profiles (red = 2008, blue = 2022/23) 114 and 115.

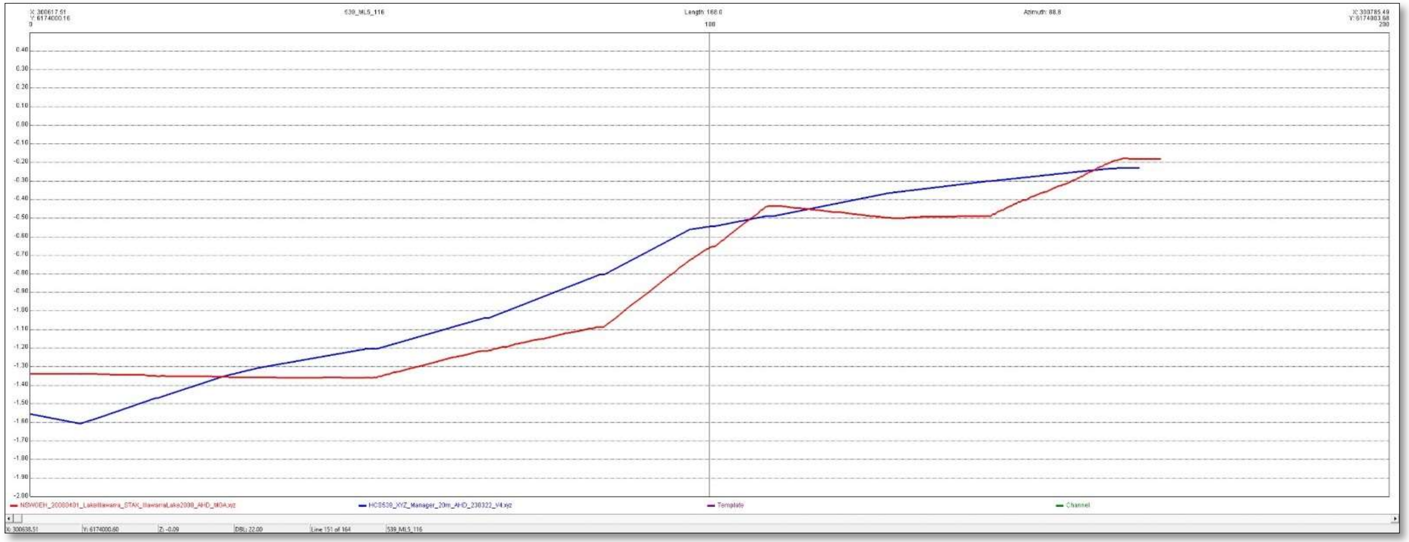


Figure 176: Lake 5 - profiles (red = 2008, blue = 2022/23) 116 and 117.

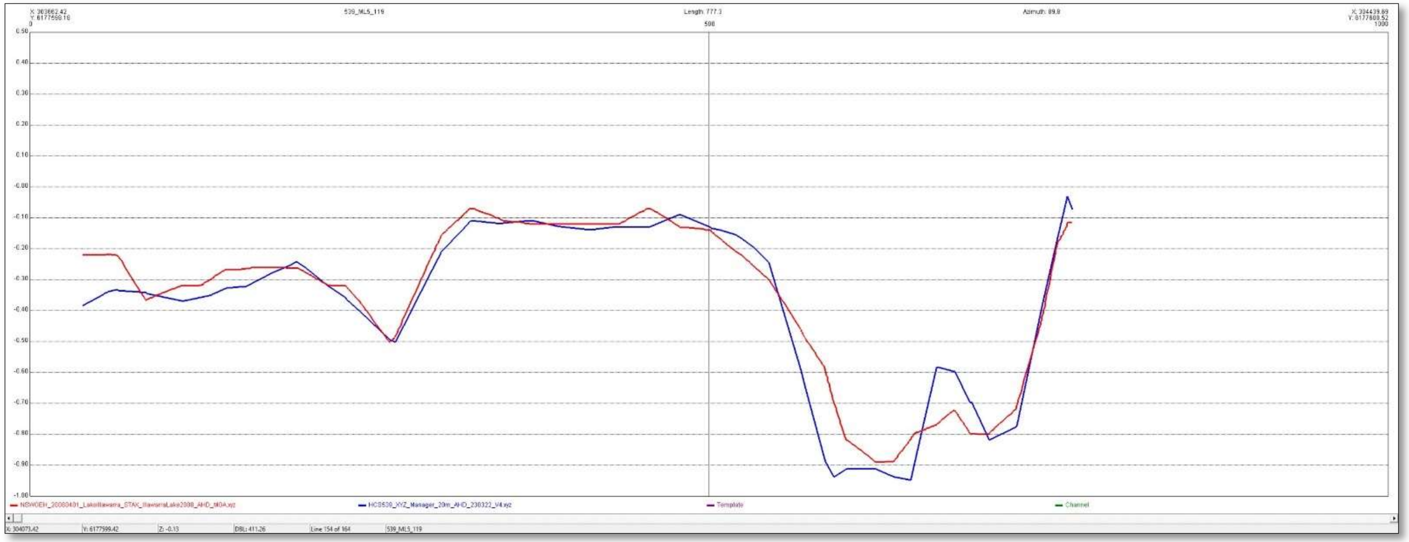
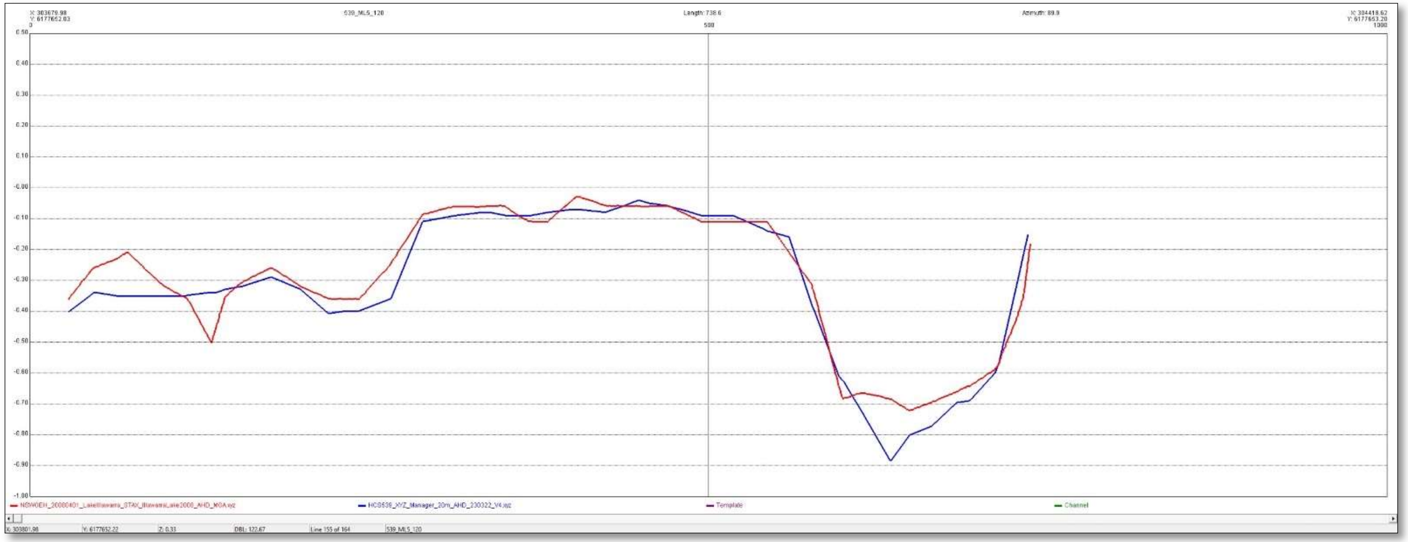


Figure 177: Lake 5 - profiles (red = 2008, blue = 2022/23) 118 and 119.



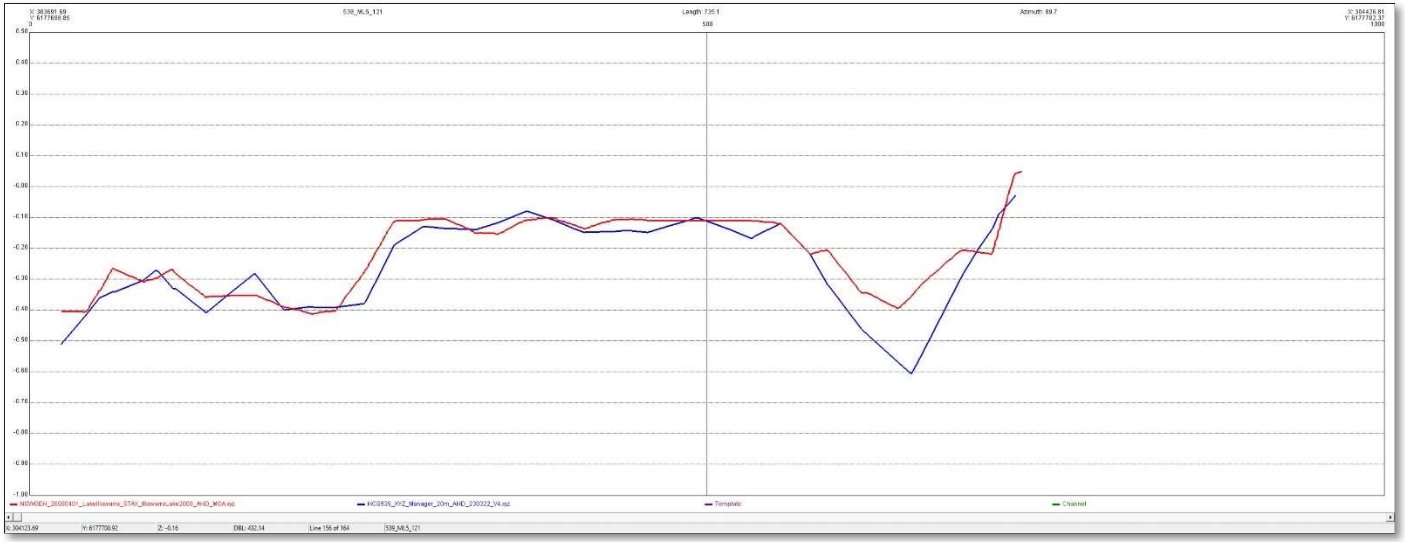


Figure 178: Lake 5 - profiles (red = 2008, blue = 2022/23) 120 and 121.

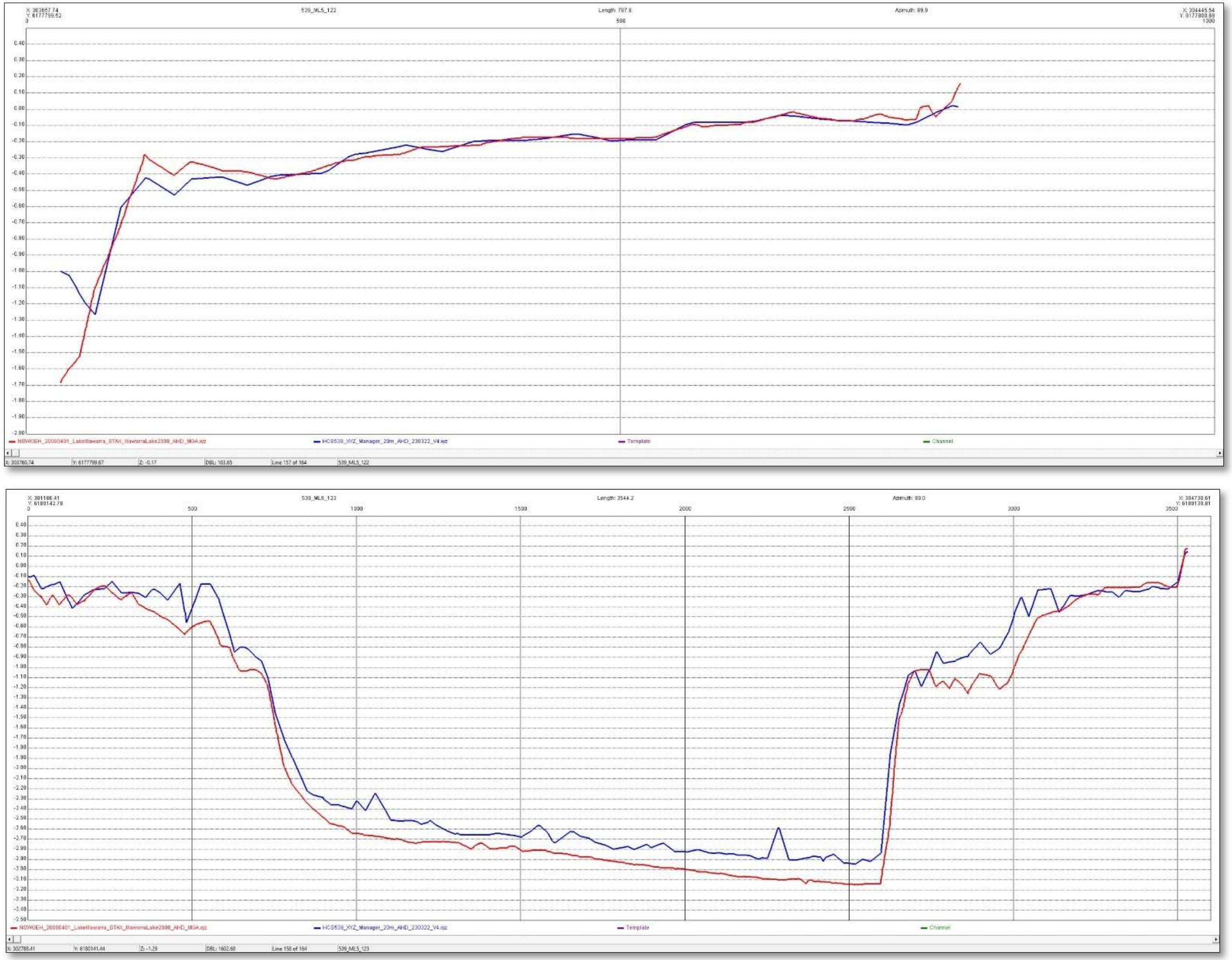


Figure 179: Lake 5 - profiles (red = 2008, blue = 2022/23) 122 and 123.

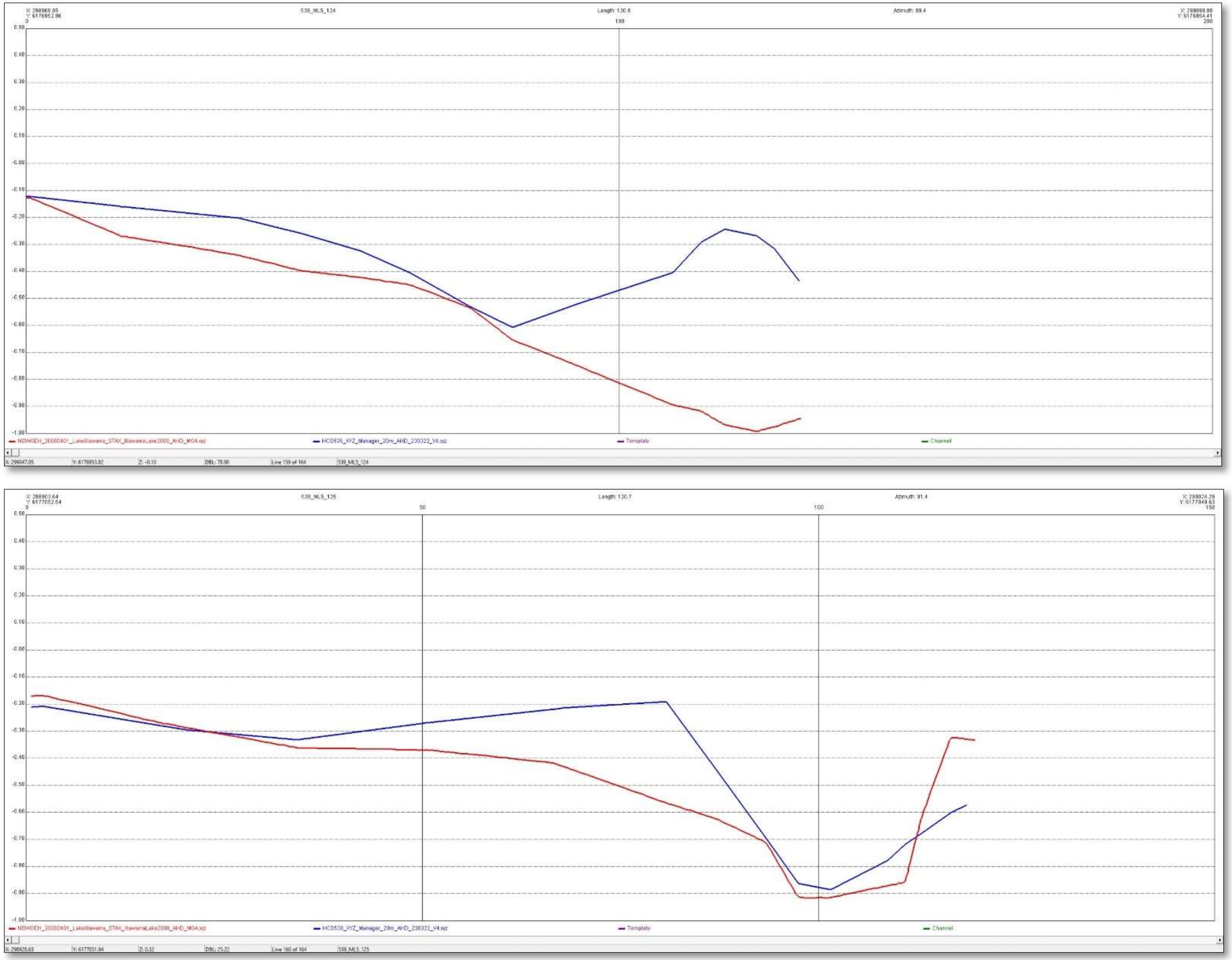
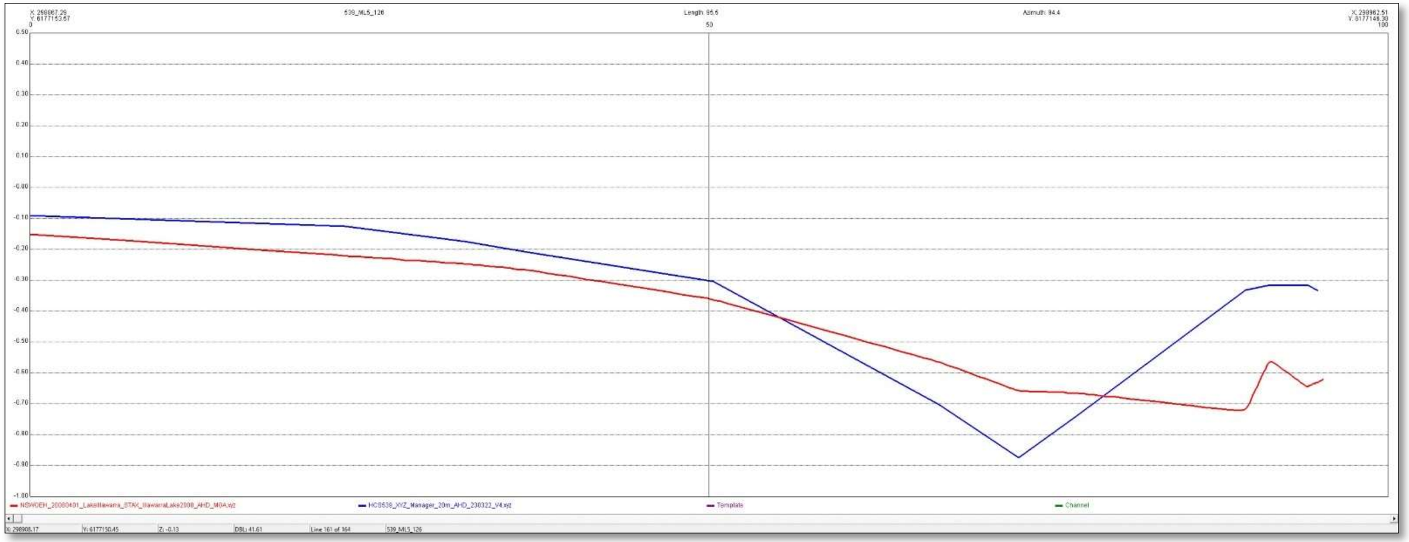


Figure 180: Lake 5 - profiles (red = 2008, blue = 2022/23) 124 and 125.



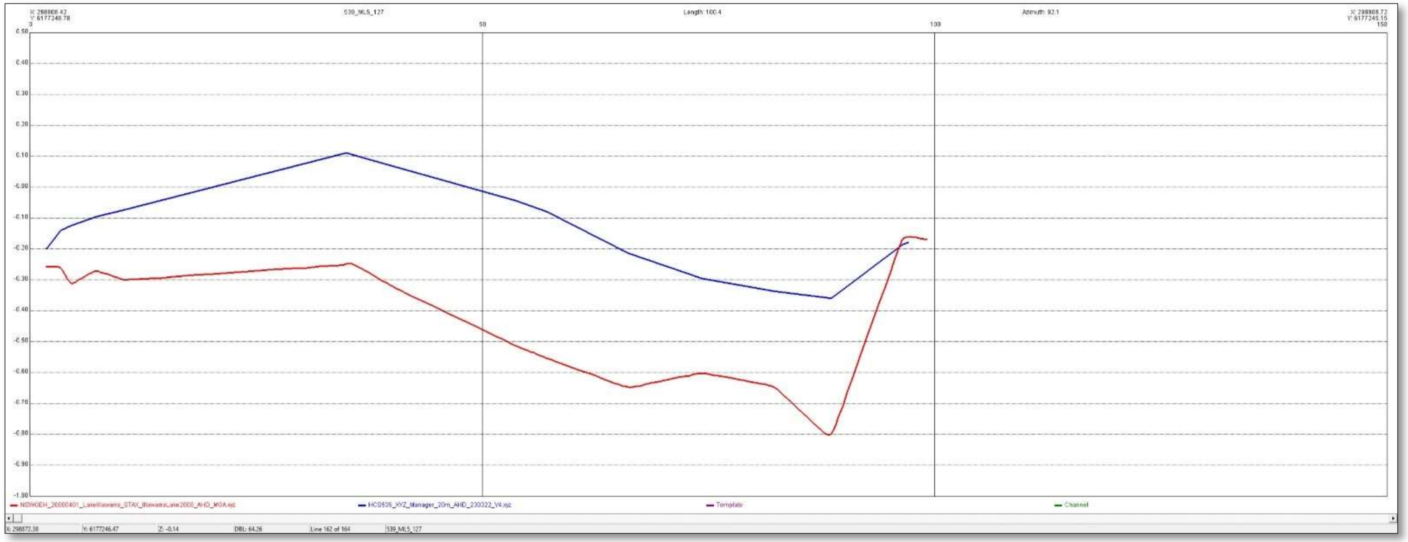


Figure 181: Lake 5 - profiles (red = 2008, blue = 2022/23) 126 and 127.

Figure 182: Lake 5 - profiles (red = 2008, blue = 2022/23) 128 and 129

Albion Creek

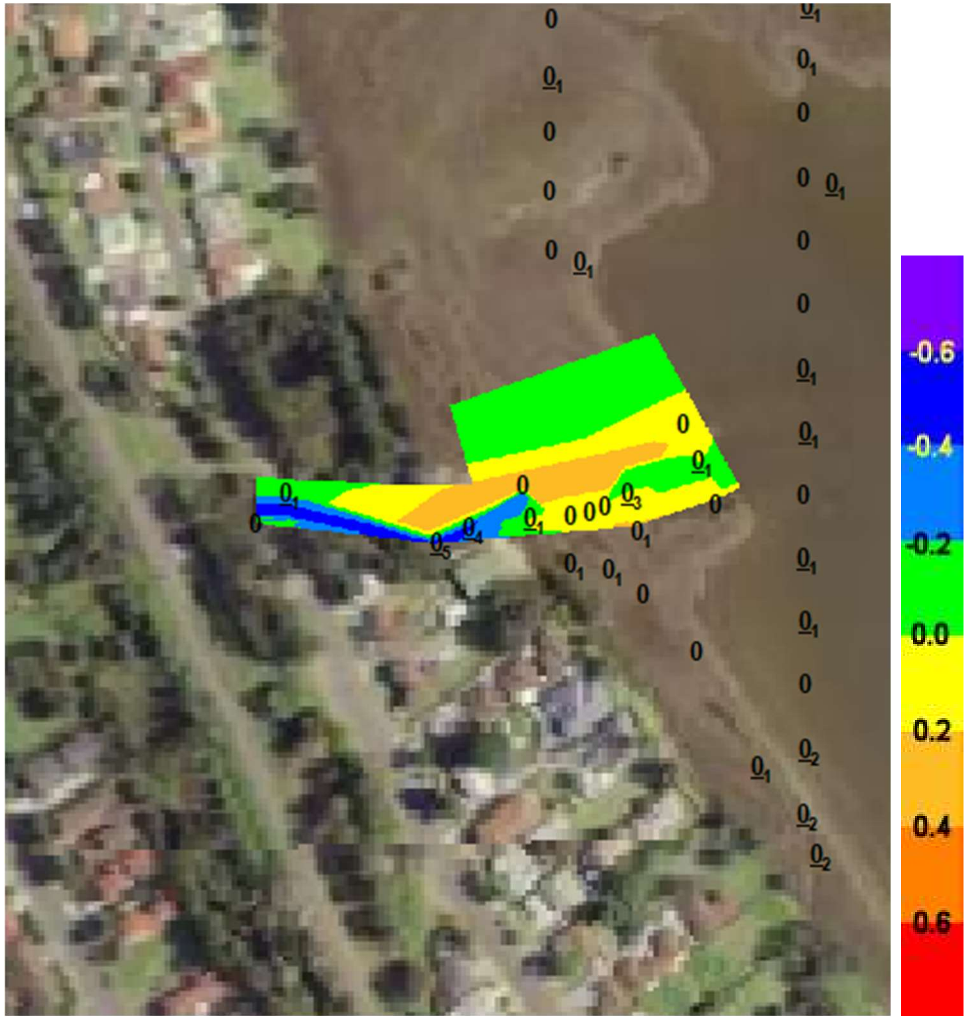


Figure 183: Albion Creek profiles utilised for analysis 1-3 (data within Plan 539-1 Sheet 5).

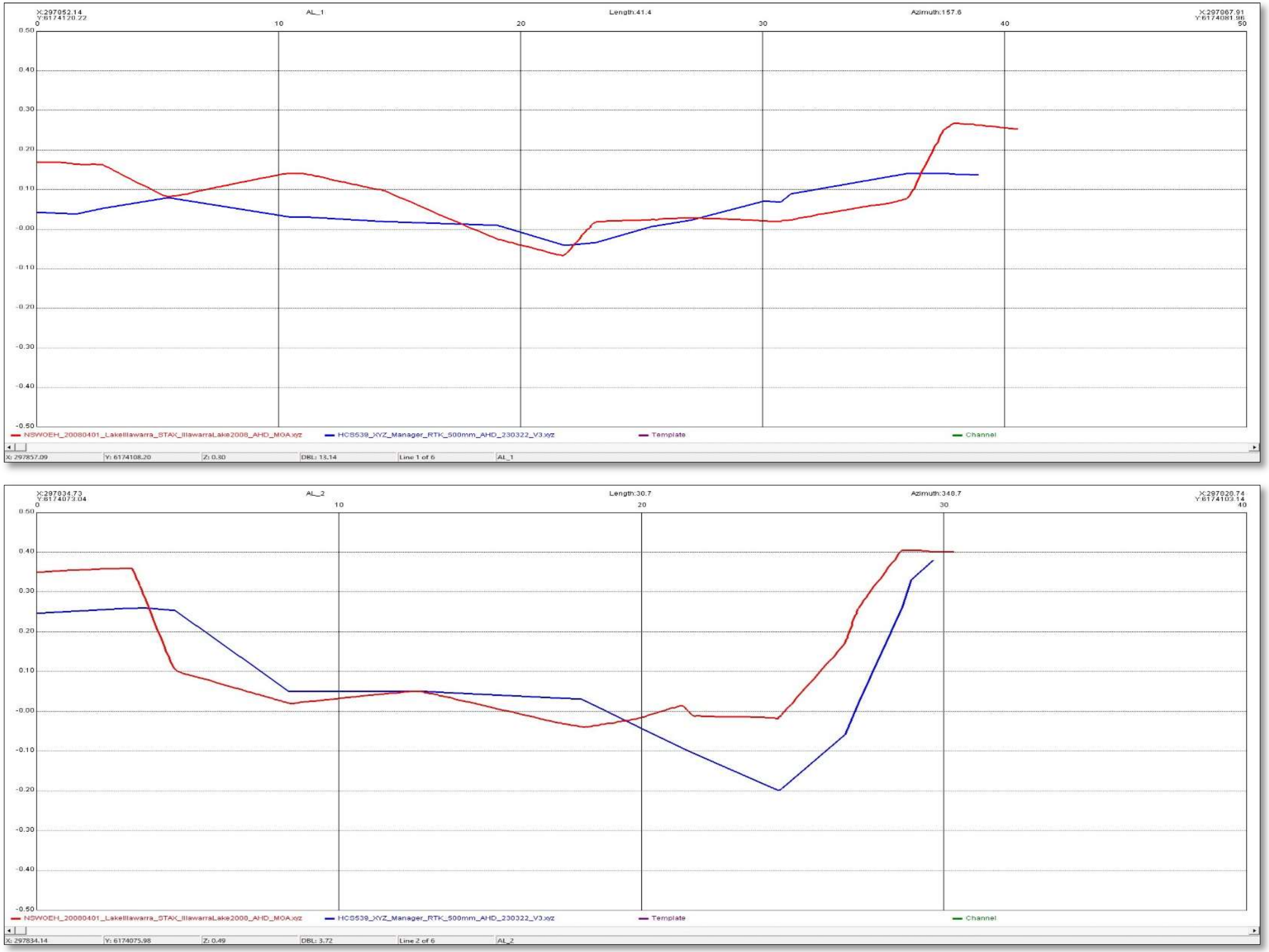


Figure 184: Albion Creek - profiles (red = 2008, blue = 2022/23) 1 and 2.

Figure 185: Albion Creek - profiles (red = 2008) 3 and 4.

Figure 186: Albion Creek – profiles (red = 2008) 5 and 6.

Brooks Creek

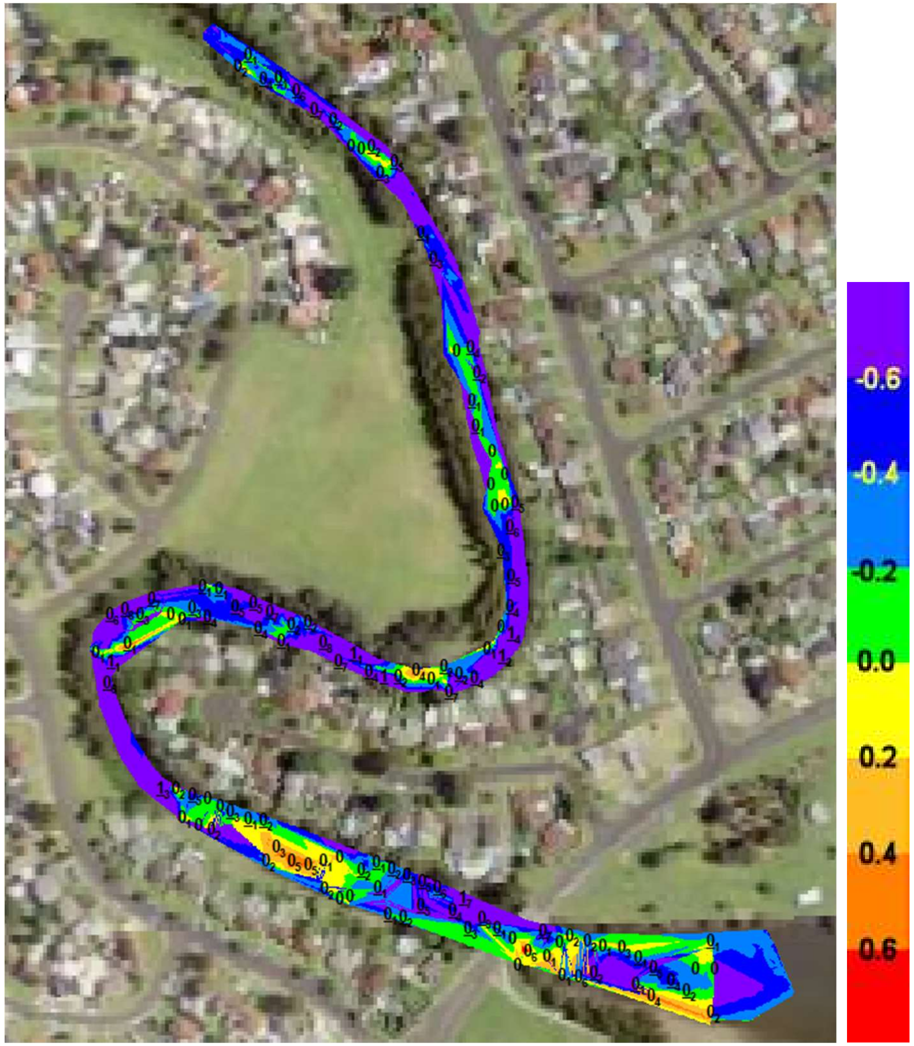
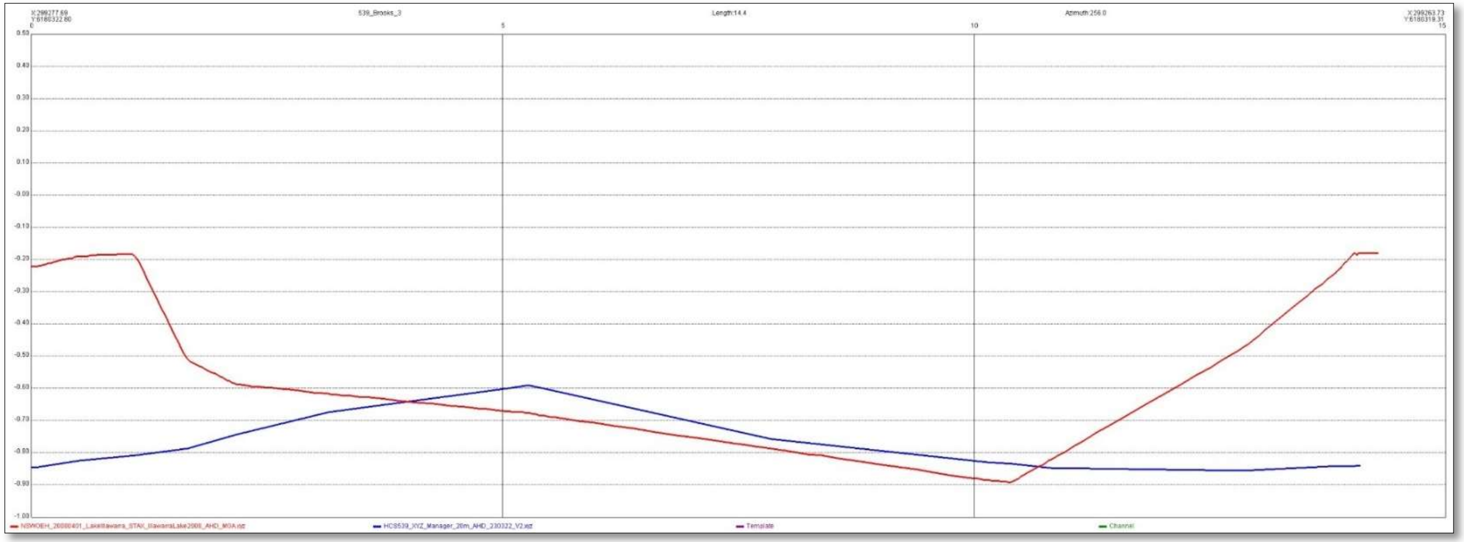


Figure 187: Brooks Creek profiles utilised for analysis (data within Plan 539-1 Sheet 2).

Figure 188: Brooks Creek - profiles (red = 2008, blue = 2022/23) 1 and 2.



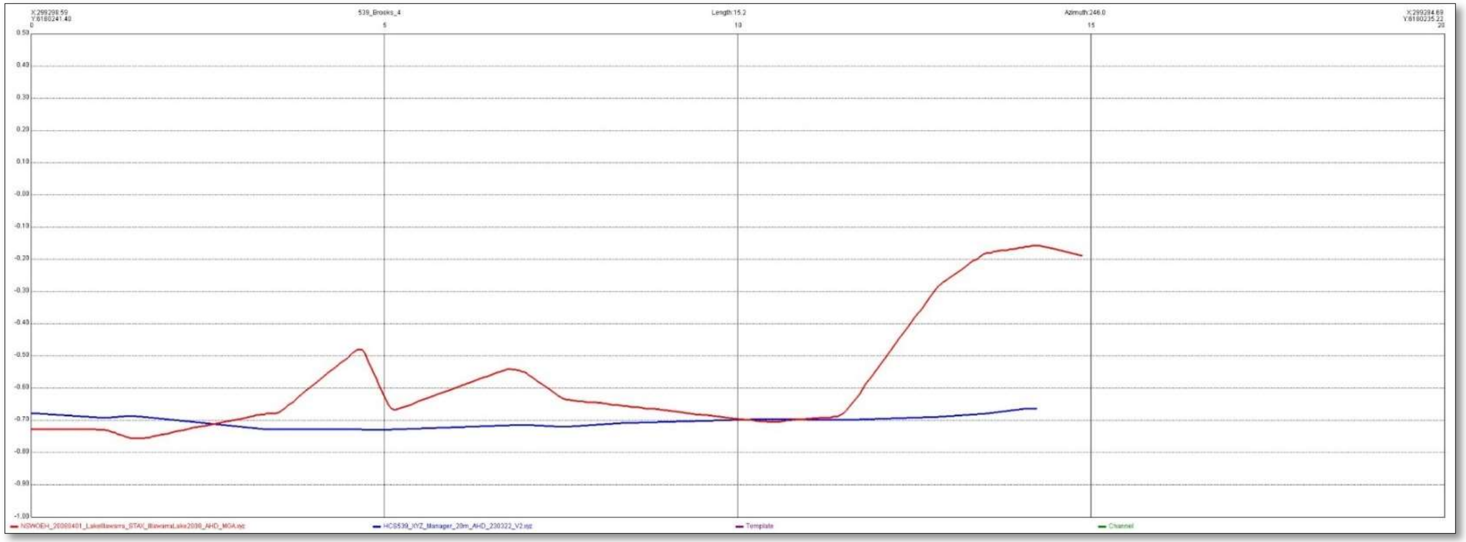
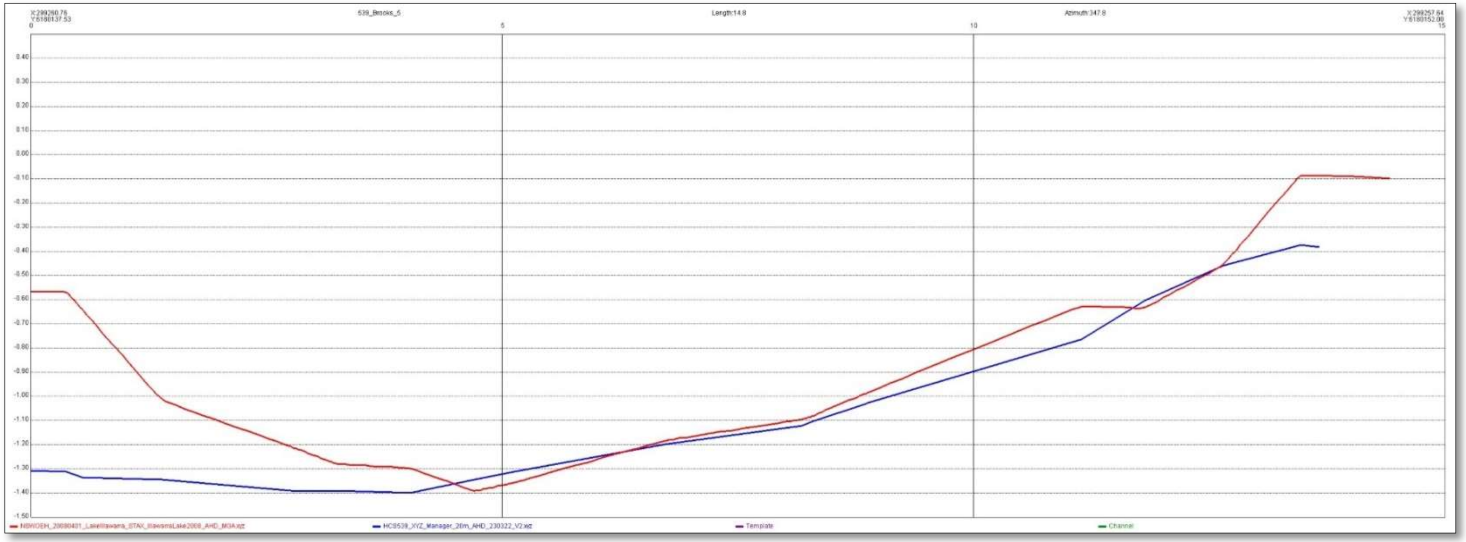


Figure 189: Brooks Creek - profiles (red = 2008, blue = 2022/23) 3 and 4.



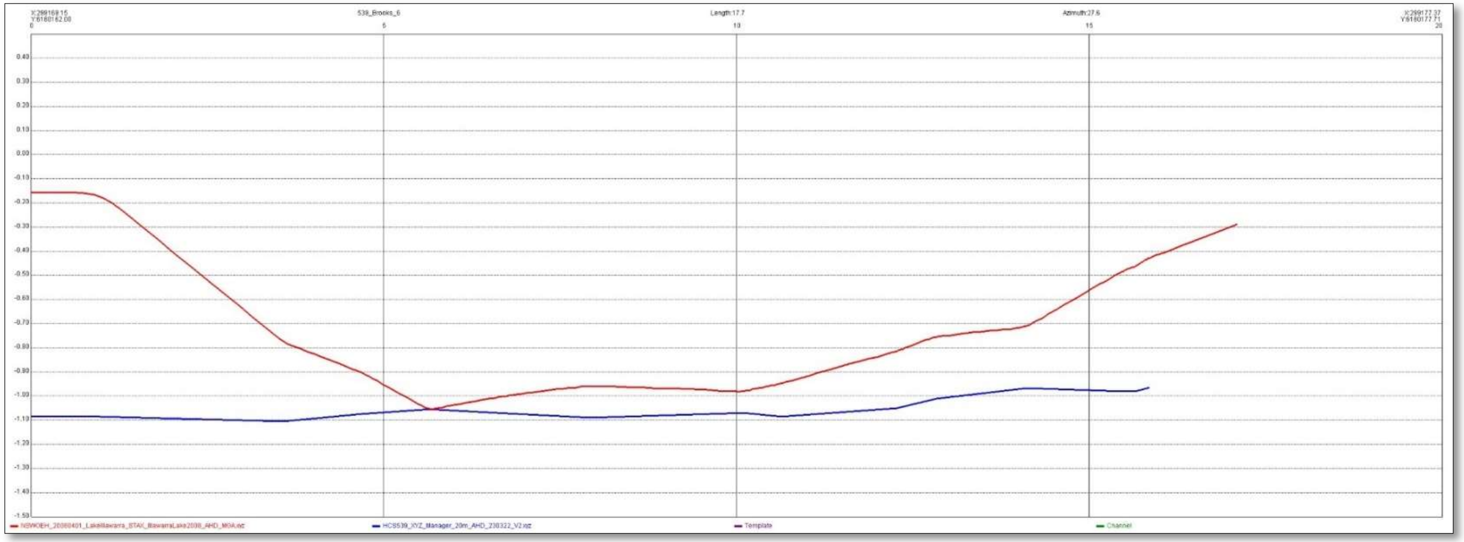


Figure 190: Brooks Creek - profiles (red = 2008, blue = 2022/23) 5 and 6.

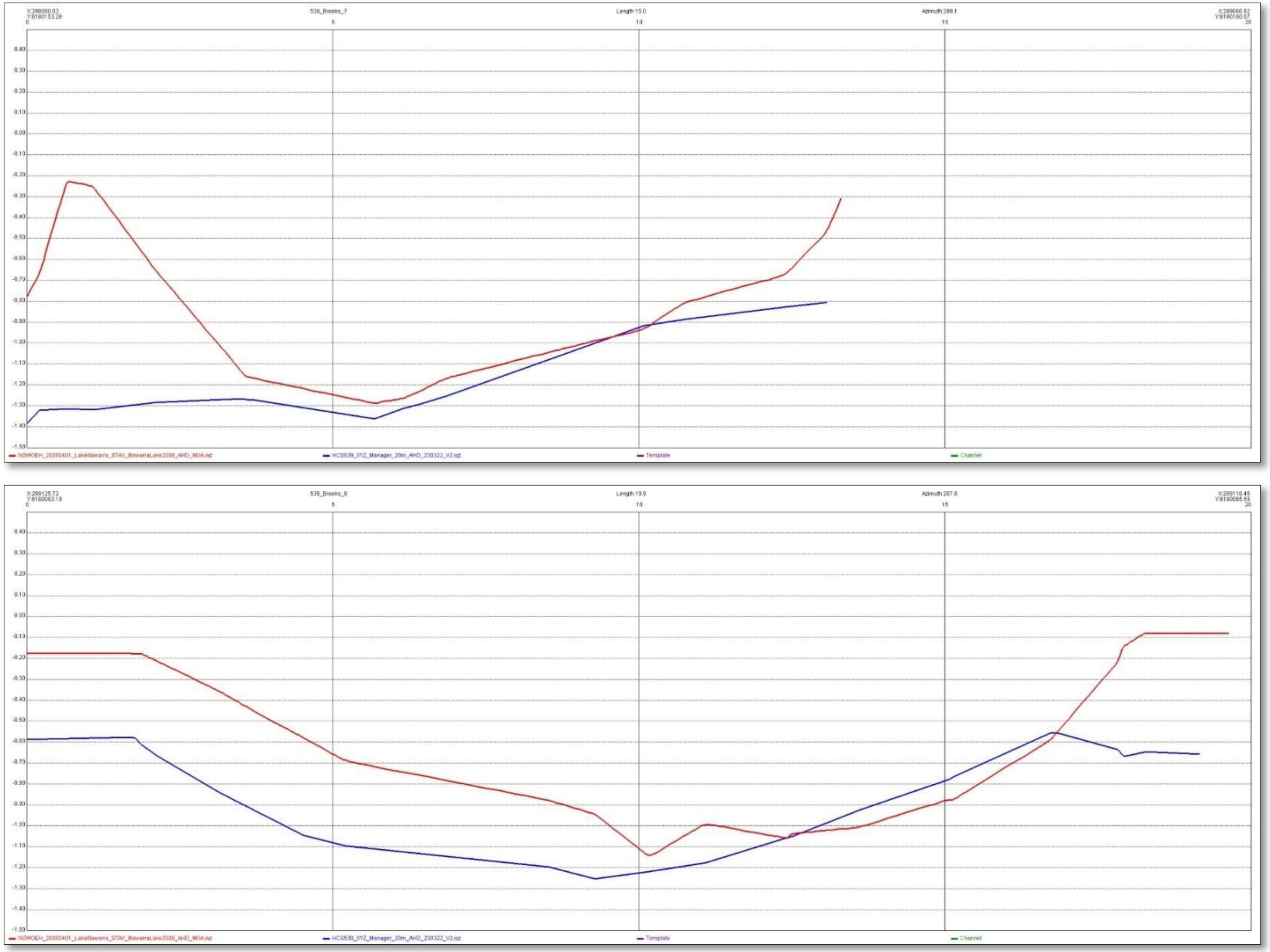
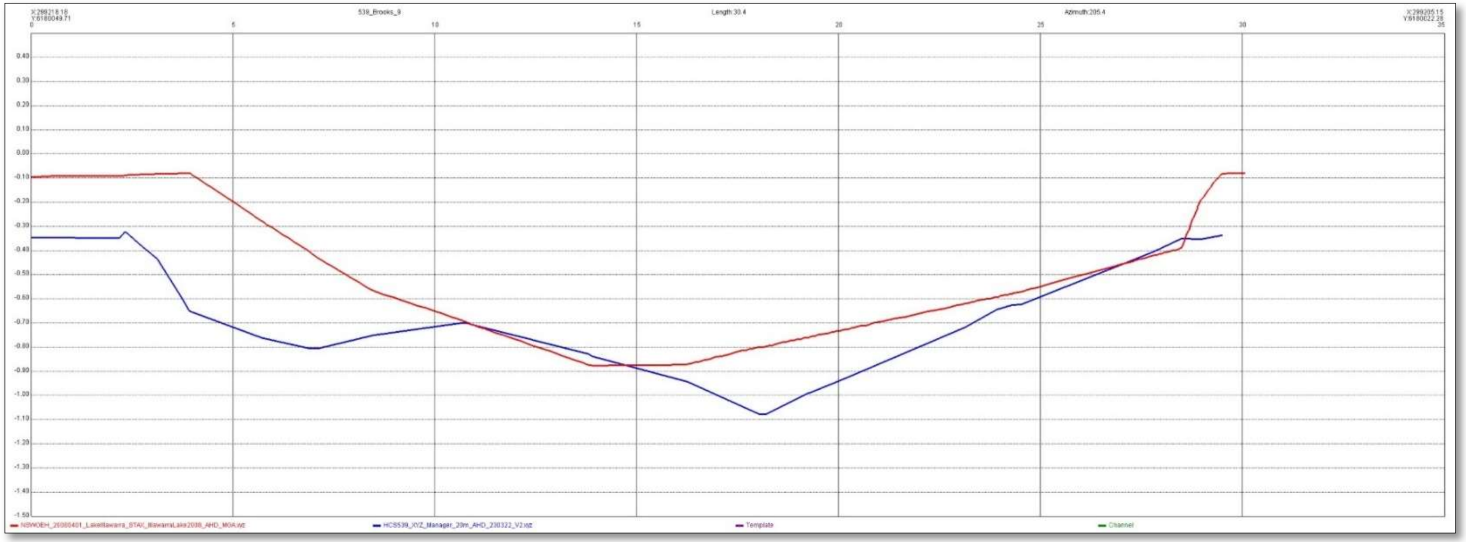


Figure 191: Brooks Creek - profiles (red = 2008, blue = 2022/23) 7 and 8.



