Measuring Accumulation of Sediment in Lake Argyle

G. W. Mauger
B. J. Hawkins

Surface Water Branch
Water Resources Directorate

REPORT NO. WS133

November 1994

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of Western Australia

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MEASURING ACCUMULATION OF SEDIMENT IN LAKE ARGYLE

G.W. Mauger & B. J. Hawkins, Water Authority of Western Australia, Report No. WS133, November 1994

PART 1: OVERVIEW

INTRODUCTION

The rate of accumulation of sediment in Lake Argyle has been of concern, firstly to know if it threatens the ability of the reservoir to provide the water as it was designed to. It is estimated that there may be a 30% loss of yield after 100 years if the originally estimated rate of sedimentation of 24 million cubic metres per year continued. It is thus desirable to reduce the rate of sedimentation if possible, but time is available to monitor the effectiveness of catchment management strategies to reduce erosion of the catchment. Measuring the rate of sediment accumulation in the lake is one tool for monitoring erosion reduction strategies, and is the second reason for maintaining an ongoing programme to monitor the volume of sediment in the lake.

The channel of the Ord River where Lake Argyle now lies was originally about 15 metres deep and about 500 metres wide. This old channel still runs for about 60 km under the lake, slightly meandering and with a 'U'-shaped cross-section. When the river floods, most of the water and the sediment it carries, enters the lake in the channel. On meeting the lake, the speed of the water is reduced, which causes the coarser sediments to settle, necessarily within the old channel until it becomes full of sediment. The channel has not filled yet, but when it does, an alluvial fan could be expected to form around where the Ord River enters the lake. Until the channel fills, survey over the area of the old channel will cover all coarse sediment which has been deposited in the lake.

Fine sediments which can remain suspended in slow water, spread with the water throughout the lake and gradually settle to form a reasonably uniformly thick ooze over the whole lake bed. These soft sediments were about 200 mm thick when surveyed in 1988, and were estimated to account for about a third of the weight of sediment deposited in the lake to that time. Fine sediments can also be discharged downstream of the lake in water going over the spillway or through the outlet pipes.

MEASUREMENT TECHNIQUES APPLIED TO DATE

1.**'Rating Curve' Method.** Samples were taken from the flowing river and the total sediment flow at that time and place were estimated. Repeating this procedure for many different flow rates enabled generation of a graph of sediment flow rate versus water flow rate. Total sediment flow over a period of time was then estimated by converting the continuous record of water flow into a record of sediment flow using the graph, and then summing over time. Disadvantages were that sediment flow was not always the same at a given water flow rate, the method did not measure bed-load (i.e. rocks rolling along the bottom), and the highest floods could not be sampled for sediment which meant the graph had to be extrapolated to estimate them. It also applied at only one or two points on the river. However, the method gave estimates before the dam was built when other methods were not possible.

2.**Surveyed Cross-sections.** A number of sections across the lake area and river channel were surveyed in great detail in 1970 before the dam was built. Resurvey of these lines in 1986, and also 1991 for some sections more upstream, has demonstrated the accumulation and erosion of sediment. Sediment cross-section areas could be measured accurately on these lines. The section locations are shown in Figure 1. The sections are known by their numbers. Cross-sections at Section 7 plotted from the surveys are shown in Figure 2, which also shows an approximate long section from the dam wall to Section 9. Volume estimates of coarse sediment have been made by interpolating the cross-section areas between the section lines, typically distances of 10 to 20 km. The estimated total volume was 210 million m^3. Assuming accumulation over 15 years, the average rate of accumulation was estimated as 14 million m^3/year, or 18 million tonnes/yr at a density of 1.27 t/m^3.