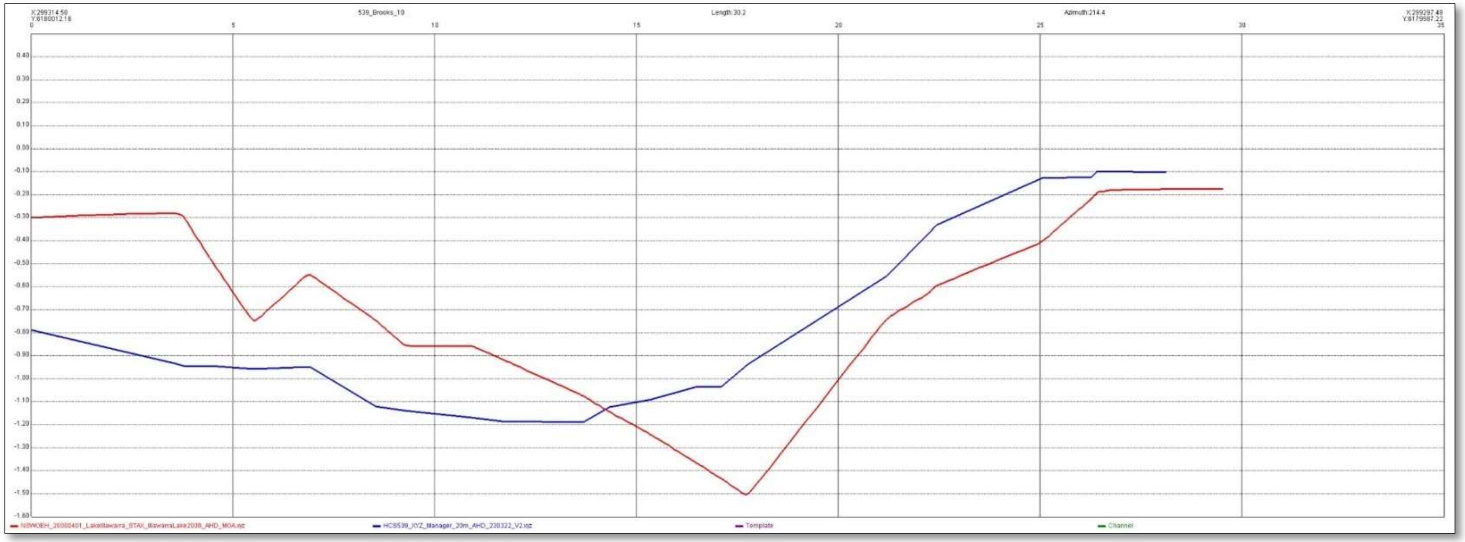


Figure 192: Brooks Creek - profiles (red = 2008, blue = 2022/23) 9 and 10.

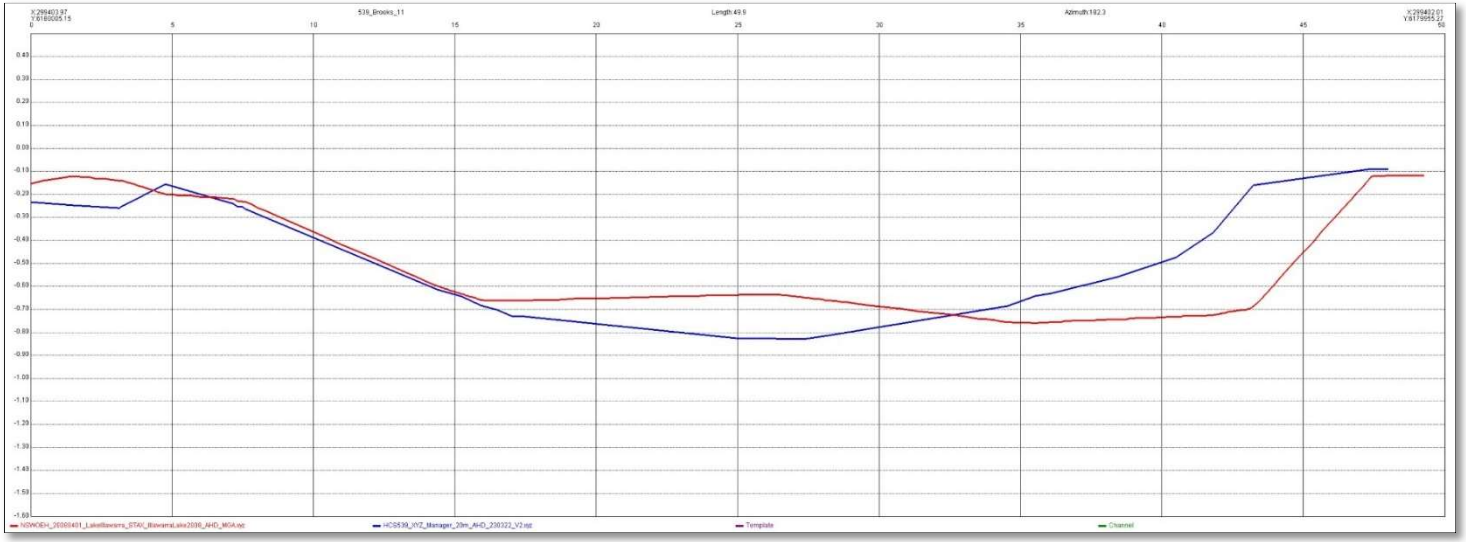


Figure 193: Brooks Creek – profile (red = 2008, blue = 2022/23) 11.

Duck Creek

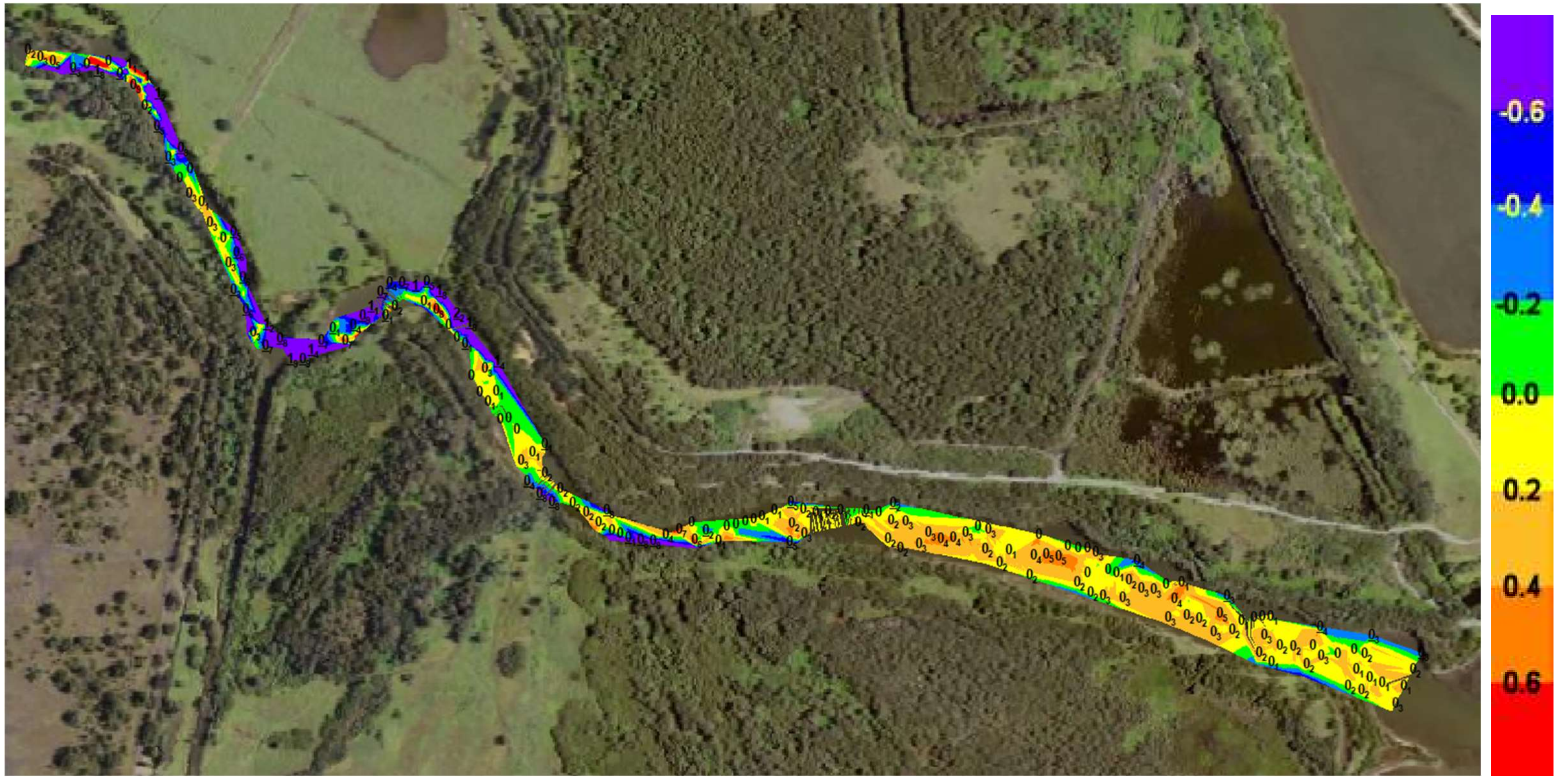


Figure 194: Duck Creek profiles utilised for analysis (data within Plan 539-1 Sheet 4).

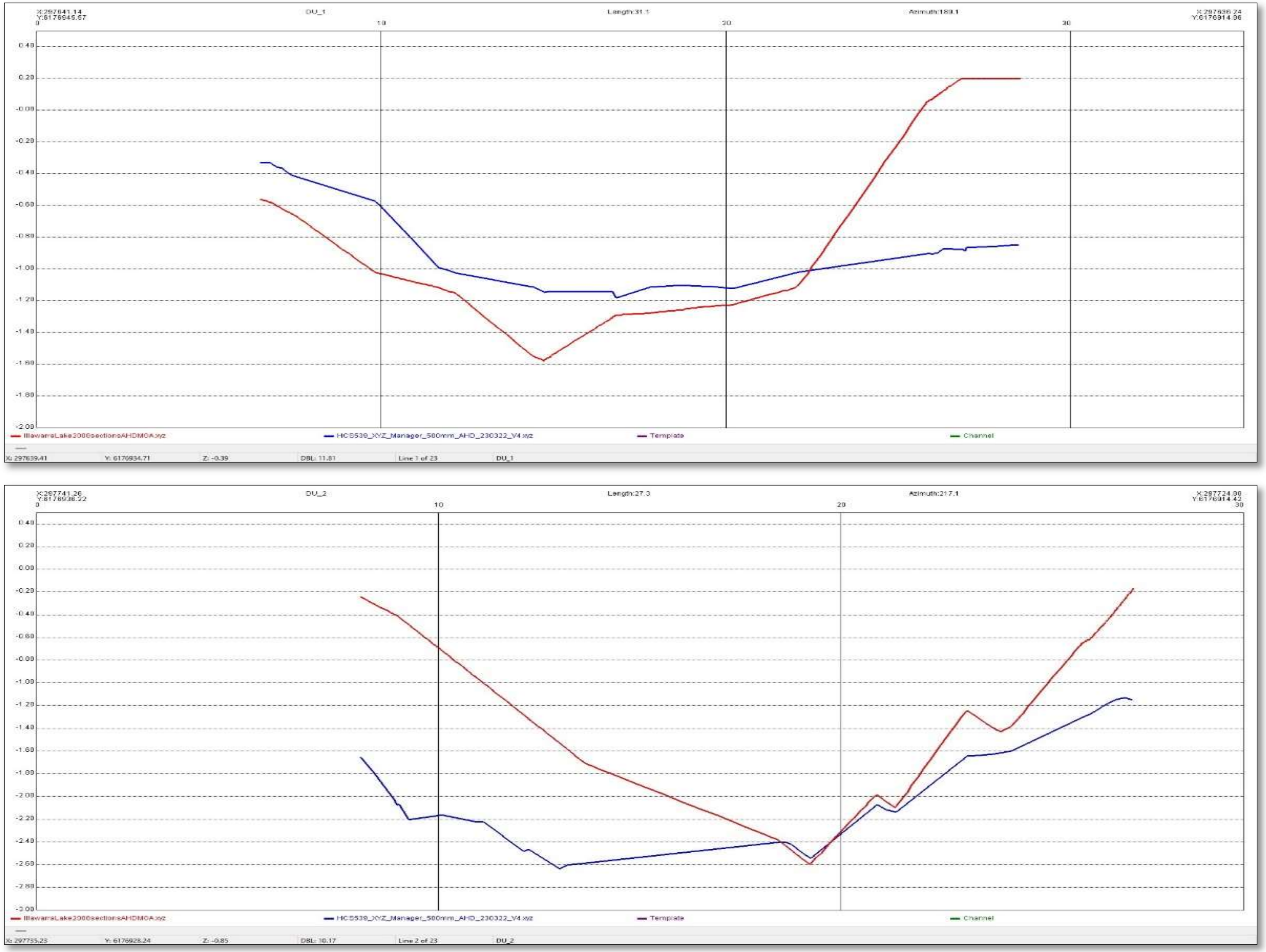


Figure 195: Duck Creek – profiles (red = 2008, blue = 2022/23) 1 and 2.

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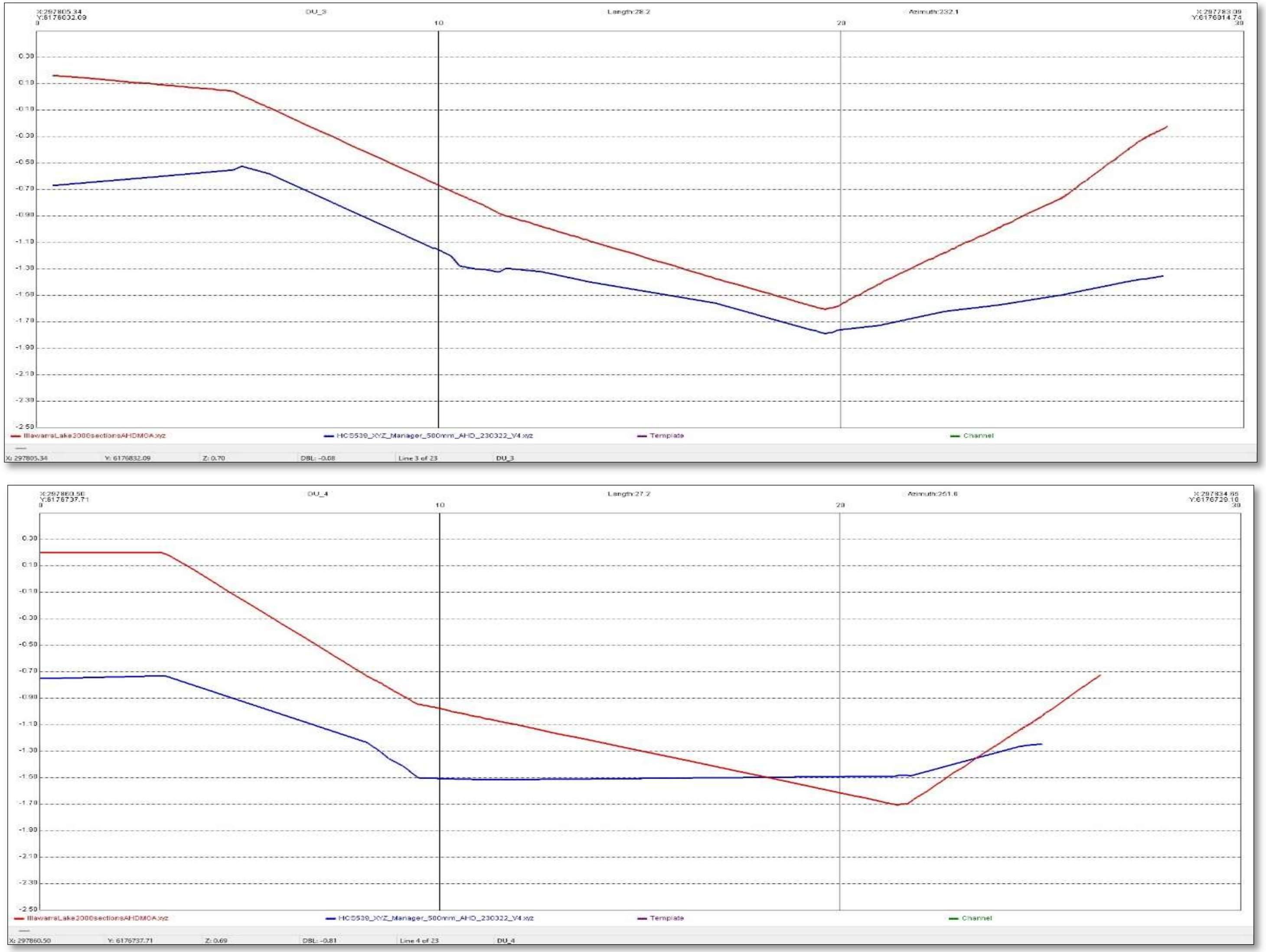


Figure 196: Duck Creek - profiles (red = 2008, blue = 2022/23) 3 and 4.

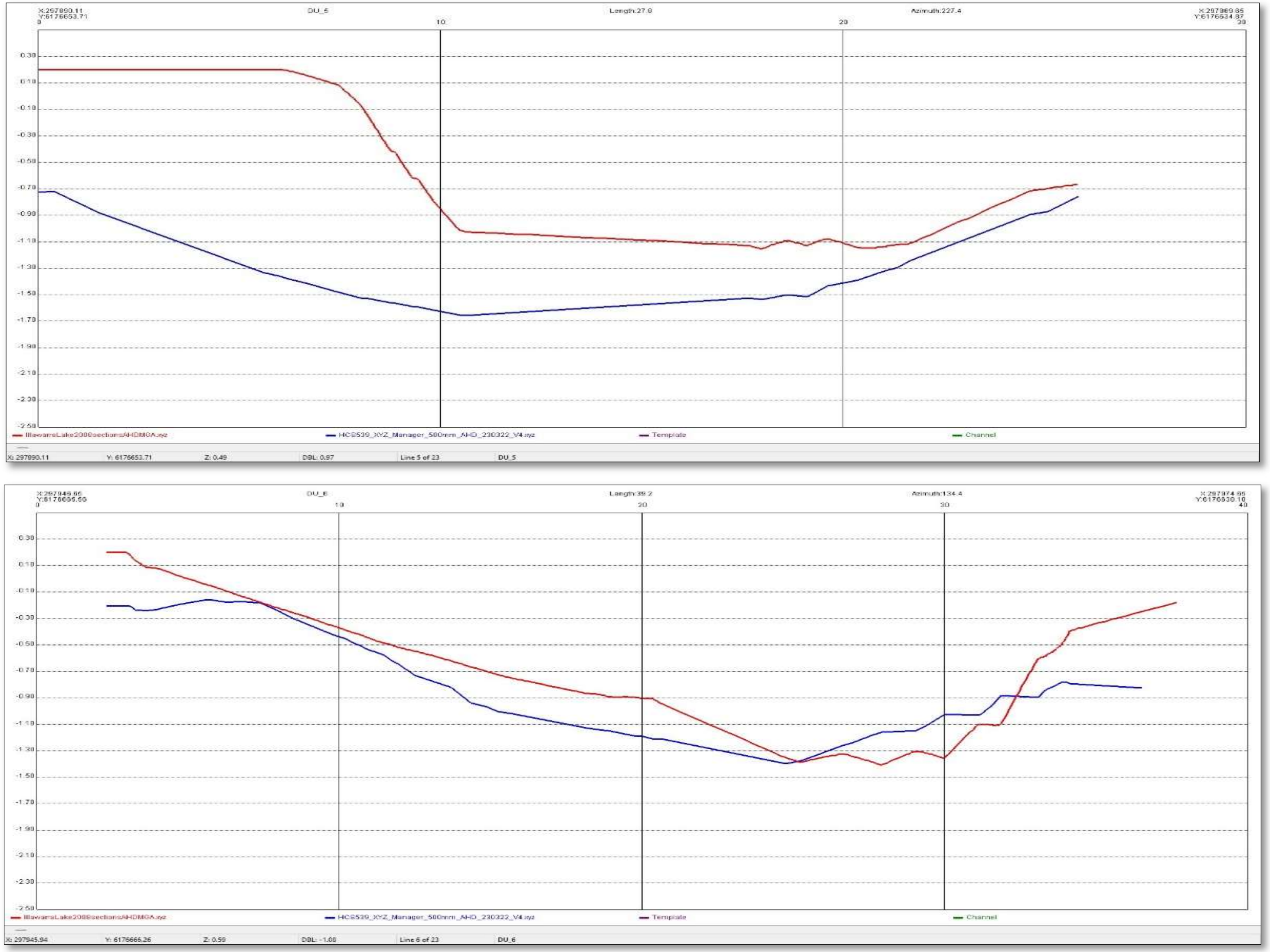


Figure 197: Duck Creek - profiles (red = 2008, blue = 2022/23) 5 and 6.

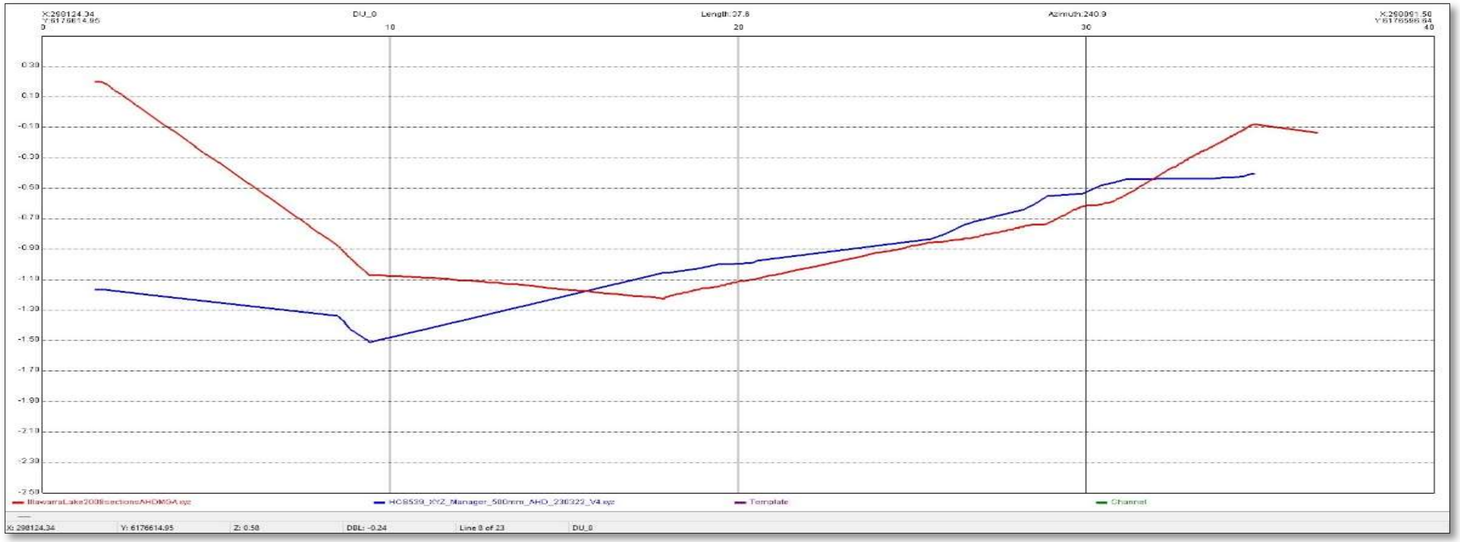
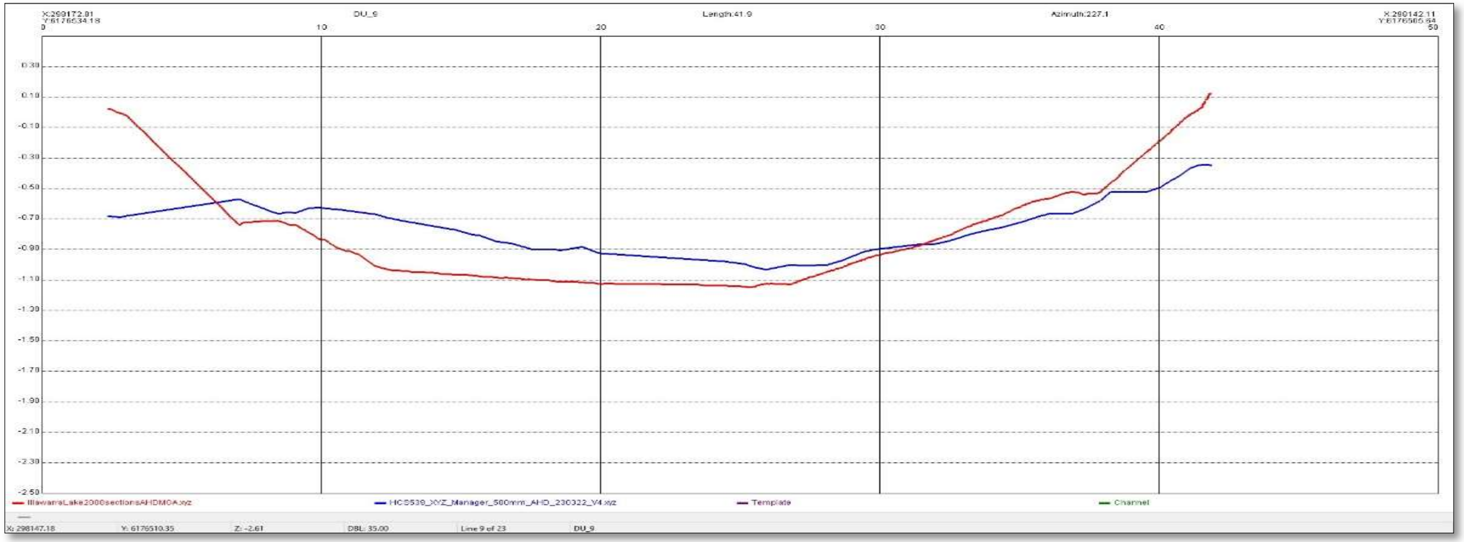


Figure 198: Duck Creek - profiles (red = 2008, blue = 2022/23) 7 and 8.



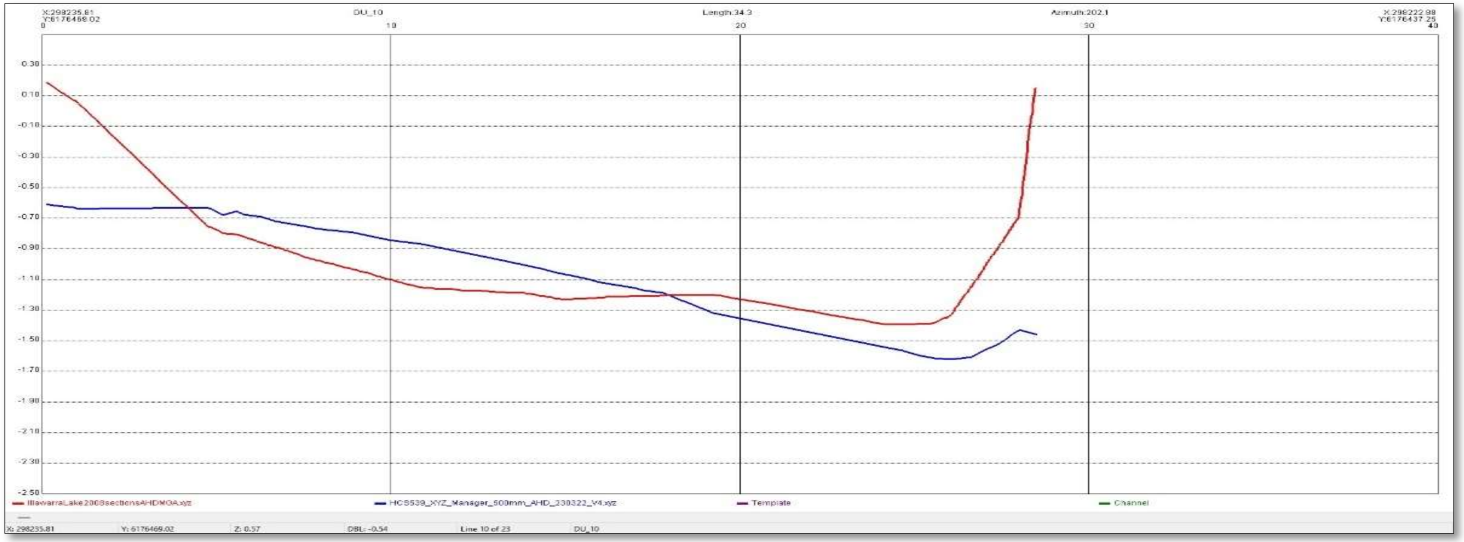


Figure 199: Duck Creek - profiles (red = 2008, blue = 2022/23) 9 and 10.

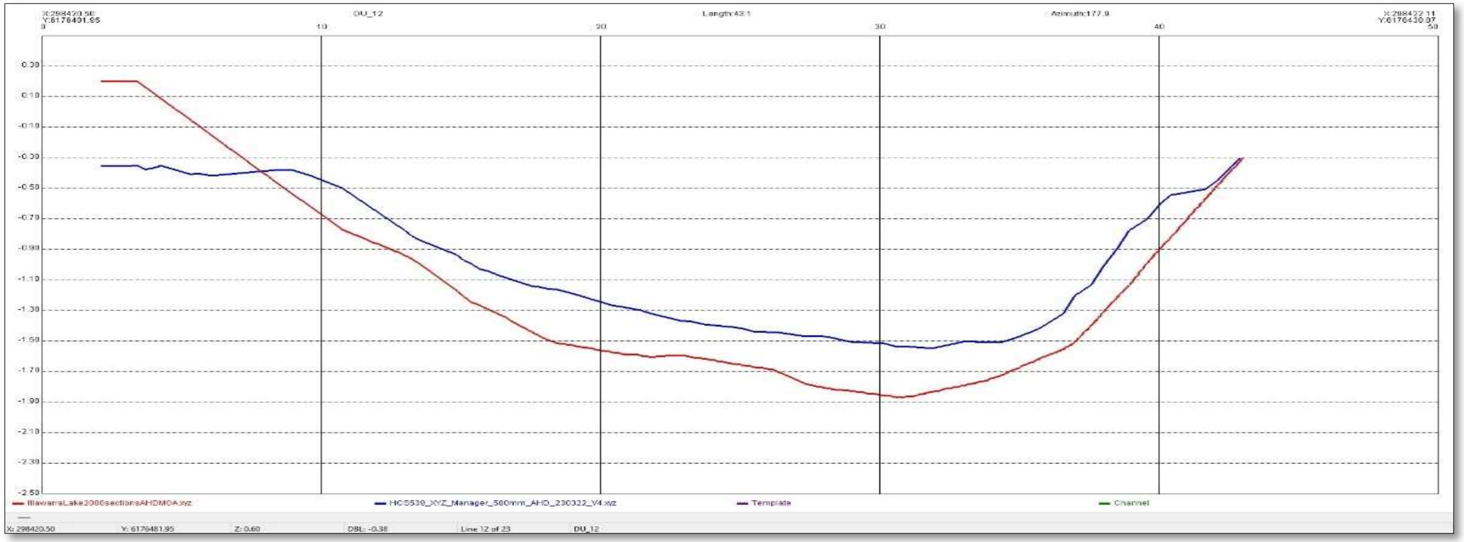
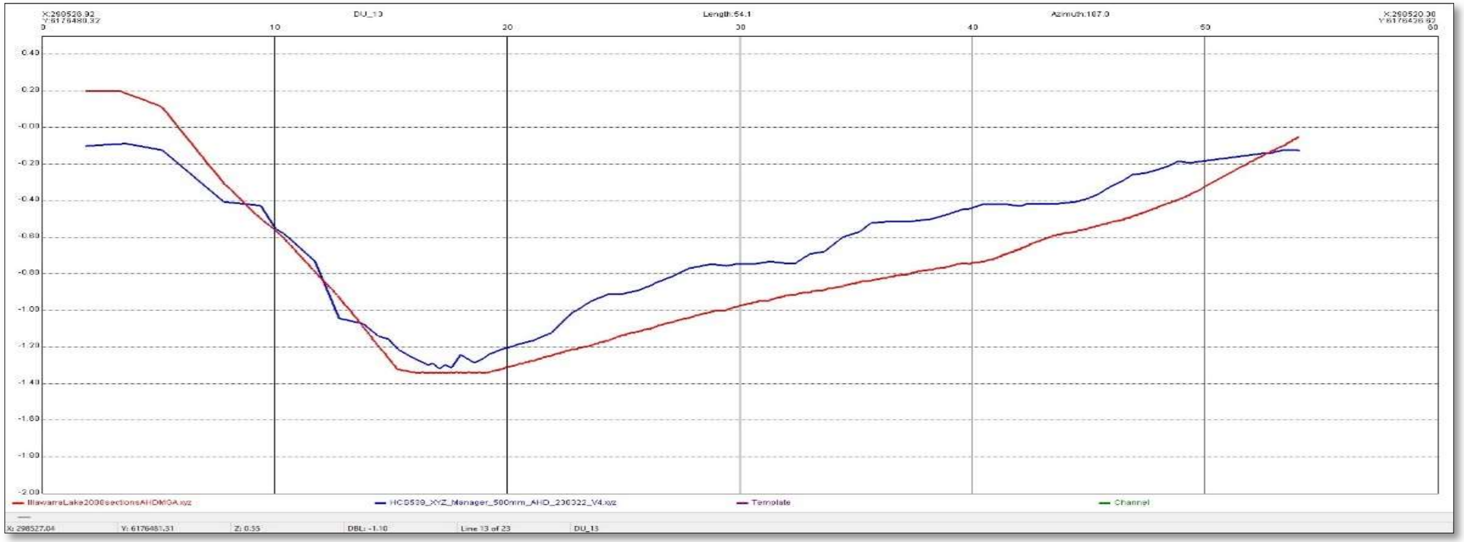


Figure 200: Duck Creek - profiles (red = 2008, blue = 2022/23) 11 and 12.



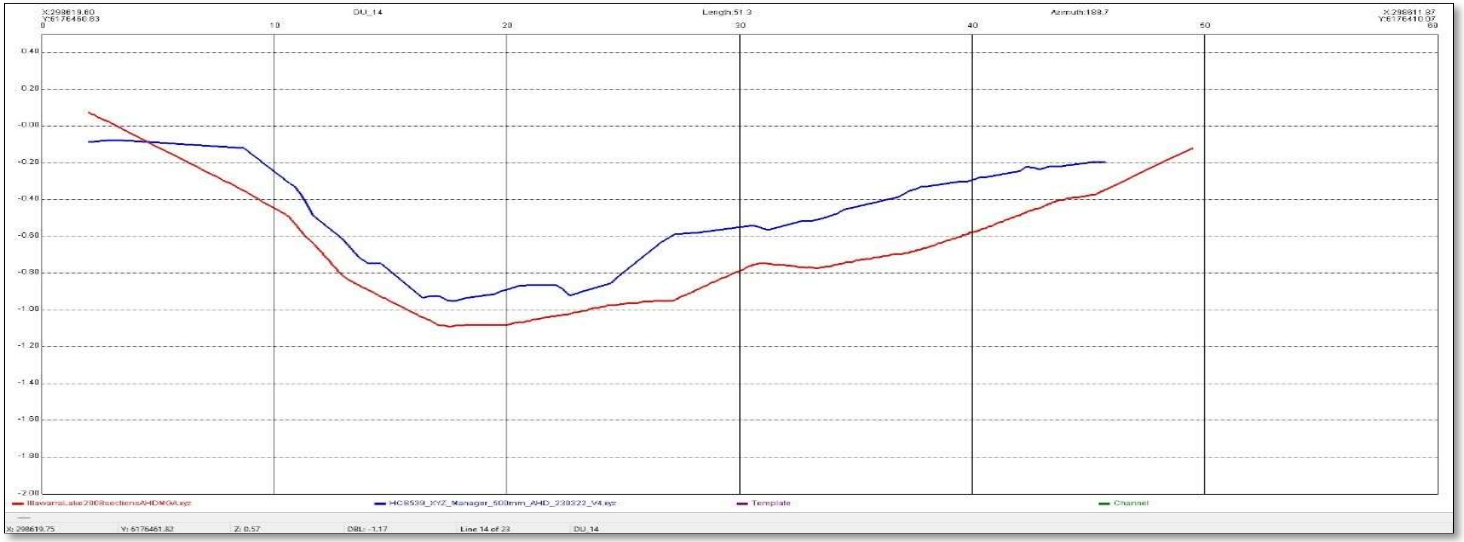
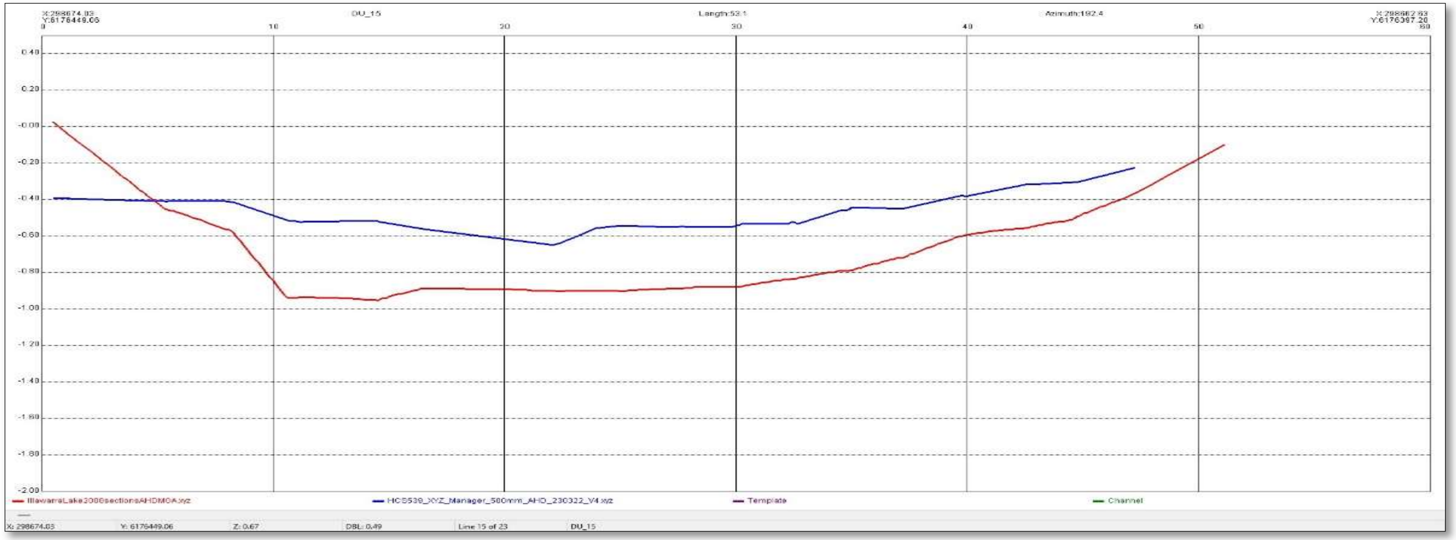


Figure 201: Duck Creek - profiles (red = 2008, blue = 2022/23) 13 and 14.



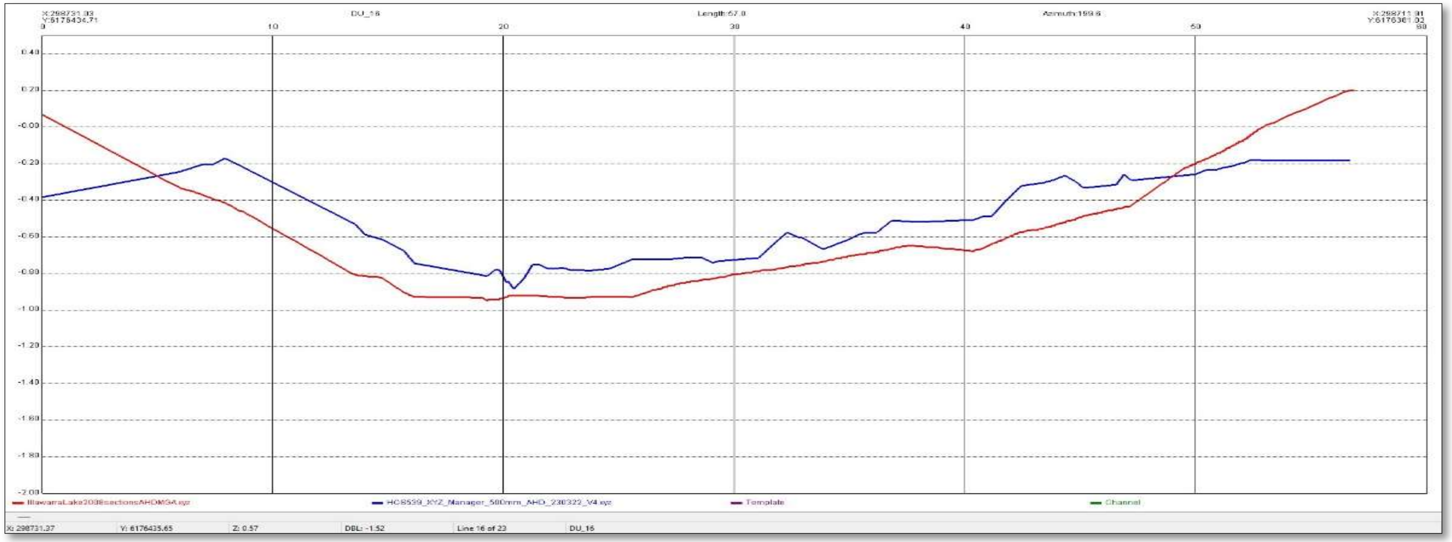


Figure 202: Duck Creek - profiles (red = 2008, blue = 2022/23) 15 and 16.

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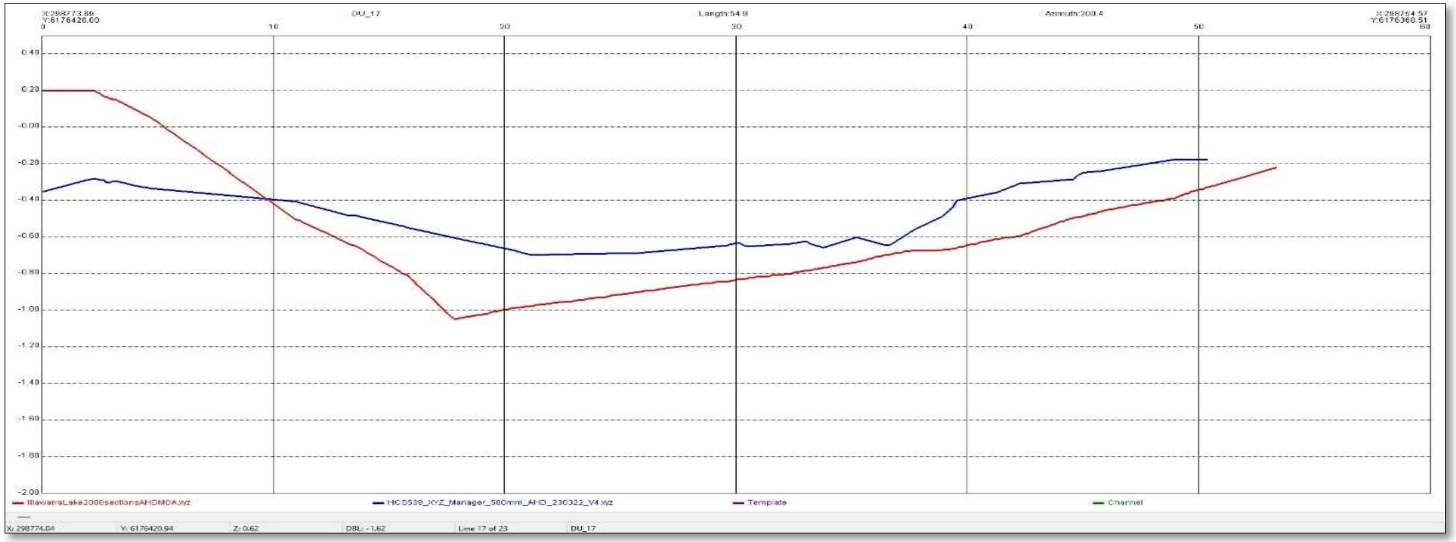


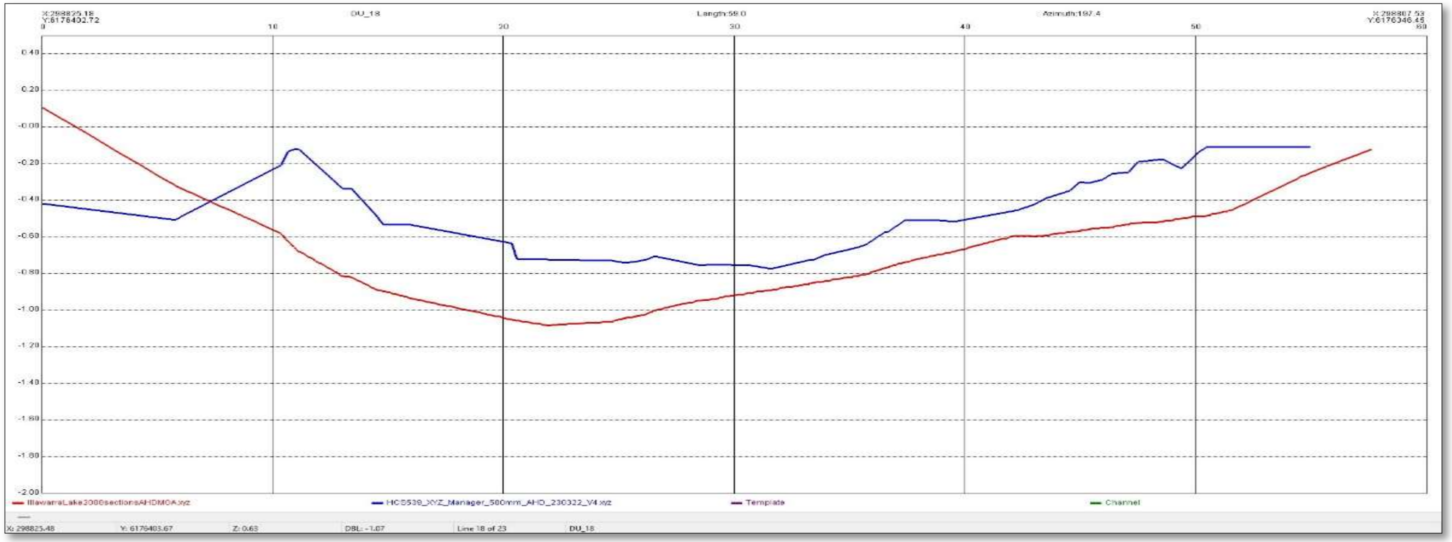


Figure 203: Duck Creek - profiles (red = 2008, blue = 2022/23) 17 and 18.

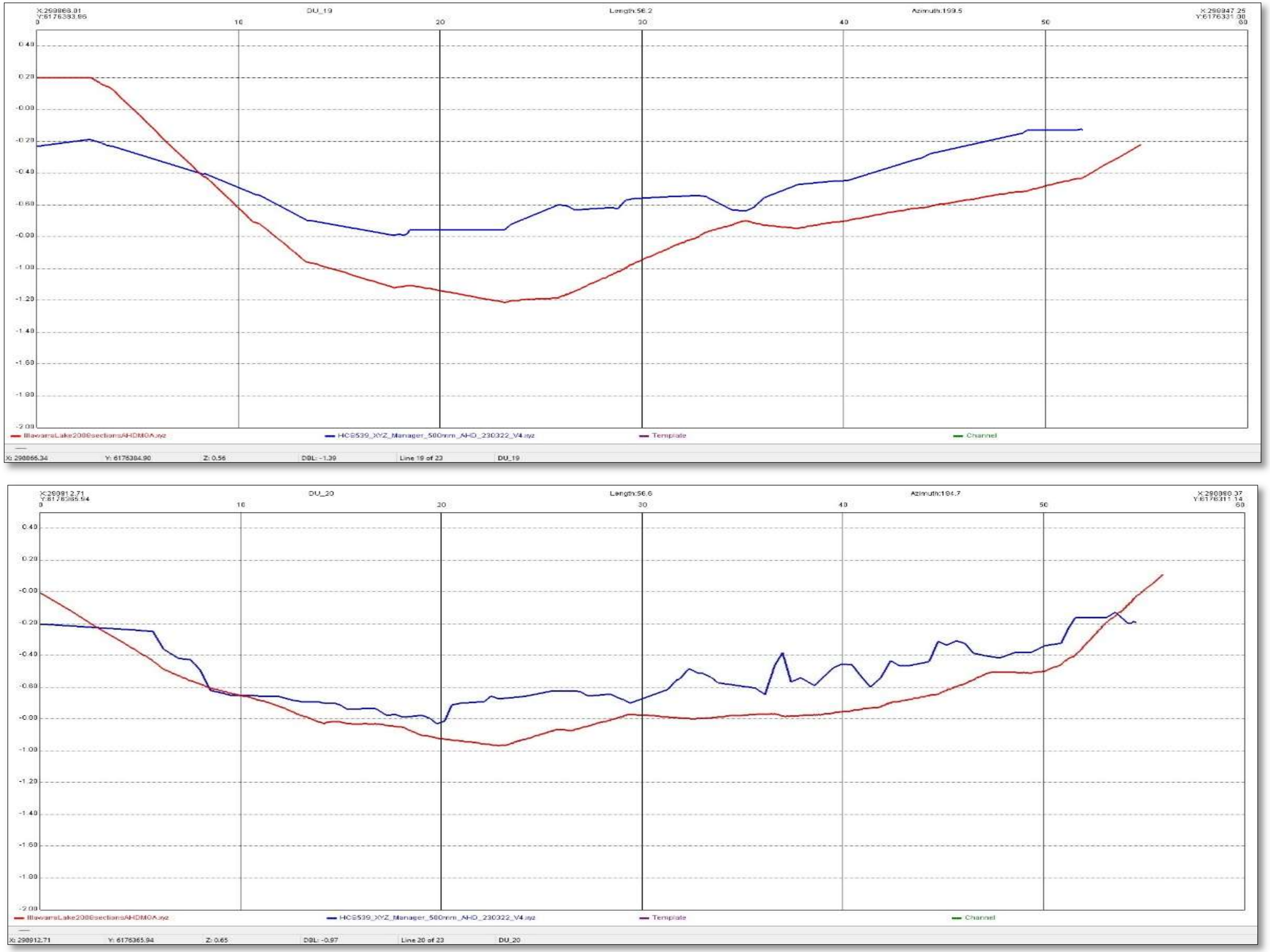
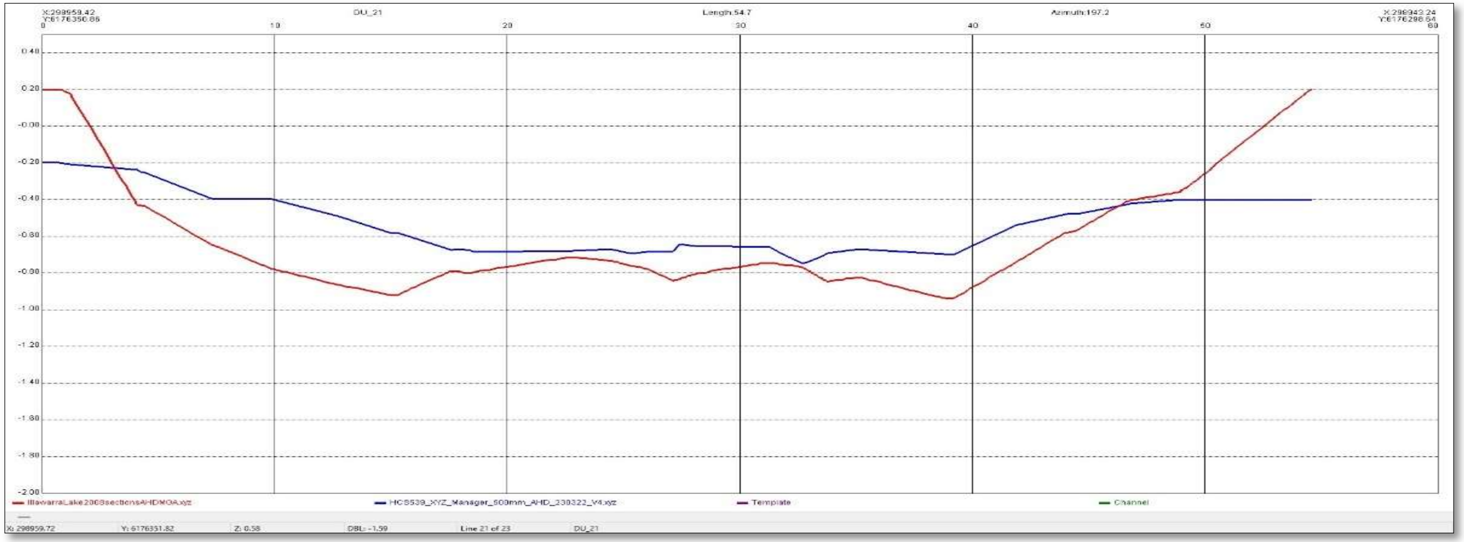


Figure 204: Duck Creek - profiles (red = 2008, blue = 2022/23) 19 and 20.



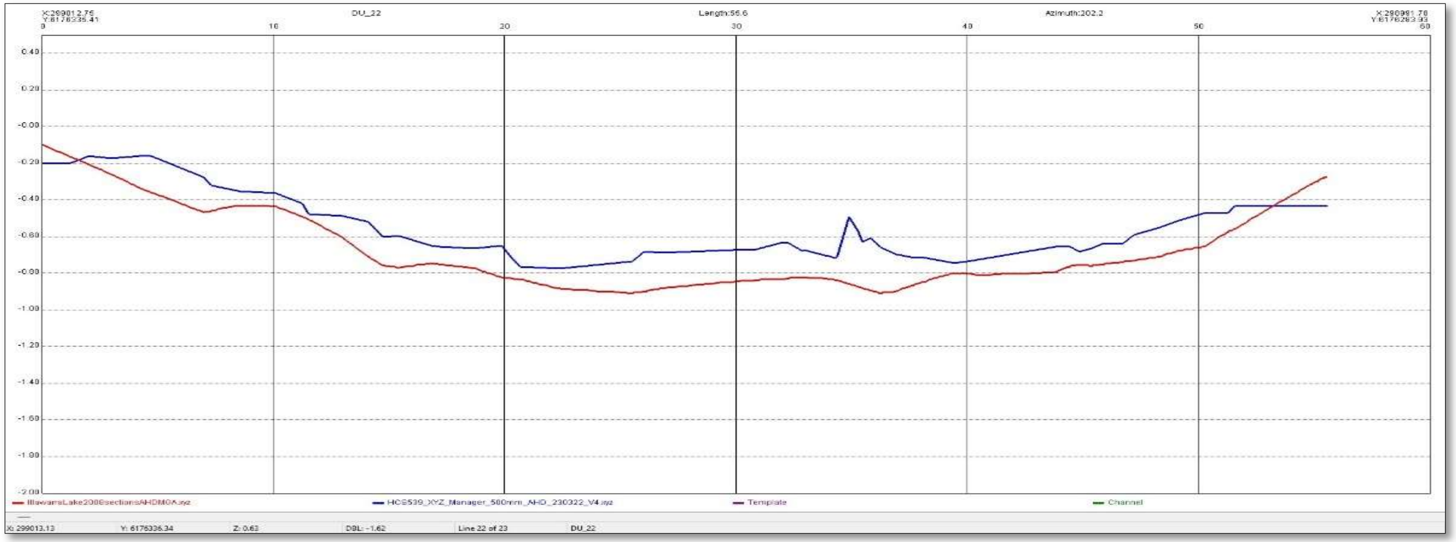
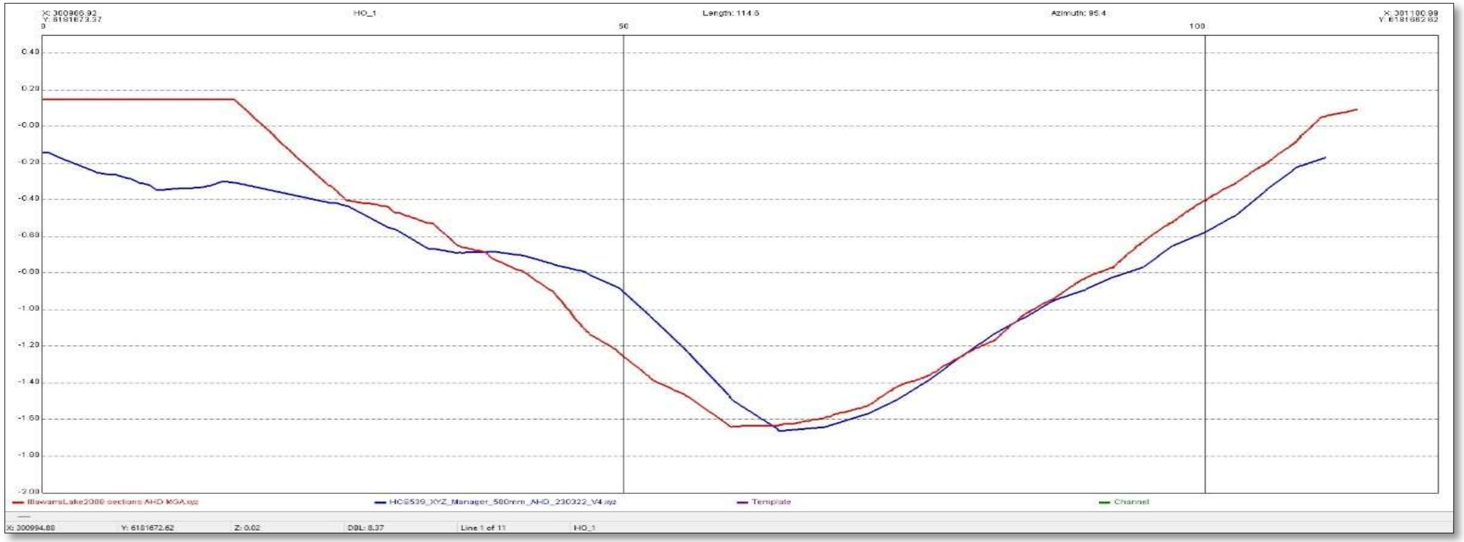


Figure 205: Duck Creek – profile (red = 2008, blue = 2022/23) 21 and 22.

Hooka Creek

Figure 206: Hooka Creek profiles utilised for analysis (1 – 11) (data within Plan 539-1 Sheet 2).



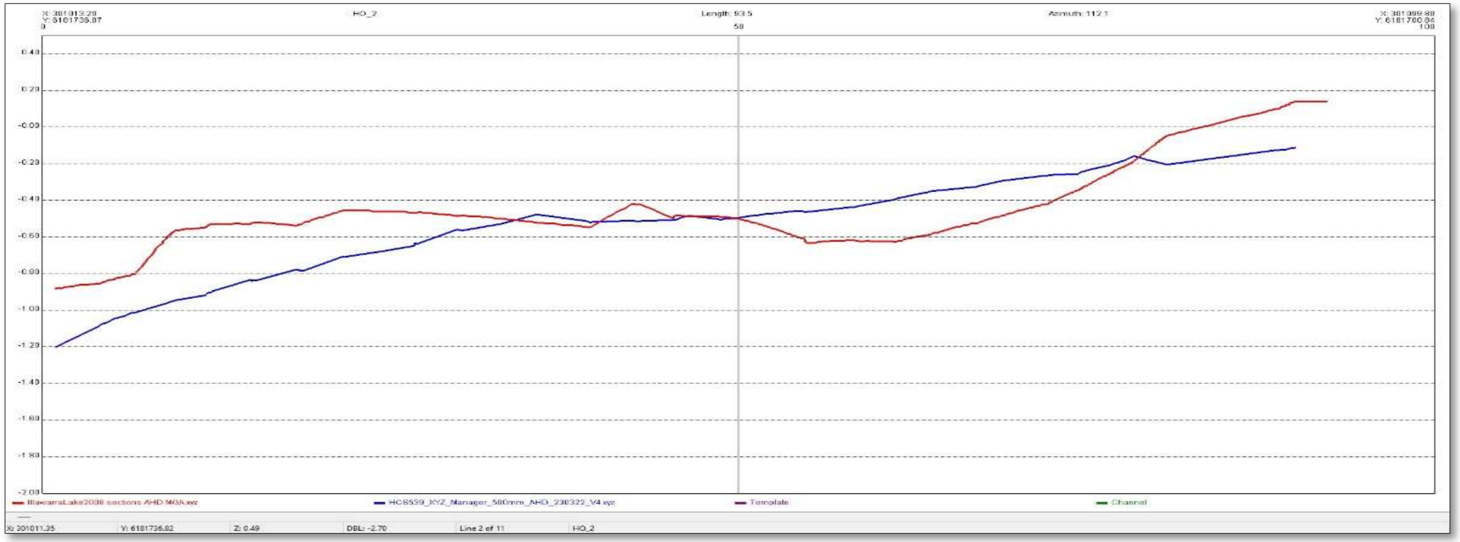
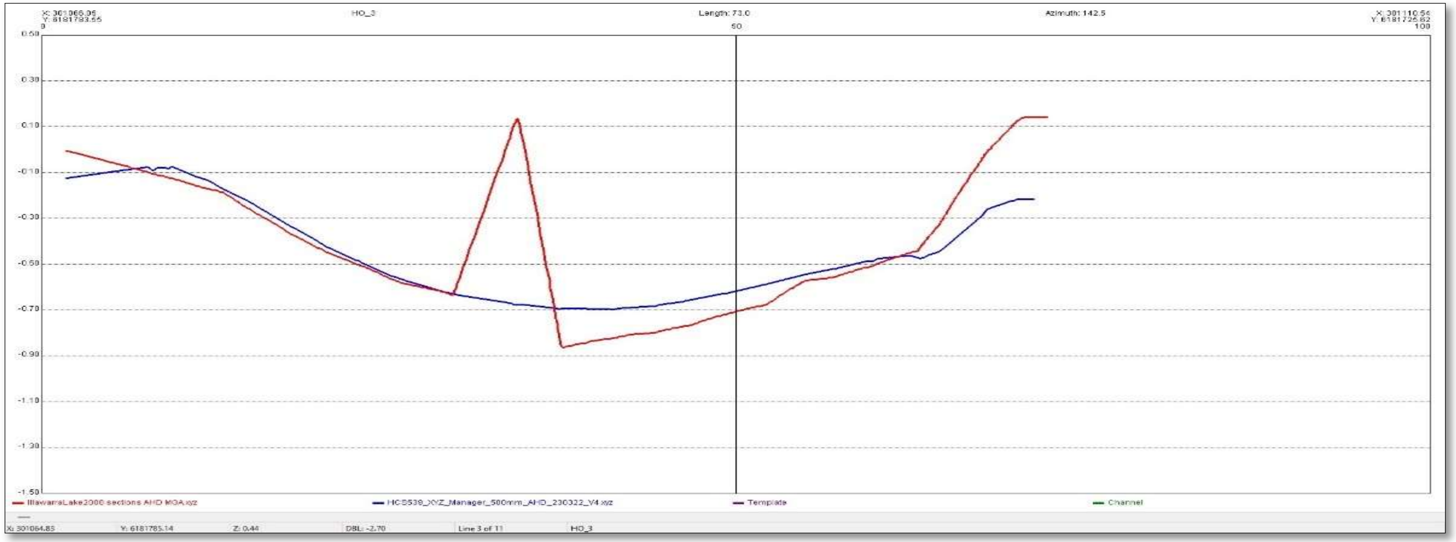


Figure 207: Hooka Creek - profiles (red = 2008, blue = 2022/23) 1 and 2.



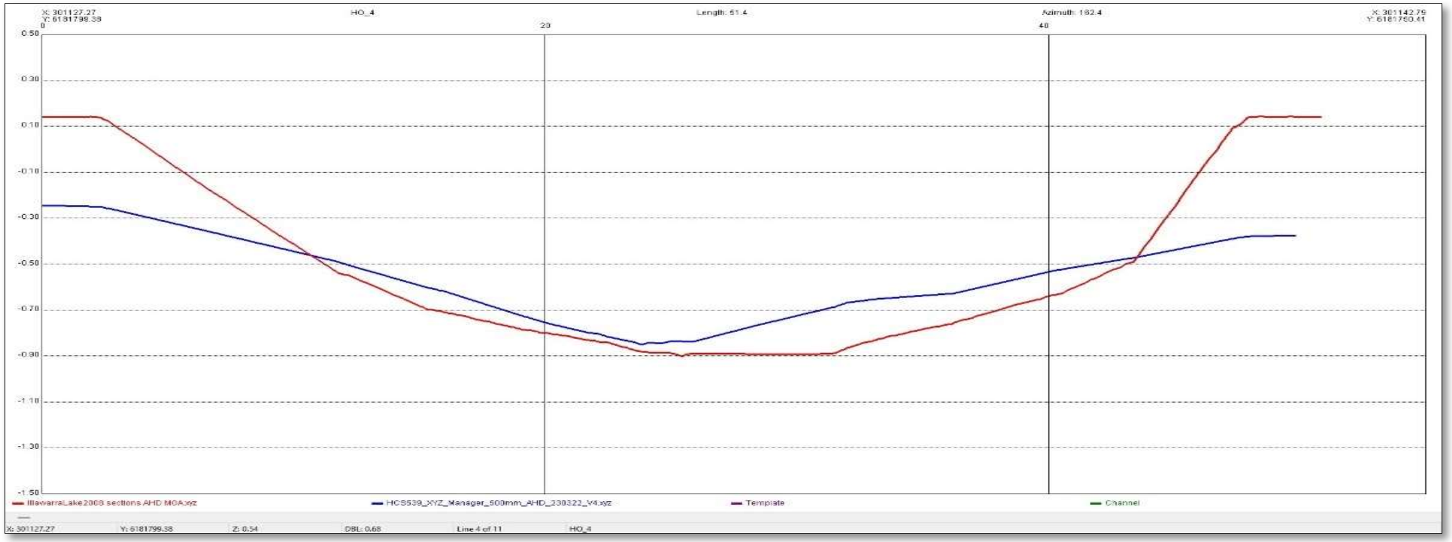
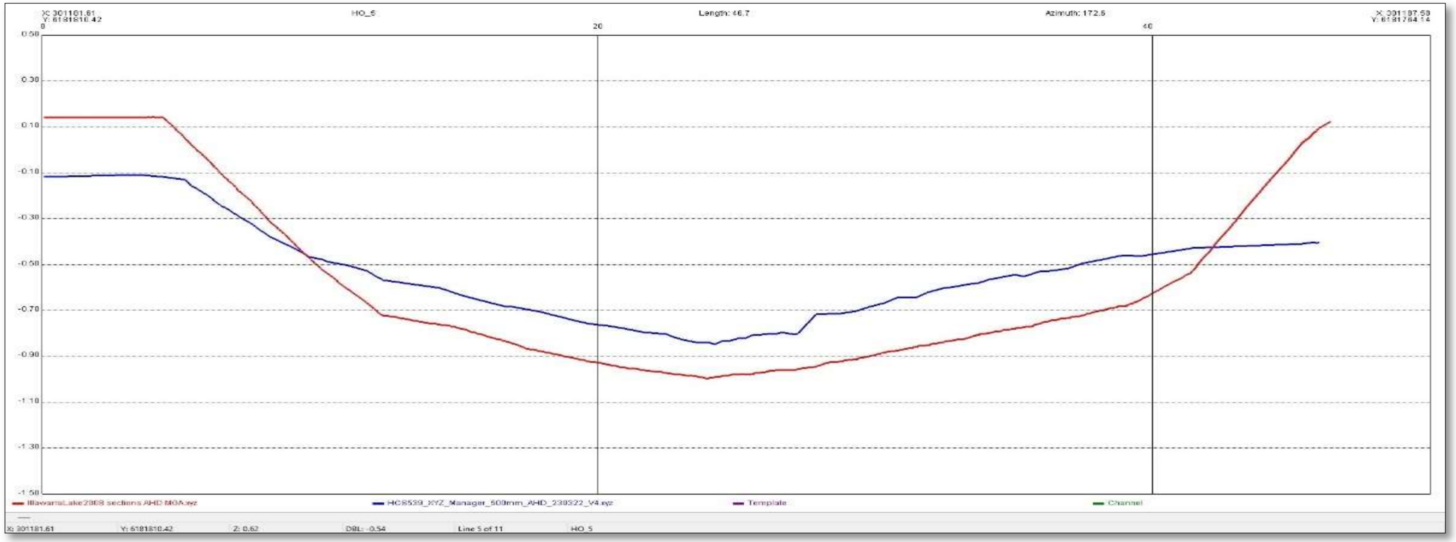


Figure 208: Hooka Creek - profiles (red = 2008, blue = 2022/23) 3 and 4.



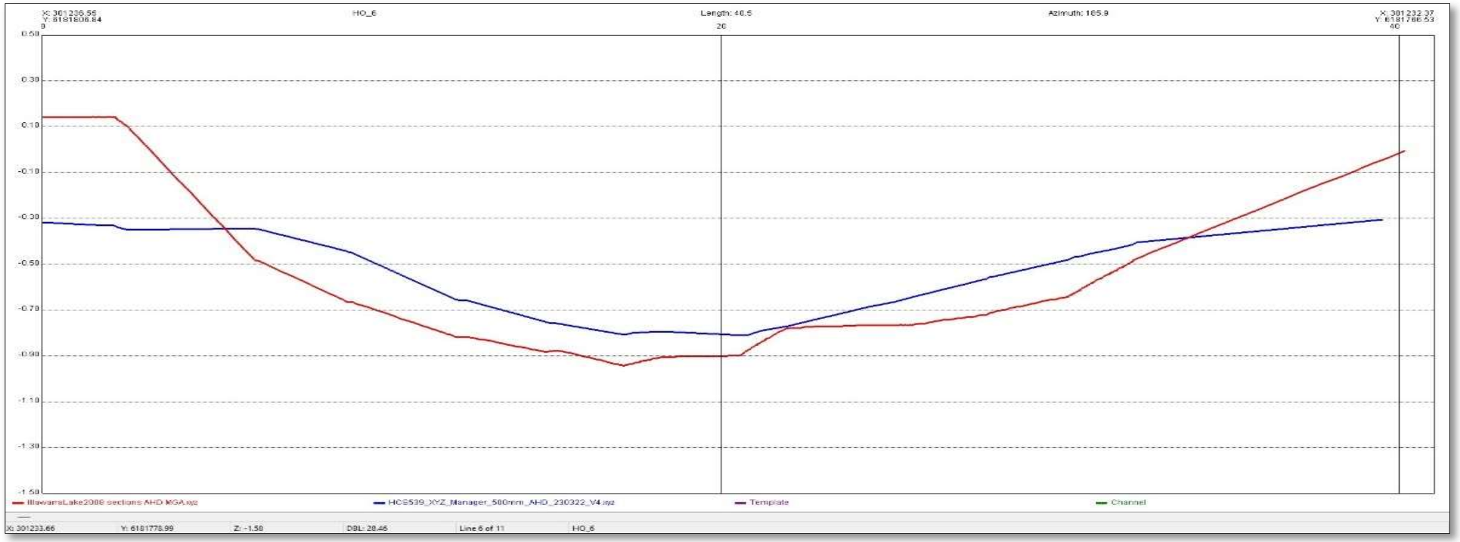
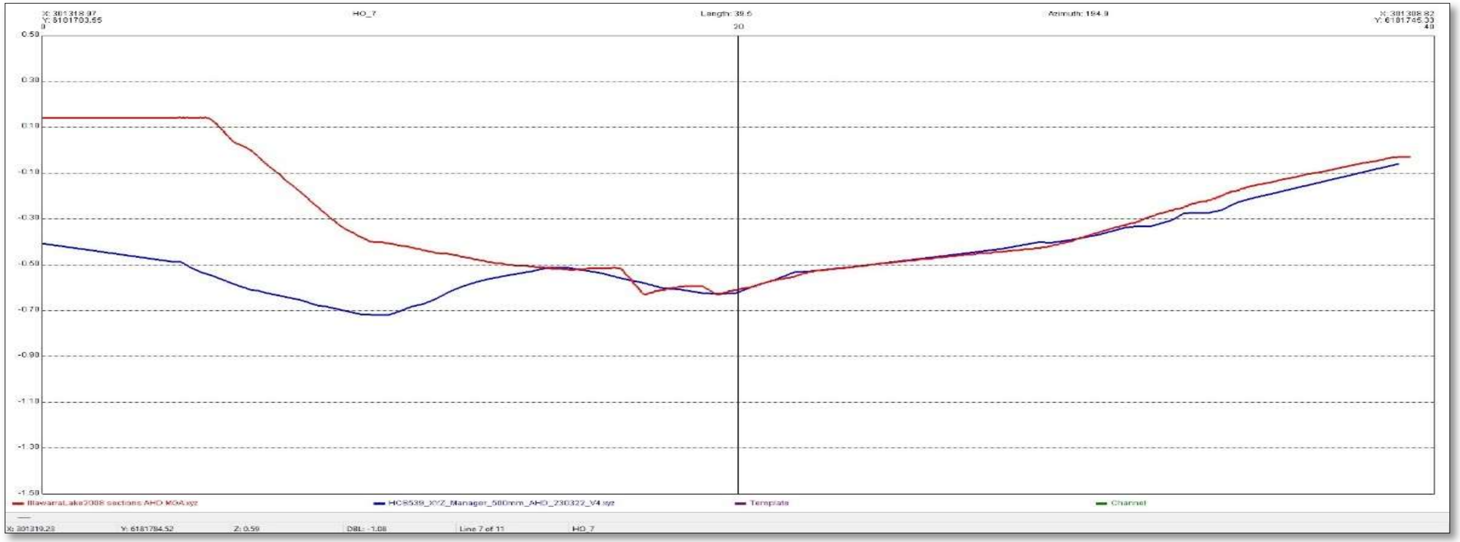


Figure 209: Hooka Creek - profiles (red = 2008, blue = 2022/23) 5 and 6.



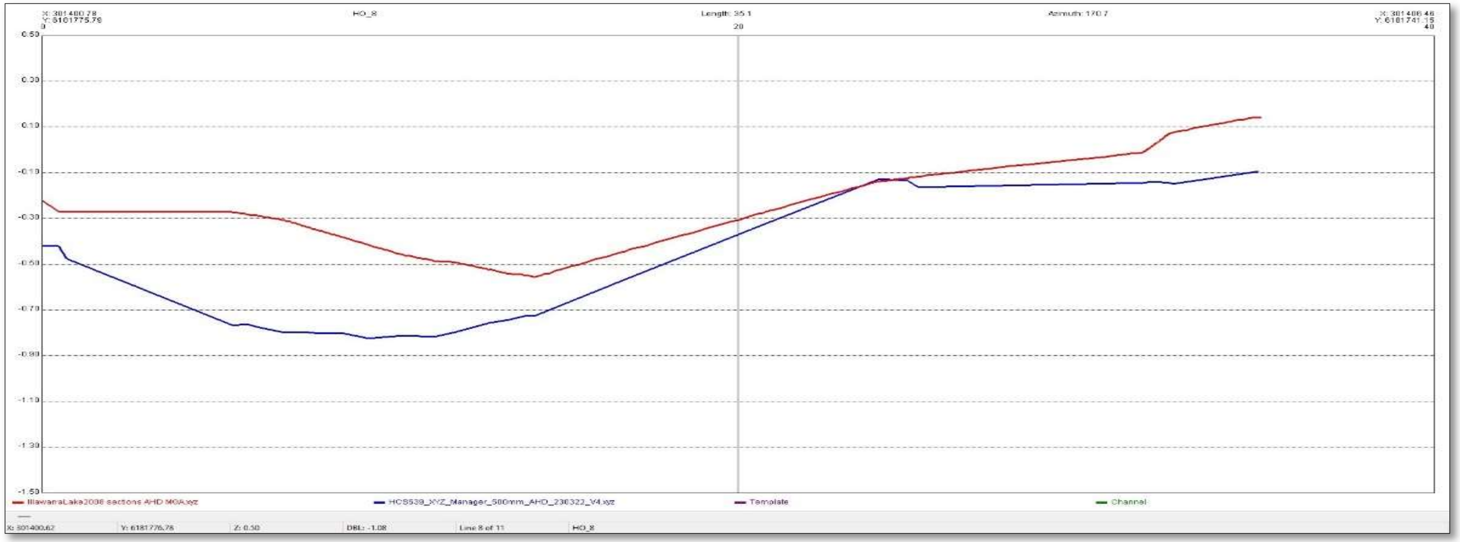


Figure 210: Hooka Creek - profiles (red = 2008, blue = 2022/23) 7 and 8.

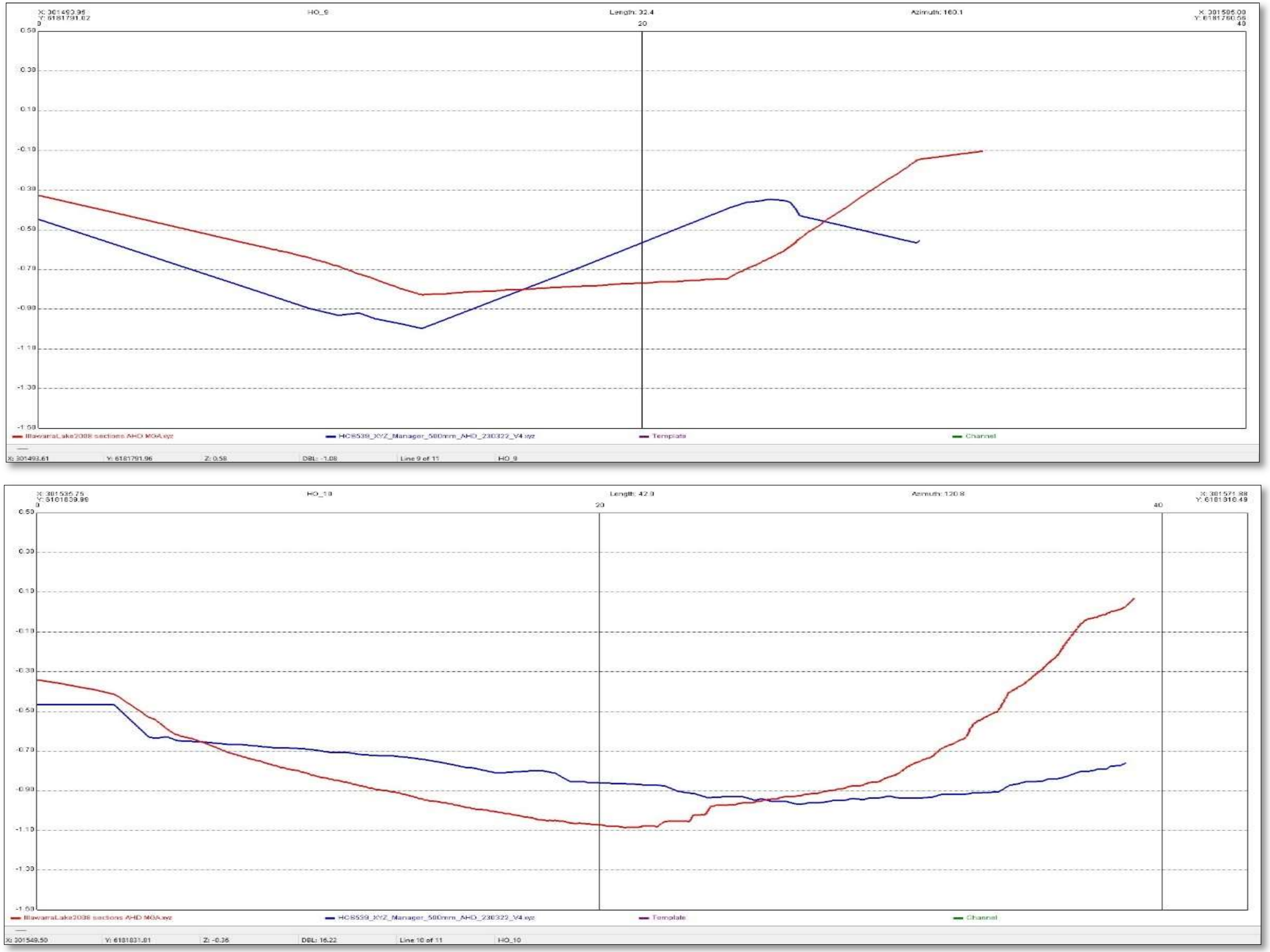


Figure 211: Hooka Creek - profiles (red = 2008, blue = 2022/23) 9 and 10.

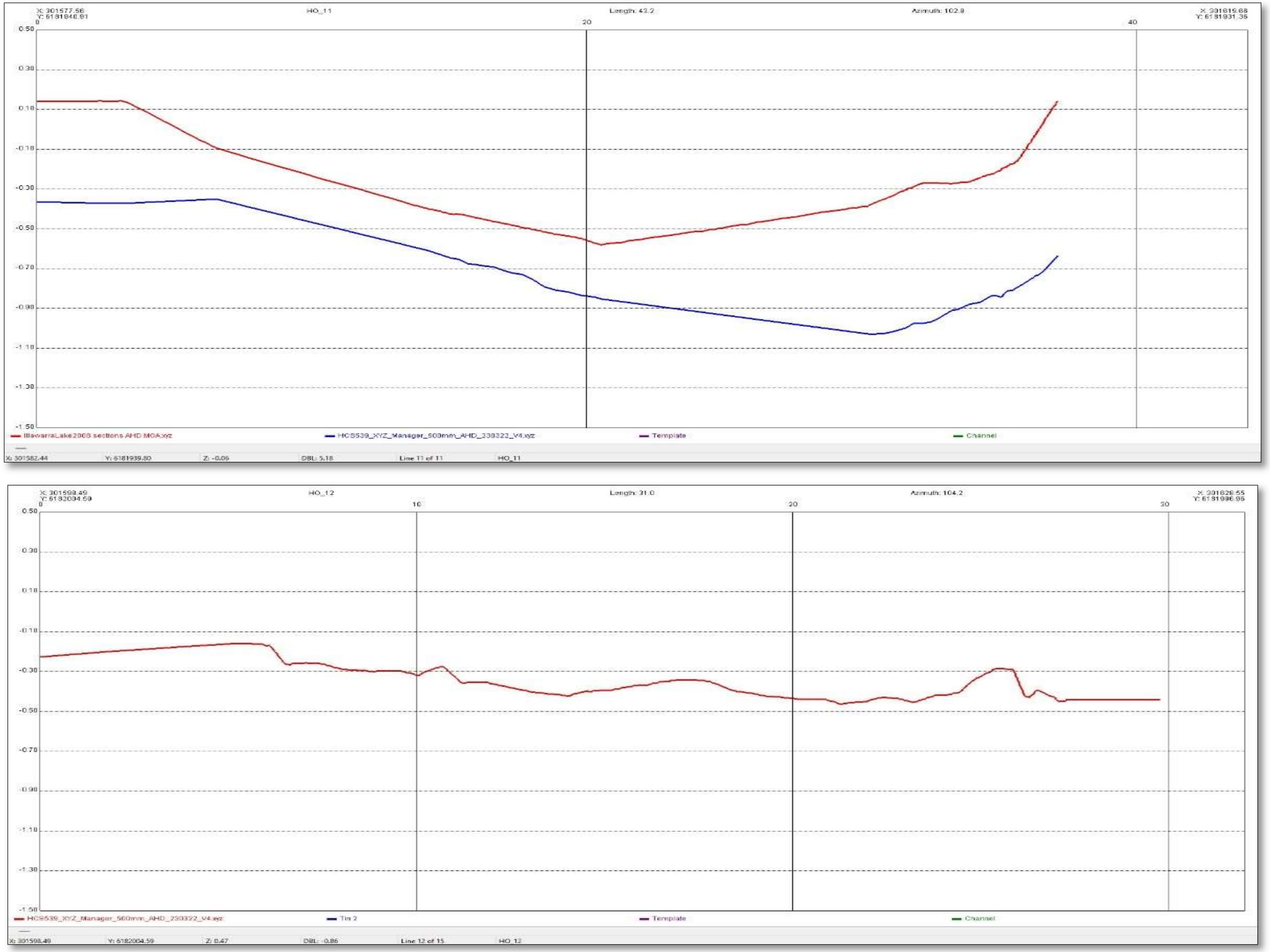
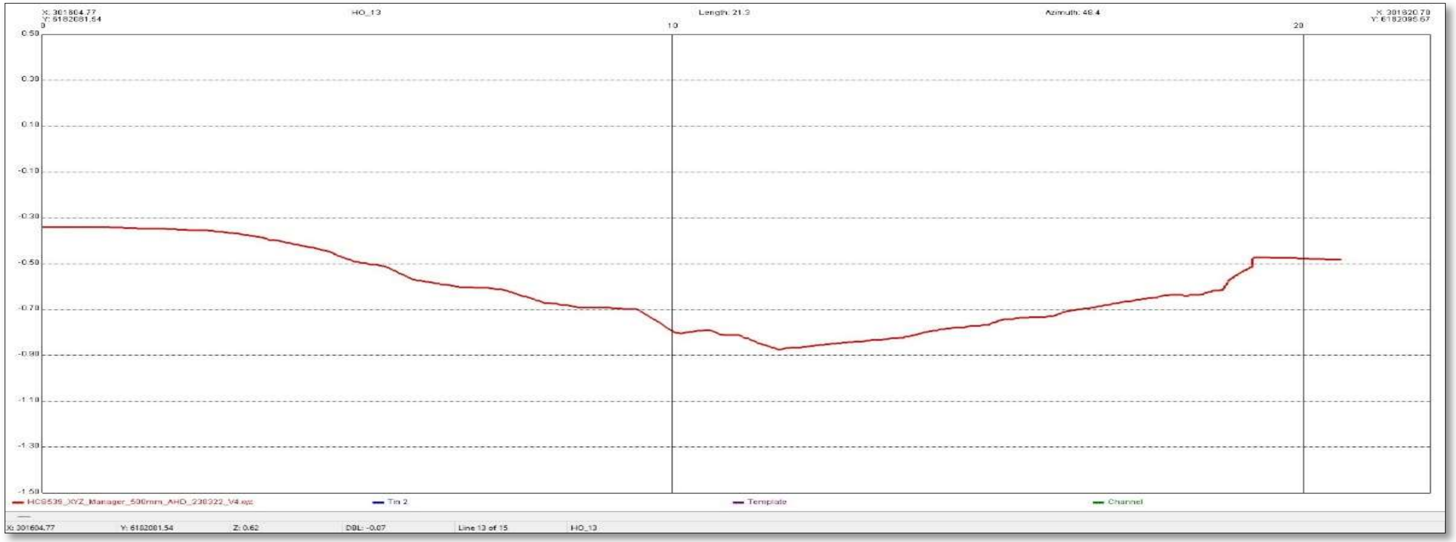


Figure 212: Hooka Creek - profiles (red = 2008, blue = 2022/23) 11 and 12.



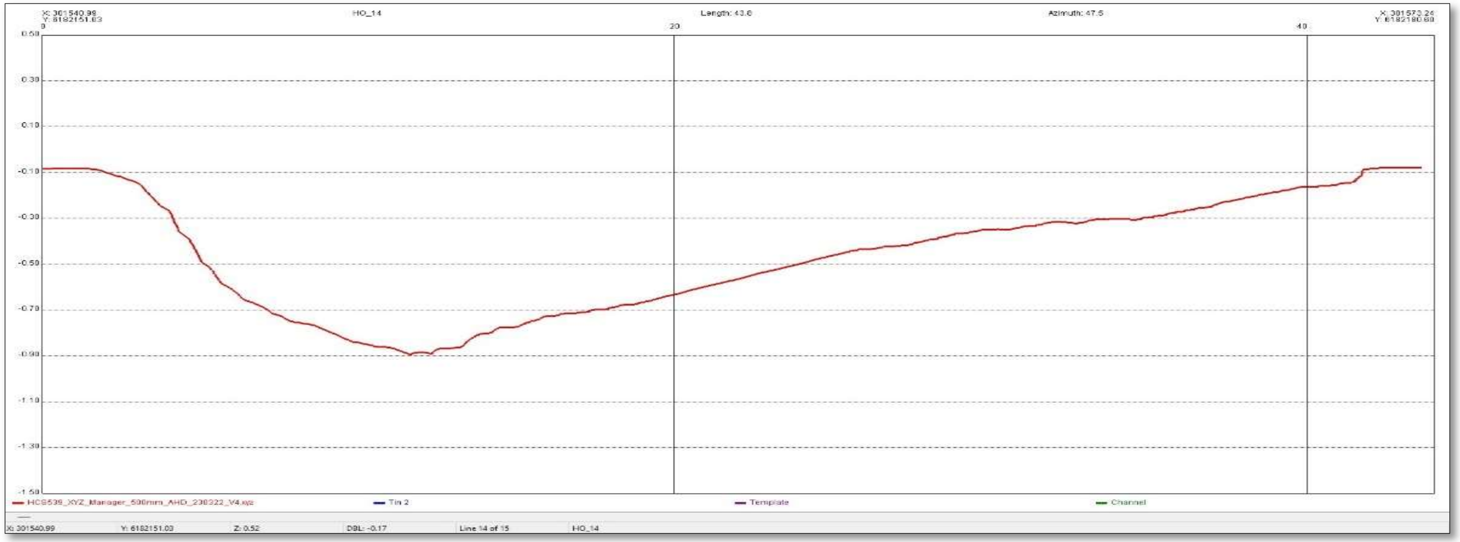


Figure 213: Hooka Creek - profiles (red = 2022/23) 13 and 14.

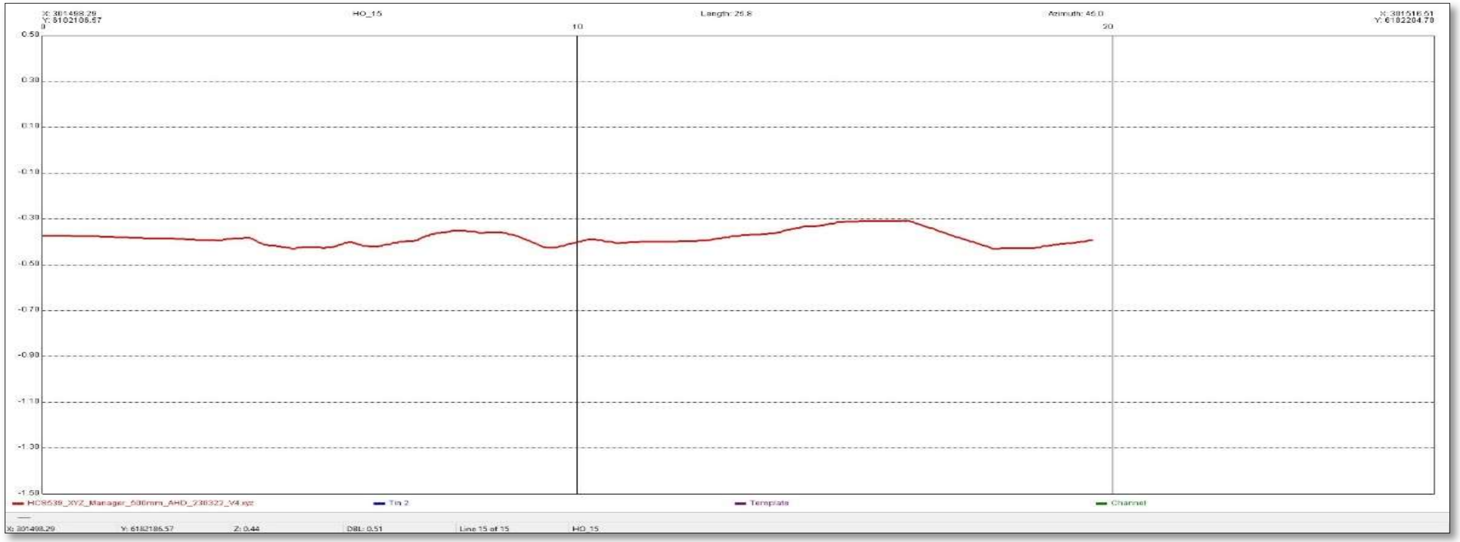


Figure 214: Hooka Creek - profiles (red = 2022/23) 15.

Horsley Creek

Figure 215: Horsley Creek profiles utilised for analysis (data within Plan 539-1 Sheet 5).

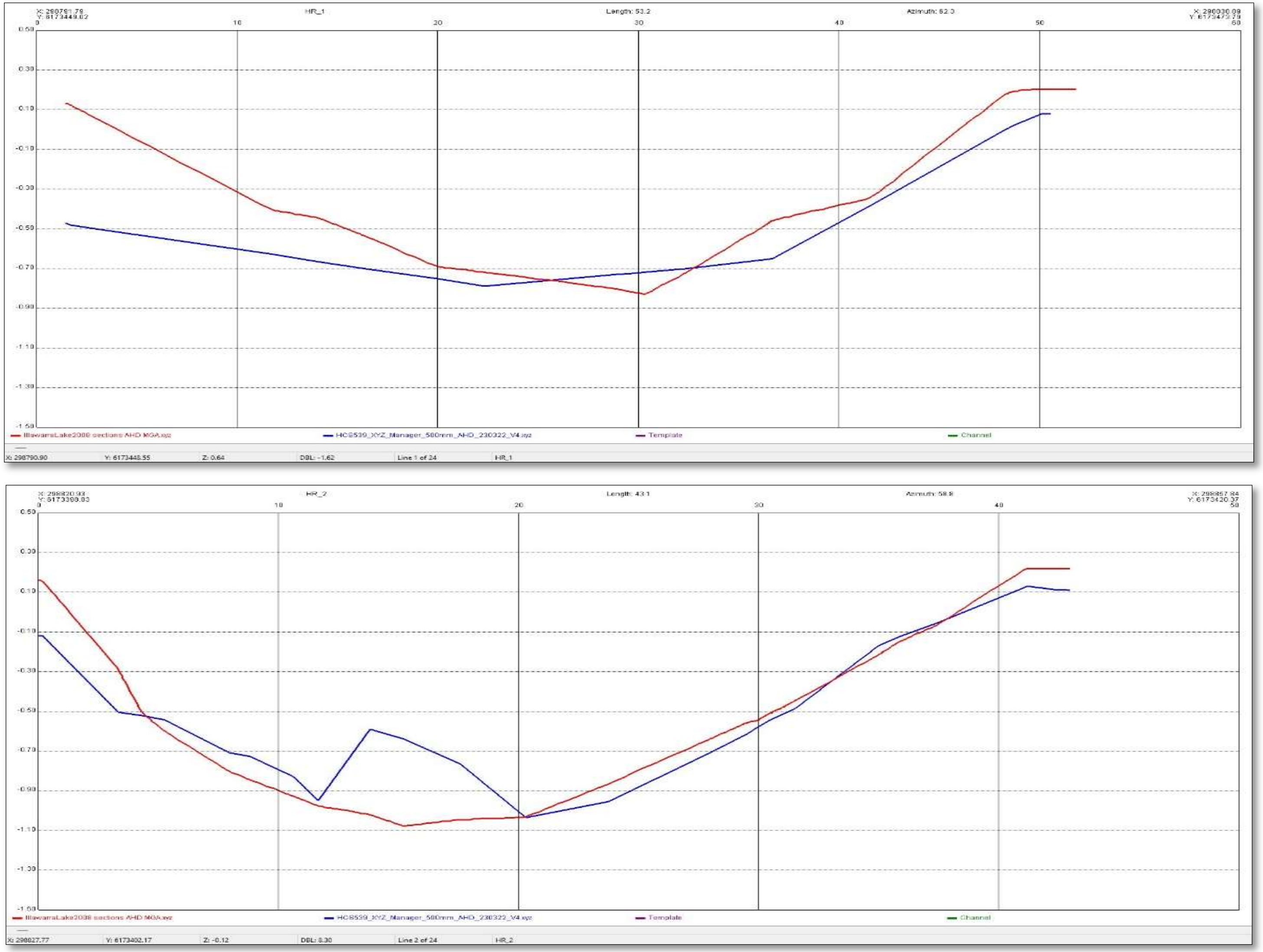


Figure 216: Horsley Creek - profiles (red = 2008, blue = 2022/23) 1 and 2.