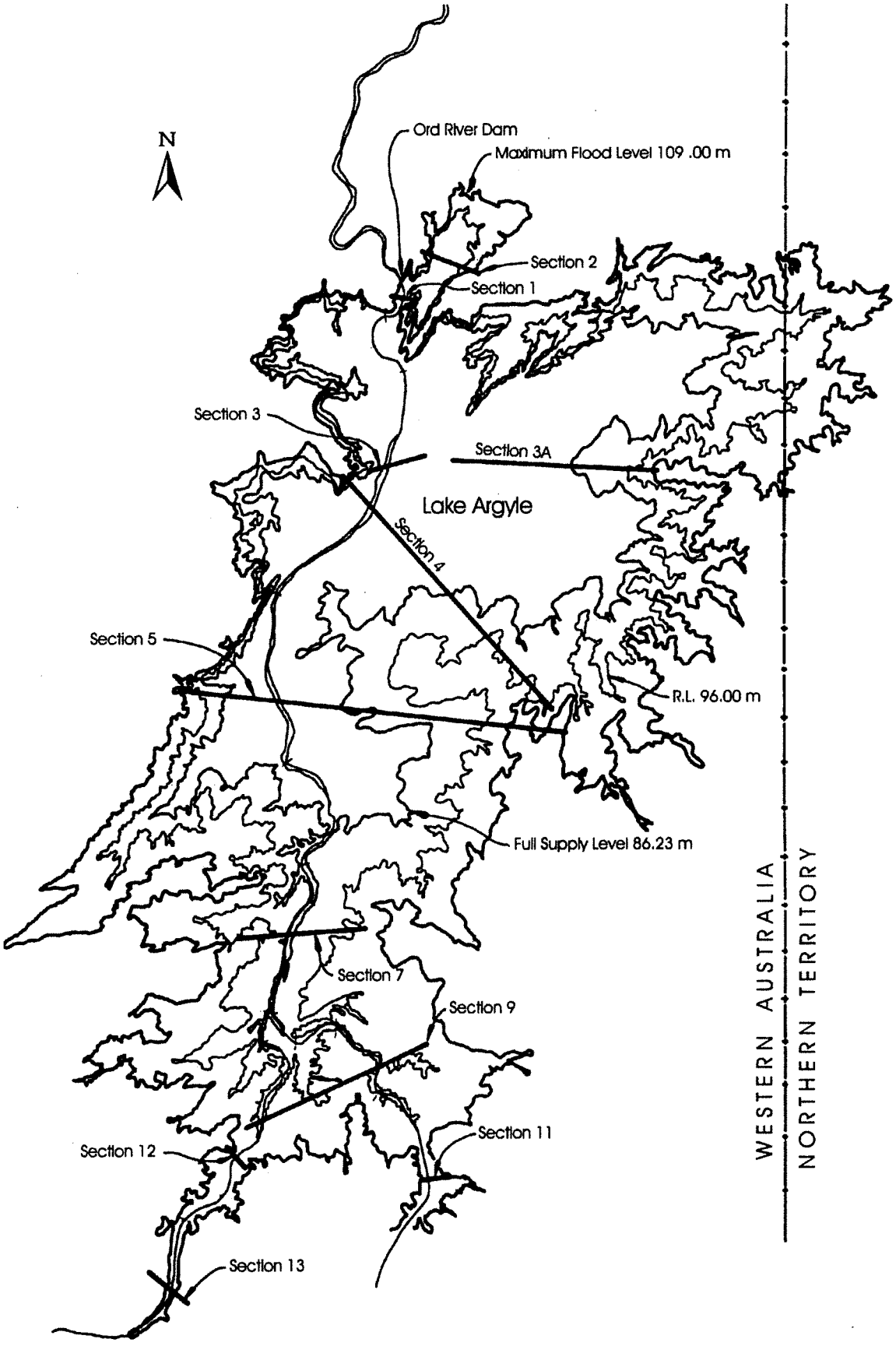
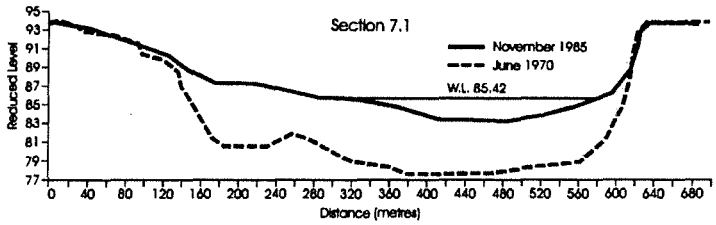
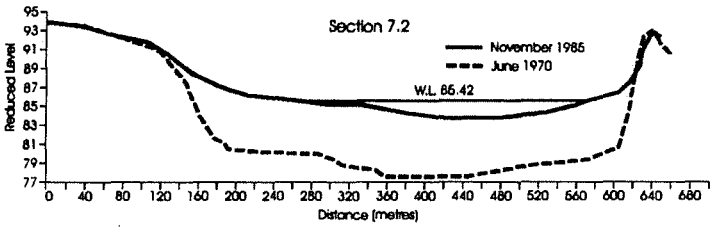