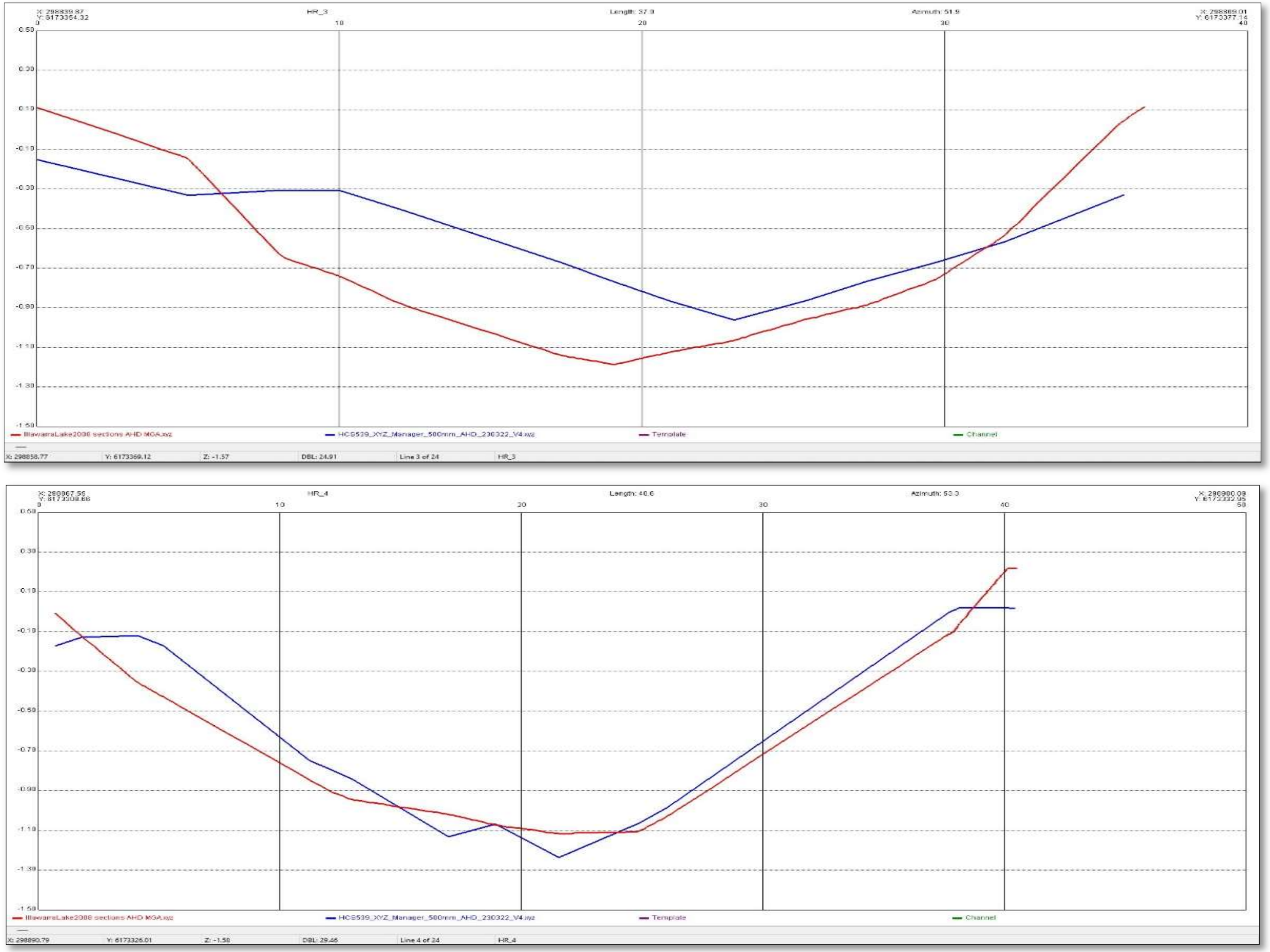
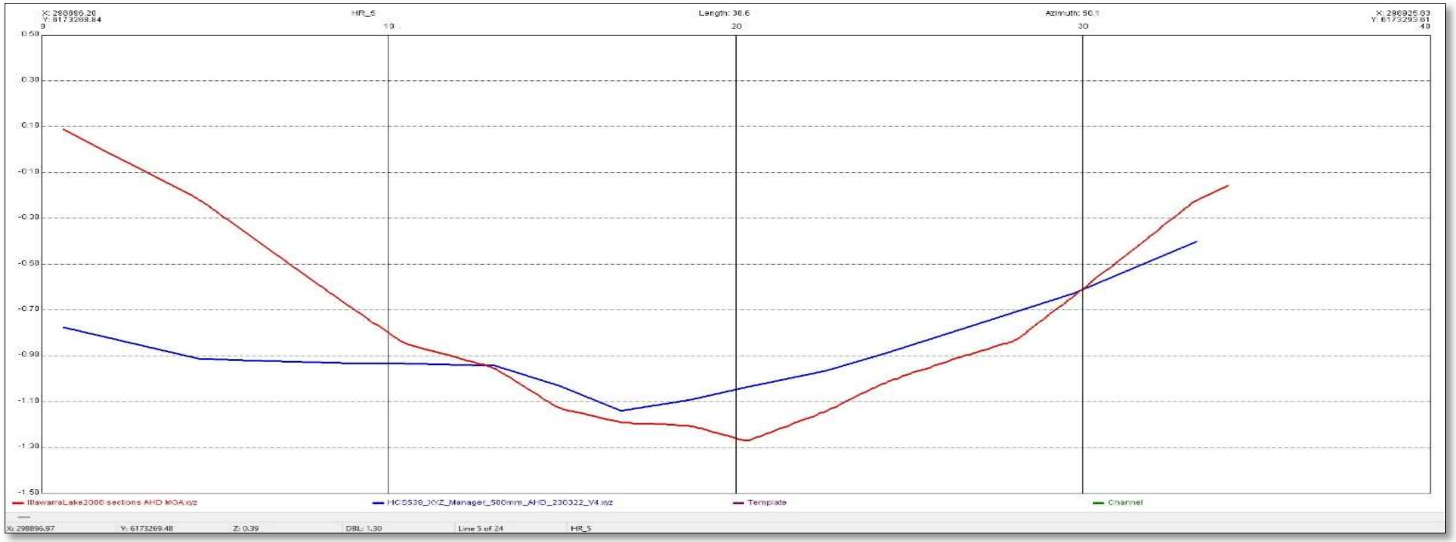


Figure 217: Horsley Creek - profiles (red = 2008, blue = 2022/23) 3 and 4.



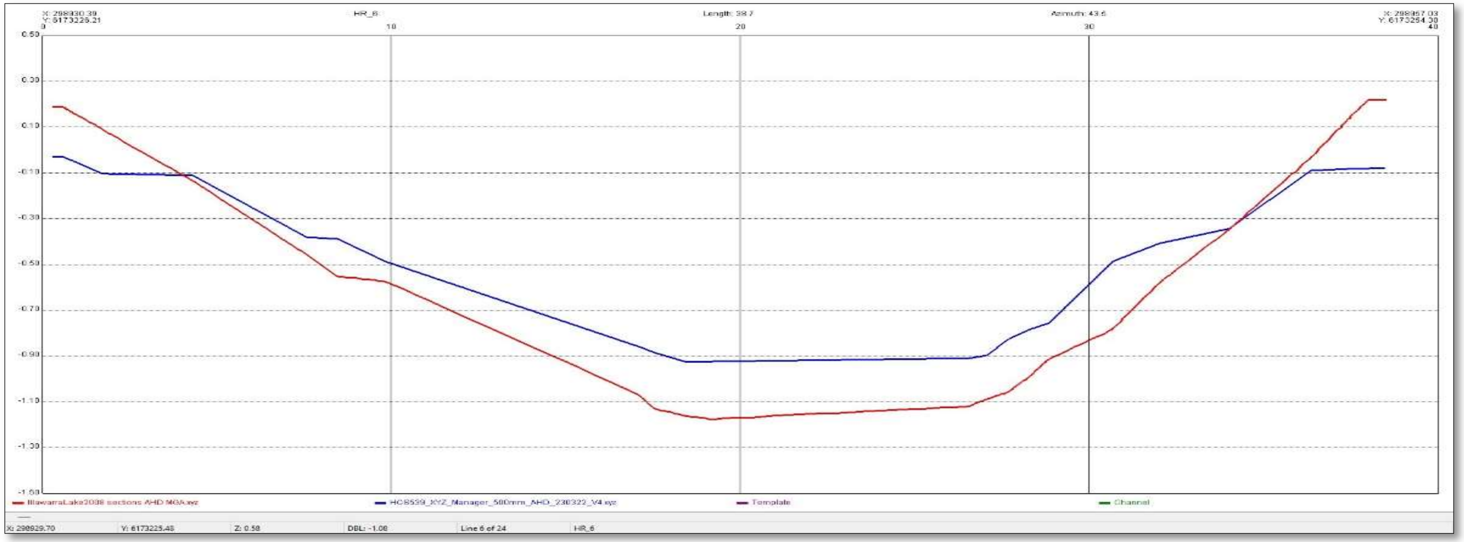


Figure 218: Horsley Creek - profiles (red = 2008, blue = 2022/23) 5 and 6.

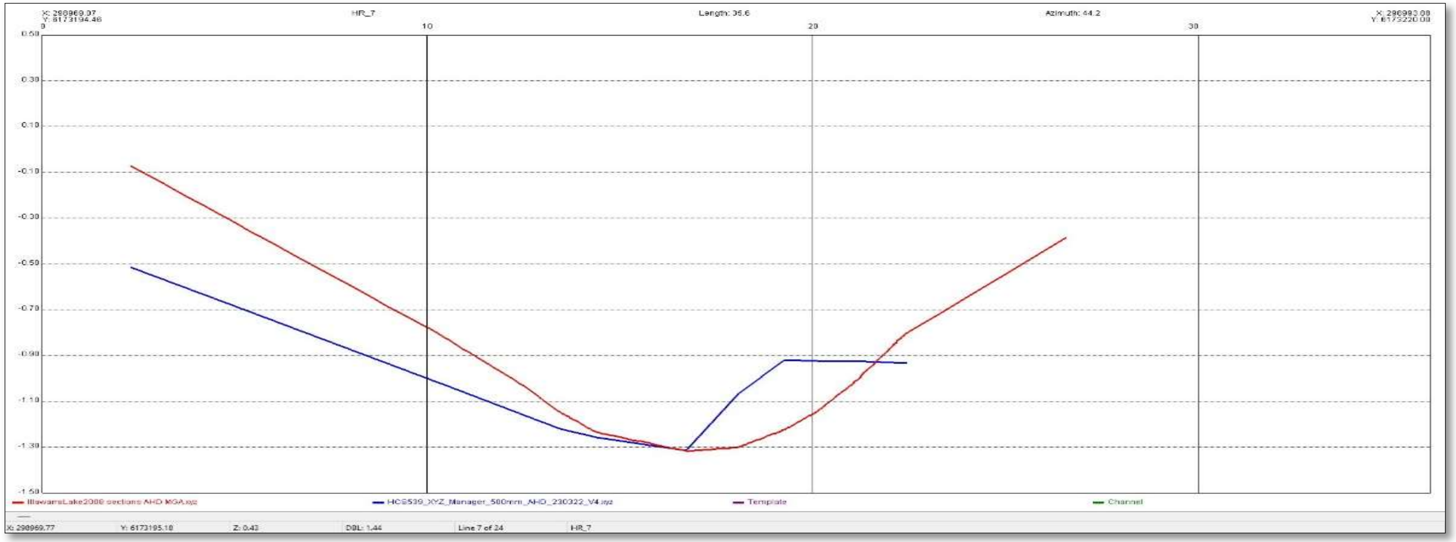


Figure 219: Horsley Creek - profiles (red = 2008, blue = 2022/23) 7 and 8.

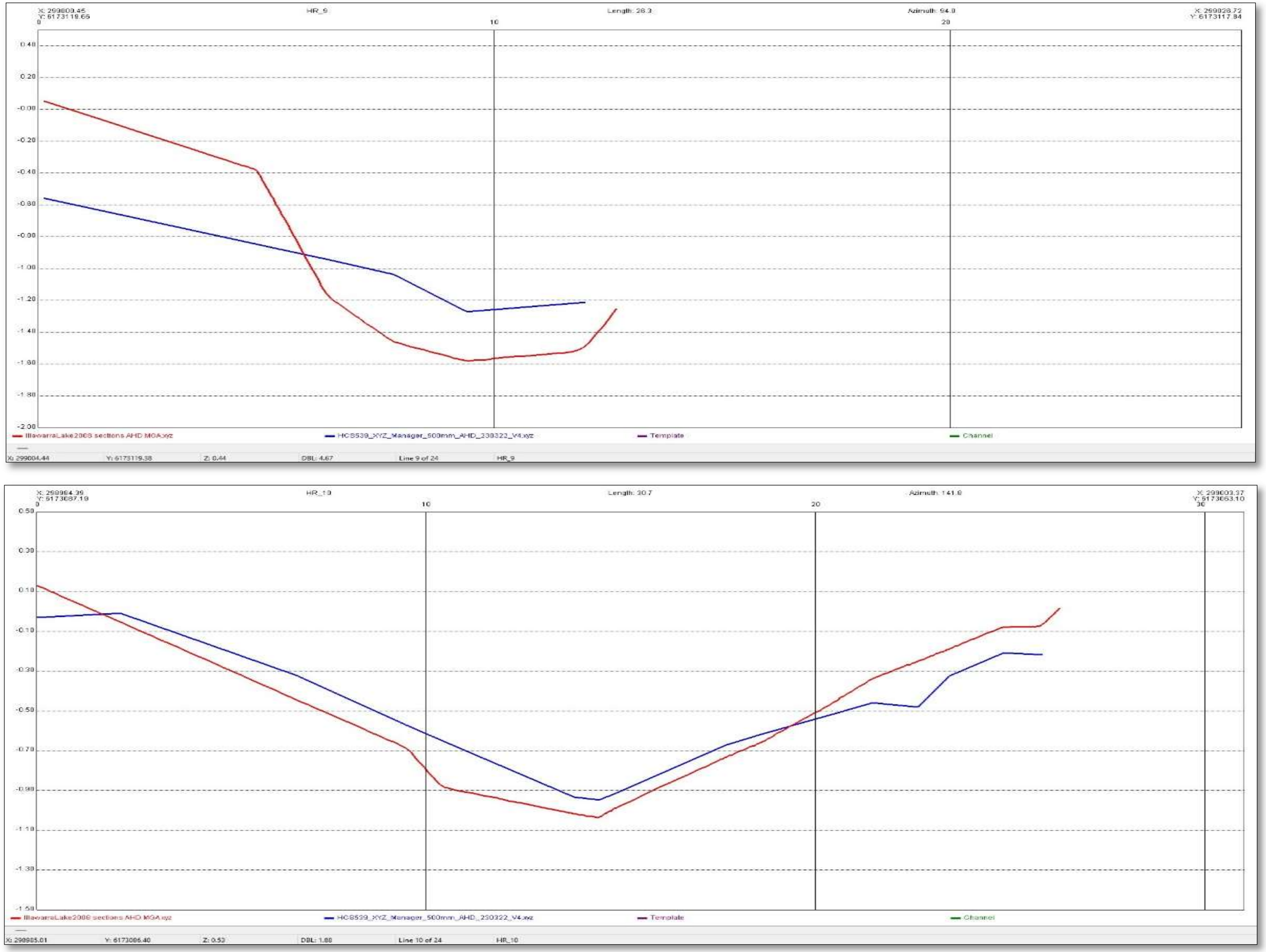


Figure 220: Horsley Creek - profiles (red = 2008, blue = 2022/23) 9 and 10.

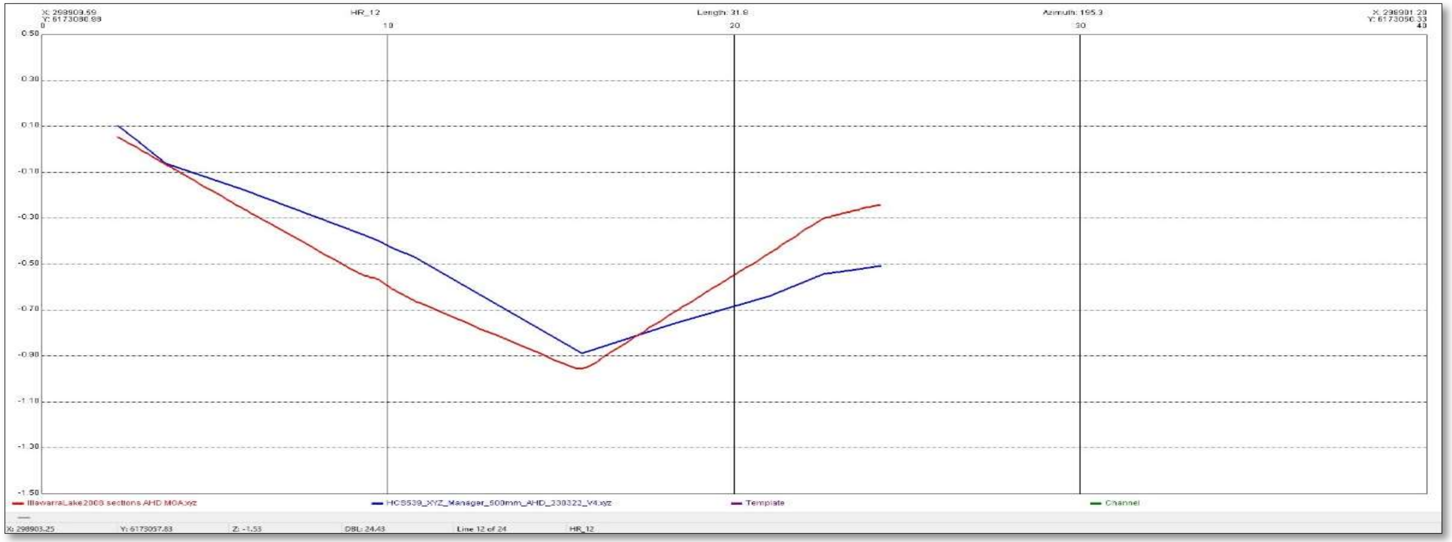


Figure 221: Horsley Creek - profiles (red = 2008, blue = 2022/23) 11 and 12.

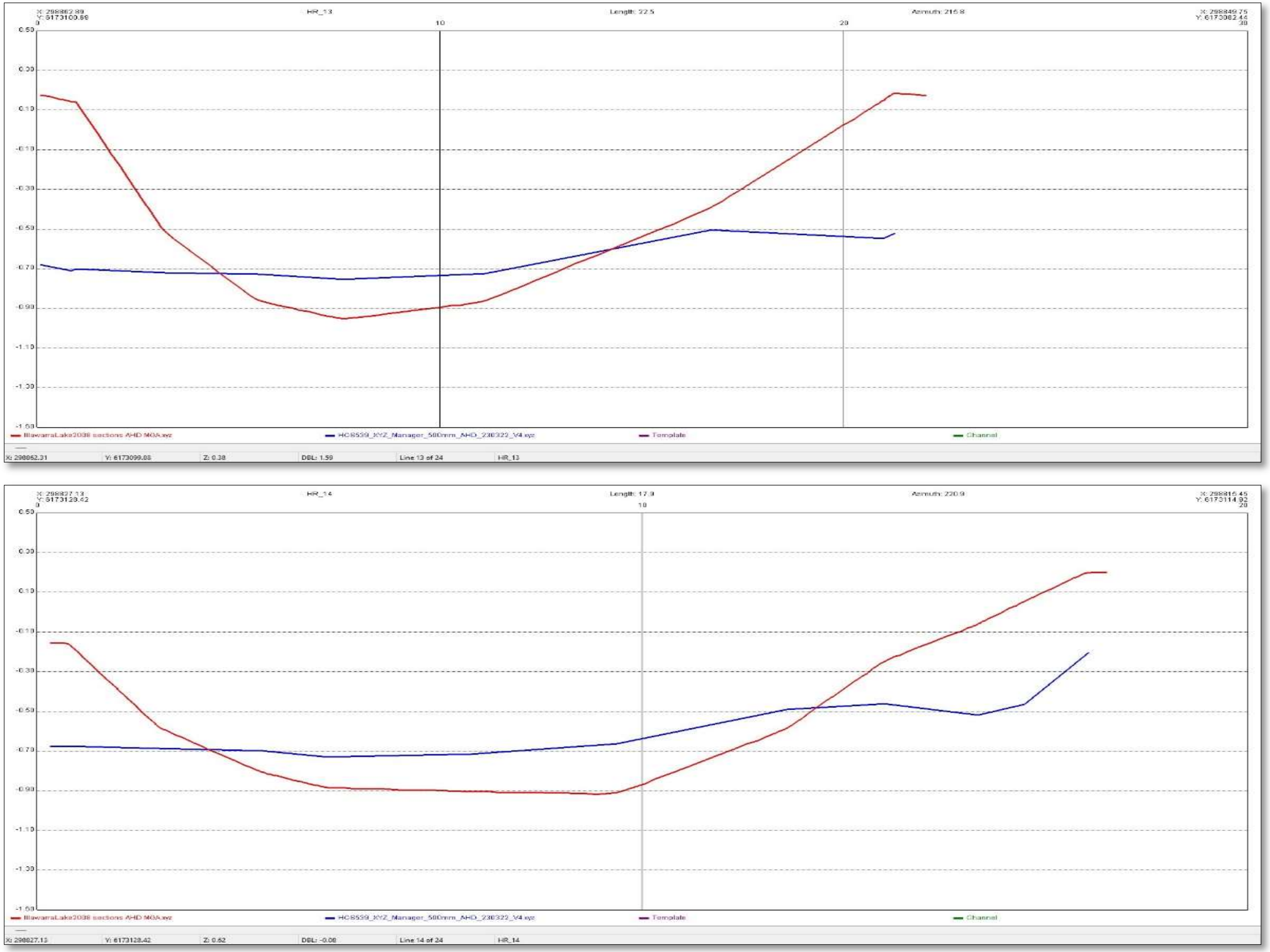


Figure 222: Horsley Creek – profiles (red = 2008, blue = 2022/23) 13 and 14.

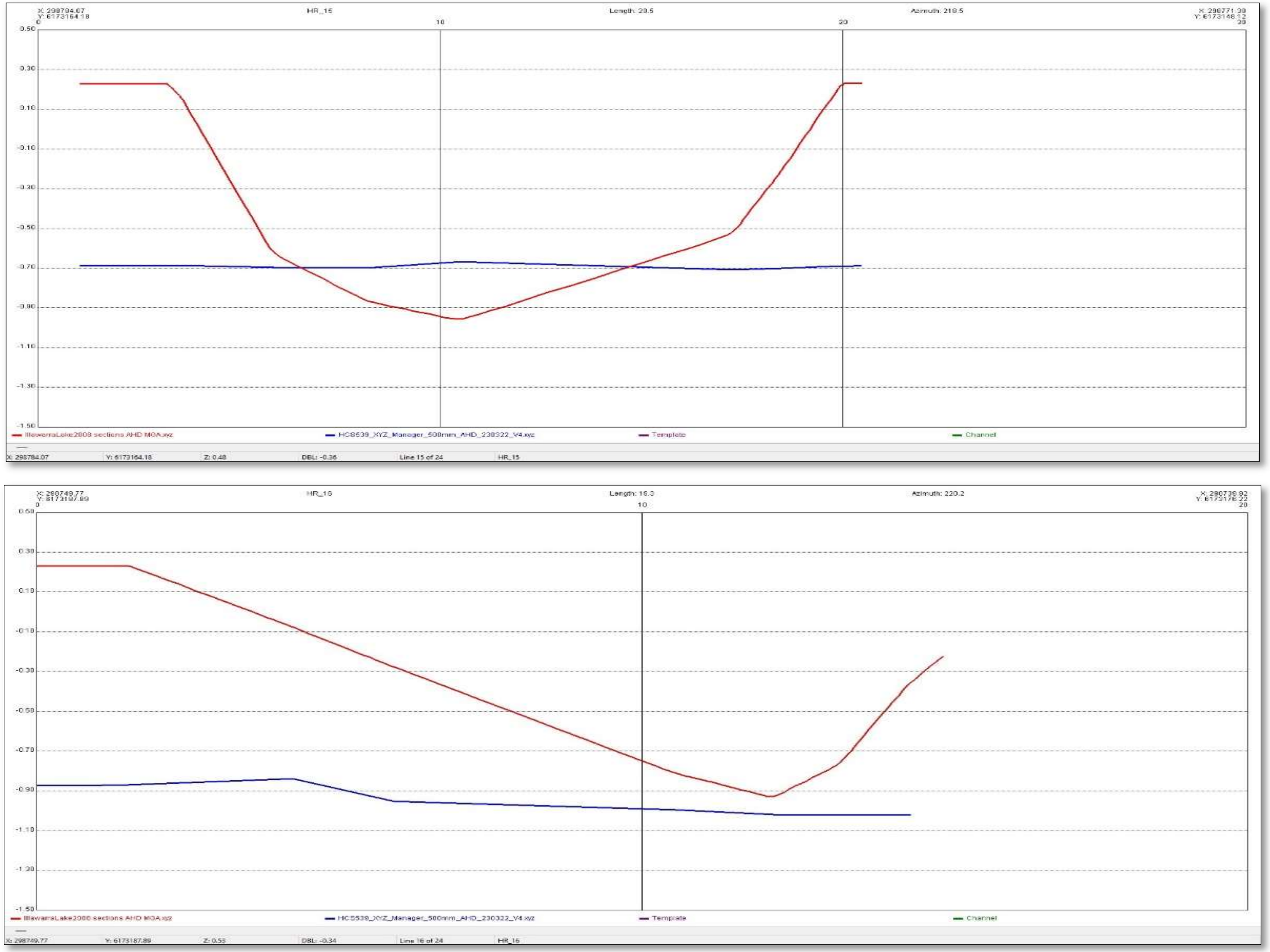
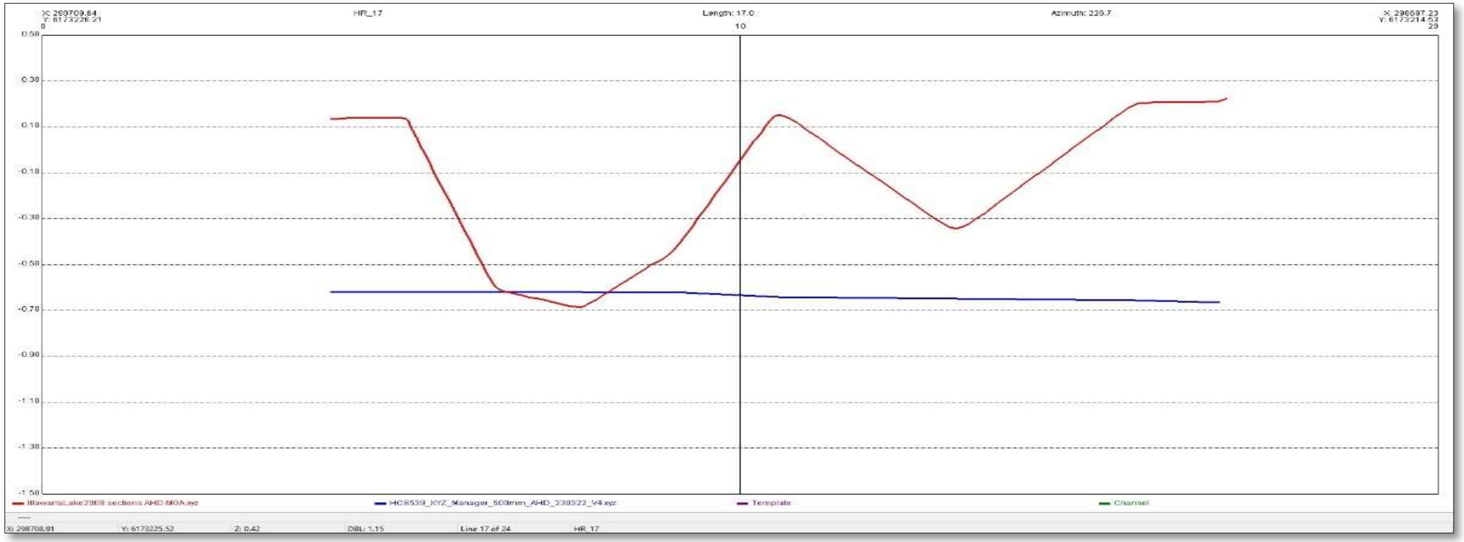


Figure 223: Horsley Creek – profiles (red = 2008, blue = 2022/23) 15 and 16.



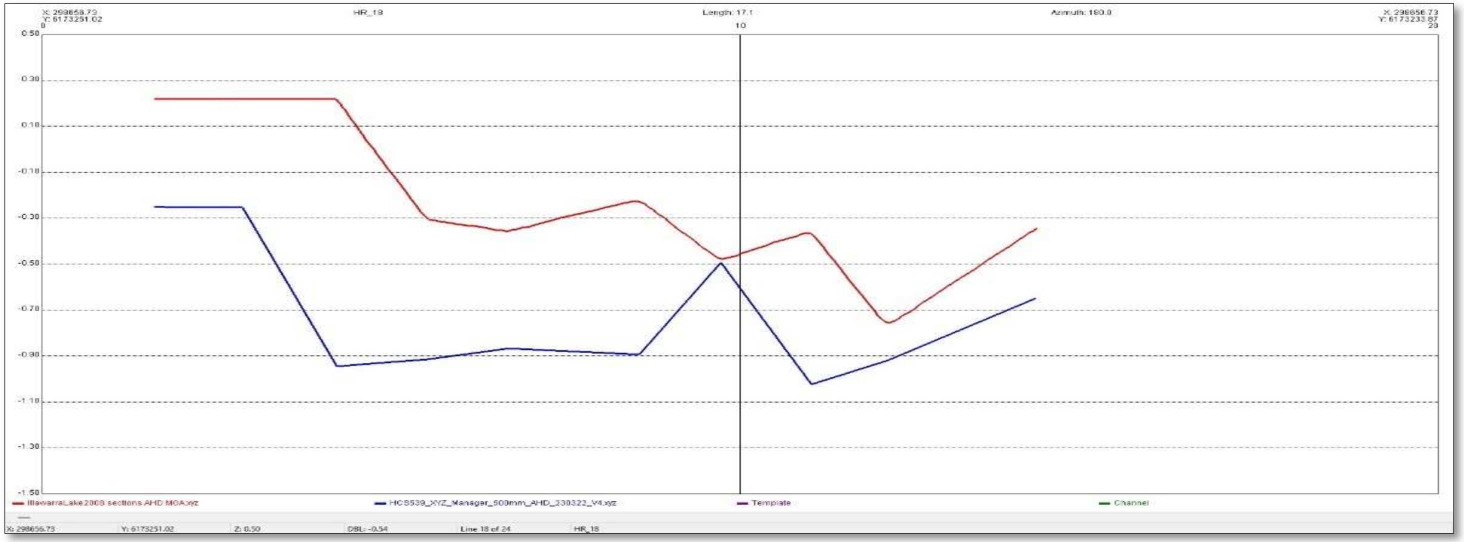


Figure 224: Horsley Creek – profiles (red = 2008, blue = 2022/23) 17 and 18.

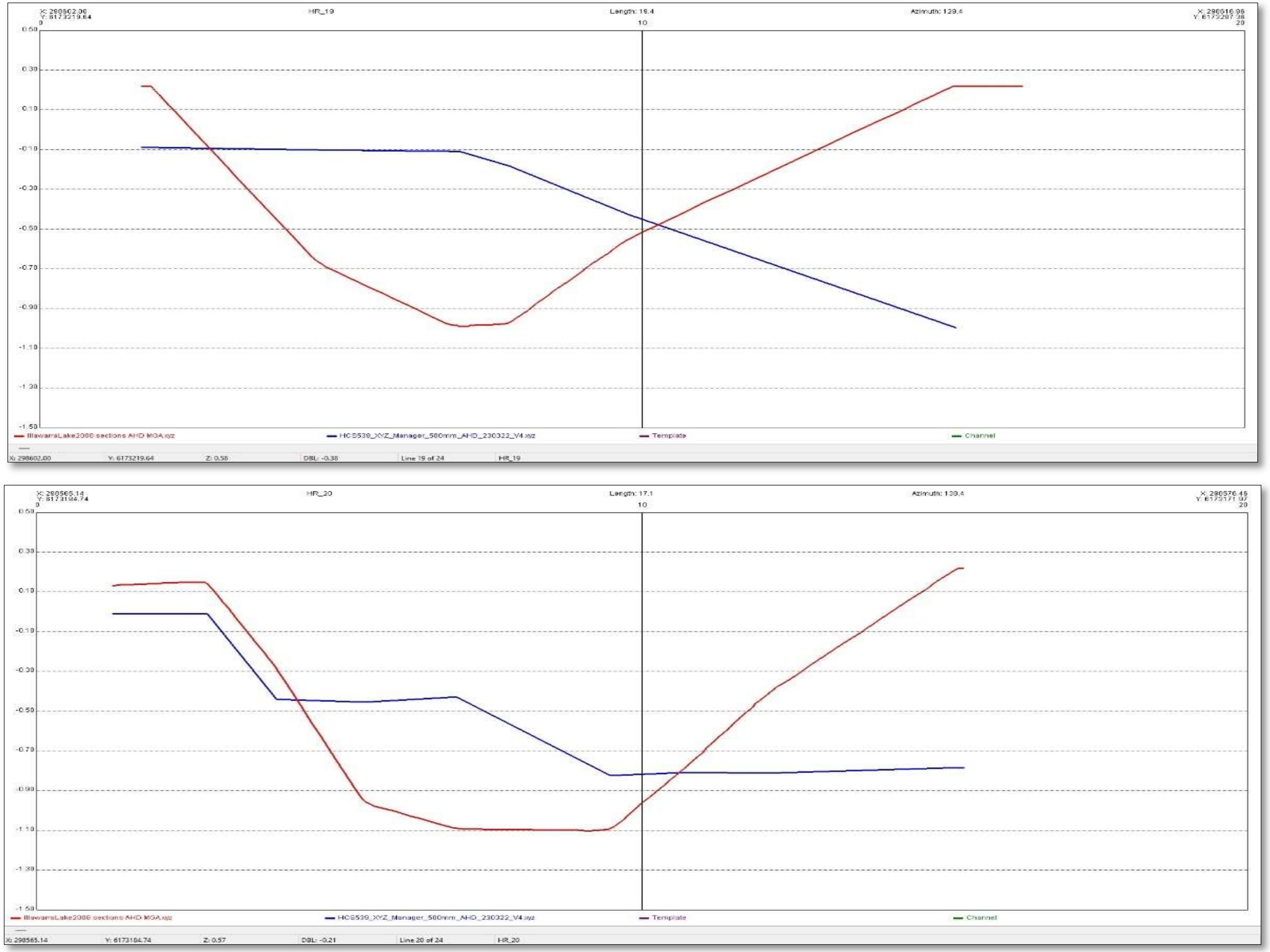


Figure 225: Horsley Creek – profiles (red = 2008, blue = 2022/23) 19 and 20.

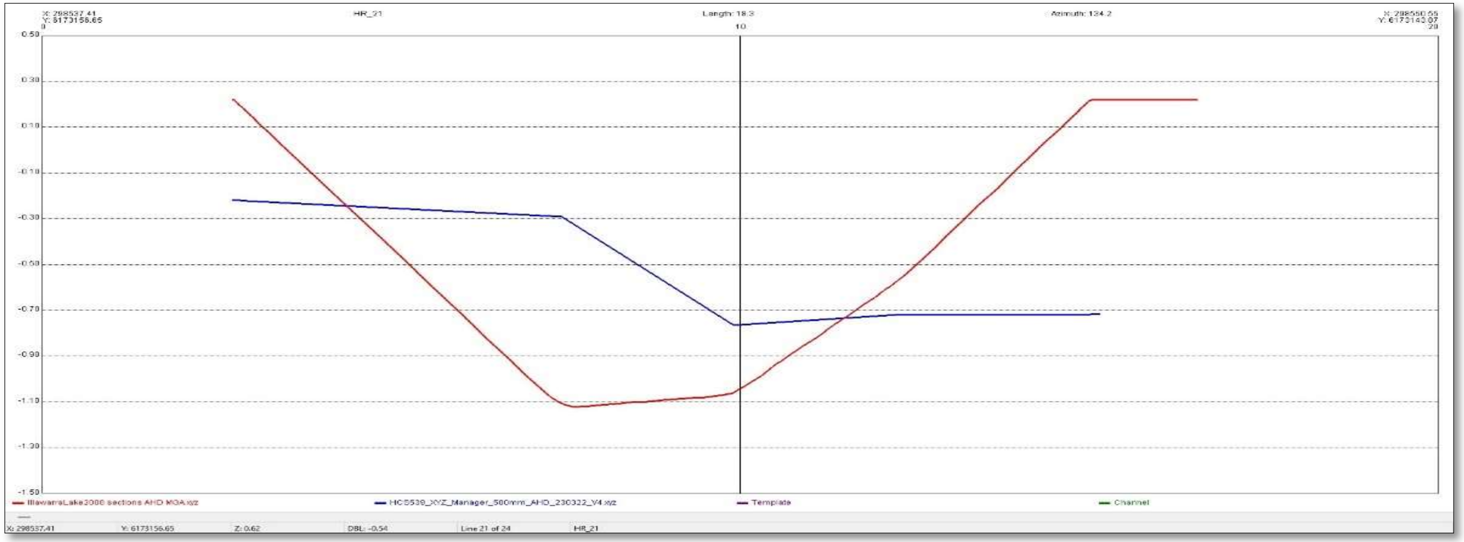


Figure 226: Horsley Creek – profiles (red = 2008, blue = 2022/23) 21 and 22.

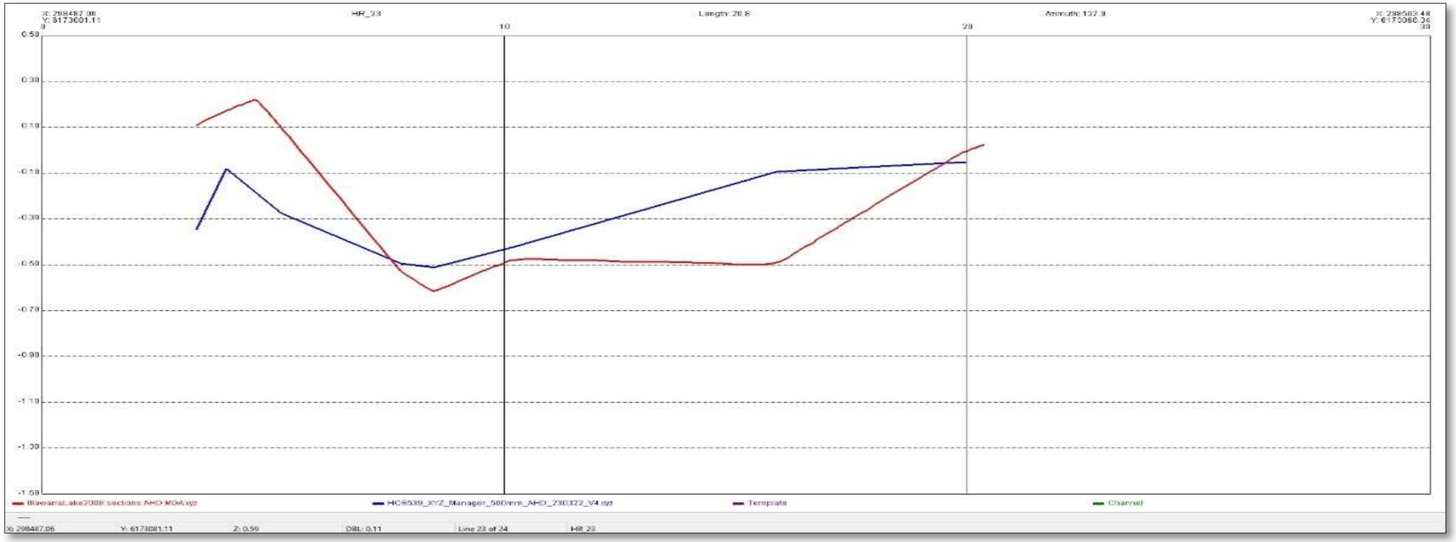


Figure 227: Horsley Creek – profile (red = 2008, blue = 2022/23) 23.

Macquarie Rivulet

Figure 228: Macquarie Rivulet profiles utilised for analysis (data within Plan 539-1 Sheet 5).

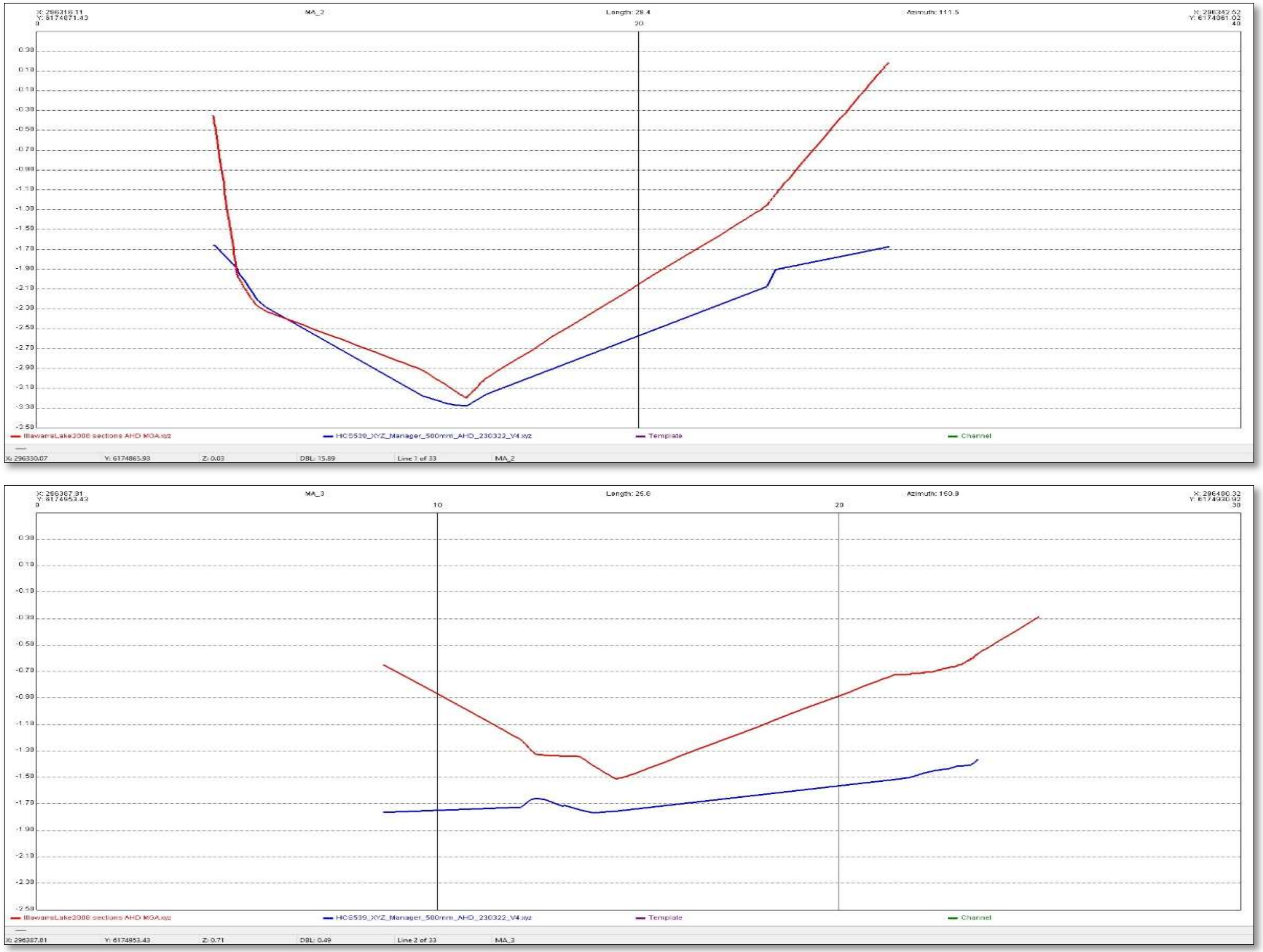


Figure 229: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 2 and 3.

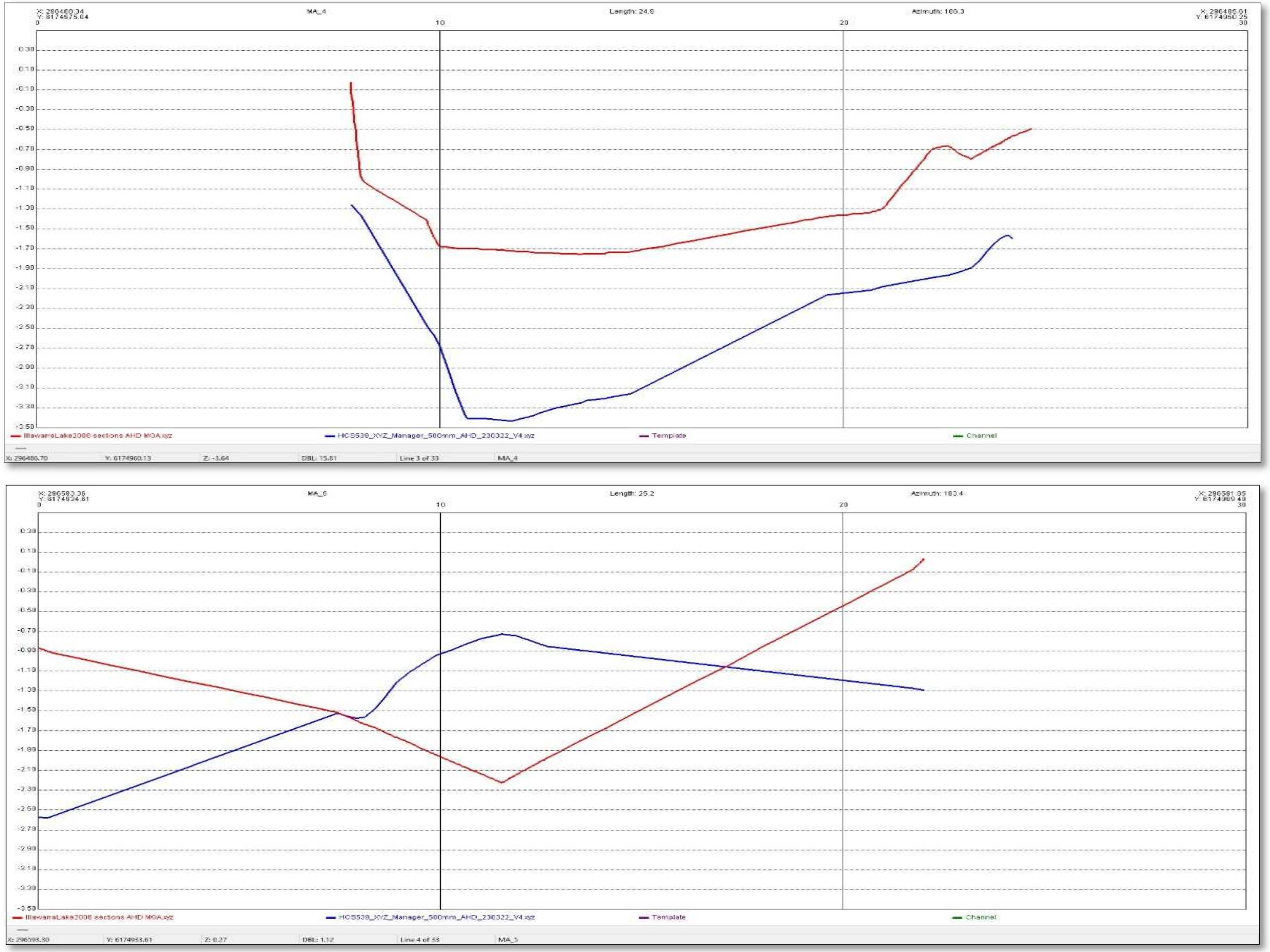


Figure 230: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 4 and 5.

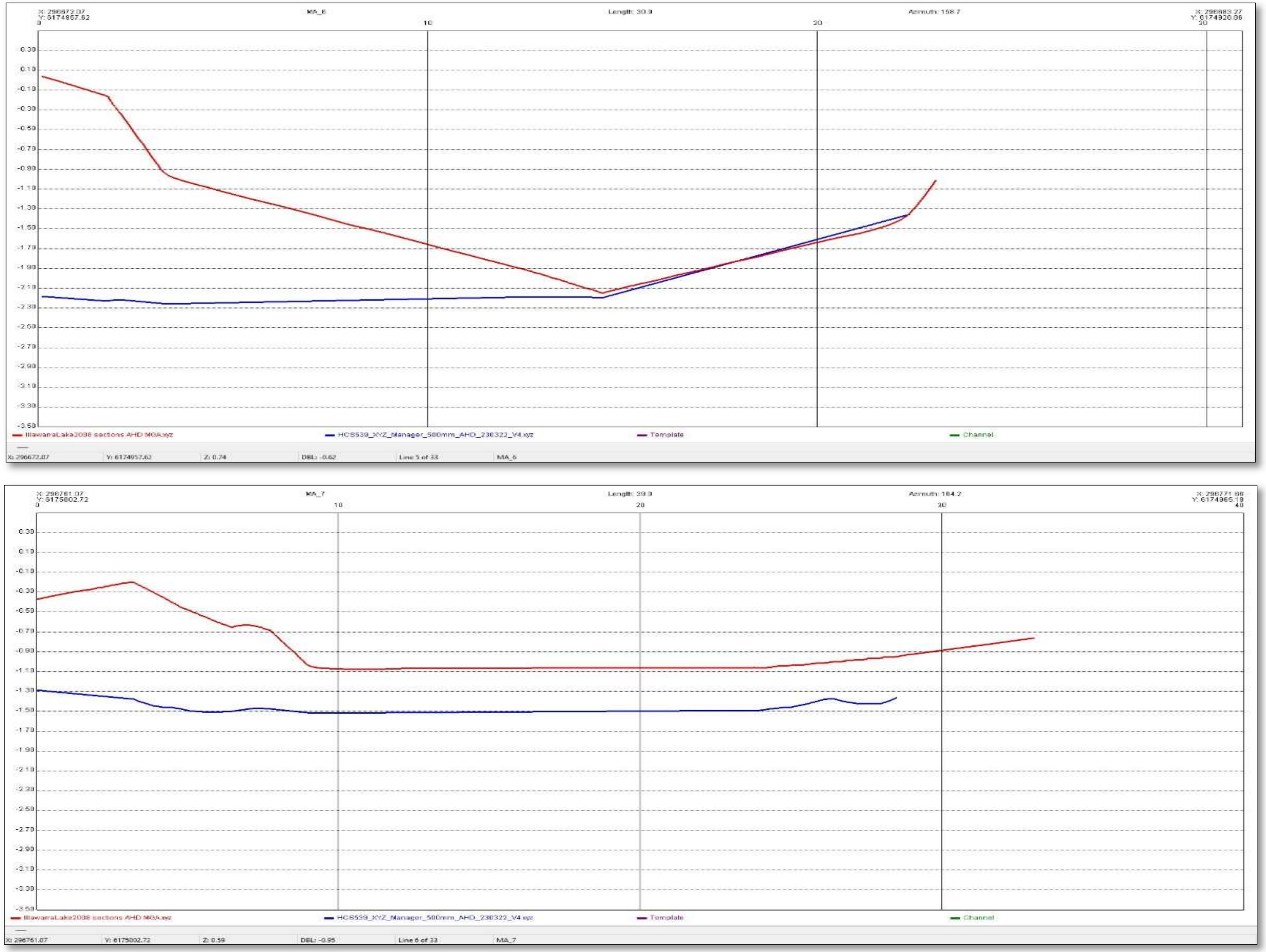
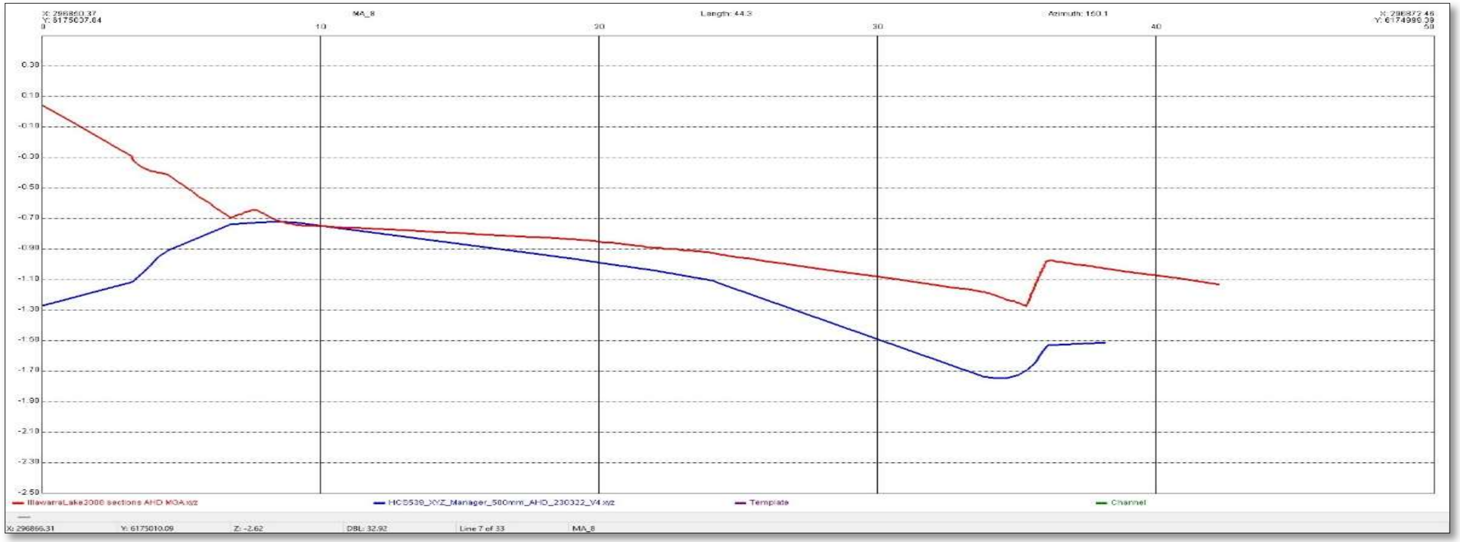


Figure 231: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 6 and 7.



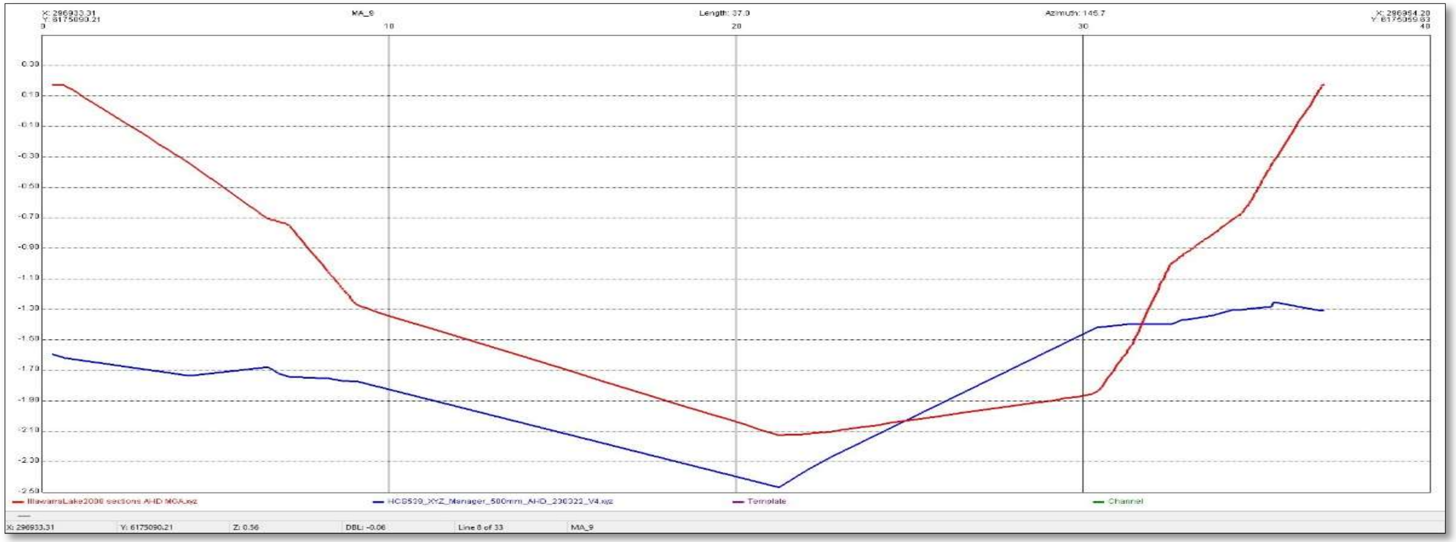


Figure 232: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 8 and 9.

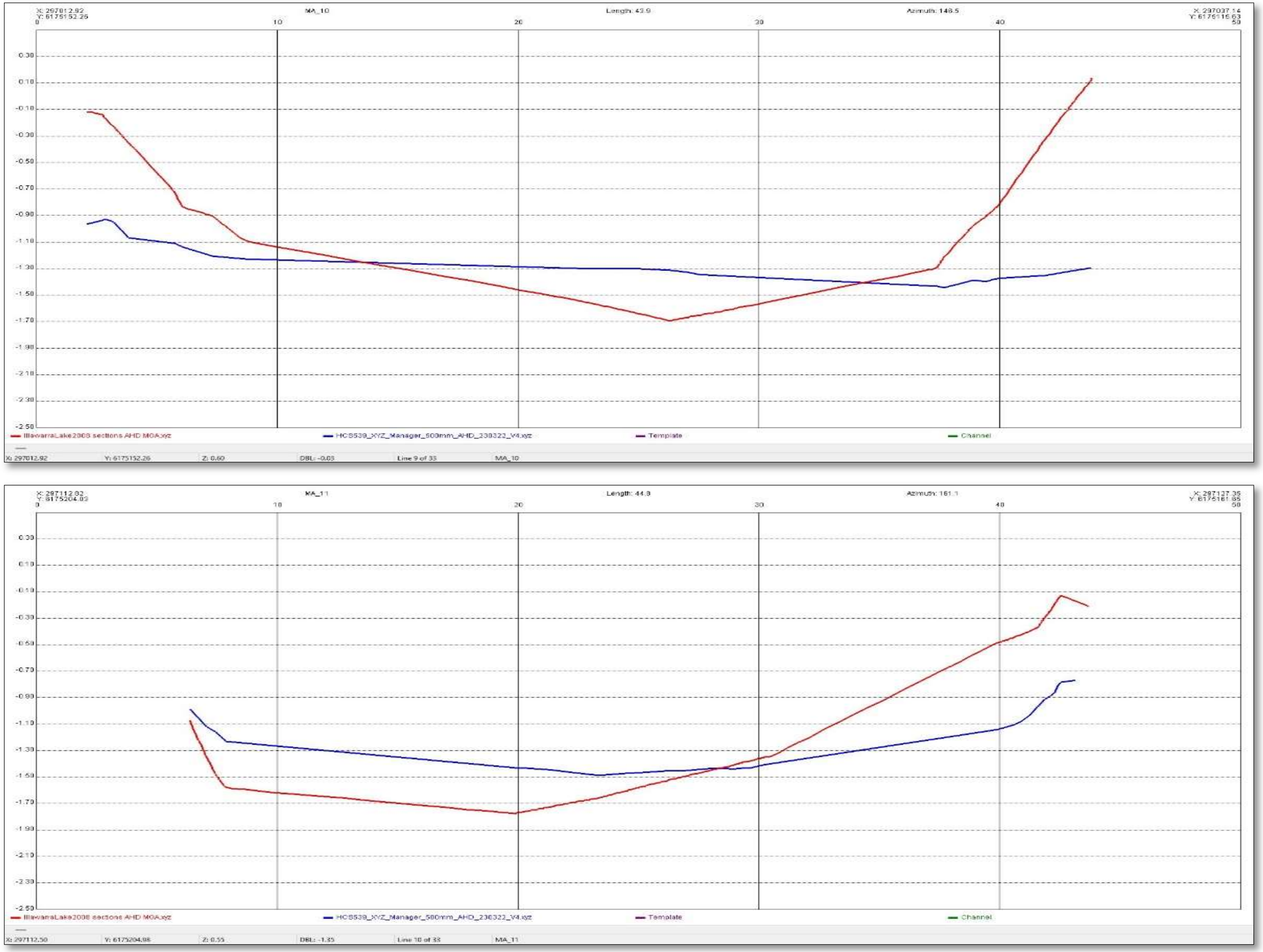


Figure 233: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 10 and 11.

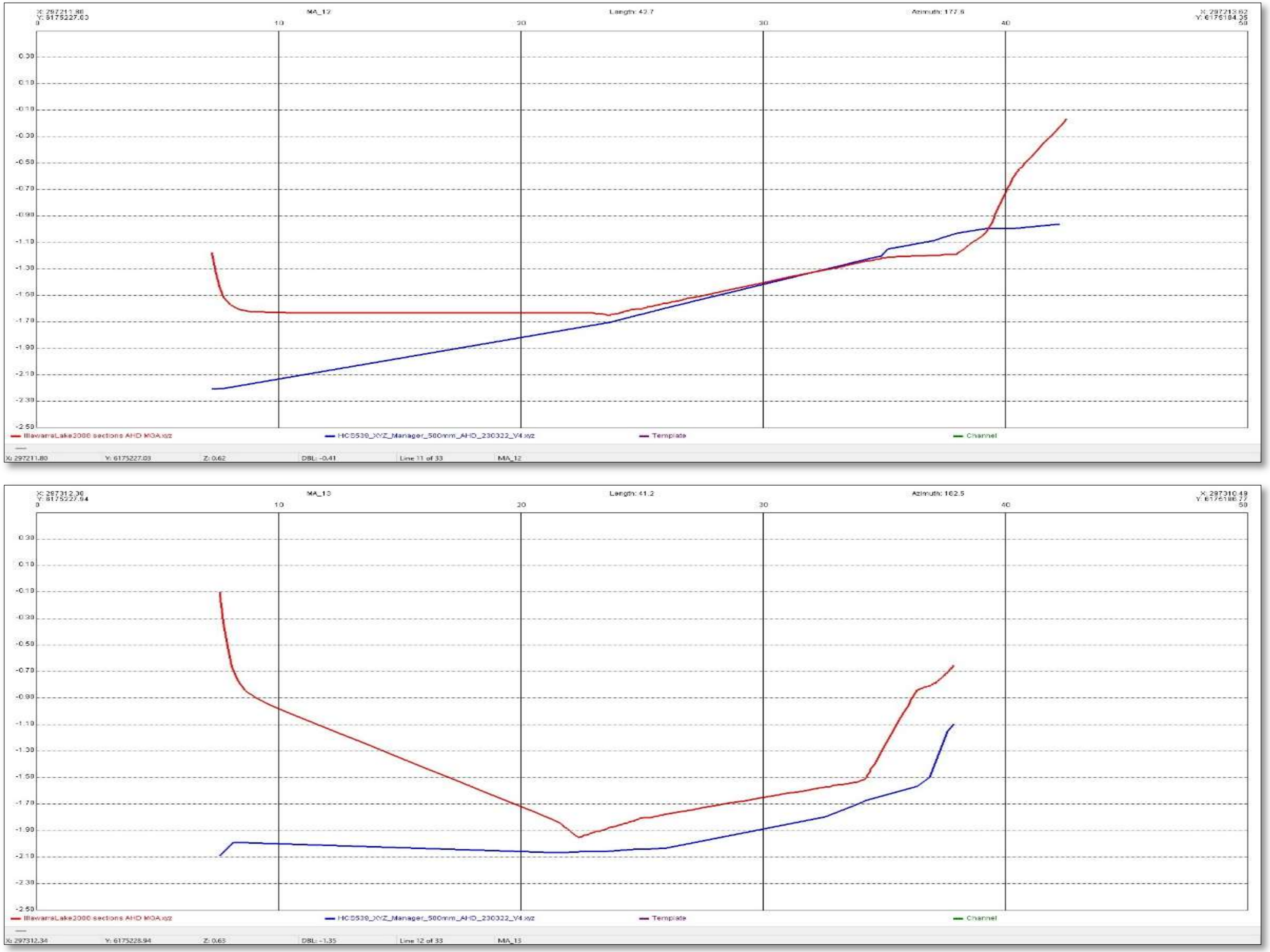


Figure 234: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 12 and 13.

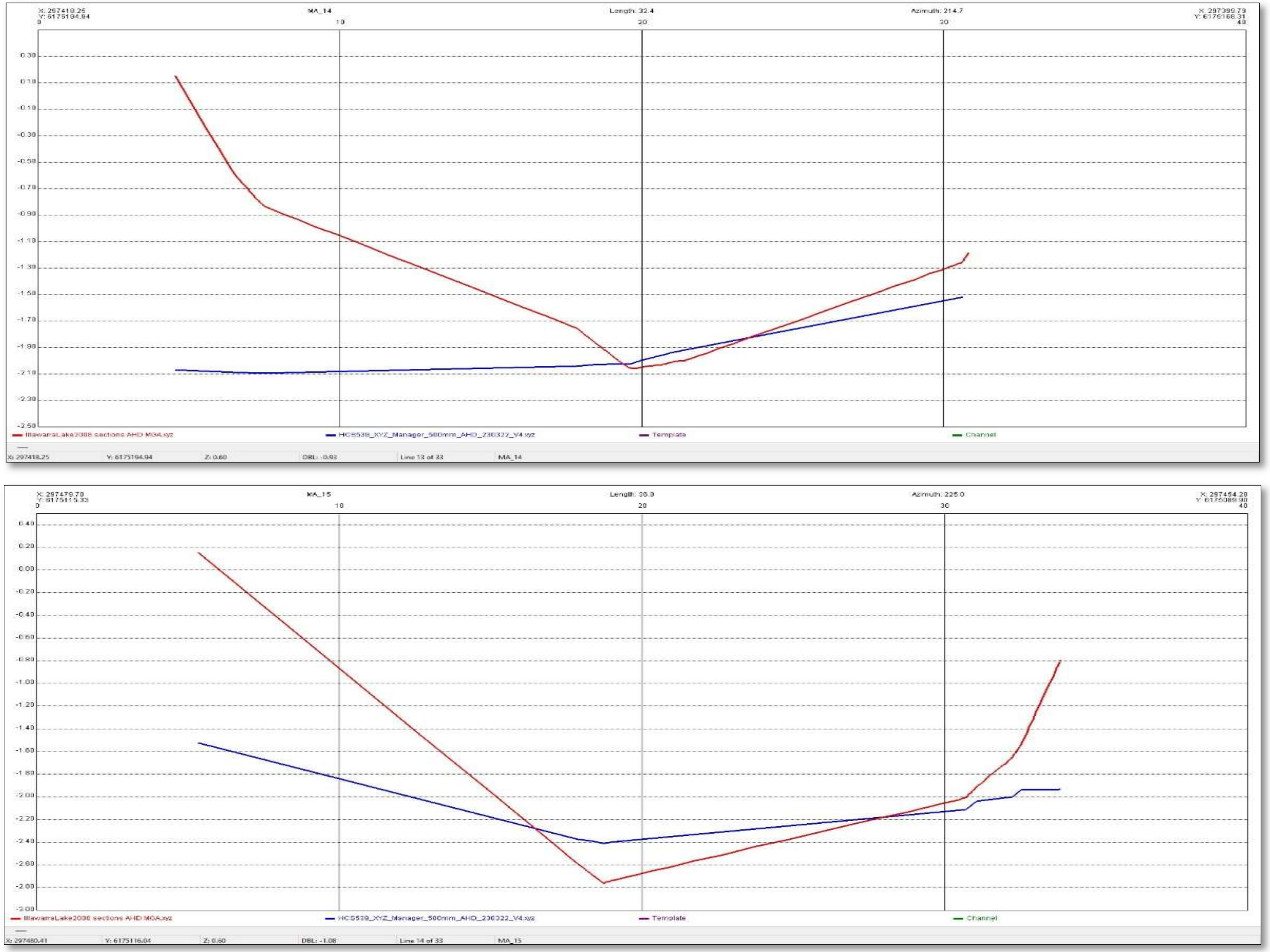


Figure 235: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 14 and 15.

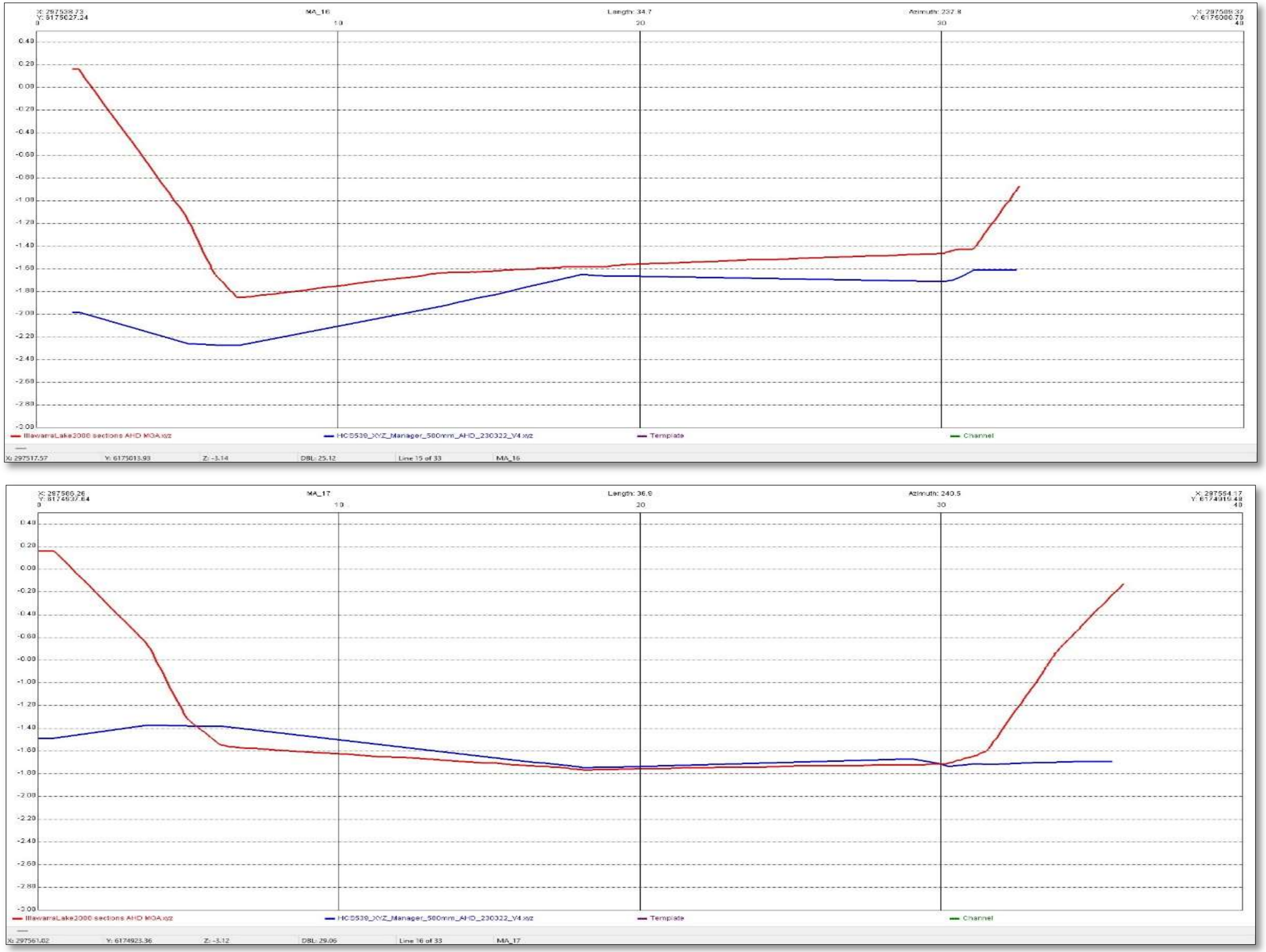


Figure 236: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 16 and 17.

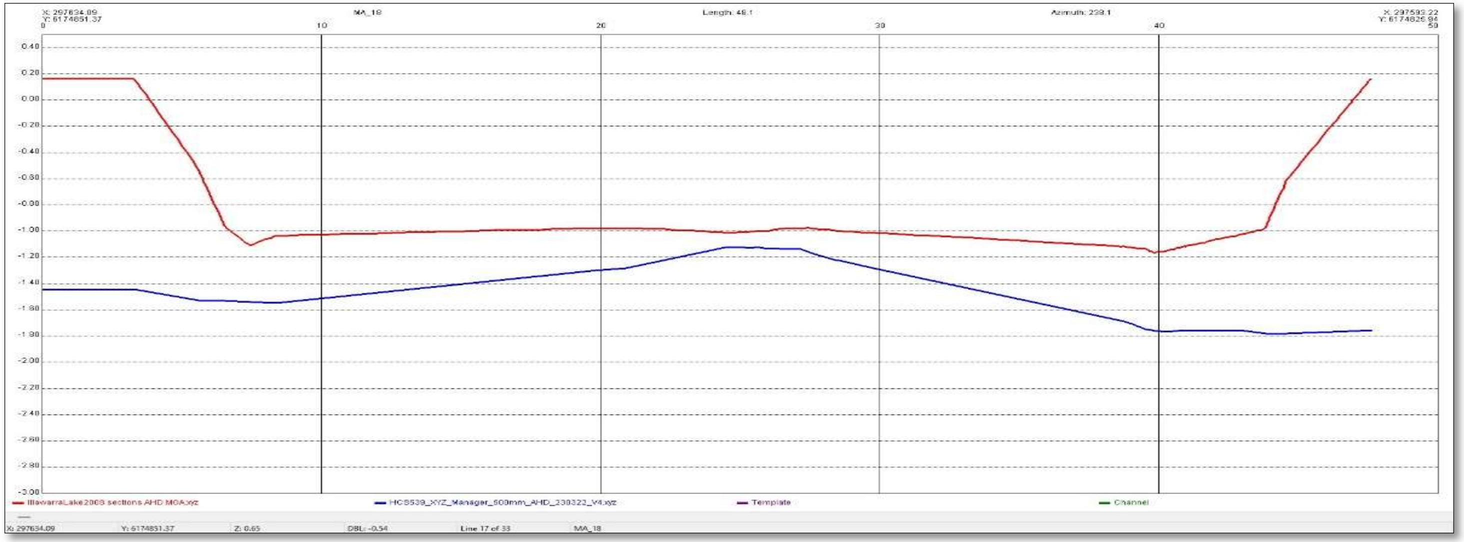


Figure 237: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 18 and 19.

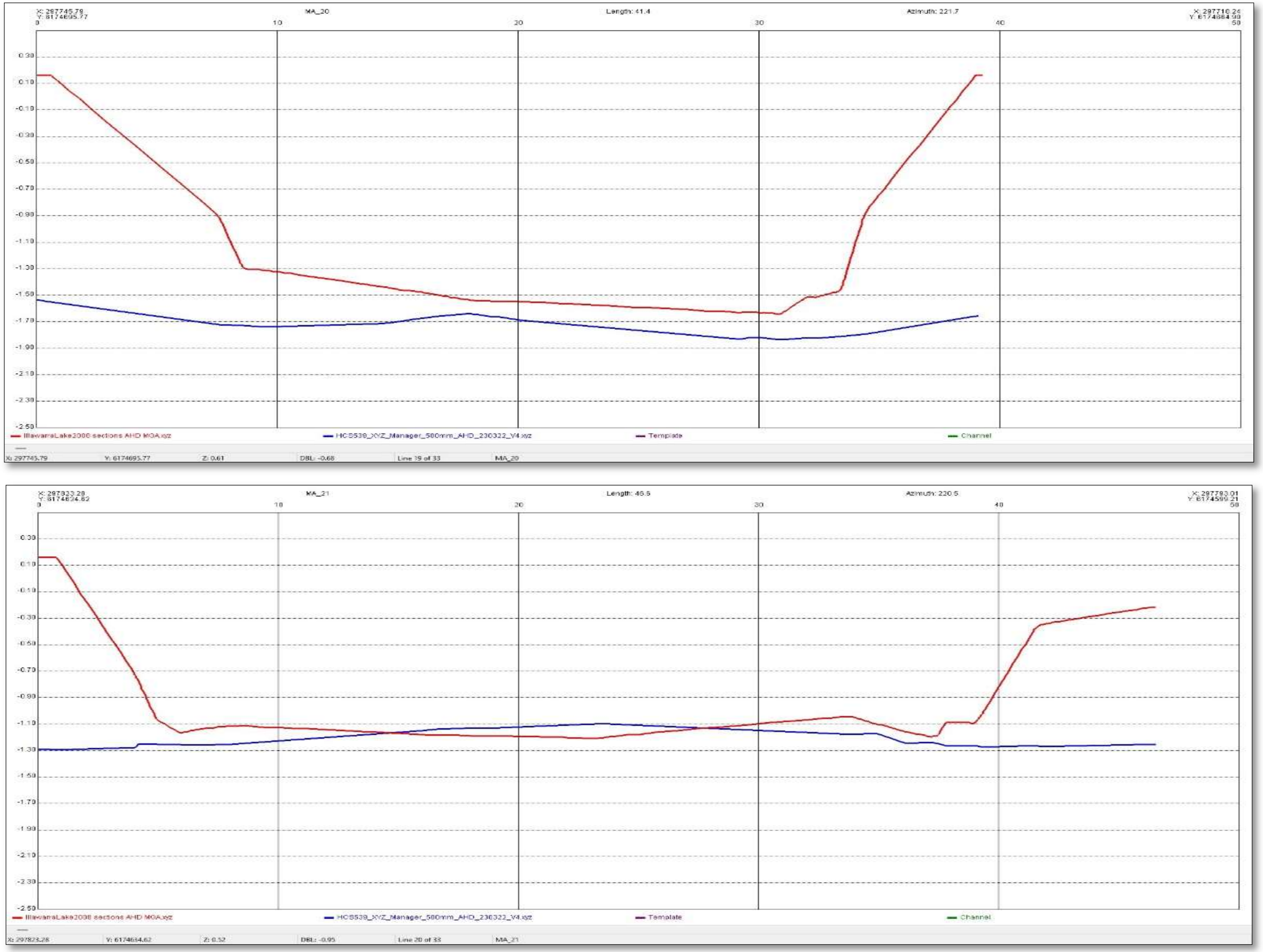
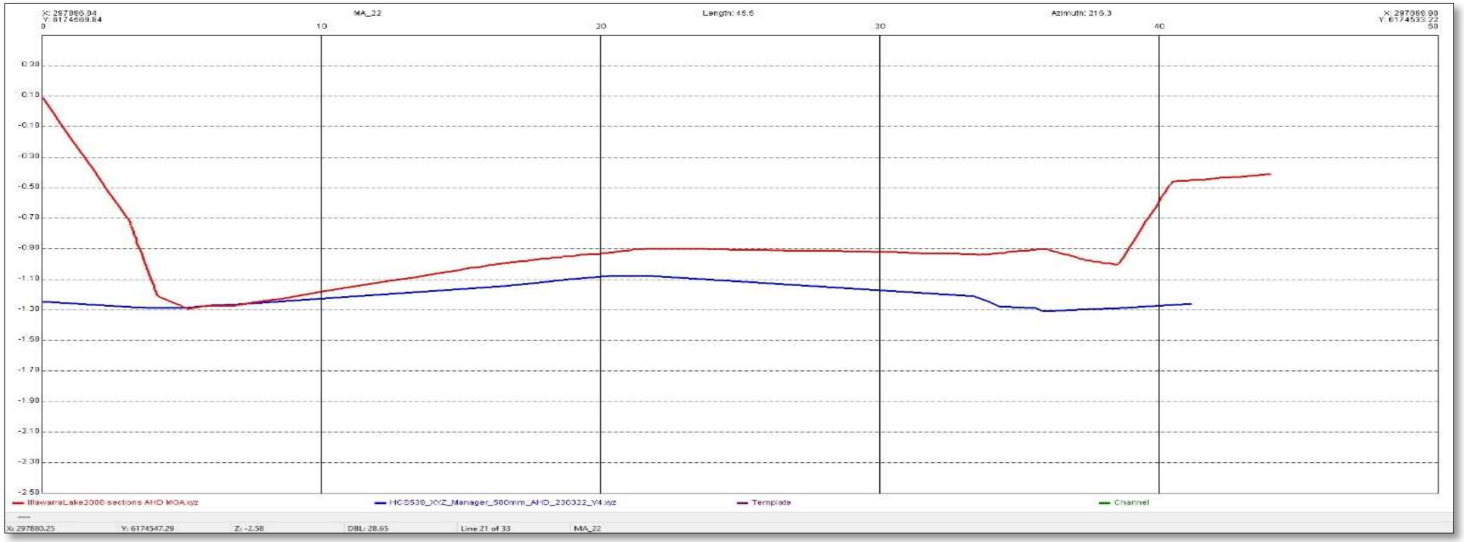


Figure 238: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 20 and 21.



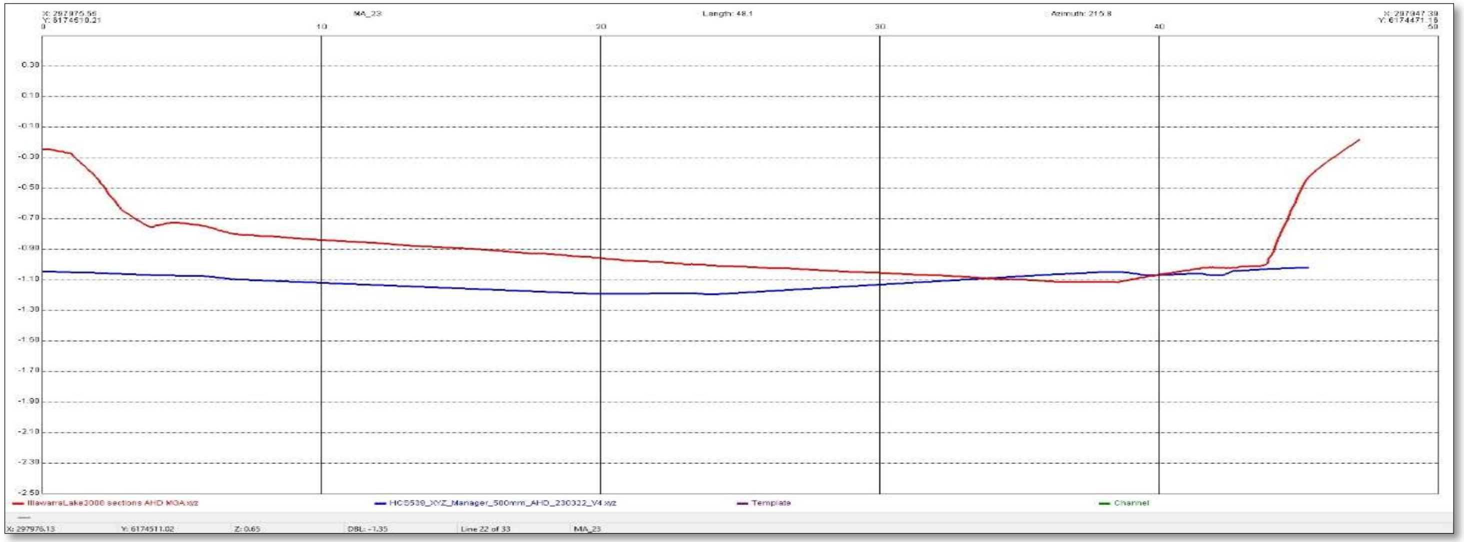


Figure 239: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 22 and 23.

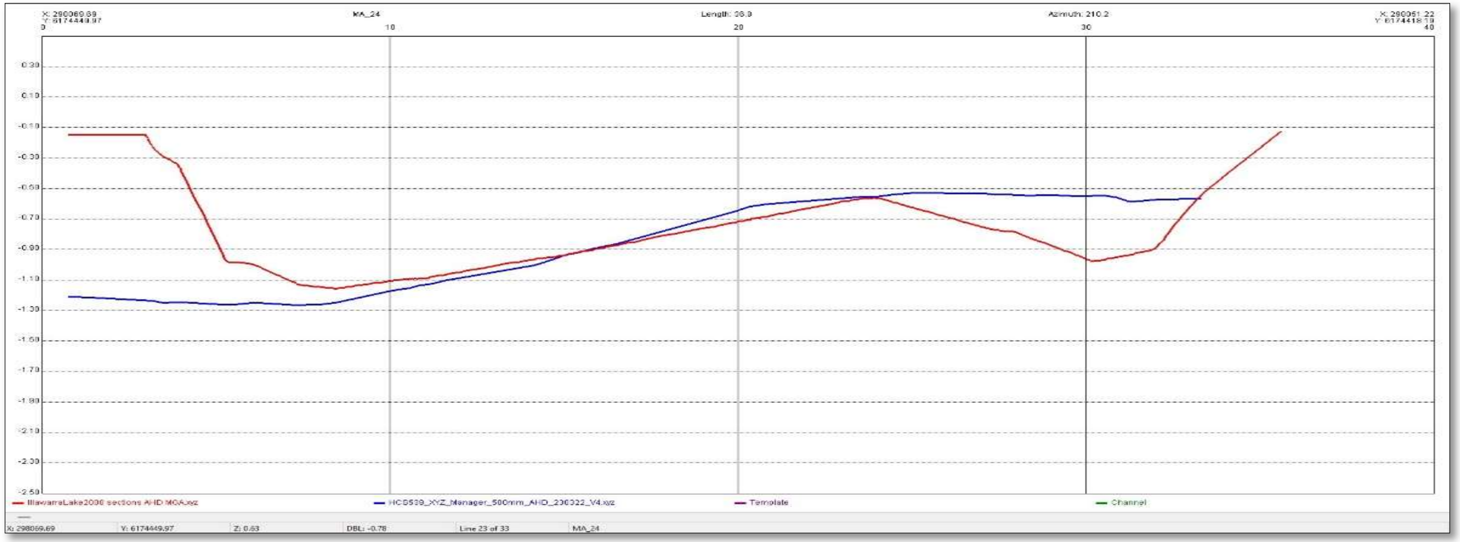


Figure 240: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 24 and 25.

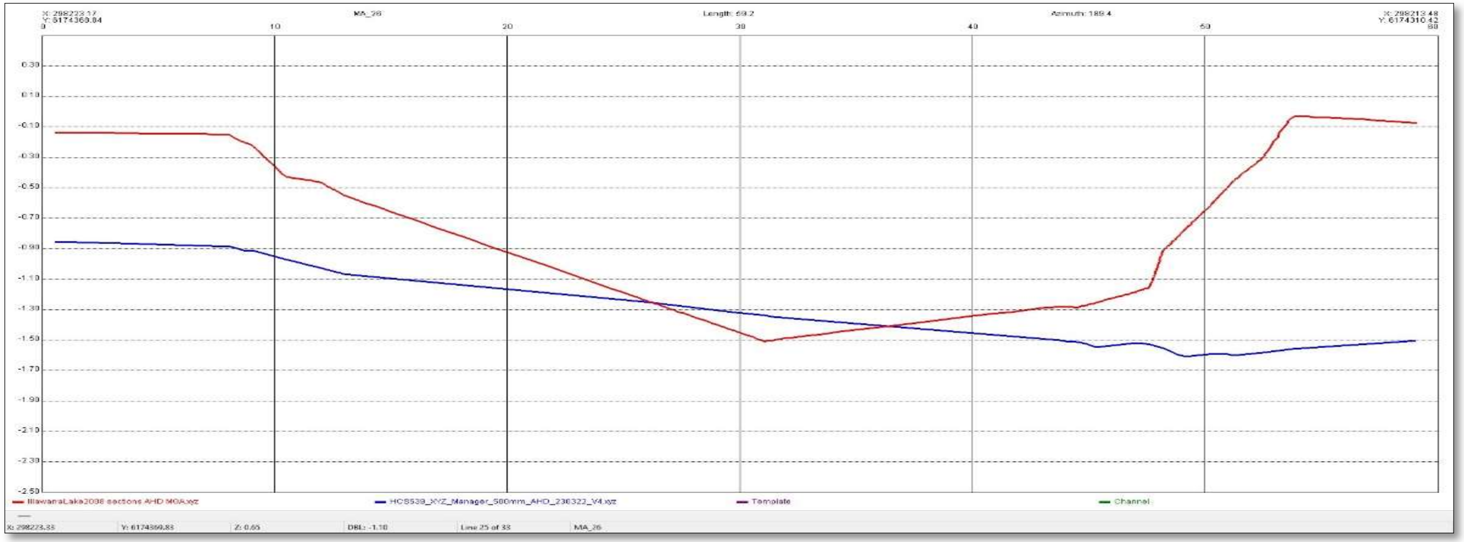


Figure 241: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 26 and 27.

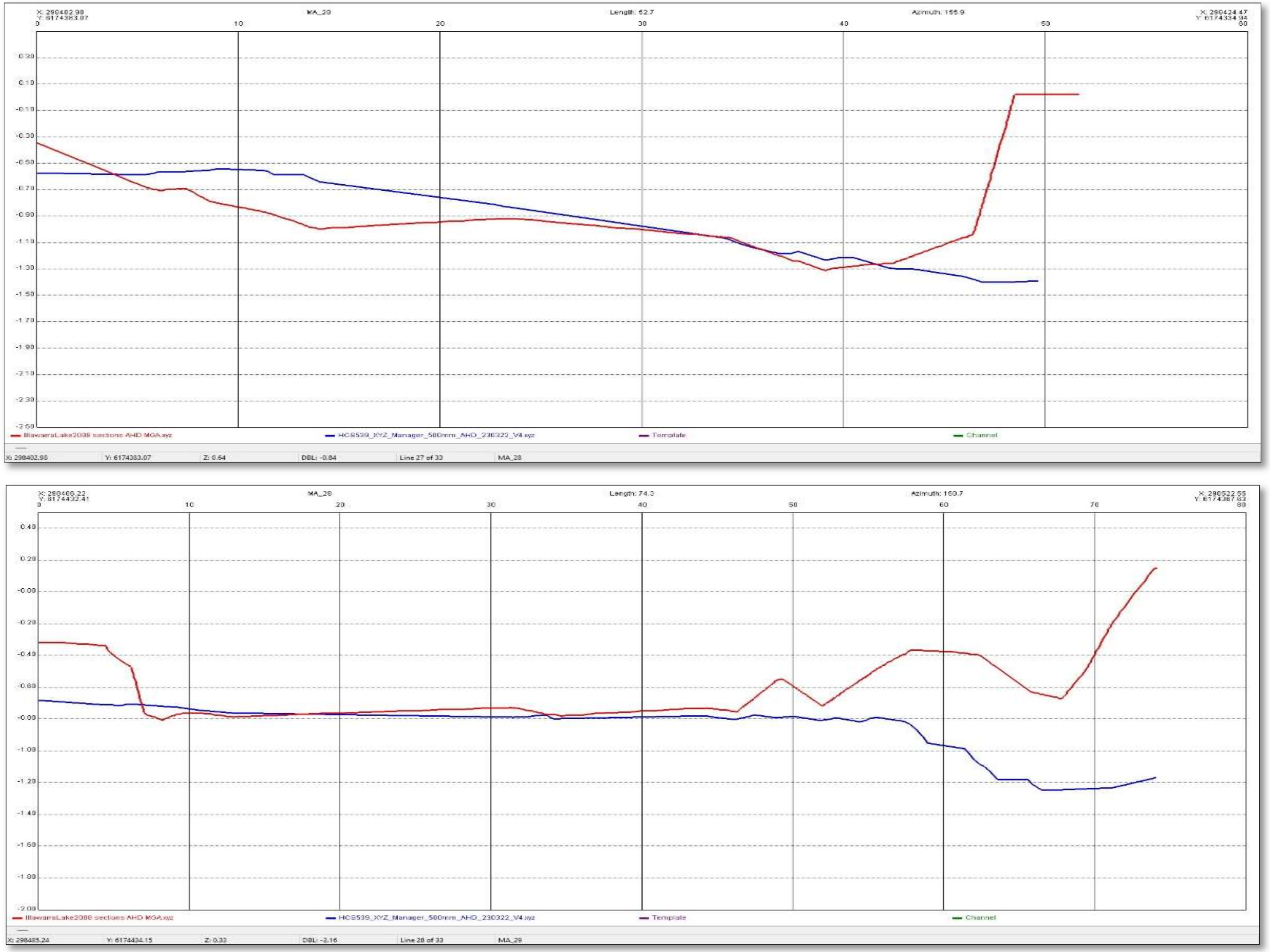
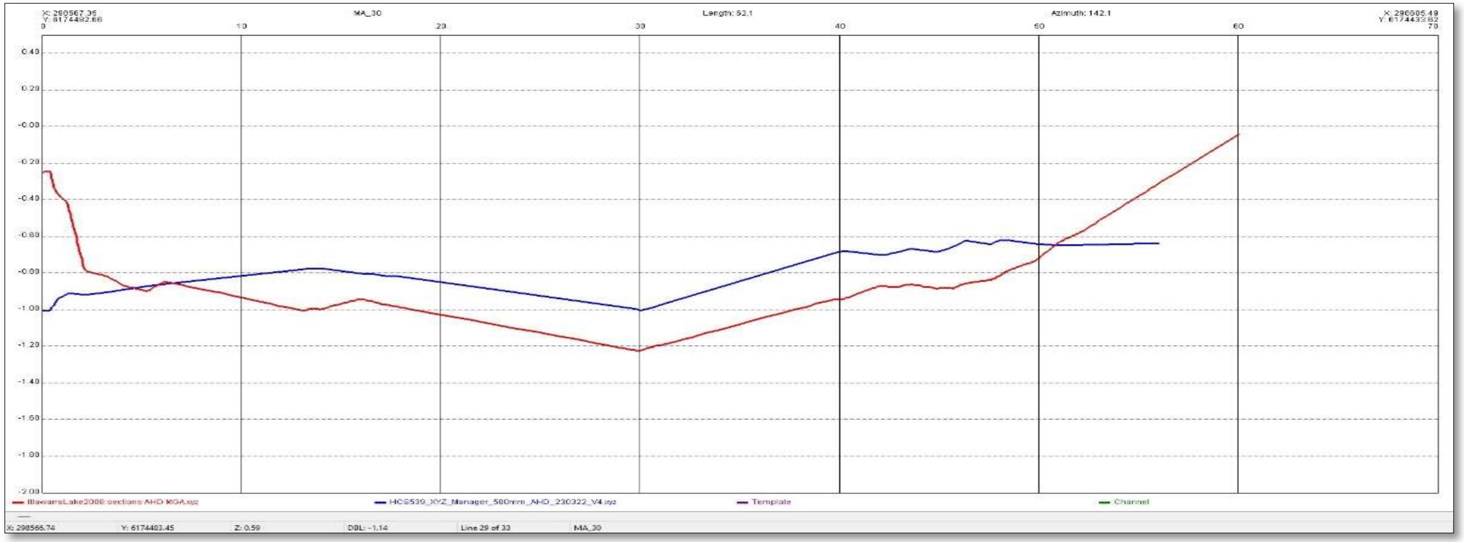


Figure 242: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 28 and 29.



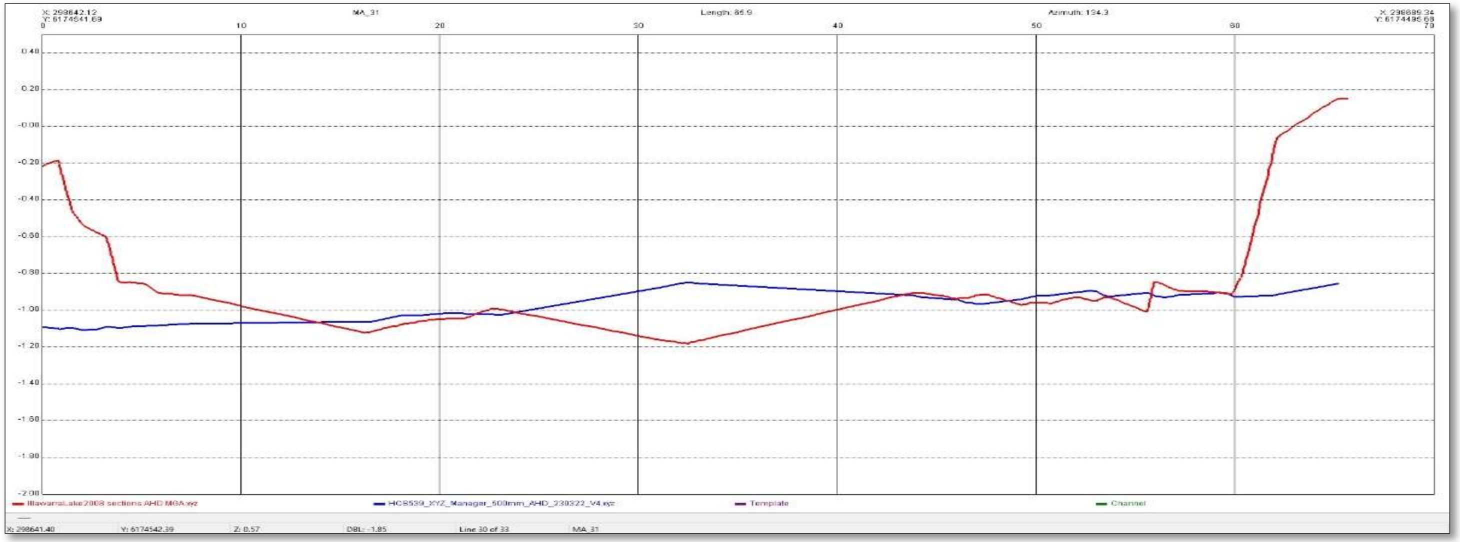


Figure 243: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 30 and 31.

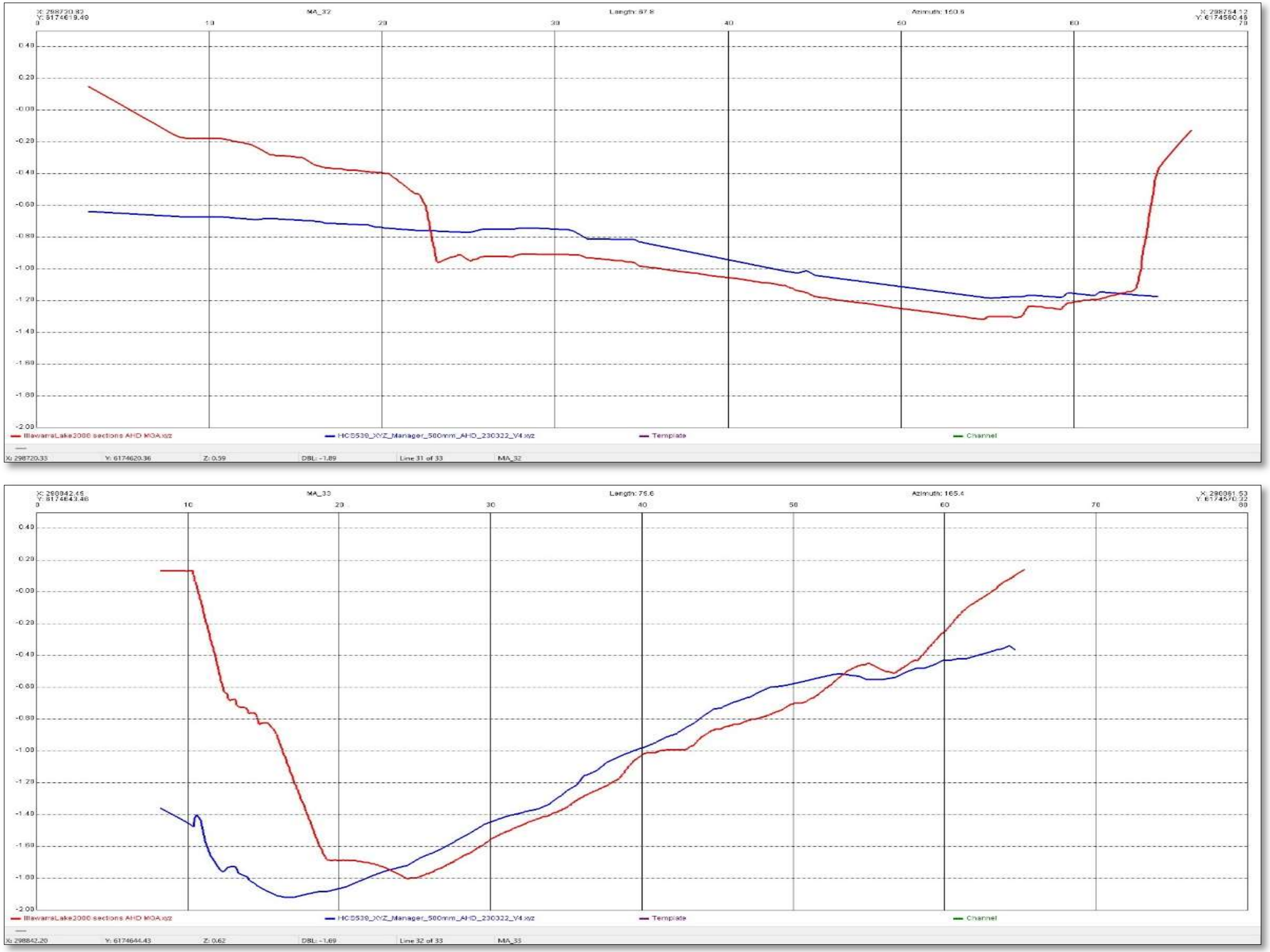


Figure 244: Macquarie Rivulet - profiles (red = 2008, blue = 2022/23) 32 and 33.