Figure 1: Location of Silt Traverse Sections in Lake Argyle





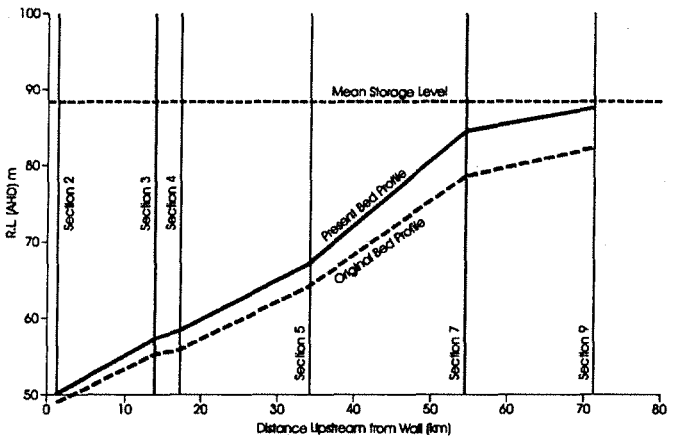


Figure 2: Plots of Sections from Surveyed Cross-sections

Section 7.1 and 7.2 are 50m upstream and downstream respectively of Section 7.

Mean Storage Level refers to water level in Lake Argyle.
W.L. means Water Level (at time of survey).
R.L. means Reduced Level. Reduced Levels are metres above AHD.
Vertical scales are exaggerated.

Figures 1 and 2 have been taken from 'Deposition of Sediment in Lake Argyle', Report WP47 by R.J. Wark, December 1987.