Mullet Creek

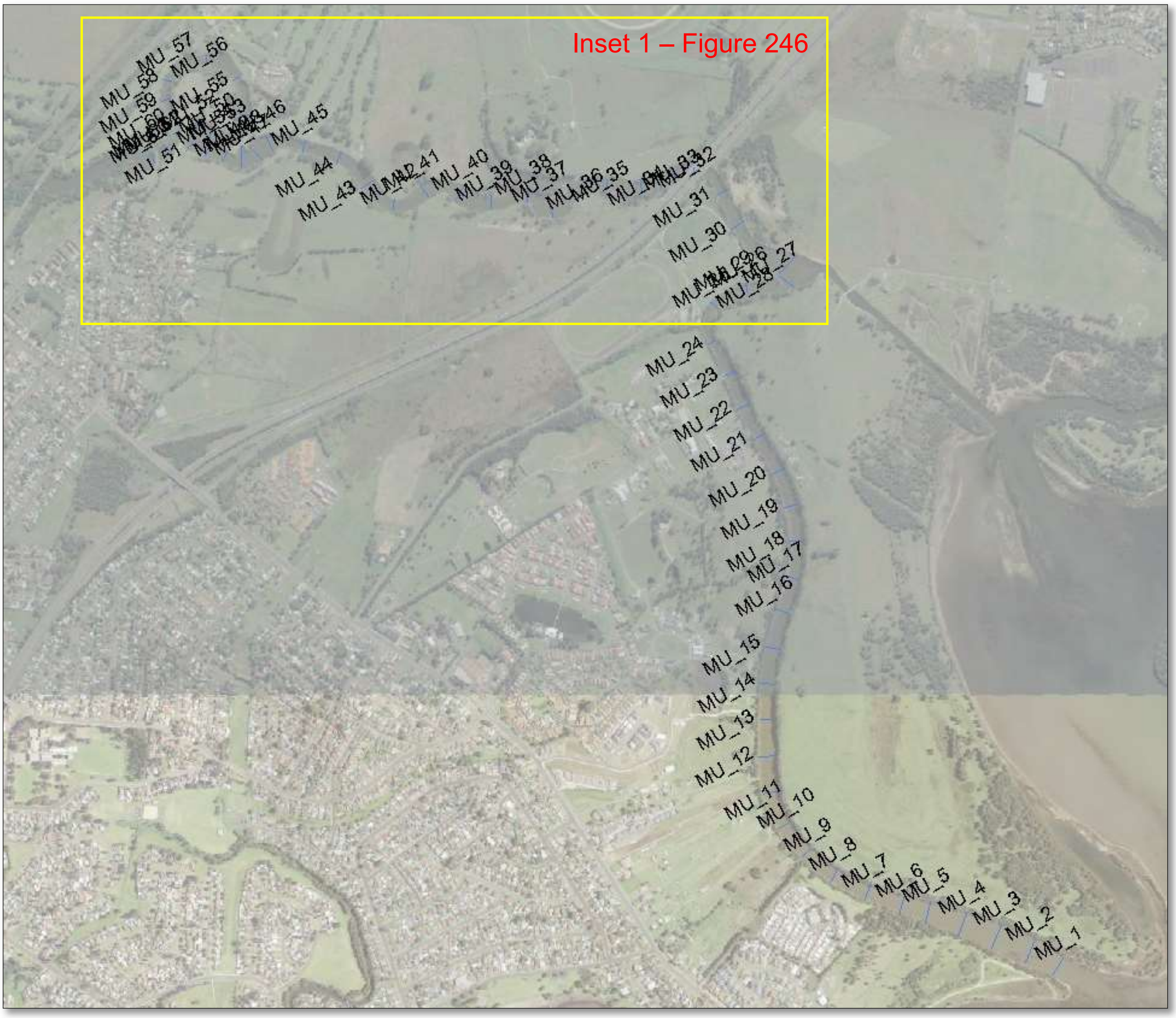
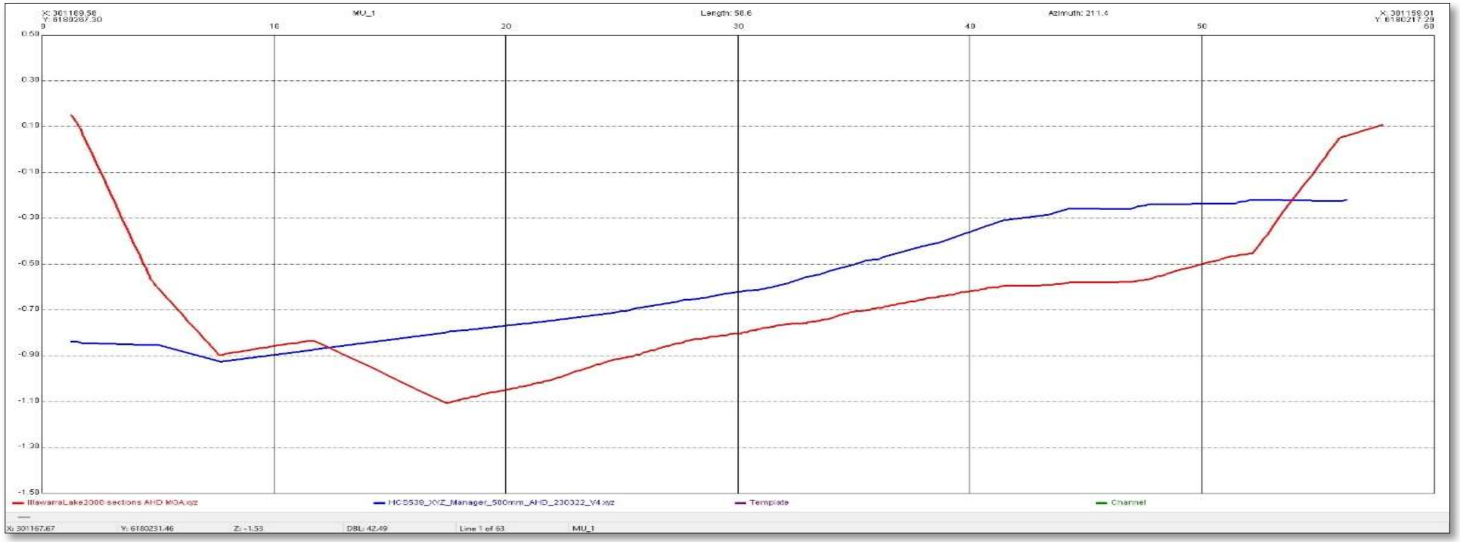


Figure 245: Mullet Creek profiles utilised for analysis (data within Plan 539-1 Sheet 2).

Figure 246: Mullet Creek profiles utilised for analysis – Inset 1 (data within Plan 539-1 Sheet 2).



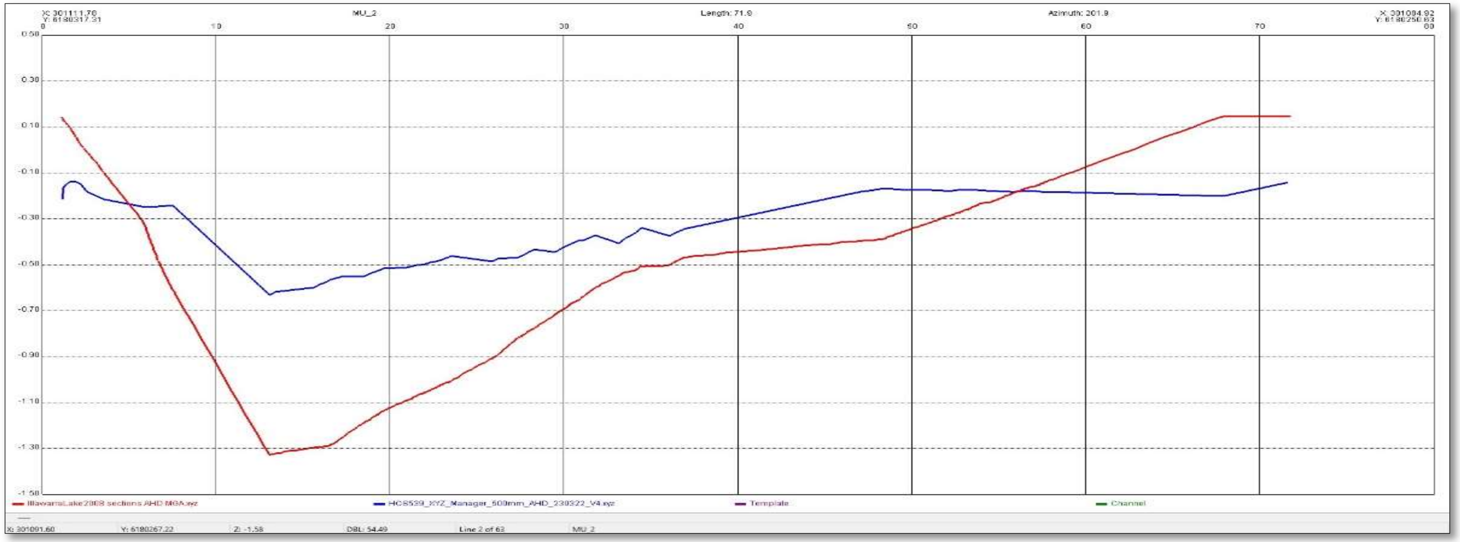


Figure 247: Mullet Creek - profiles (red = 2008, blue = 2022/23) 1 and 2.

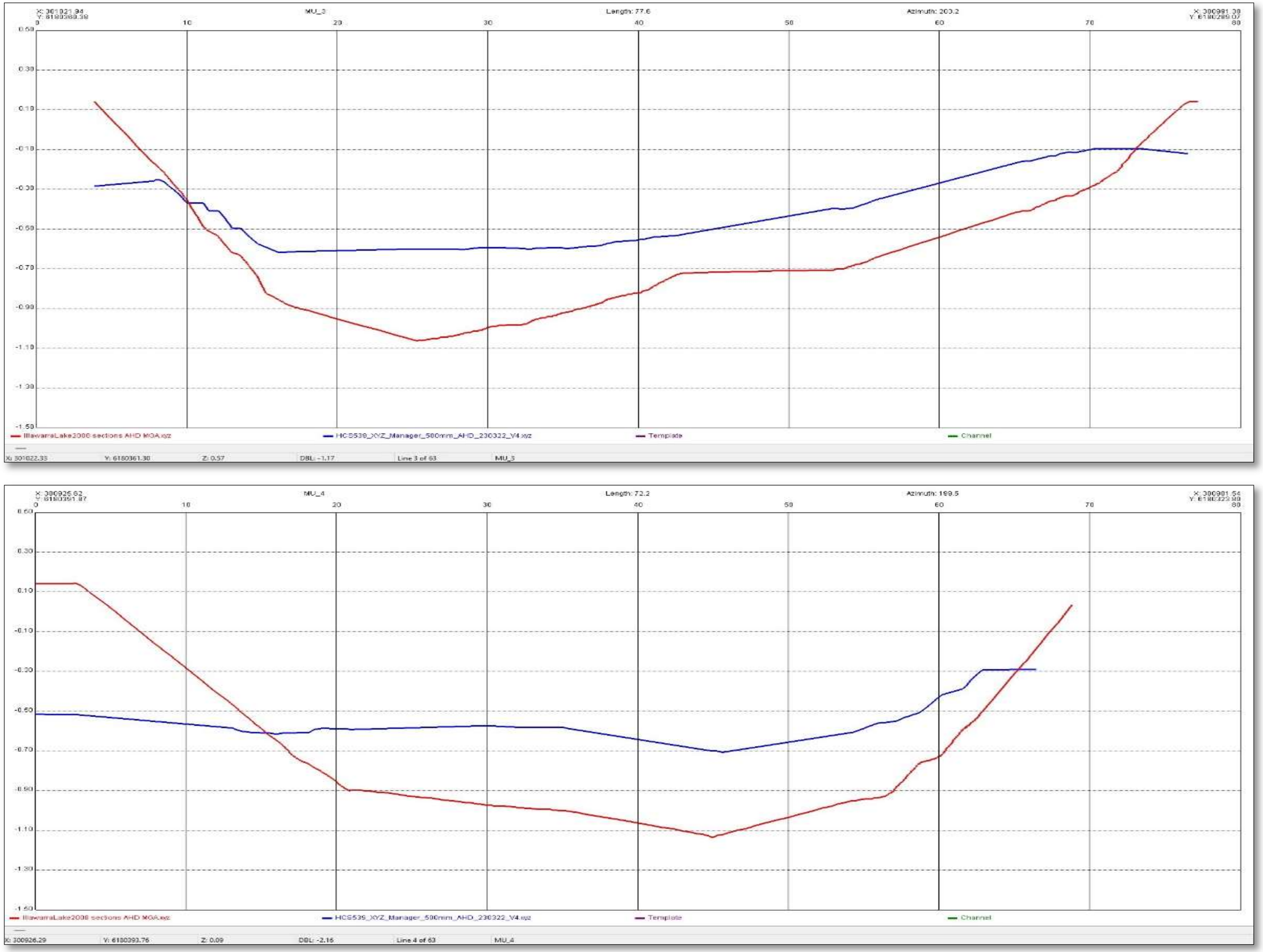


Figure 248: Mullet Creek - profiles (red = 2008, blue = 2022/23) 3 and 4.

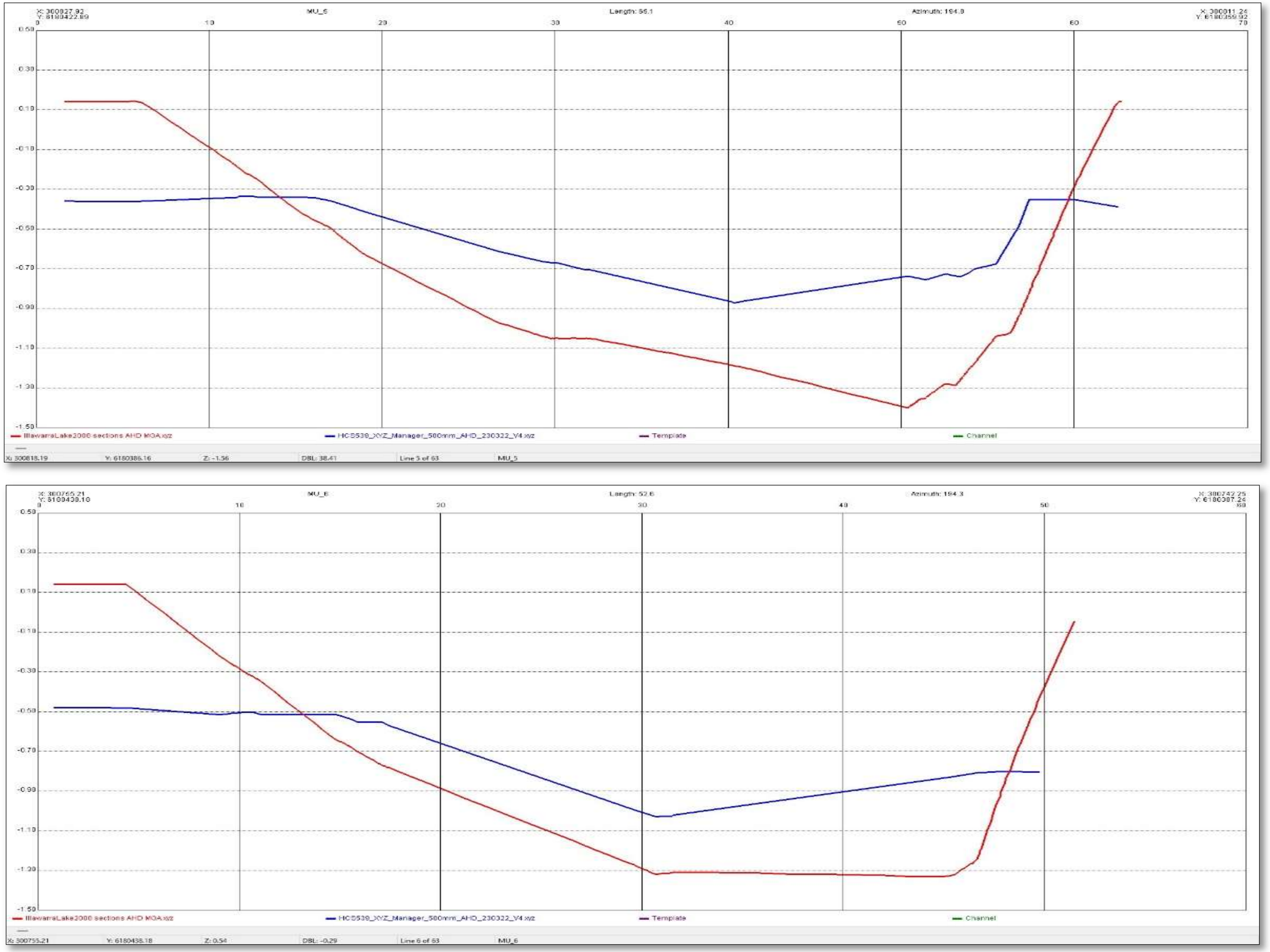


Figure 249: Mullet Creek - profiles (red = 2008, blue = 2022/23) 5 and 6.

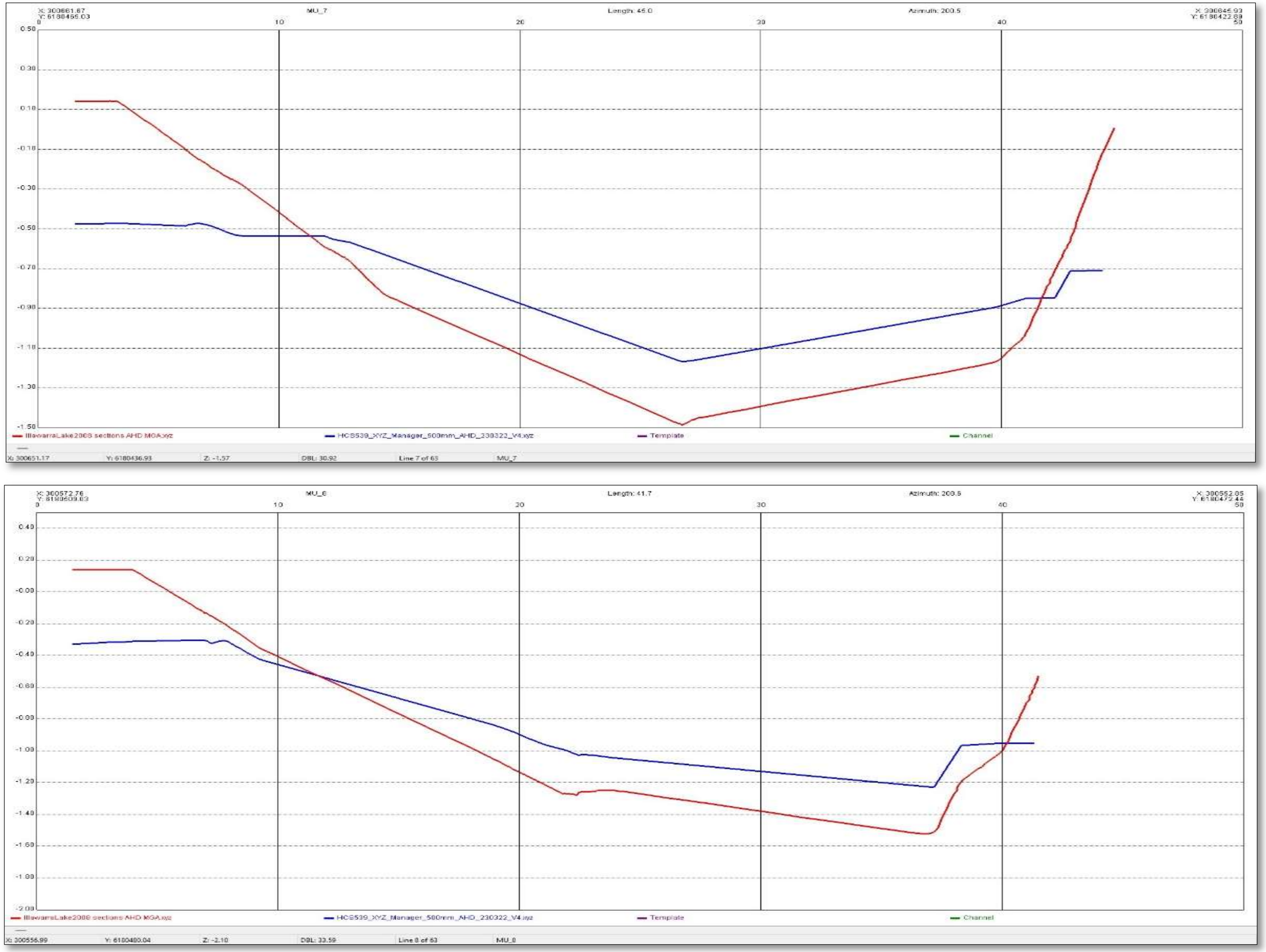


Figure 250: Mullet Creek - profiles (red = 2008, blue = 2022/23) 7 and 8.

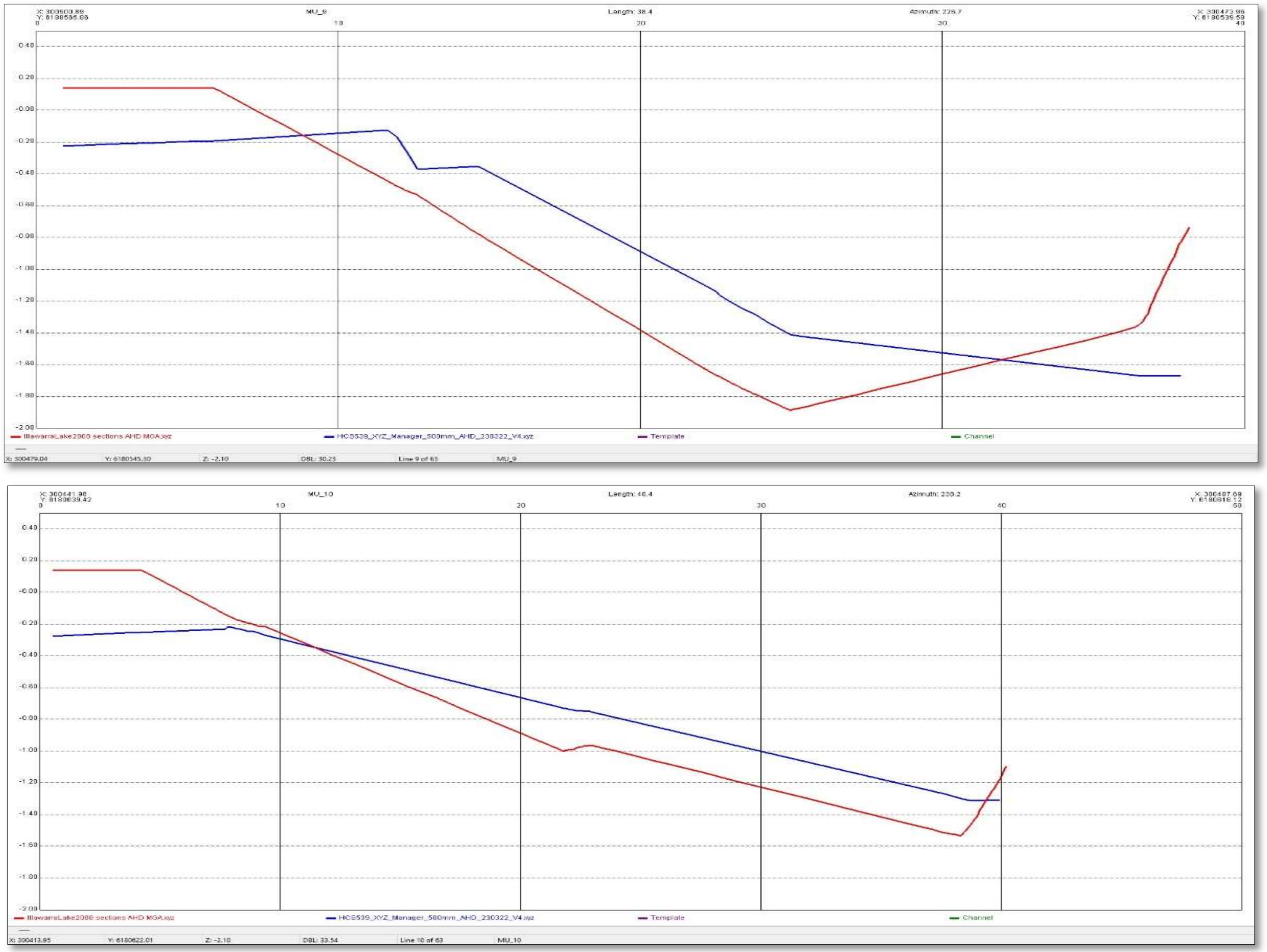


Figure 251: Mullet Creek - profiles (red = 2008, blue = 2022/23) 9 and 10.

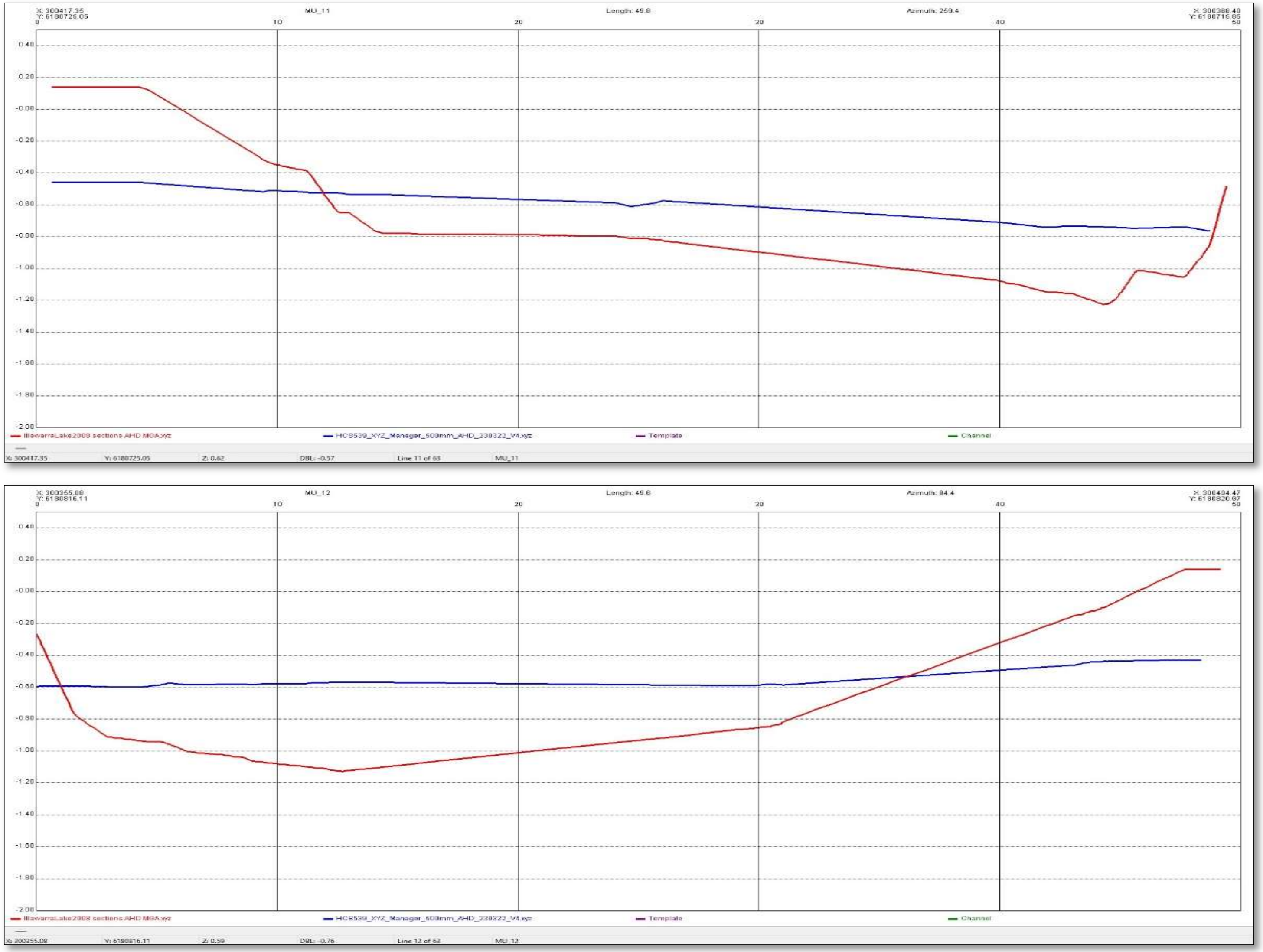


Figure 252: Mullet Creek - profiles (red = 2008, blue = 2022/23) 11 and 12.

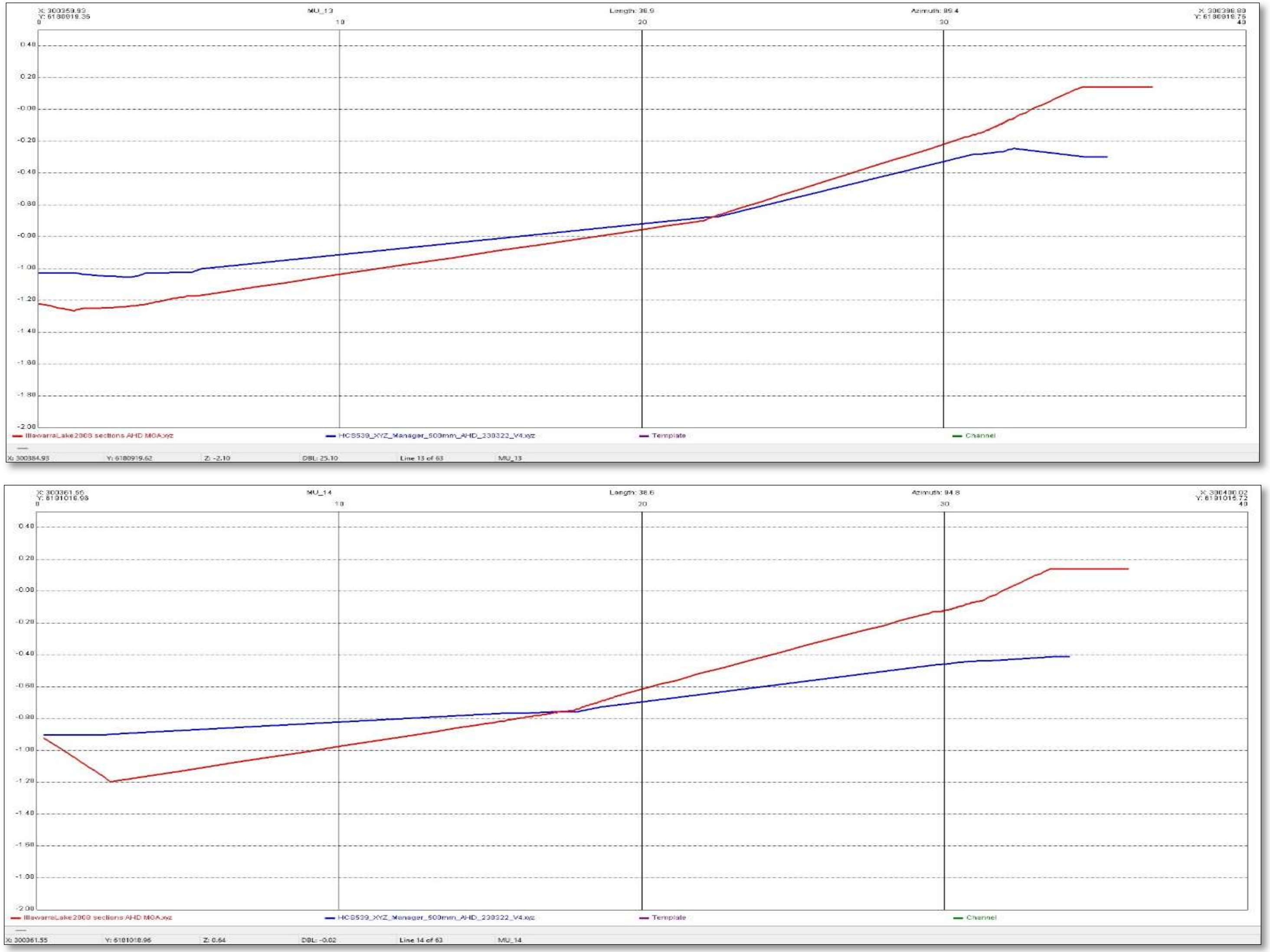


Figure 253: Mullet Creek - profiles (red = 2008, blue = 2022/23) 13 and 14.

Figure 254: Mullet Creek - profiles (red = 2008, blue = 2022/23) 15 and 16.

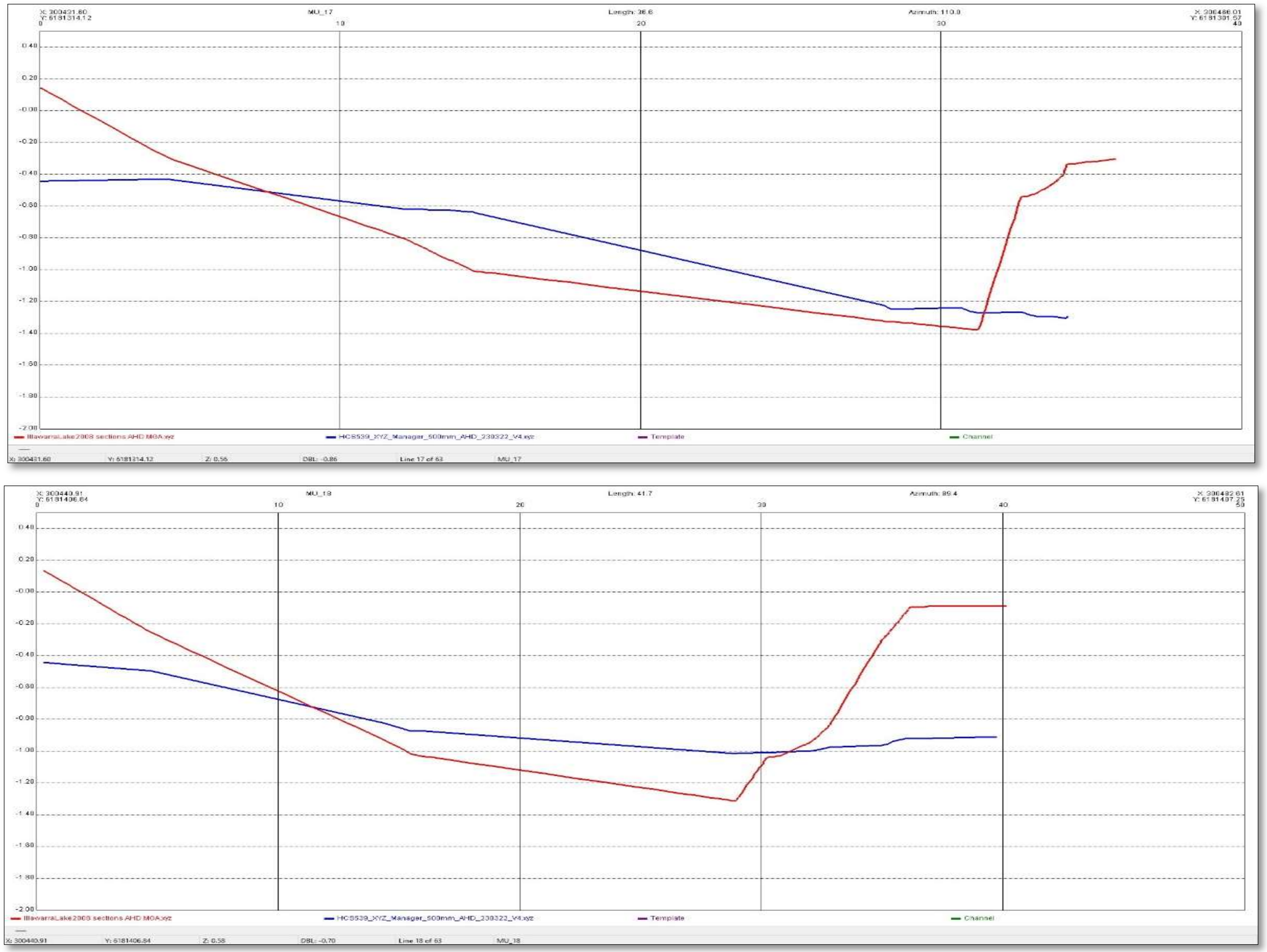
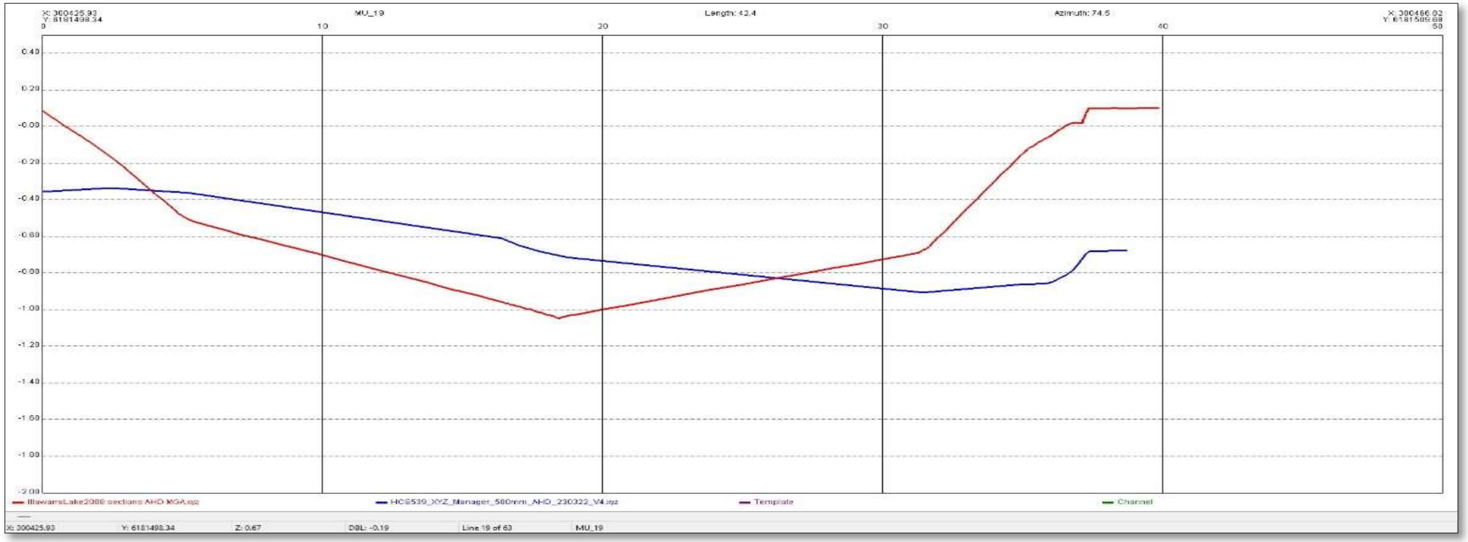


Figure 255: Mullet Creek - profiles (red = 2008, blue = 2022/23) 17 and 18.



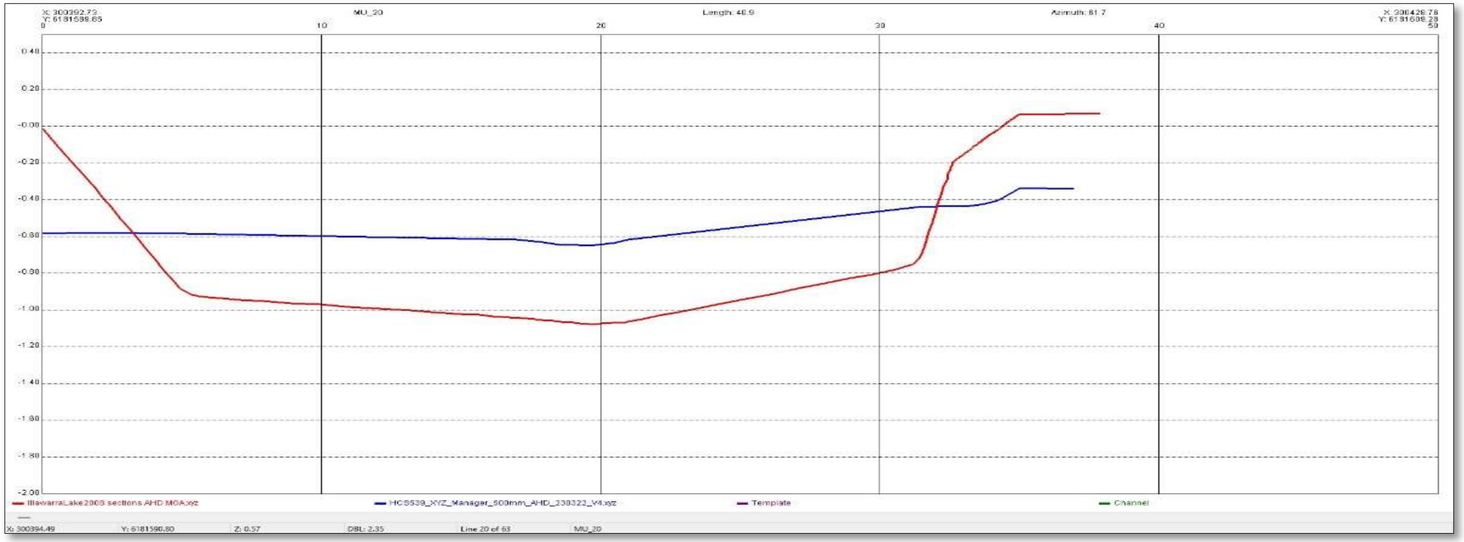
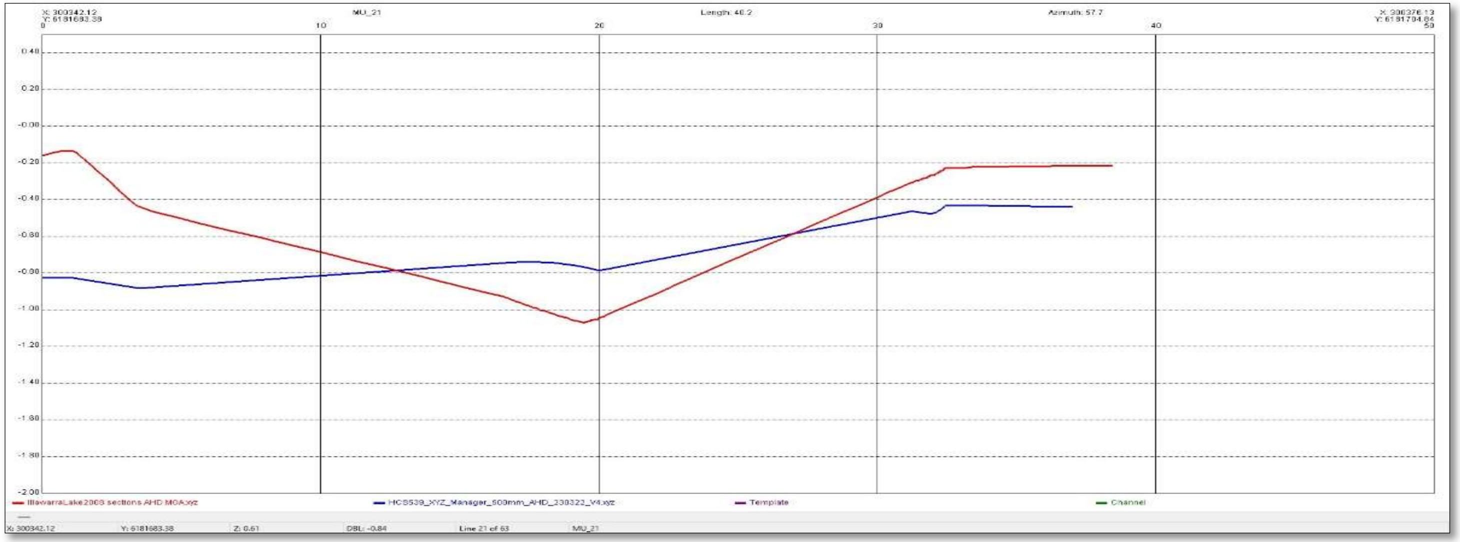


Figure 256: Mullet Creek - profiles (red = 2008, blue = 2022/23) 19 and 20.



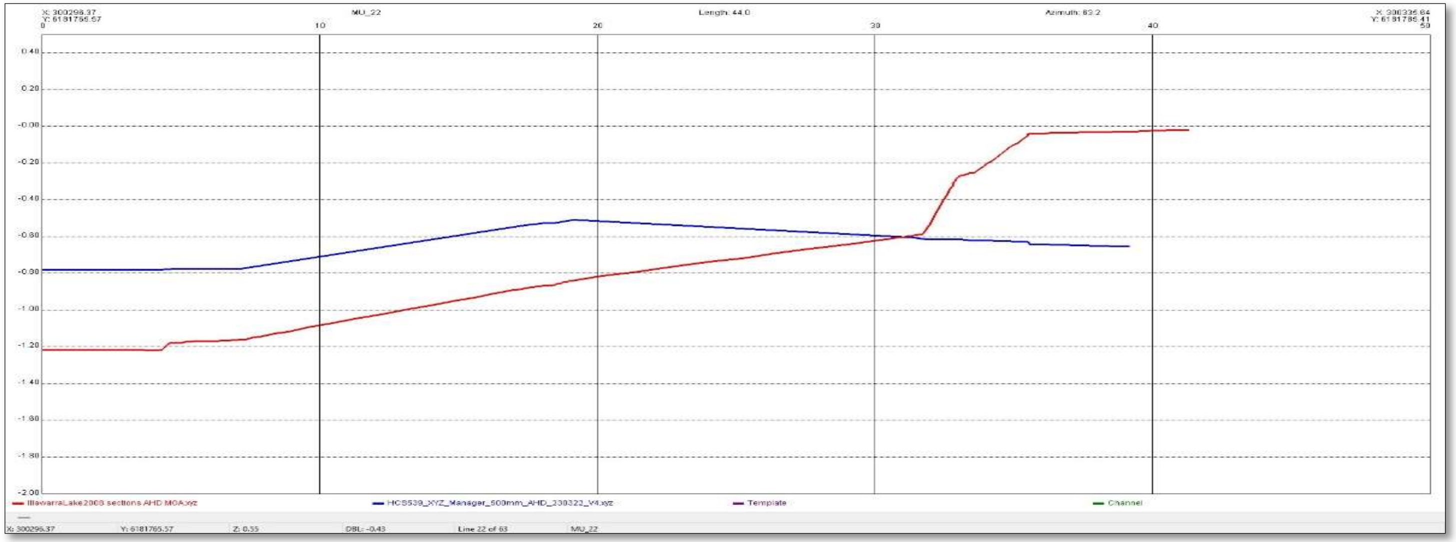


Figure 257: Mullet Creek - profiles (red = 2008, blue = 2022/23) 21 and 22.