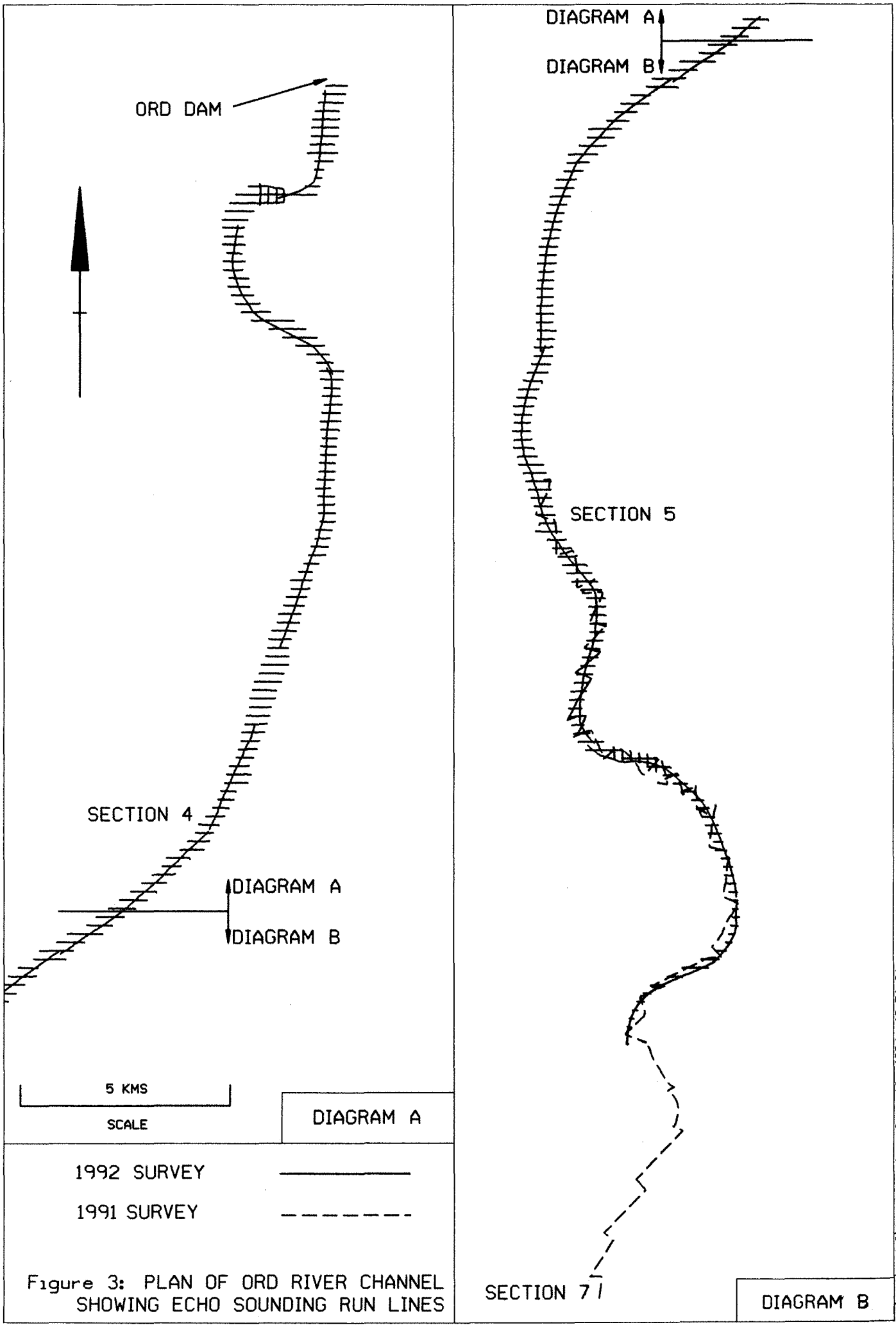


Figure 3: PLAN OF ORD RIVER CHANNEL SHOWING ECHO SOUNDING RUN LINES

The volume estimates were not expected to be highly accurate, but did give some basis for estimating sedimentation rates occurring since the dam was built.

3. **Core Sampling.** Thickness of soft sediments covering the lake bed have been estimated by driving a coring tube into the sediment and measuring the depth of material recovered. One survey consisting of 37 samples spaced over the lake, was made in 1988. The samples indicated a mean depth of sediment of 200mm after 16 years. This is the basis for estimating that the rate of accumulation of soft sediments is 10 million m^3/yr, or 5.7 million tonnes/year.at a density of 0.57 t/m^3.

4. **Coring of Coarse Sediments.** As part of the study by Dr R. Wasson to identify the sources of the sediments, a number of cores of channel sediments have been taken and analysed for particle size distribution (PSD). Through comparison with the PSD of source materials, this data may help estimate total sediment load from an understanding of the proportion of the total sediment which remains trapped in the channel.

5. **Echo sounding.** Detailed survey of the surface of coarse sediment in the old river channel using echo sounding from a boat became feasible when depths were able to be automatically recorded digitally, and linked to their geographic position using the satellite-based Global Positioning System (GPS), again automatically and digitally. The technique was seen to have potential to calculate volumes of sediment through digital terrain modelling (DTM). The echo sounded data would form one model, contours digitised from the plans of the original channel would form another model, and the difference would be the volume of sediment deposited. Likewise, a resurvey after some time, would form a new model, and difference from the model from the previous survey would show where sediment had been added or moved.

A trial of the echo sounding technique was run along the channel in October 1991 between Sections 5 and 7. The original channel contours were digitised over this reach to make the volume calculation. The trial gave promising results and confirmed the volume estimate made using only the cross-section areas.

6. **Baseline Survey of Channel.** In September 1992, a more comprehensive echo sounding survey of the channel was made. The echo sounding traces were collected along parallel lines spaced 200 m apart and aligned either E-W or N-S according to which direction was nearest to perpendicular to the river channel. The lines were positioned on even multiples of AMG coordinates so that they could be readily re-traced in the future. In addition, a long trace approximately along the channel centre-line was made. The survey covered from the dam wall to the maximum distance upstream which could be reached by the boat, about 53 km. The layout of run-lines is shown in Figure 3. Depth data from the echo sounder and position data from a GPS were assembled digitally by a computer on the boat. Subsequent processing in the office with the program HYDRO made the data suitable for loading into a graphic display system. The system was Microstation, and the ancillary program SITEWORKS was used to convert the data into a DTM.