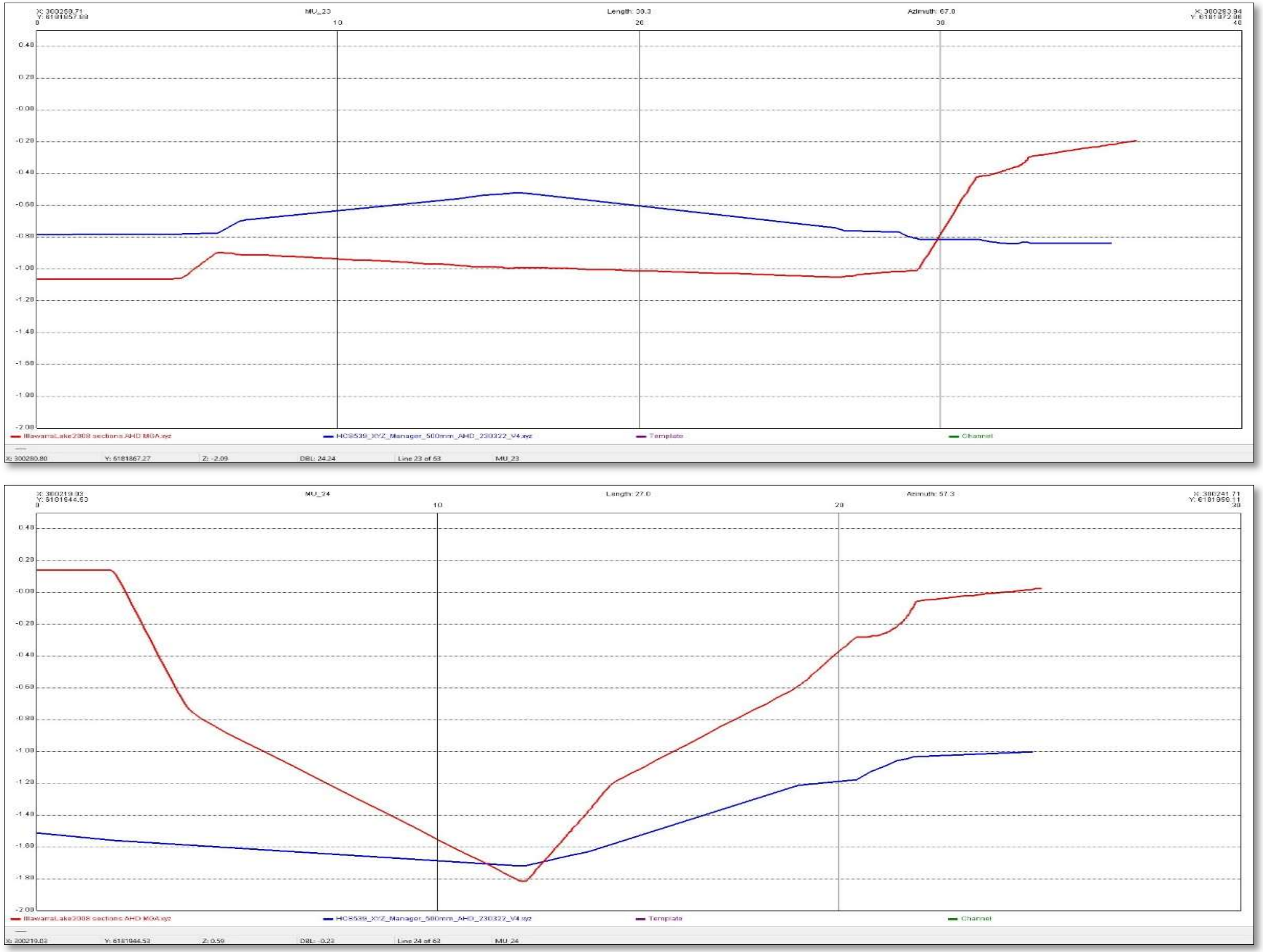


Figure 258: Mullet Creek - profiles (red = 2008, blue = 2022/23) 23 and 24.

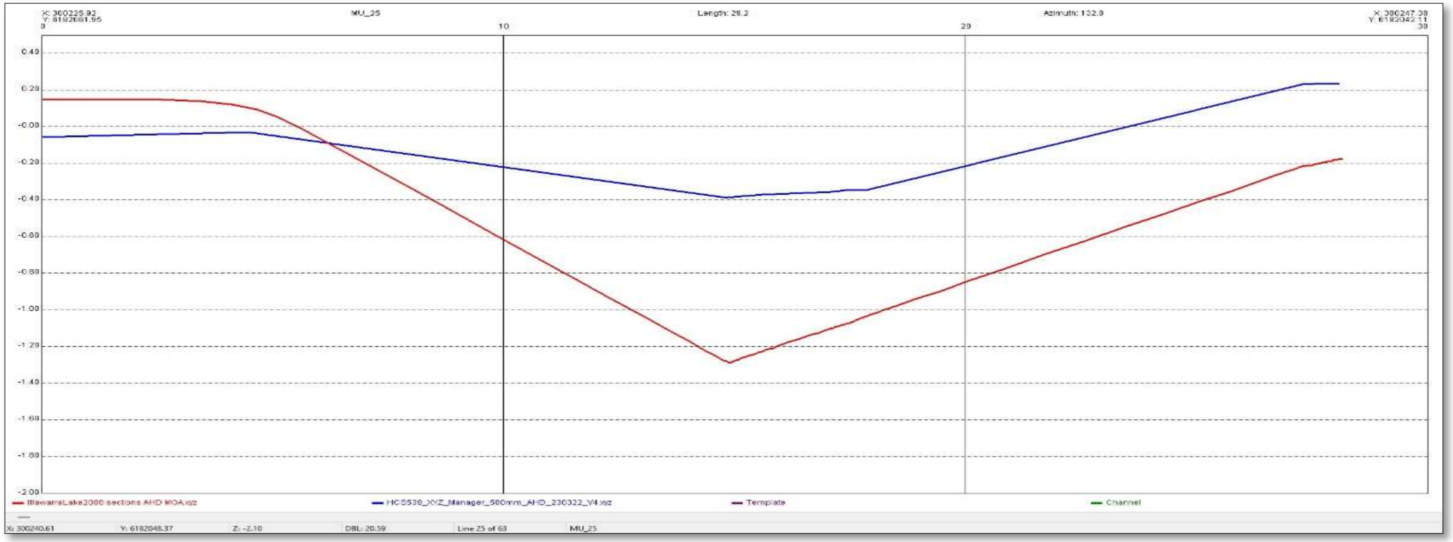


Figure 259: Mullet Creek - profiles (red = 2008, blue = 2022/23) 25 and 26.

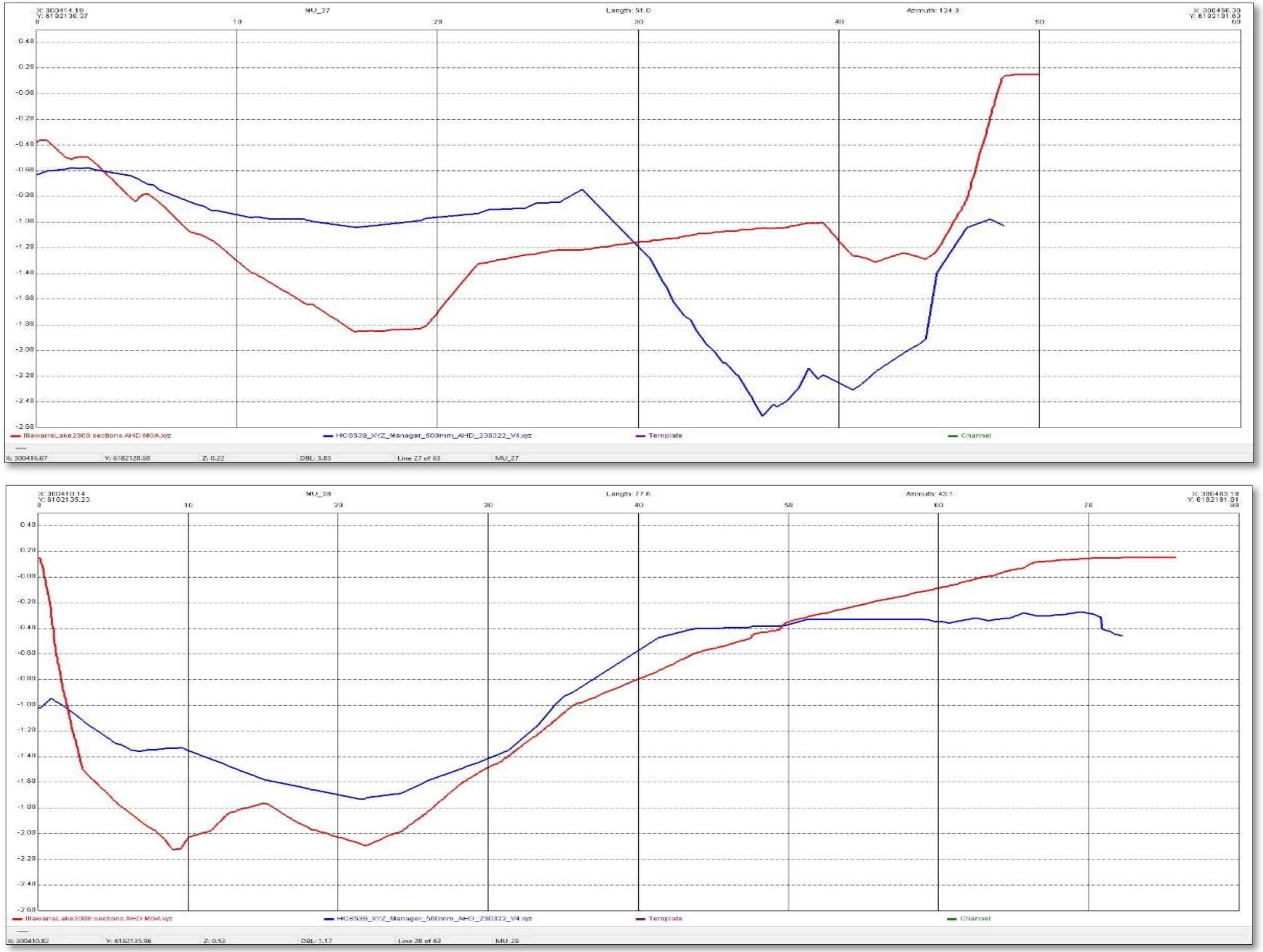


Figure 260: Mullet Creek - profiles (red = 2008, blue = 2022/23) 27 and 28.

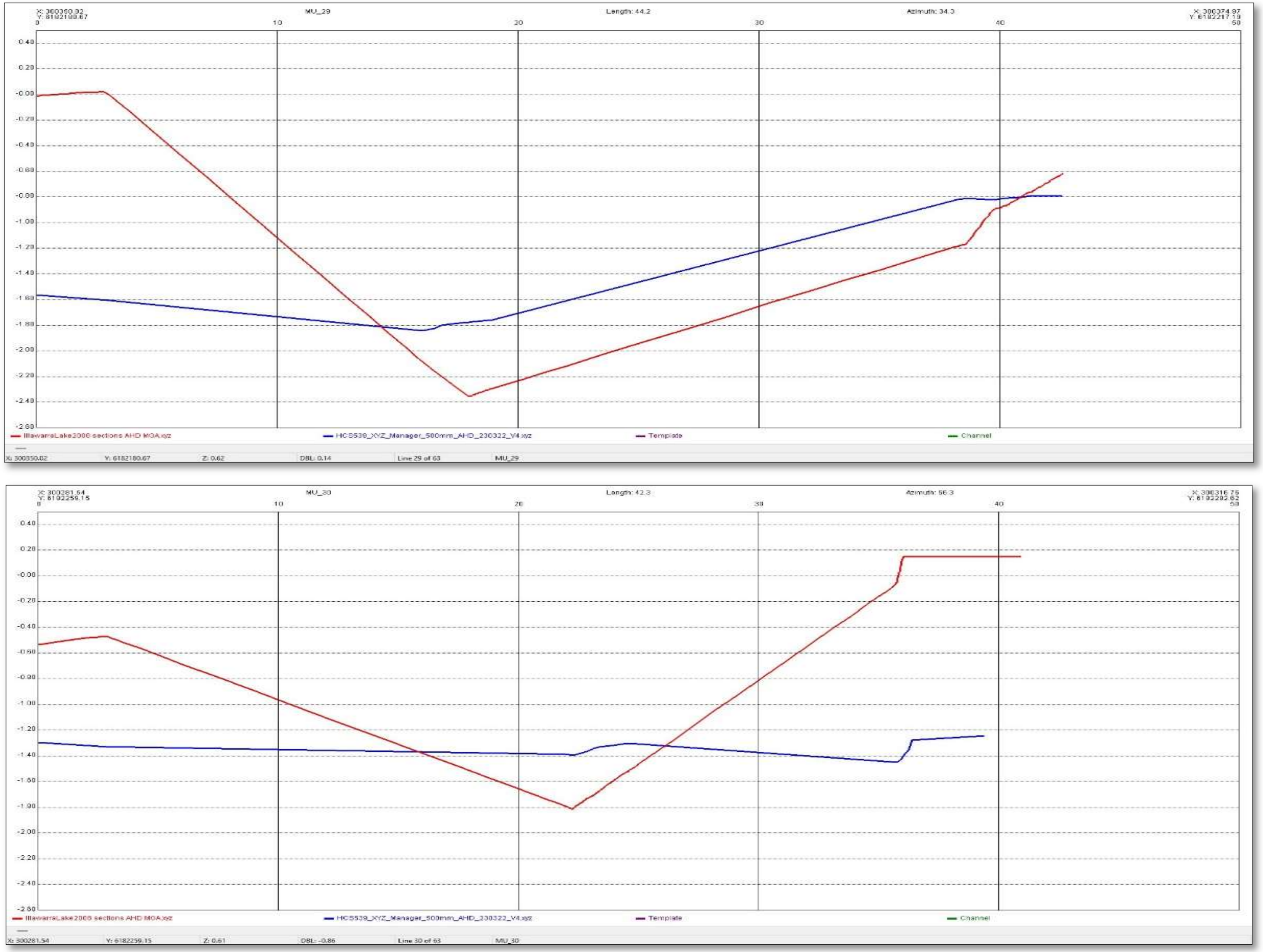
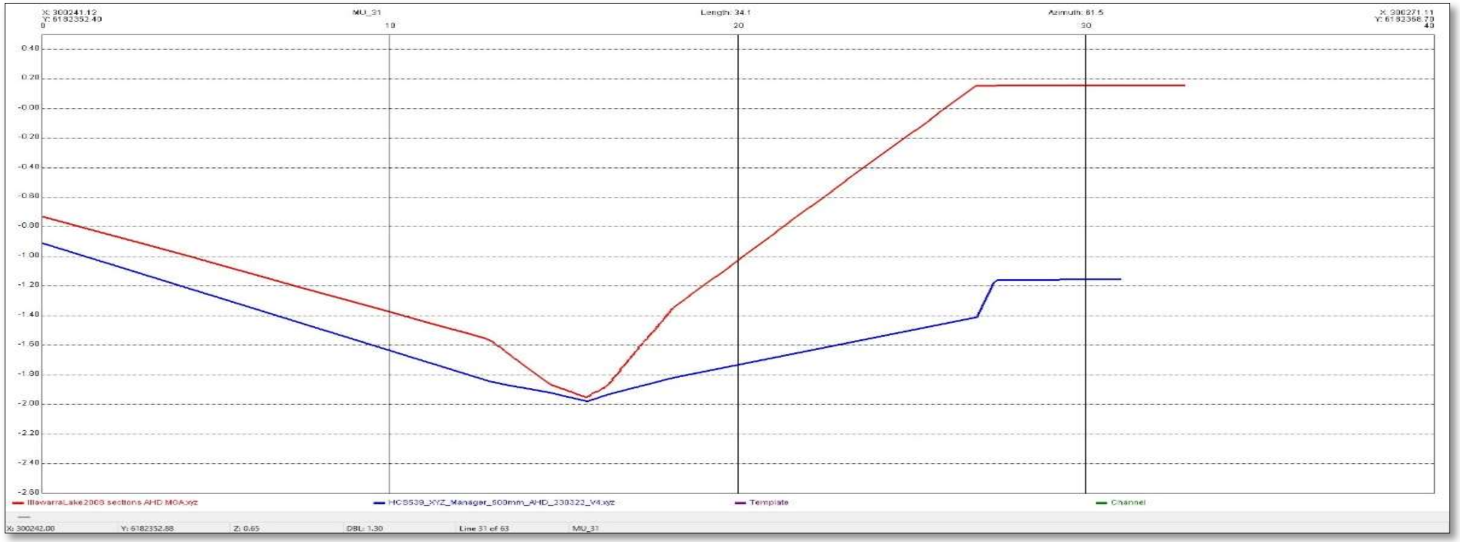


Figure 261: Mullet Creek - profiles (red = 2008, blue = 2022/23) 29 and 30.



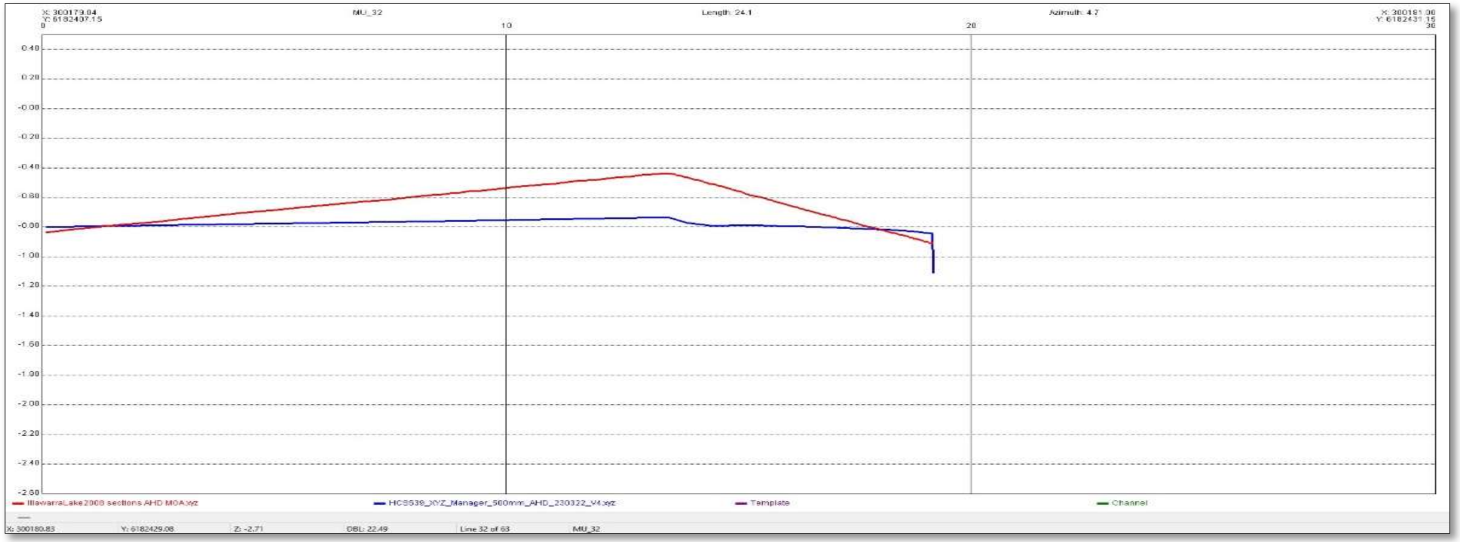
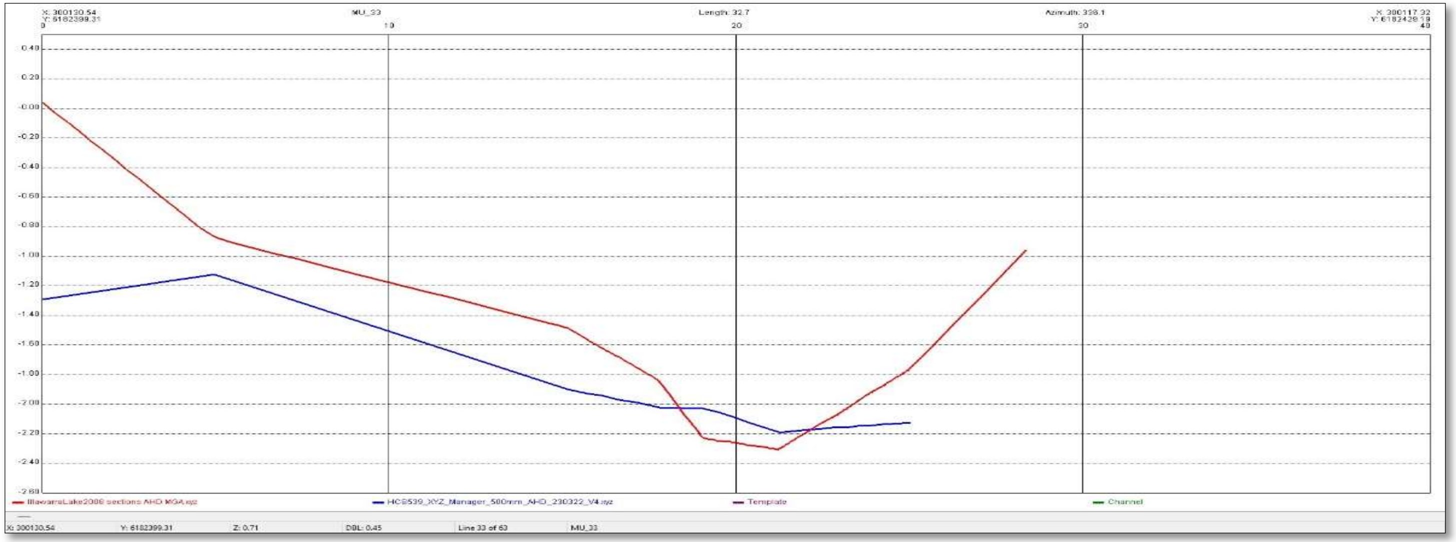


Figure 262: Mullet Creek - profiles (red = 2008, blue = 2022/23) 31 and 32.



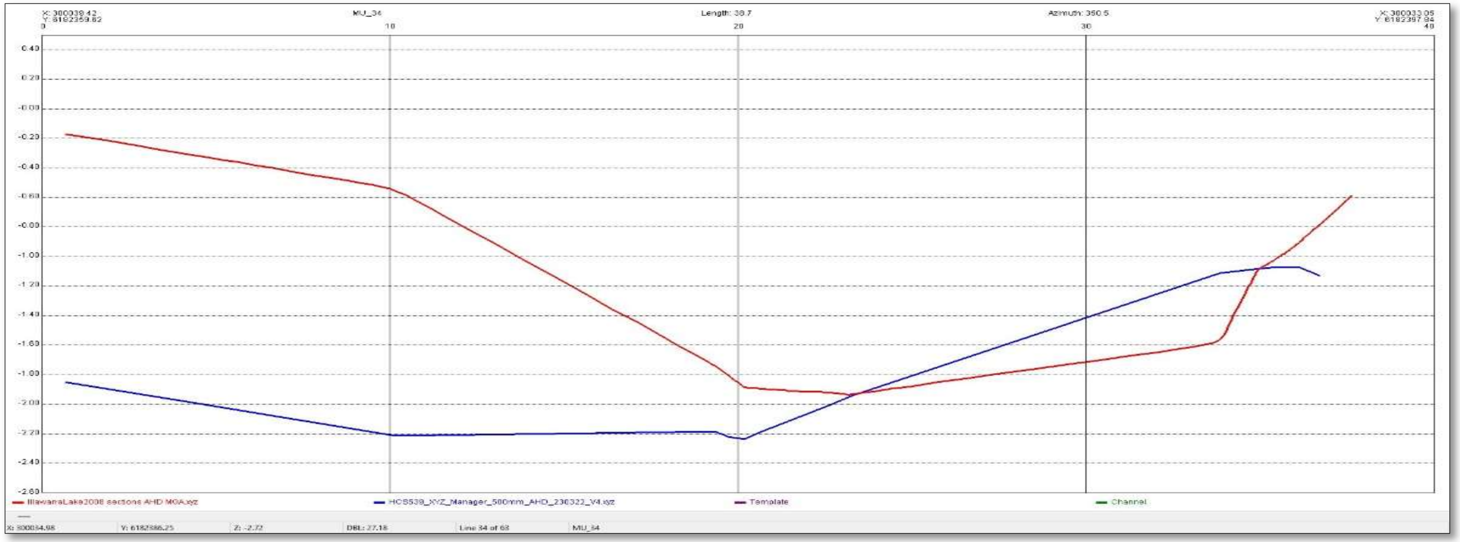


Figure 263: Mullet Creek - profiles (red = 2008, blue = 2022/23) 33 and 34.

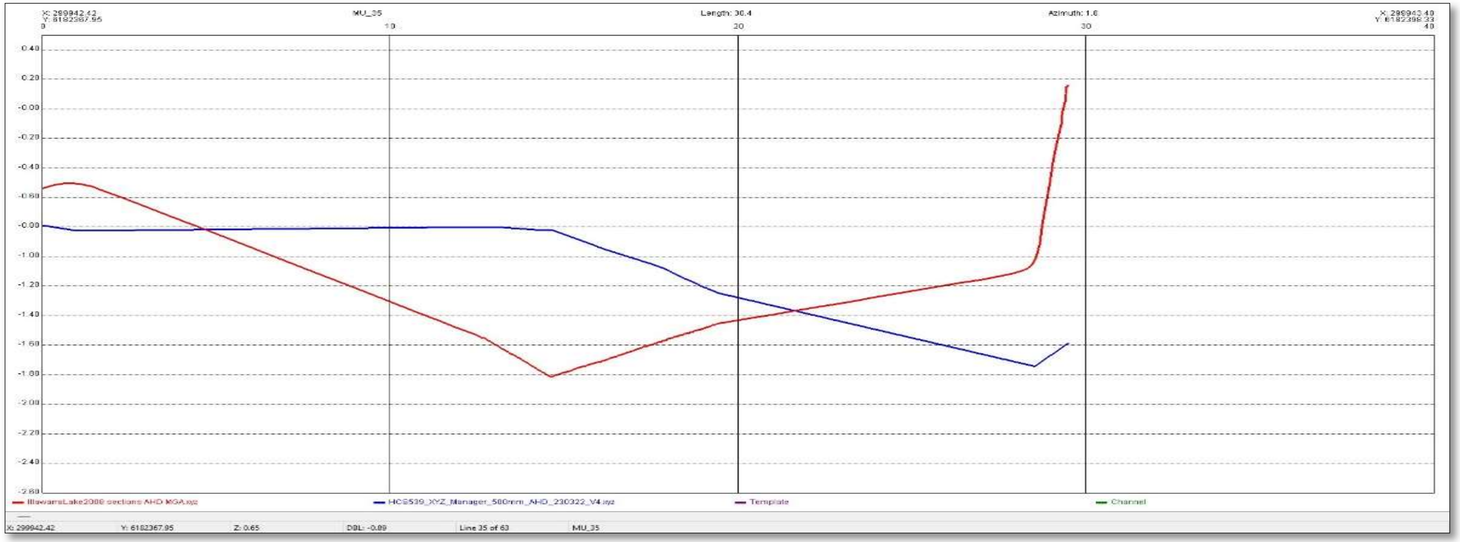


Figure 264: Mullet Creek - profiles (red = 2008, blue = 2022/23) 35 and 36.

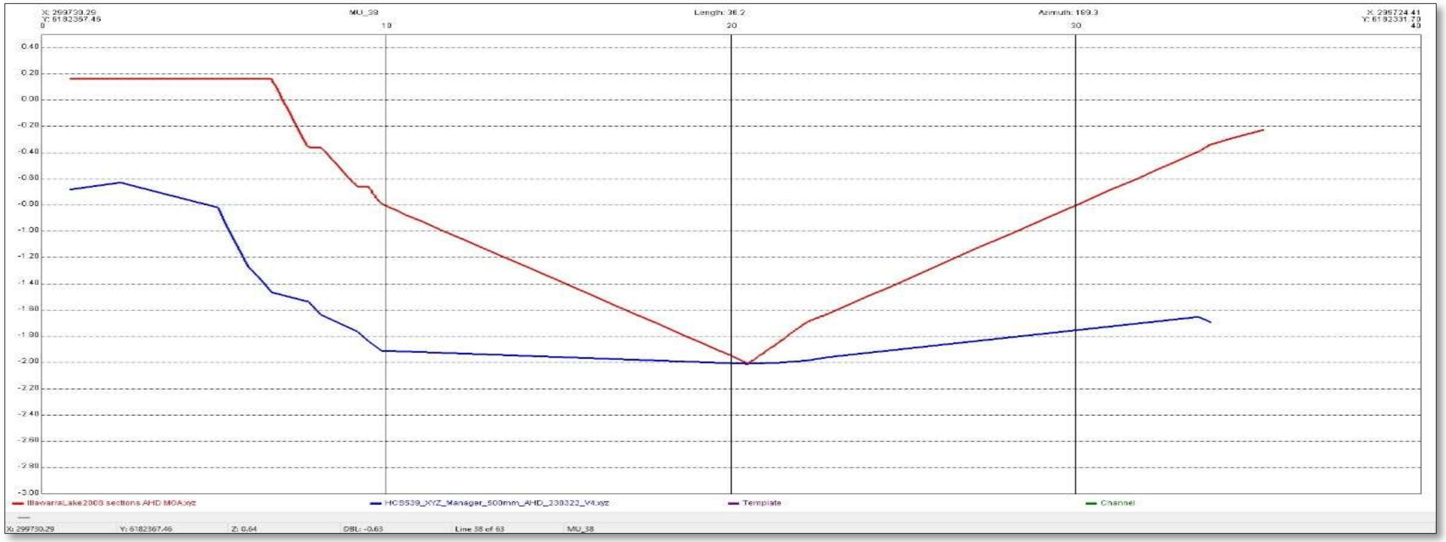
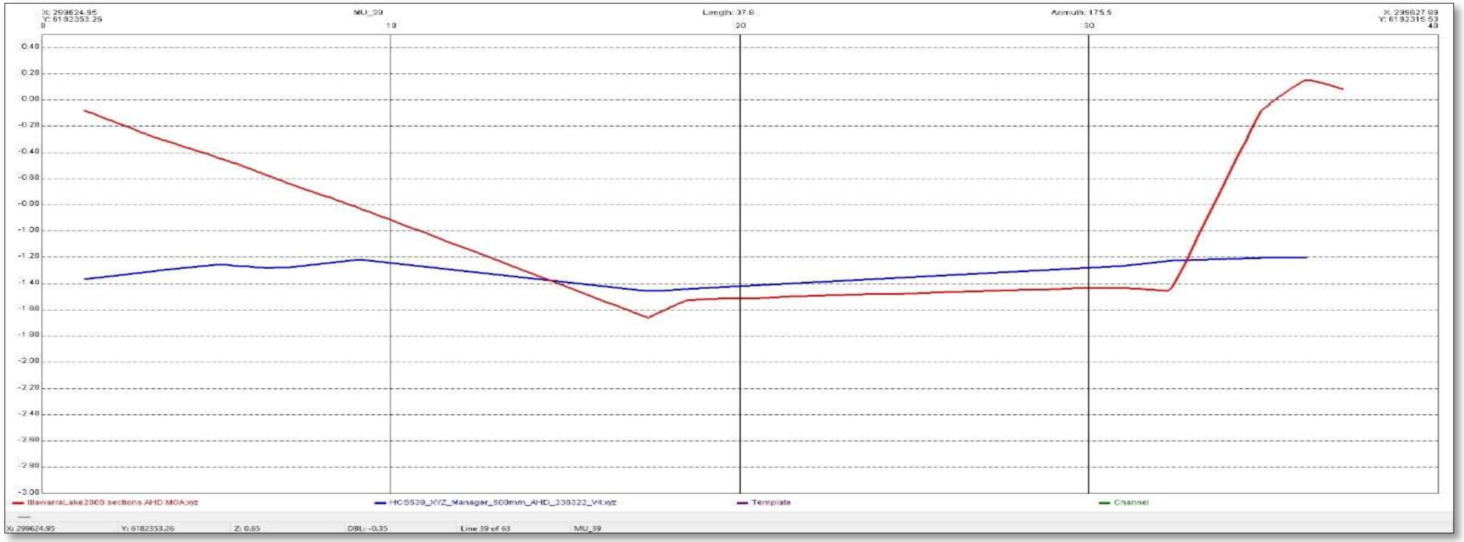


Figure 265: Mullet Creek - profiles (red = 2008, blue = 2022/23) 37 and 38.



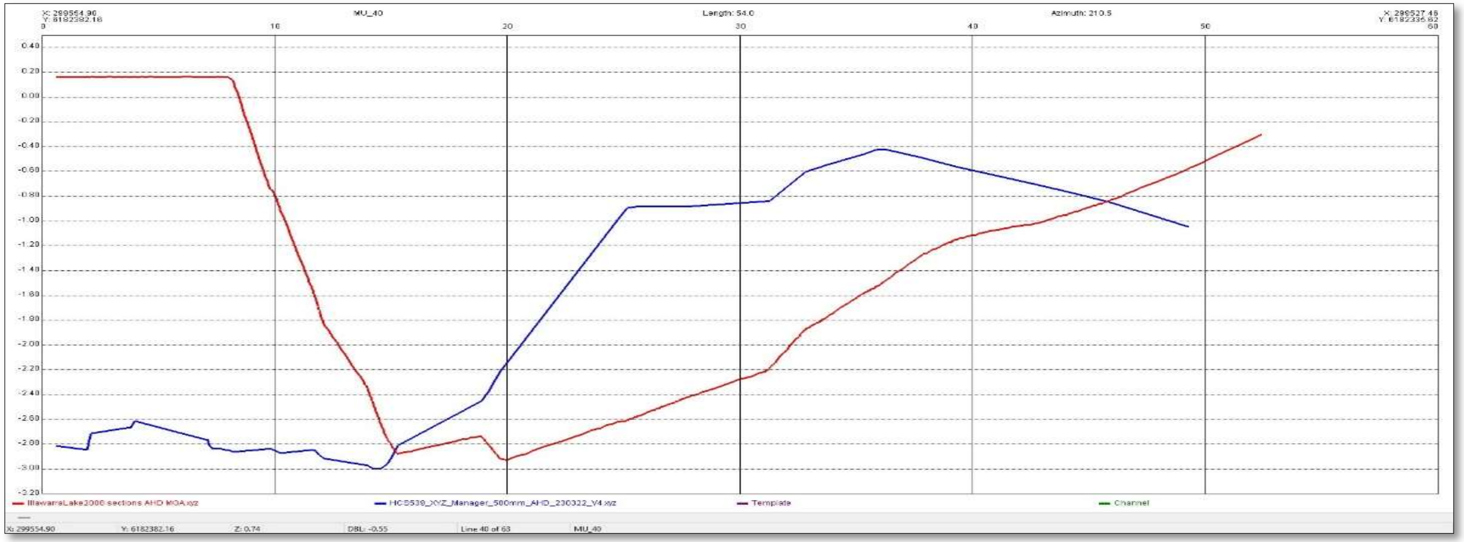


Figure 266: Mullet Creek - profiles (red = 2008, blue = 2022/23) 39 and 40.

Figure 267: Mullet Creek - profiles (red = 2008, blue = 2022/23) 41 and 42.

Figure 268: Mullet Creek - profiles (red = 2008, blue = 2022/23) 43 and 44.

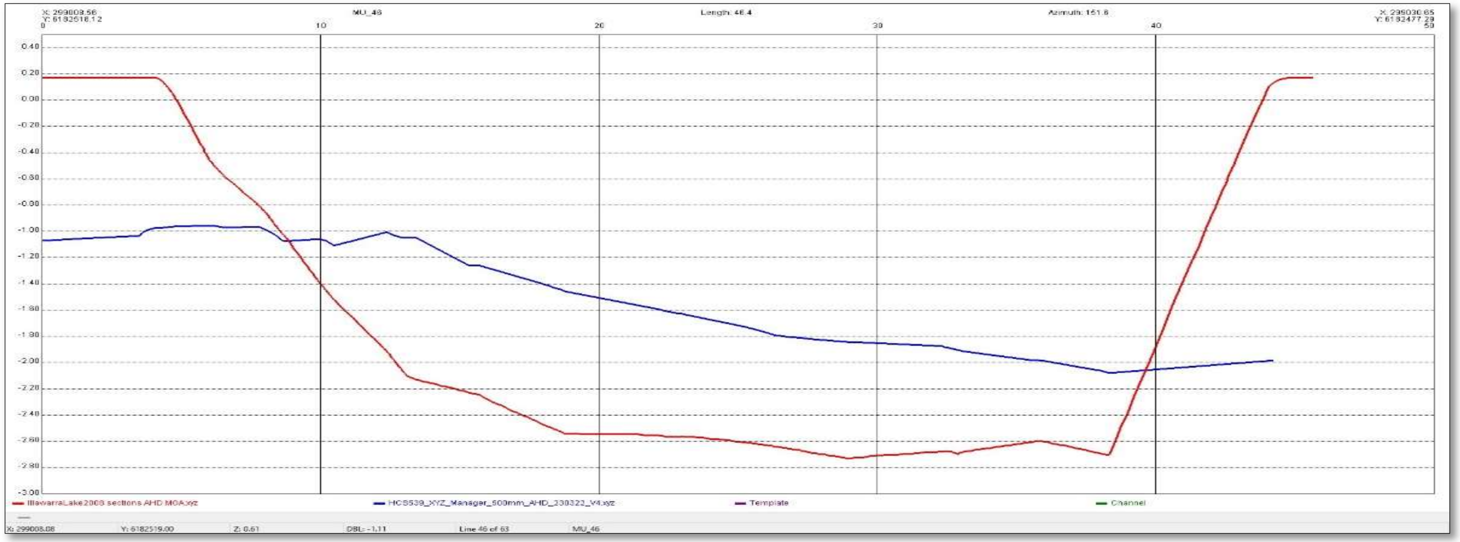
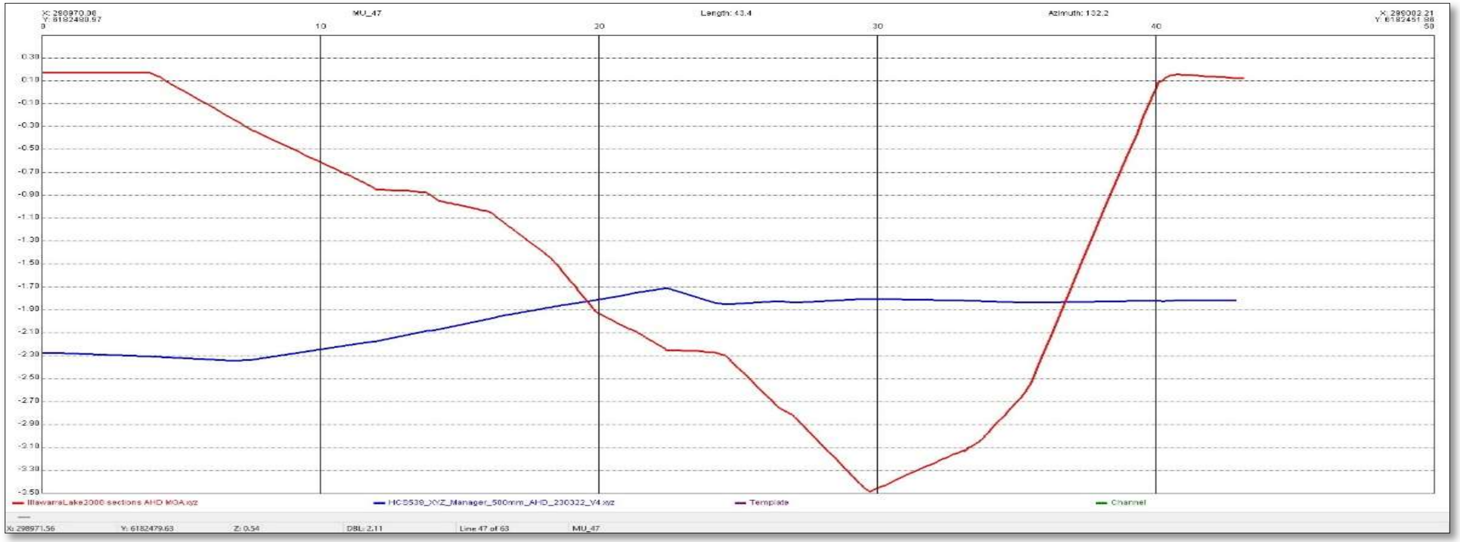


Figure 269: Mullet Creek - profiles (red = 2008, blue = 2022/23) 45 and 46.



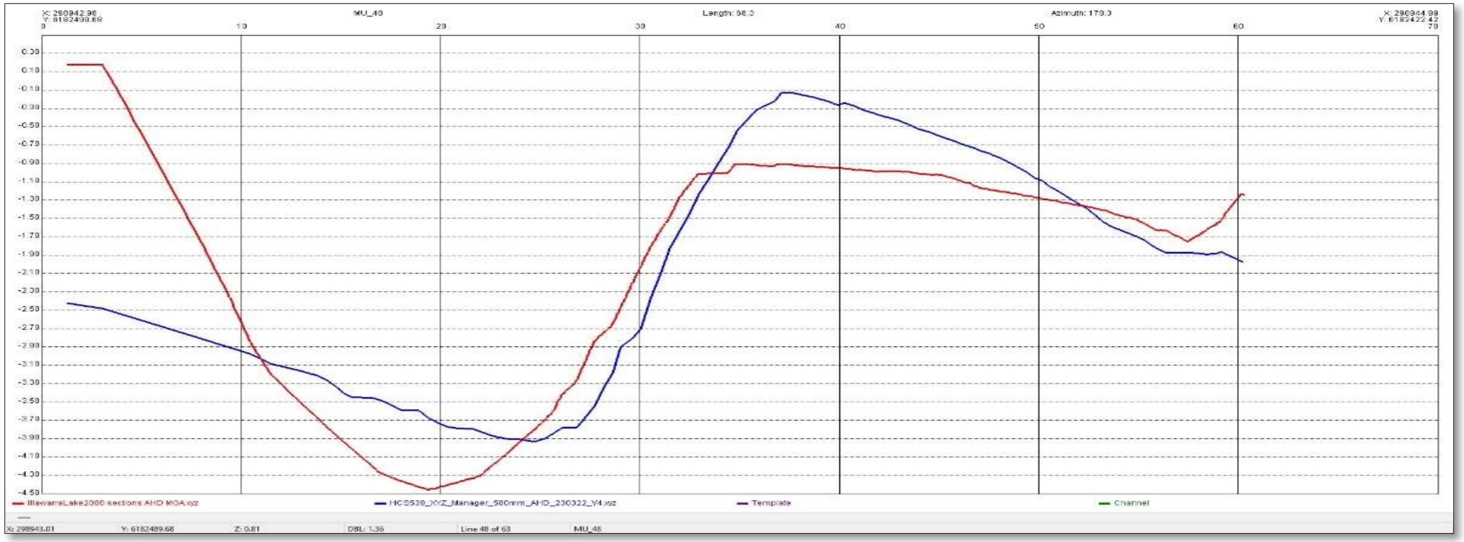
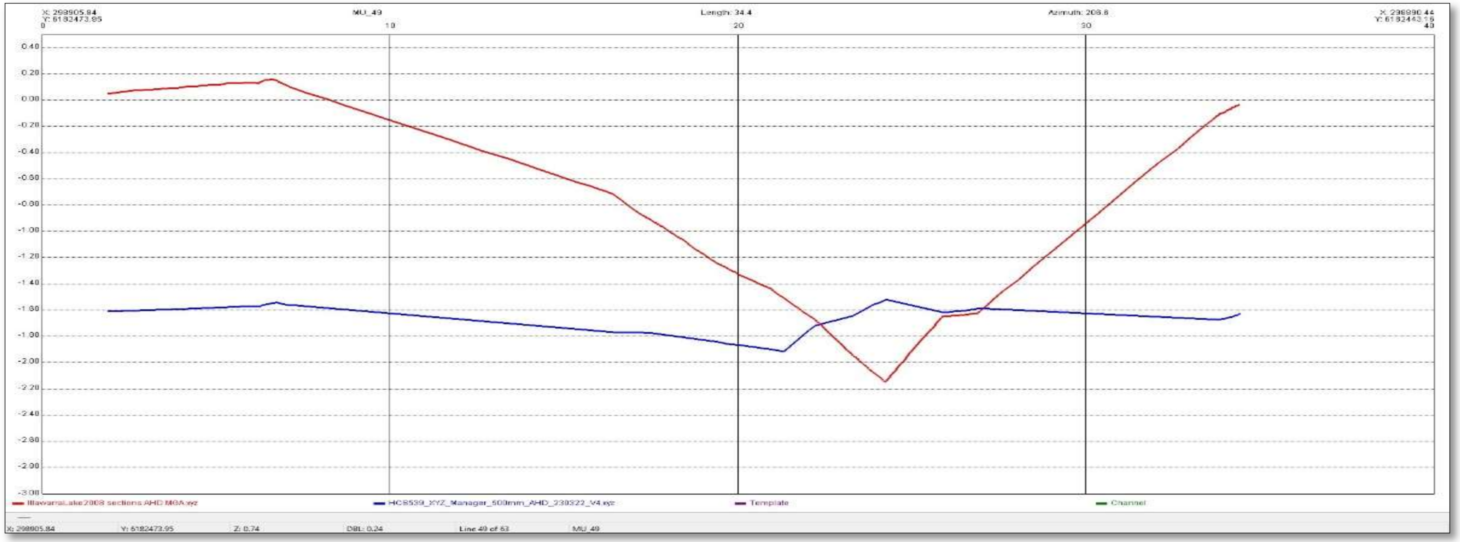


Figure 270: Mullet Creek - profiles (red = 2008, blue = 2022/23) 47 and 48.



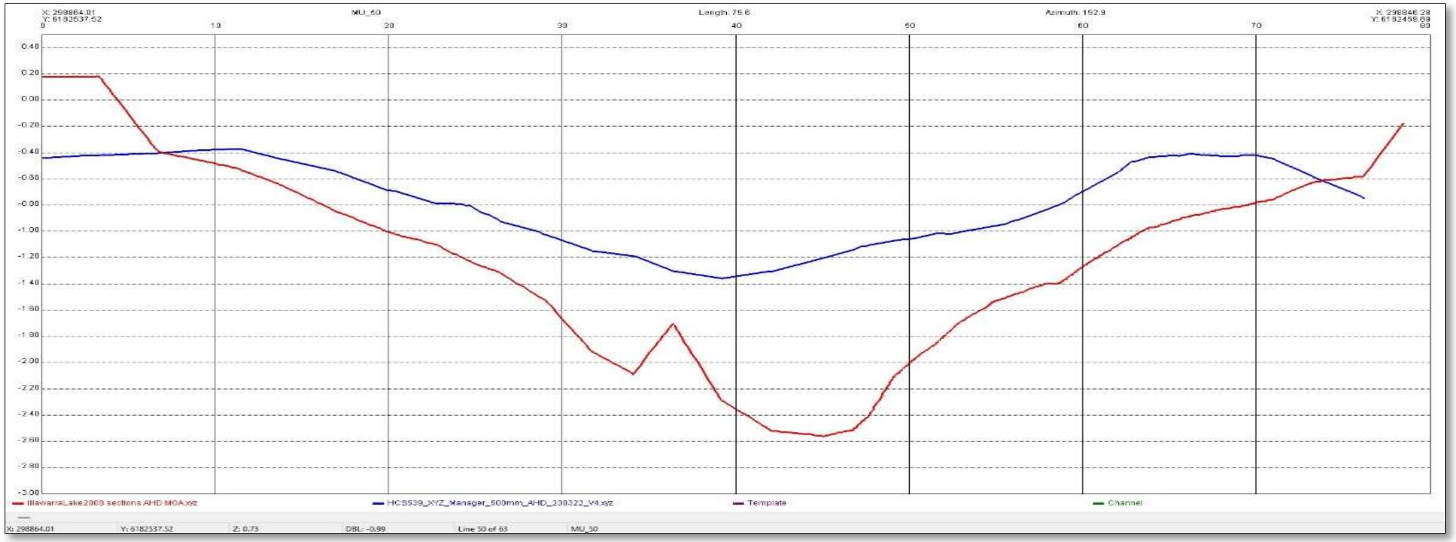


Figure 271: Mullet Creek - profiles (red = 2008, blue = 2022/23) 49 and 50.