The survey was somewhat limited by the unusually low level of the lake at the time. A subsequent survey could expect much higher water levels which would allow it to extend further upstream, particularly if it was taken after a significant flood event. A subsequent survey would be expected to retrace the lines of this survey to enable the most accurate estimate of changes. A comparison of the new survey DTM to the DTM of the baseline survey would give a precise measure of the quantity of silt which moved downwards into the reservoir from levels above the water level in the baseline survey, to areas below that level, as shown in Figure 4.

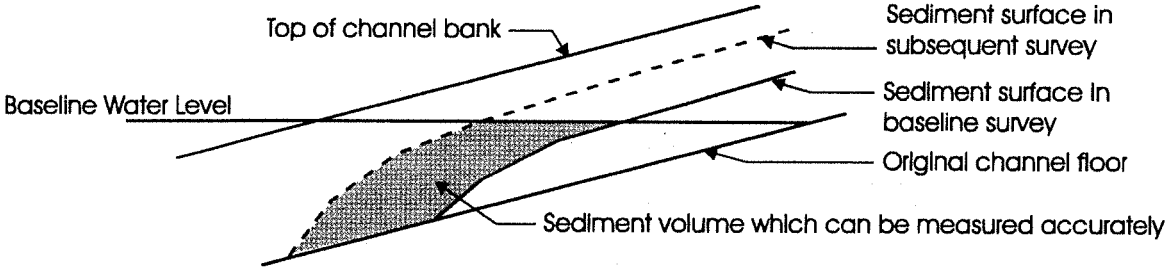


Figure 4: Long section to illustrate a volume calculation possible after two surveys

This would be a good measure of the rate of sediment entering the reservoir. Rates of movement from upstream to downstream of sections completely underwater in the baseline survey, could also be made accurately. Surveys after the next survey will enable these calculations to be made for levels and sections much further up the channel.

Comparison of cross-sections from the 1991 and 1992 surveys showed no significant difference where they overlapped. Consequently the 1991 survey was used where it had coverage and the 1992 survey did not. Where the 1991 survey did not cover the full width of the channel, the DTM was extended to meet the contours by including an appropriate contour from the digitised channel data when generating the DTM.

Generation of grid-meshed surfaces of the DTM allow graphic views to be created which give an appreciation of the form of the sediment deposits. A sample view is shown in Figure 5. Views of this kind revealed that the first DTM to be generated was a poor model of the channel shape between the parallel run-lines where the channel alignment was skewed to the run-lines. The problem was overcome by resequencing the points from the run-lines into strings parallel to the channel, and using the revised sequence to generate the DTM. A special program was written to perform the resequencing of points. The final grid-meshed surfaces were used to prepare a 'fly-through' slide show of the DTM surfaces in perspective, titled 'The Ord Channel Under Lake Argyle'.

The remainder of the channel from the Ord Dam to Section 5 was digitised from the original contour plans. The digitised contours and echo sounding data from 1991 were also loaded into Microstation and DTMs generated from them. Cross-sections were generated by SITEWORKS from the resulting DTM's of the original channel and the echo-sounded channel. The cross-sections, at 200 m intervals, were used to estimate the volume of sediment accumulated in the channel. Plots of the cross-sections allow a visual assessment of the DTM's and provide confirmation of the calculations. Sample cross-sections are shown in Figure 6. The volume estimates are shown graphically in Figure 7. Random errors in matching positions cause a degree of fluctuation from section to section, but the major features (the extent and total volumes of deposits) are clear and consistent.

In the volume estimates from the surveyed cross-sections, the total volume from the dam to Section 7 was 141 million m^3. The baseline survey has estimated 64 million m^3 less. The corresponding estimate of average sediment inflow rate should thus be revised to 19.7 million m^3/yr, or 20.1 million tonnes/yr.

Further confirmation of the DTM's was obtained by generating cross-sections to coincide with Sections 4, 5 and 7, and comparing them with the earlier surveys of those Sections. These plots (Figure 8) indicate that there has been no significant change at Sections 4 and 7 since the 1986 survey of the Sections. The difference between the original contours and the 1970 survey at Section 4 suggests that a shingle bank may have been eroded in that area after 1961 when the photography for the contours was taken. The variations in bank shapes at Section 5 suggest that the various surveys were on slightly different alignments. Consequently it is difficult to draw conclusions about changes in sediment depth at that Section.

7. **Fine Sediment Sampling in Discharge from Reservoir.** Through the two 'Irrigation Years' (August - July) commencing 1991 and 1992, a sampling program was undertaken by the Water Authority to monitor sediment discharge in water released or overflowing from Lake Argyle. The totals are reported in the following table:

Irrigation year	Sediment Load (tonnes)		
	At outlet valves	At spillway	Total
1991-1992	1,676	nil	1,676
1992-1993	19,661	3,697	23,358

Although these totals are very small compared to the estimated average sediment inflow to the lake, the total sediment inflow in these years is also likely to be small because of the relatively low river flows.

3 models are shown, identified by colour:
- Original channel from contours
- Channel in 1991 from echo-sounding
- Channel in 1992 from echo-sounding

View is to north, towards Ord Dam
Channel is approximately 500m wide
Vertical scale is 10 x horizontal scale

Figure 5: Perspective View of Digital Terrain Models 37.9 km from dam (Section 5)