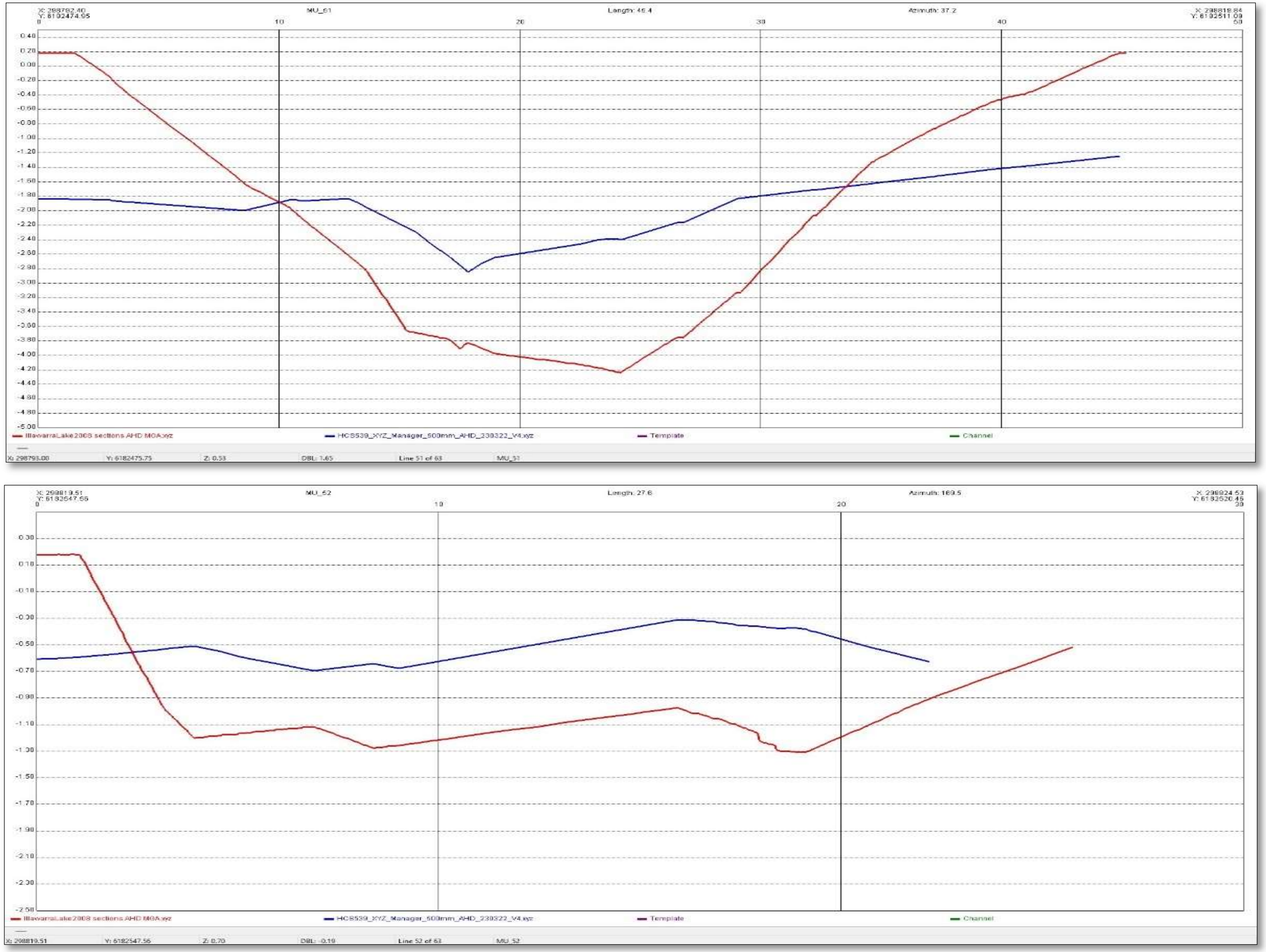
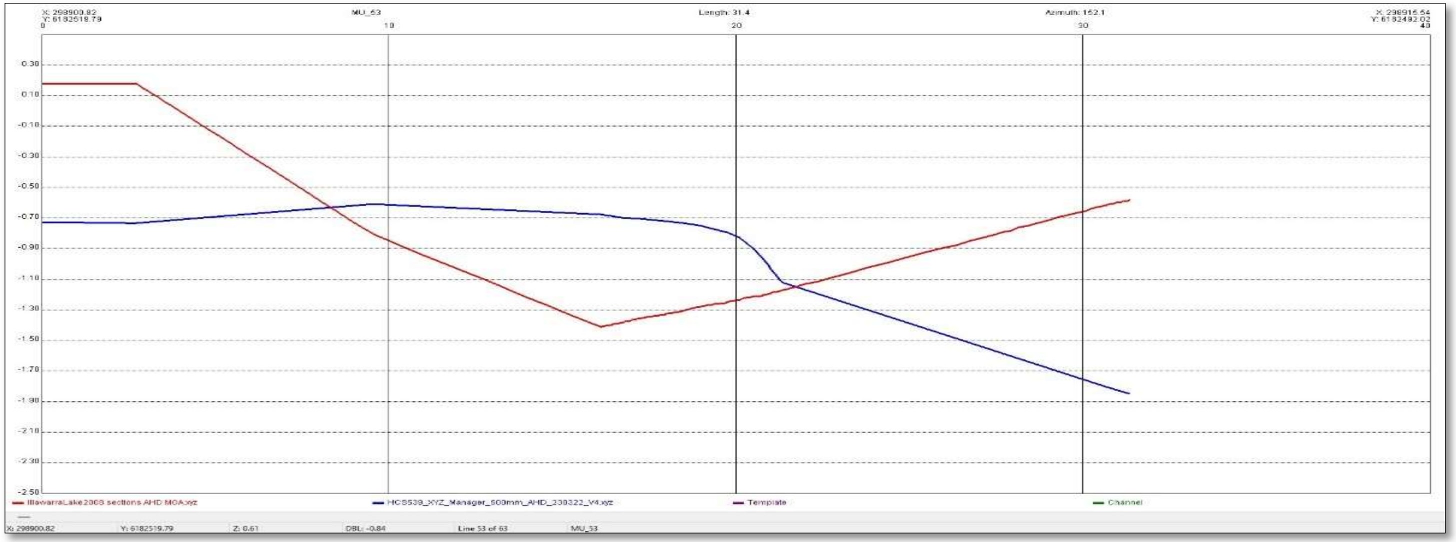


Figure 272: Mullet Creek - profiles (red = 2008, blue = 2022/23) 51 and 52.



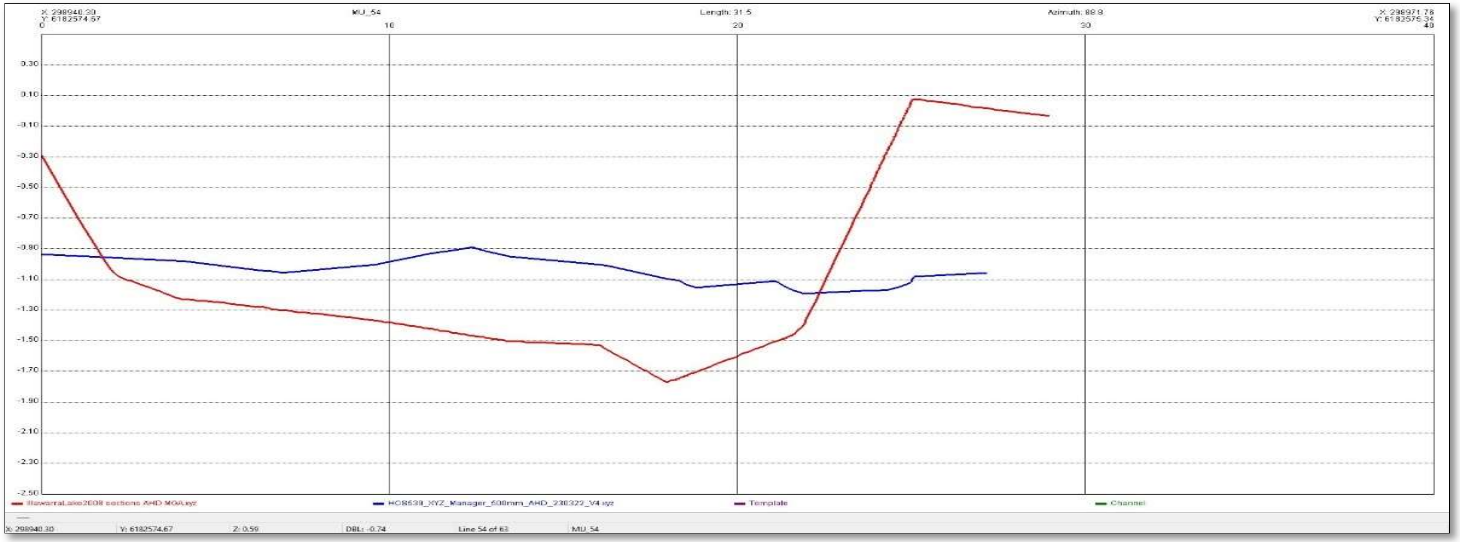


Figure 273: Mullet Creek - profiles (red = 2008, blue = 2022/23) 53 and 54.

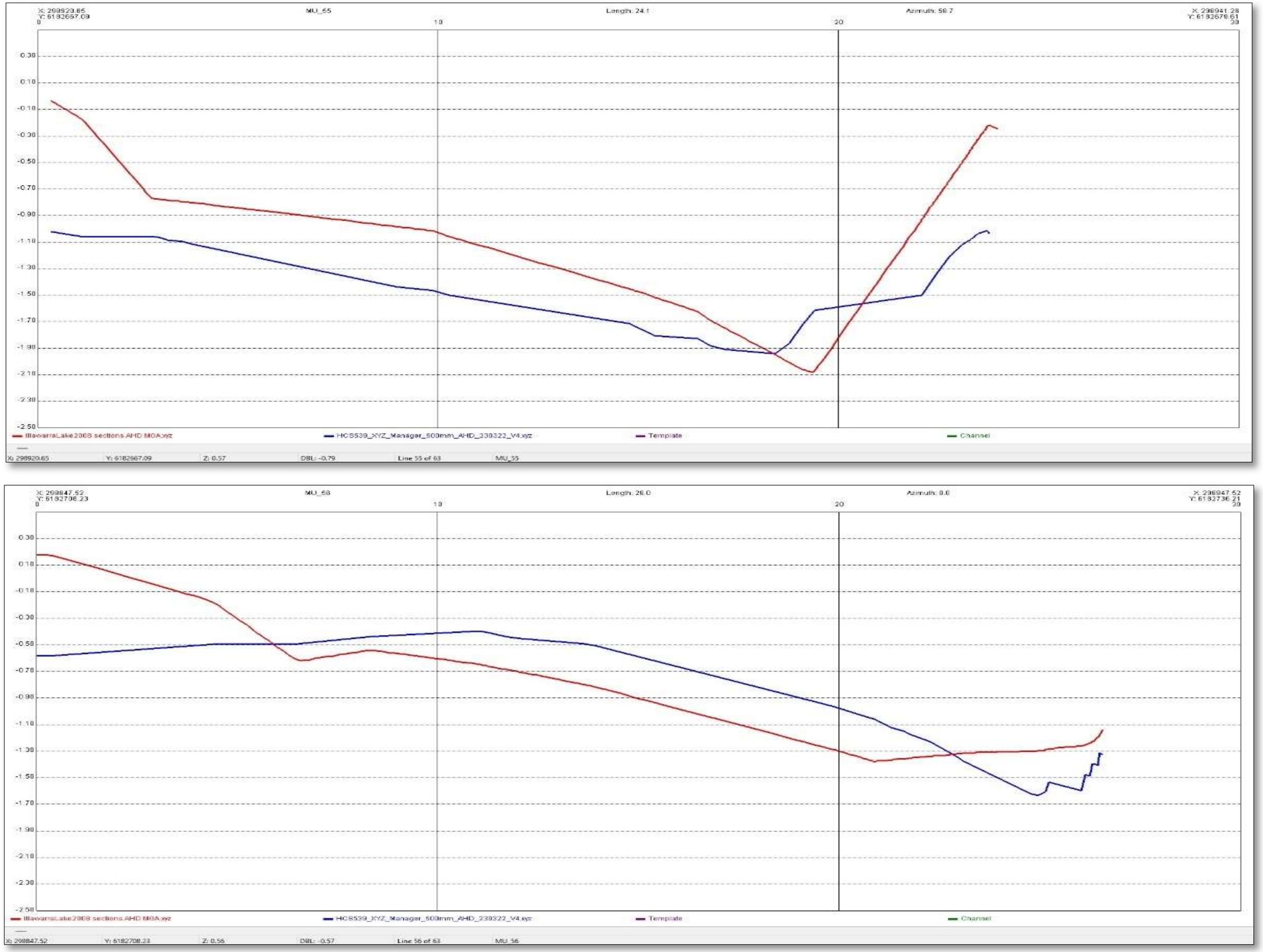
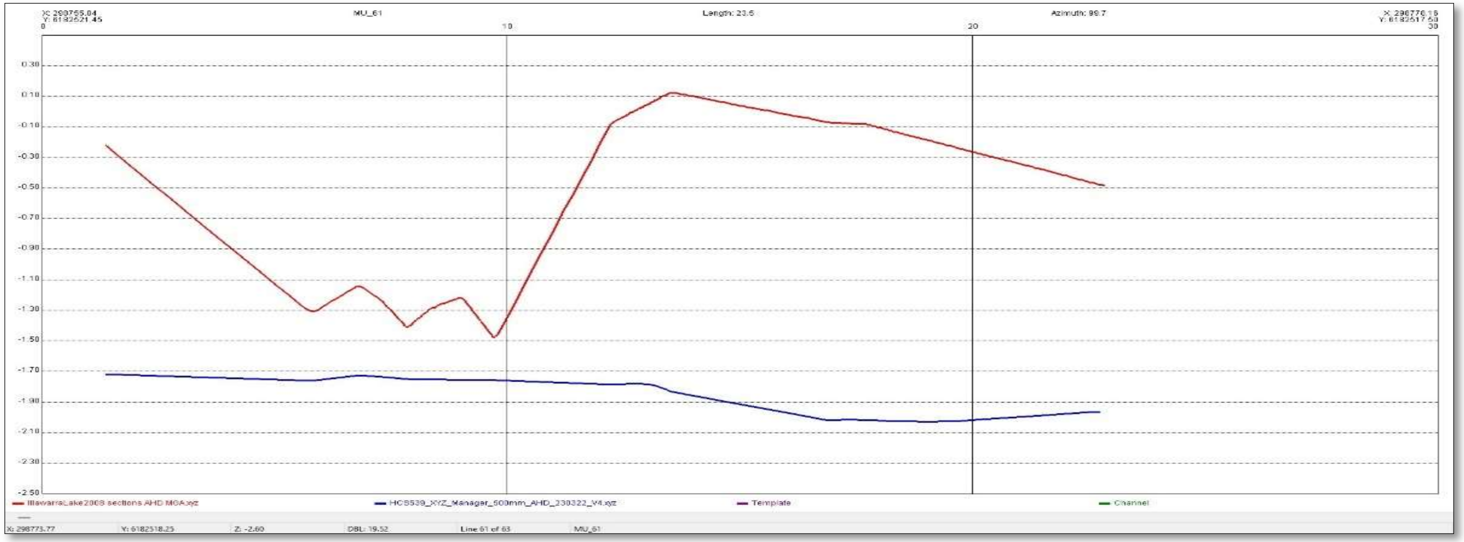


Figure 274: Mullet Creek - profiles (red = 2008, blue = 2022/23) 55 and 56.

Figure 275: Mullet Creek – profile (red = 2008, blue = 2022/23) 57 and 58.

Figure 276: Mullet Creek – profile (red = 2008, blue = 2022/23) 59 and 60



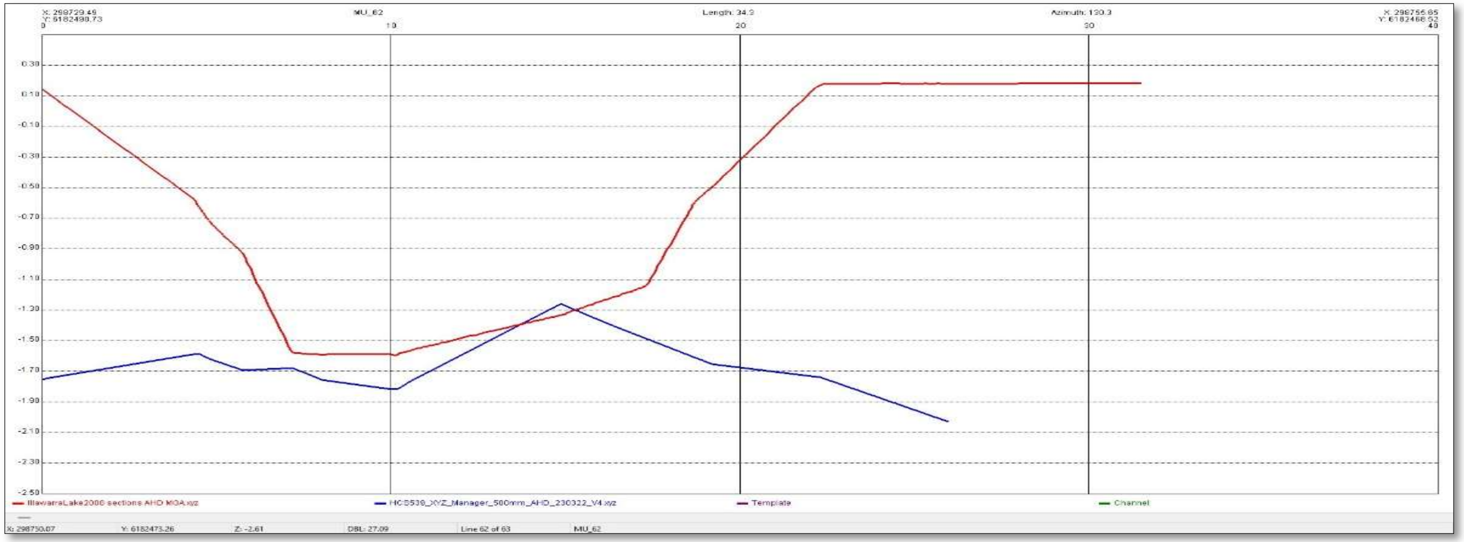


Figure 277: Mullet Creek – profile (red = 2008, blue = 2022/23) 61 and 62

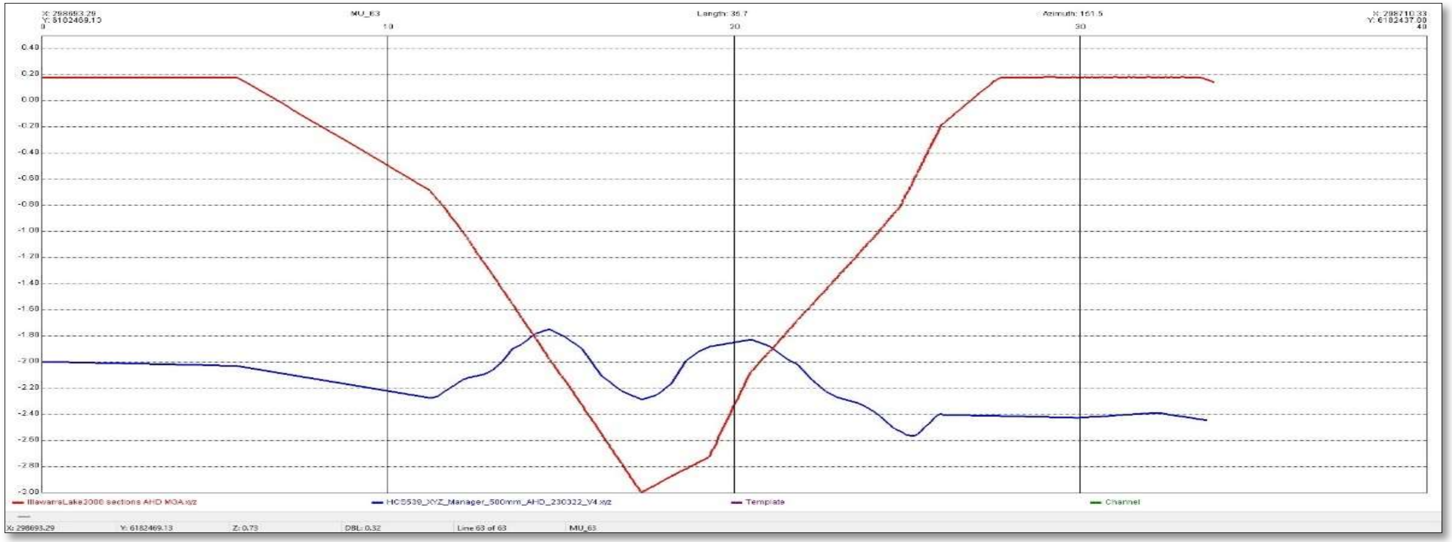


Figure 278: Mullet Creek – profile (red = 2008, blue = 2022/23) 63.

Mullet Tank Trap

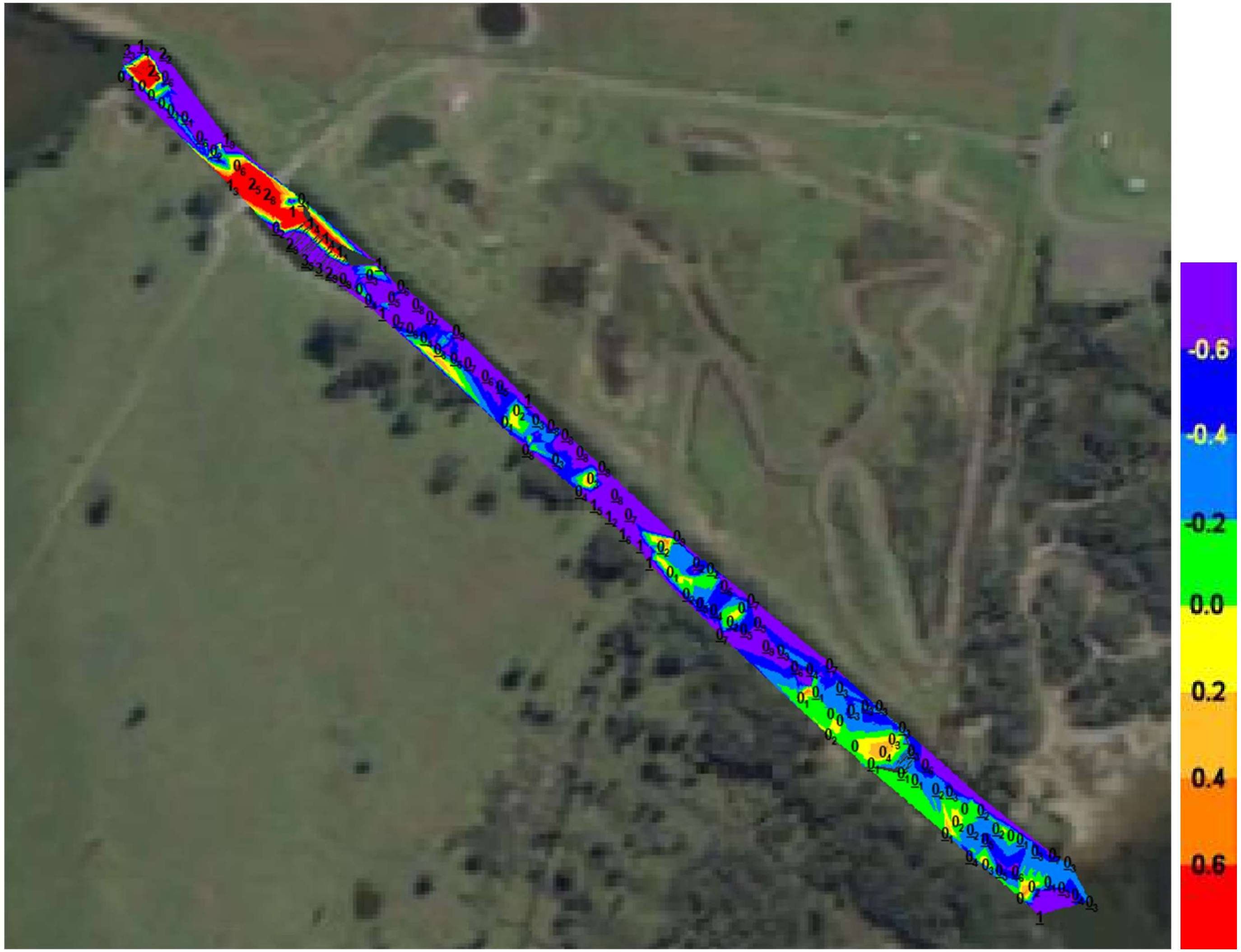


Figure 279: Mullet Tank Trap profiles utilised for analysis (data within Plan 539-1 Sheet 2).

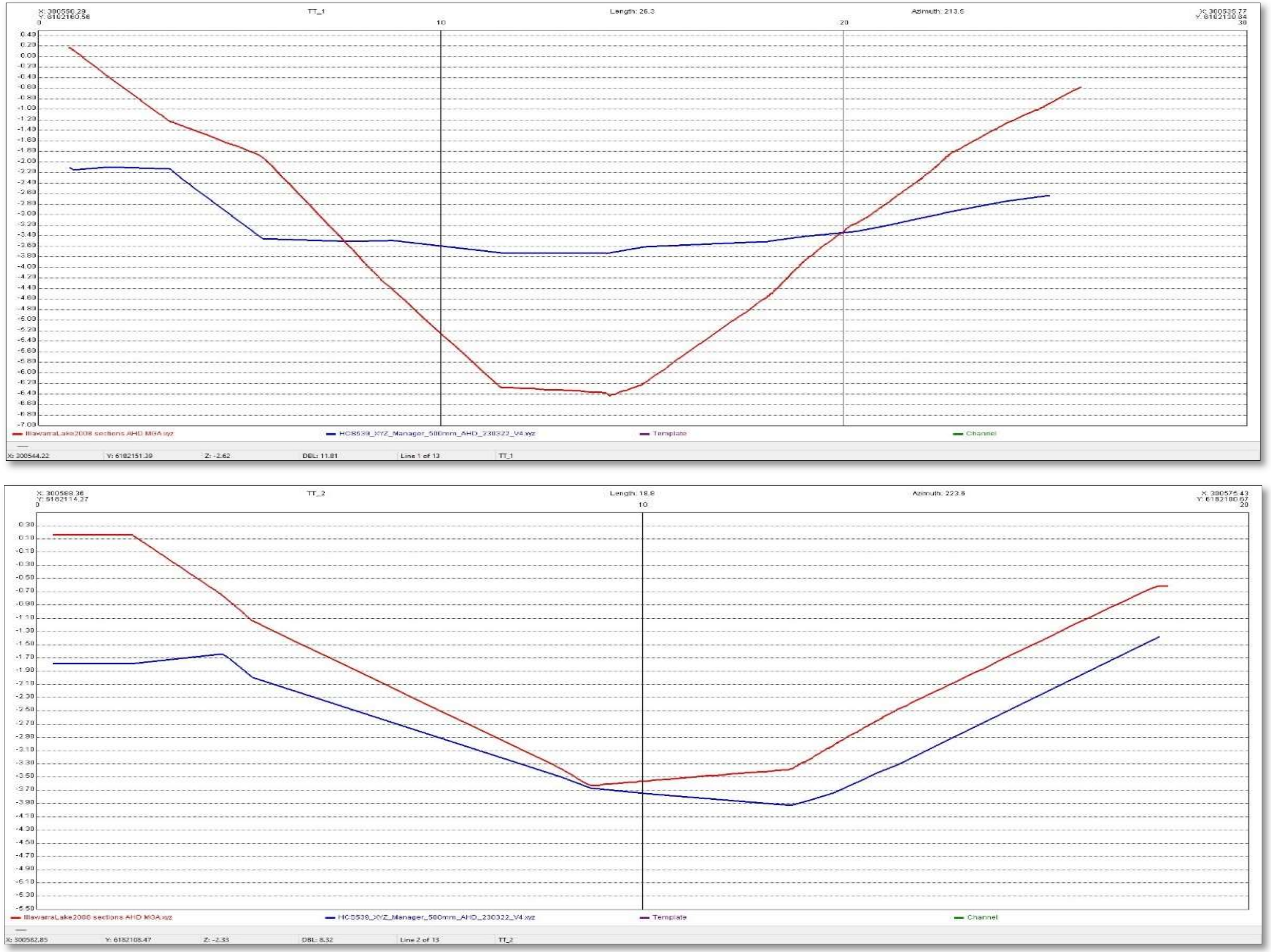


Figure 280: Mullet Tank Trap - profiles (red = 2008, blue = 2022/23) 1 and 2.

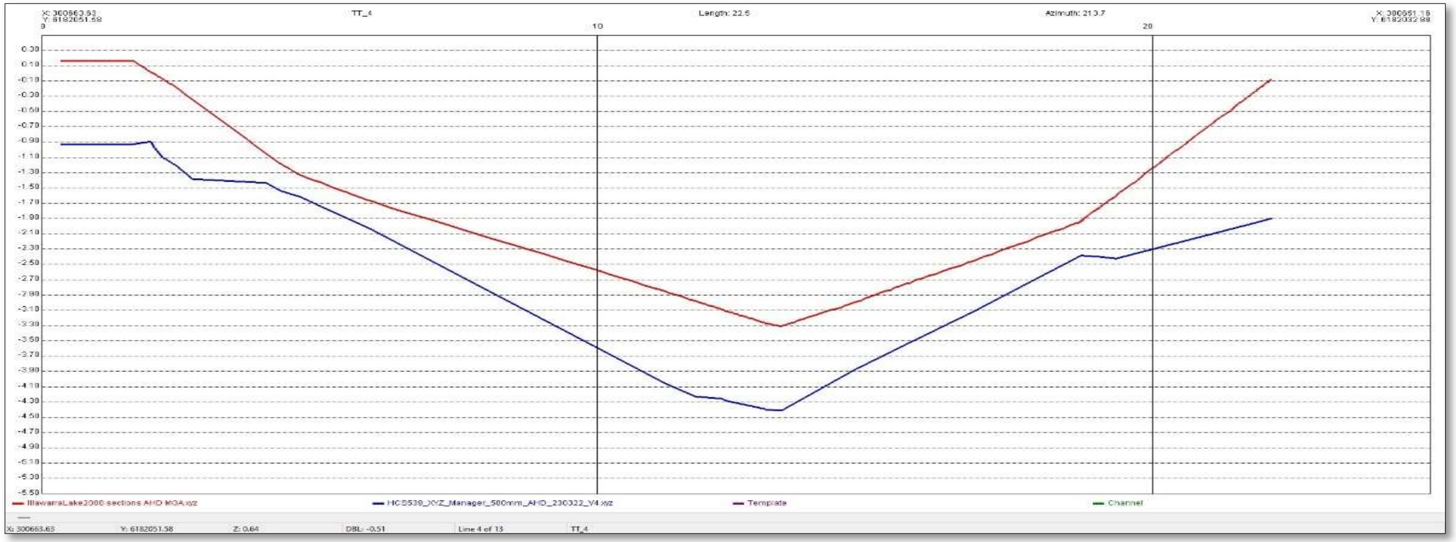


Figure 281: Mullet Tank Trap - profiles (red = 2008, blue = 2022/23) 3 and 4.

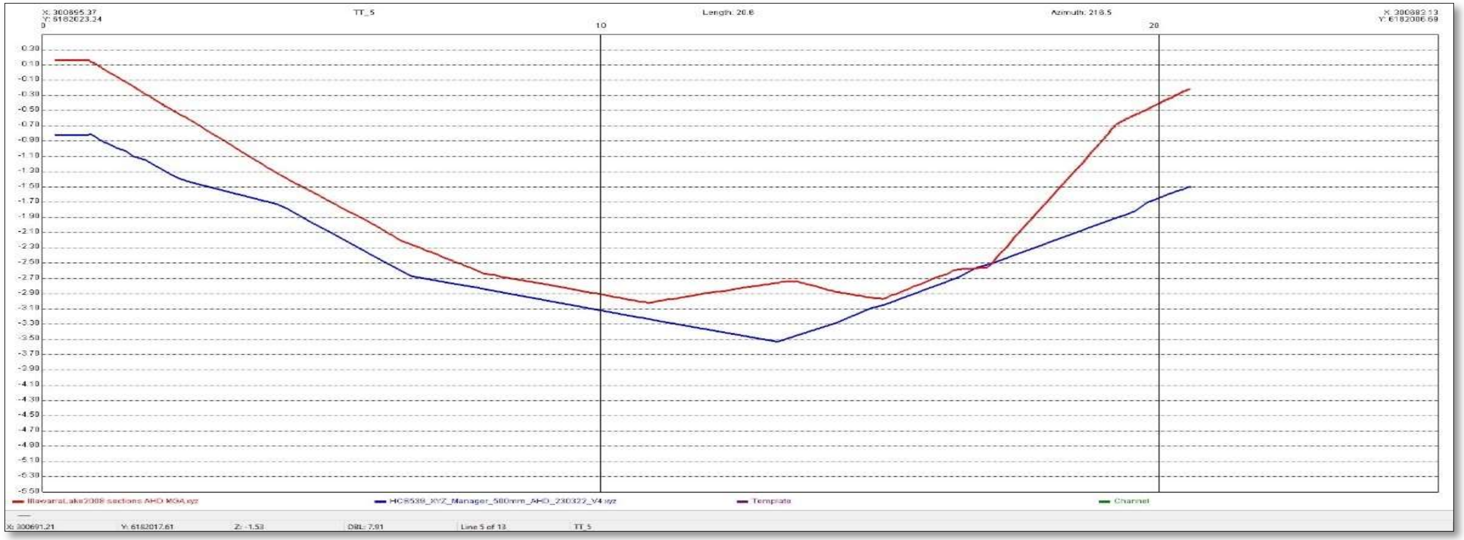


Figure 282: Mullet Tank Trap - profiles (red = 2008, blue = 2022/23) 5 and 6.

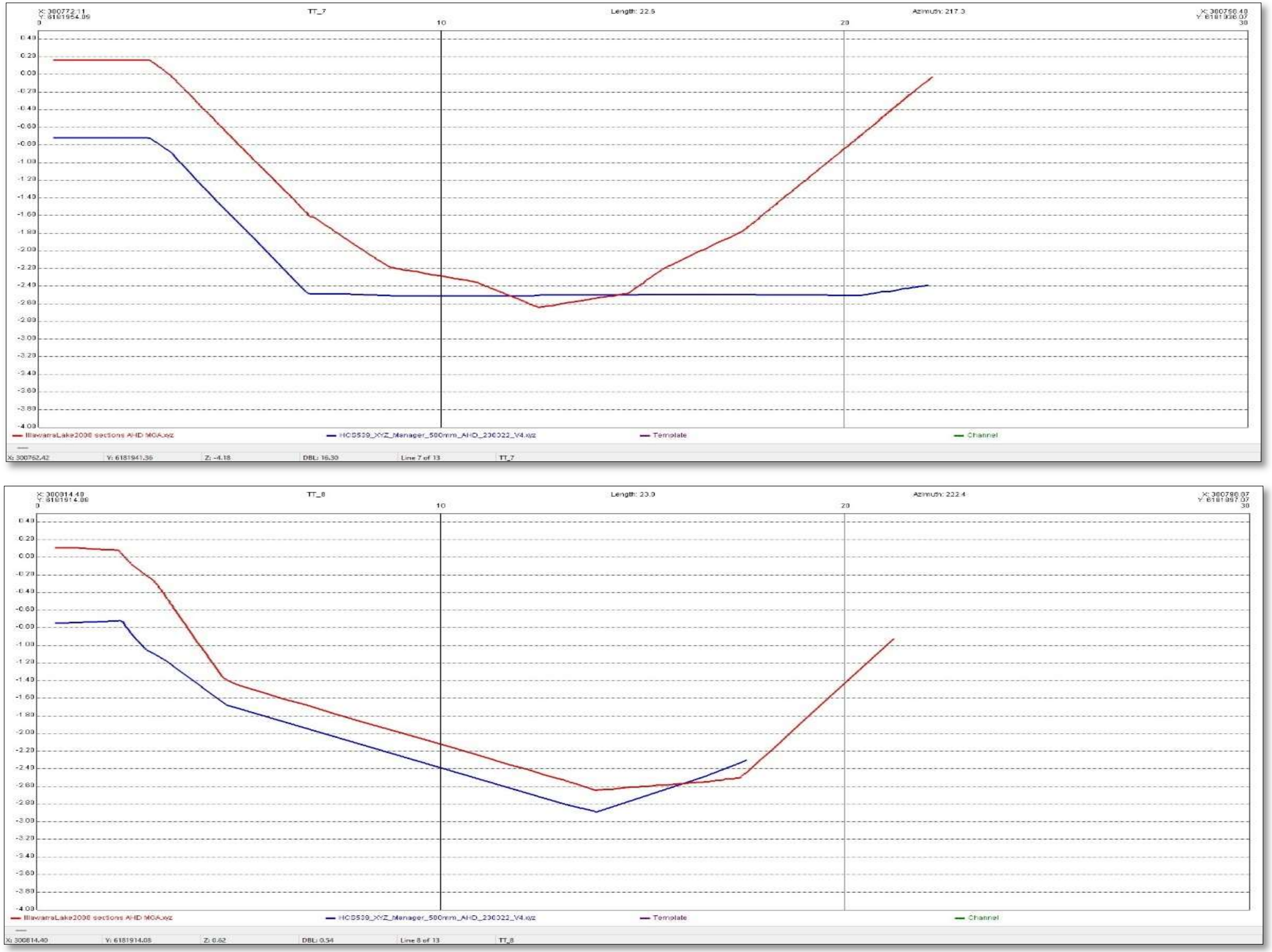


Figure 283: Mullet Tank Trap - profiles (red = 2008, blue = 2022/23) 7 and 8.

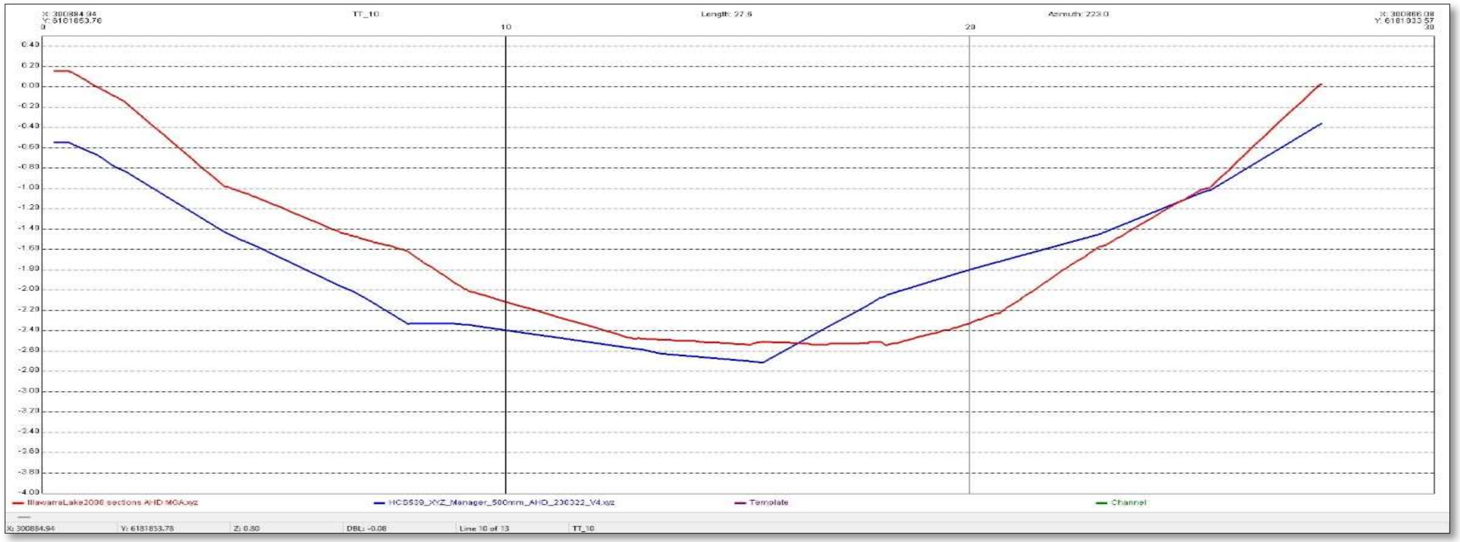


Figure 284: Mullet Tank Trap - profiles (red = 2008, blue = 2022/23) 9 and 10.

Figure 285: Mullet Tank Trap - profiles (red = 2008, blue = 2022/23) 11 and 12.

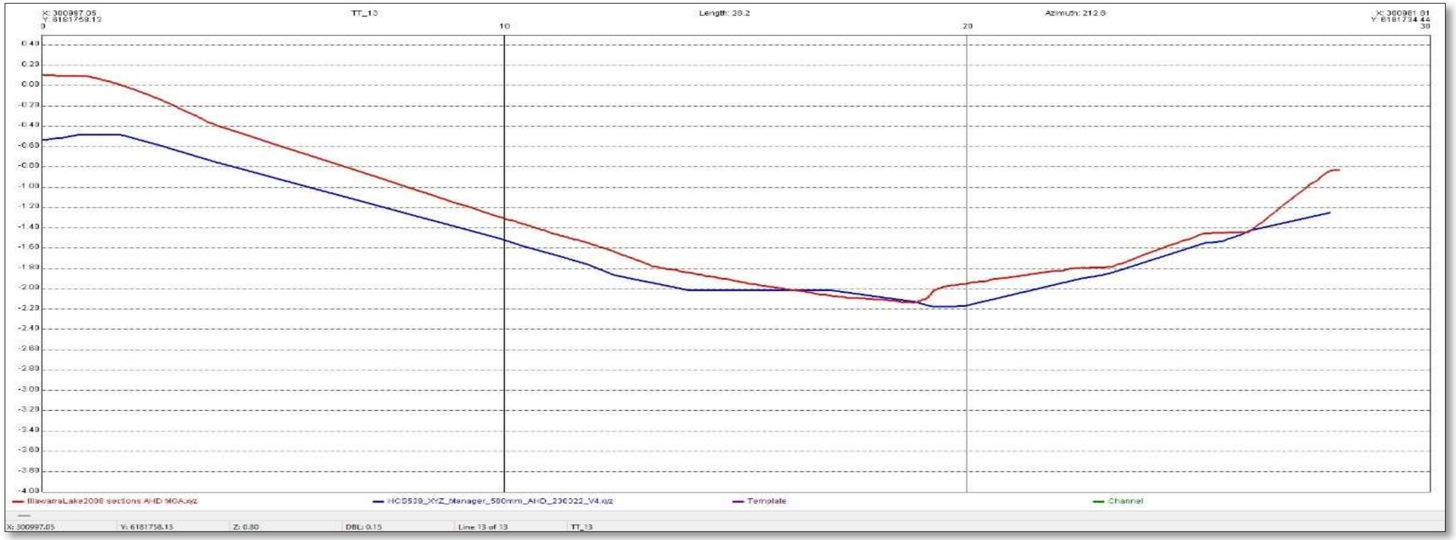


Figure 286: Mullet Tank Trap - profile (red = 2008, blue = 2022/23) 13.

Oaky Gully

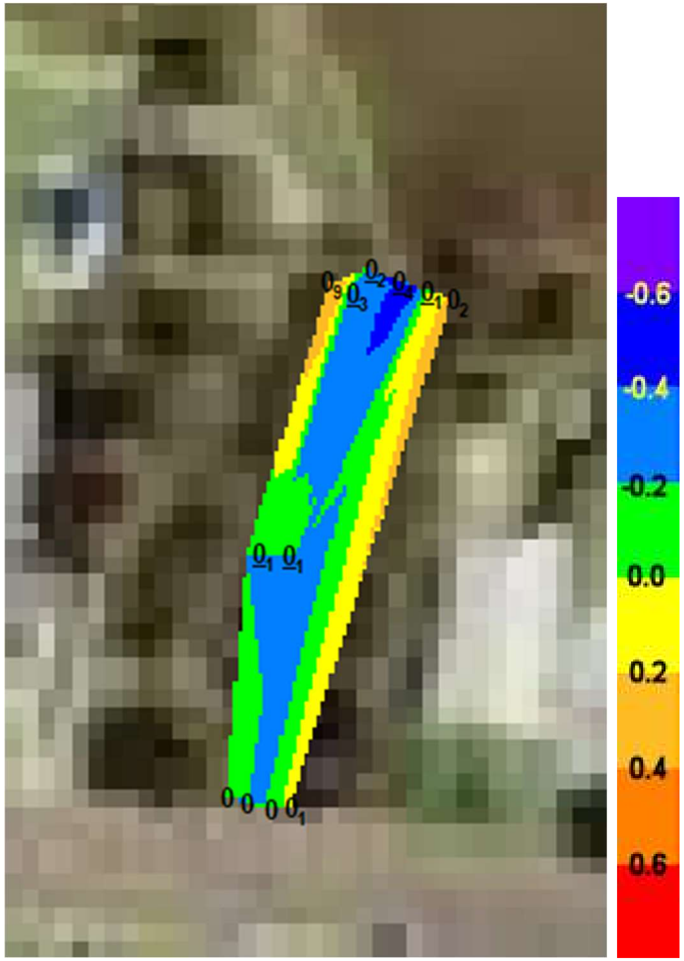


Figure 287: Oaky Gully profiles utilised for analysis (data within Plan 539-1 Sheet 4).

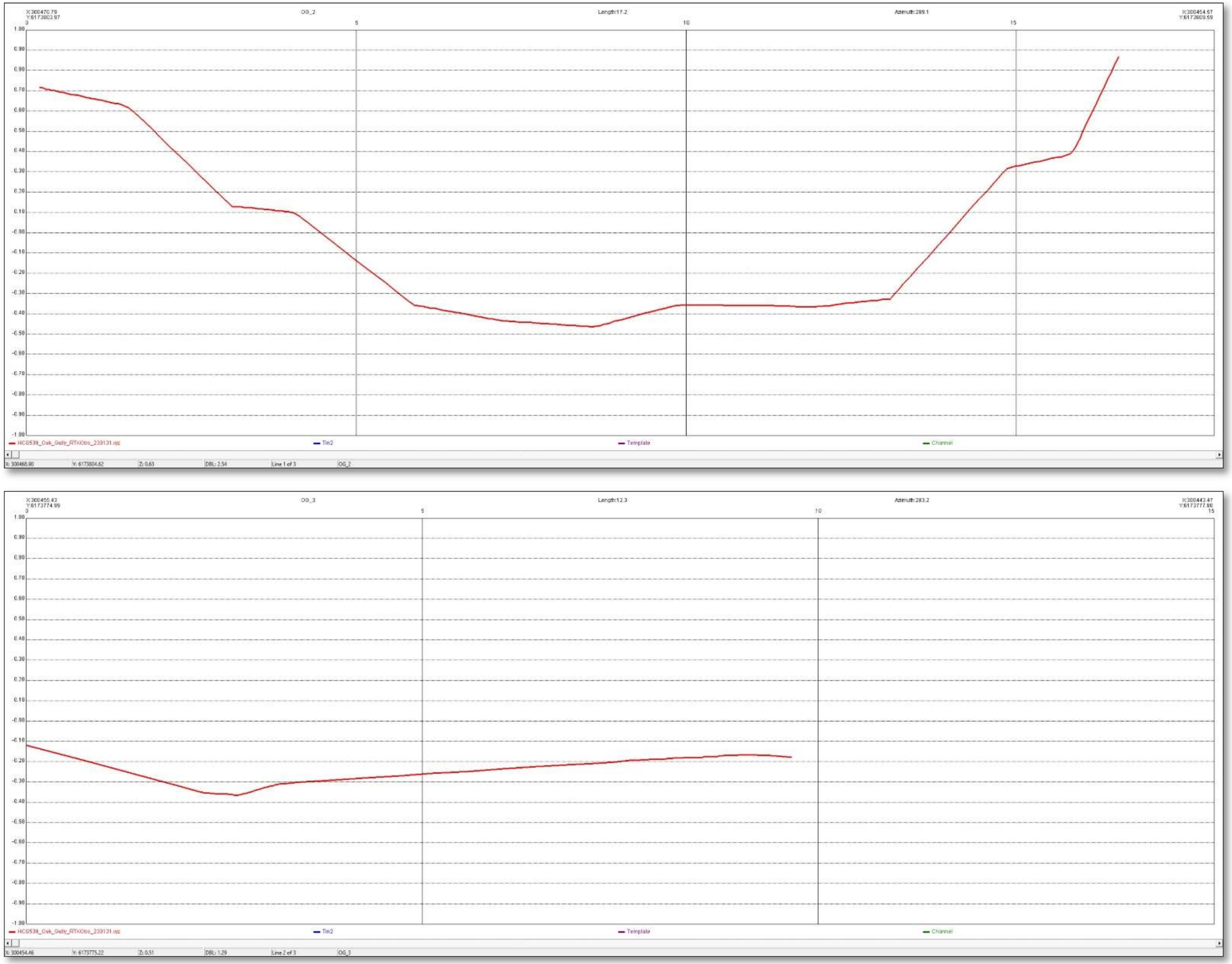


Figure 288: Oaky Gully – profiles (red = 2008, blue = 2022/23) 2 and 3.

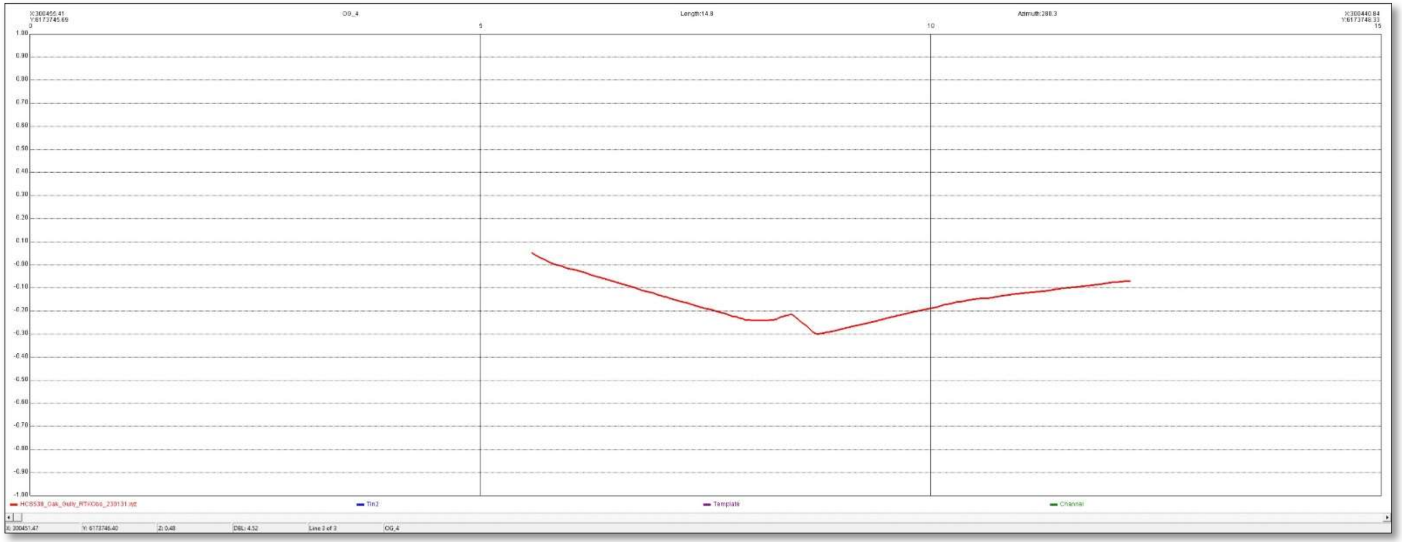


Figure 289: Oaky Gully - profile (red = 2008, blue = 2022/23) 4.