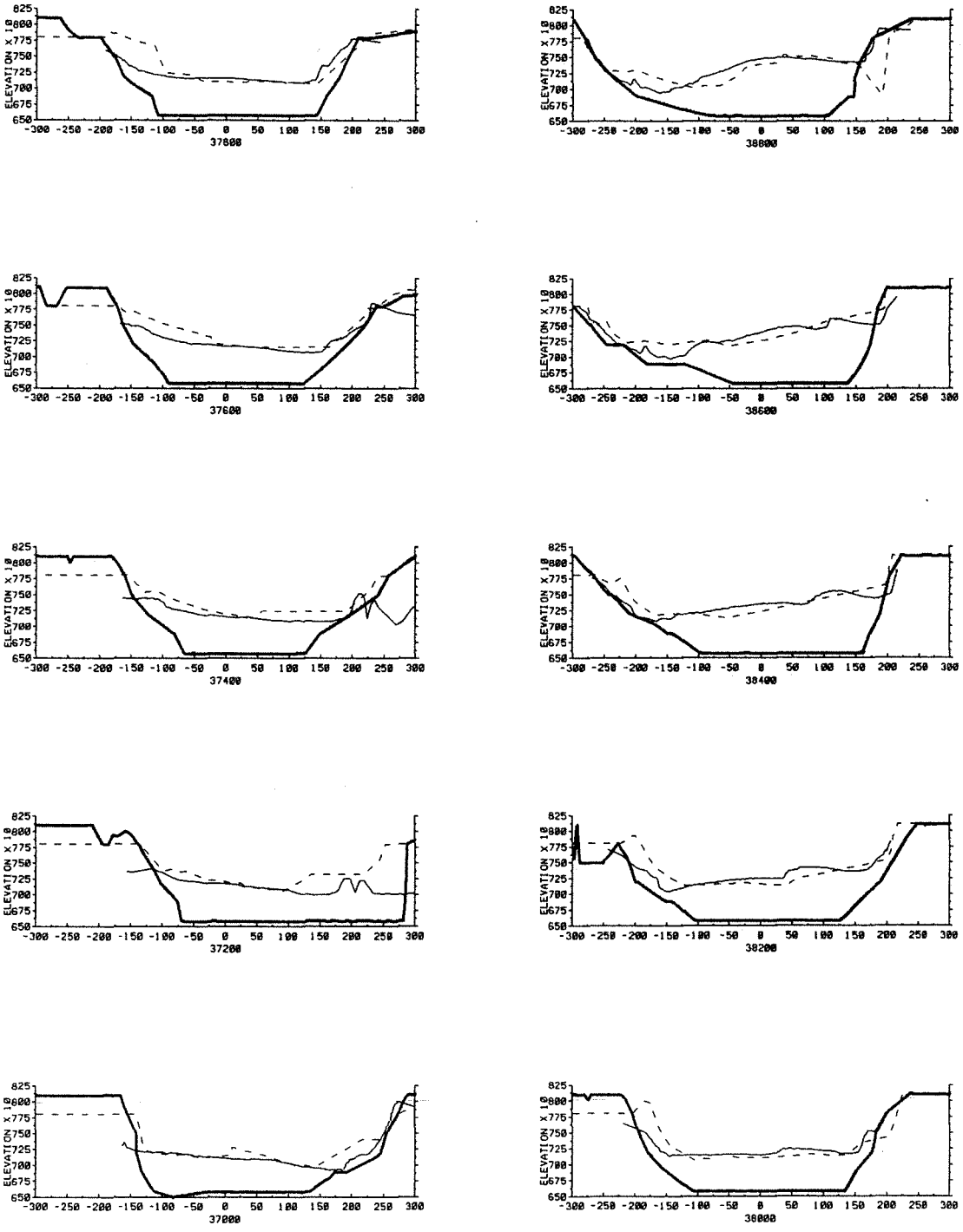
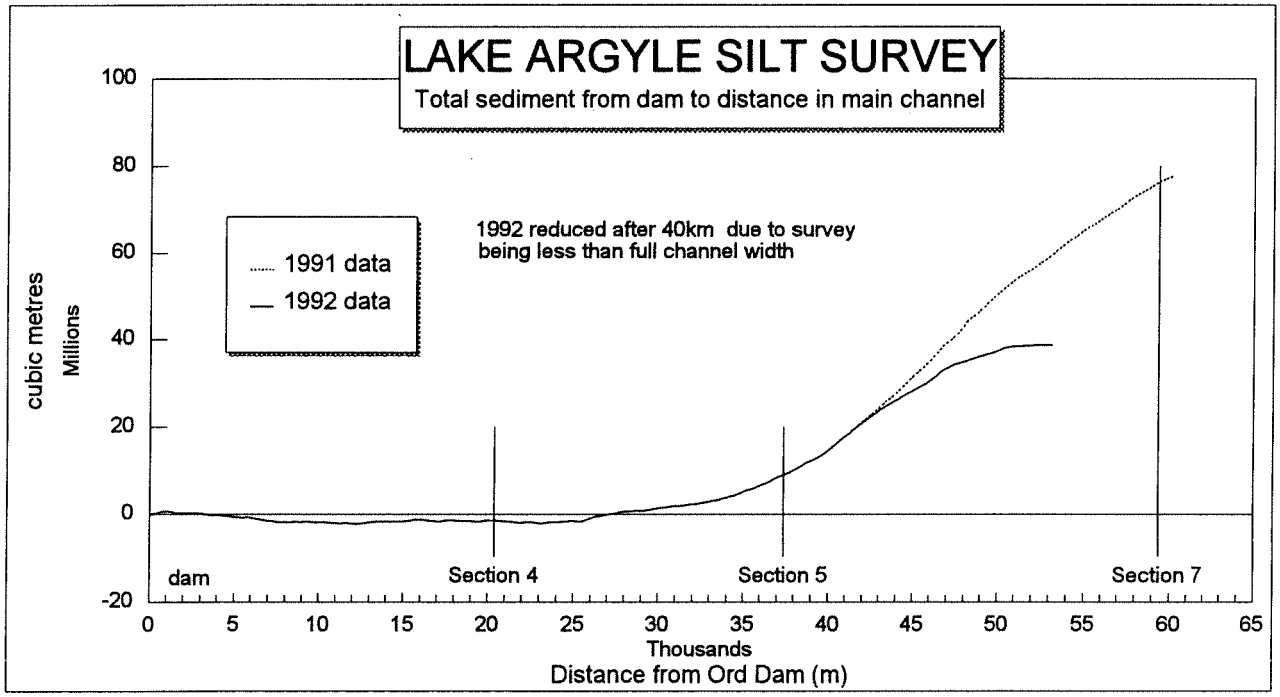


Figure 6: Sample Cross-sections Generated from DTM's



	Section 4		Section 5		Section 7
Distance from dam (m)	20,400		37,400		59,400
Volume from dam to Section (cu.m)	-1361758		9,115,723		76,559,417
Volume between Sections (cu.m)		10,477,480		67,443,694	

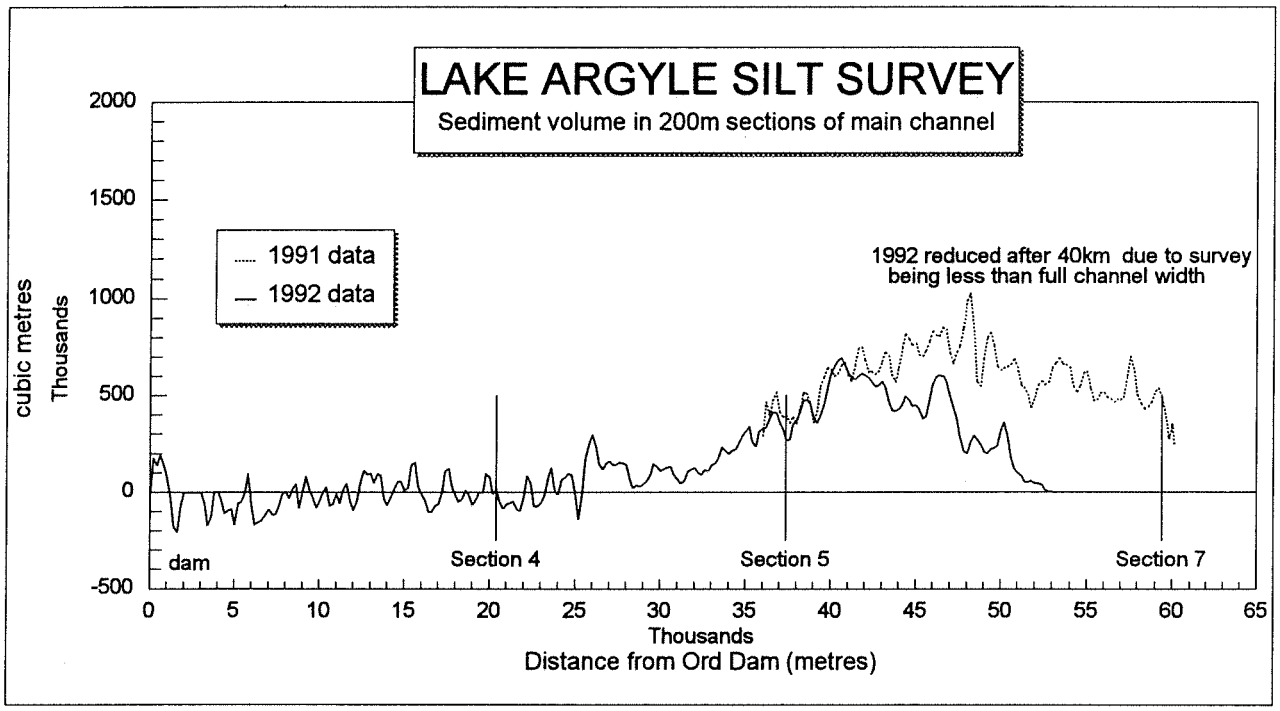
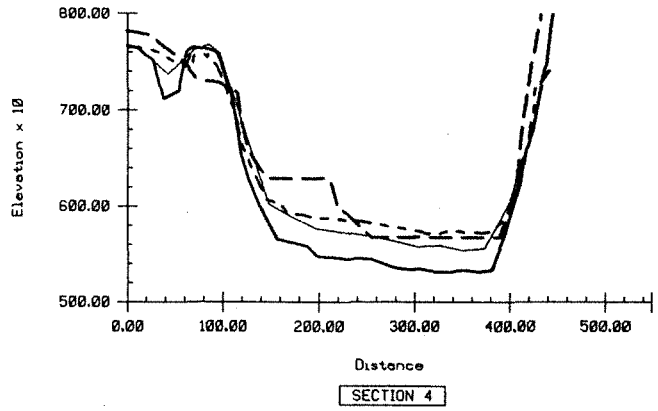
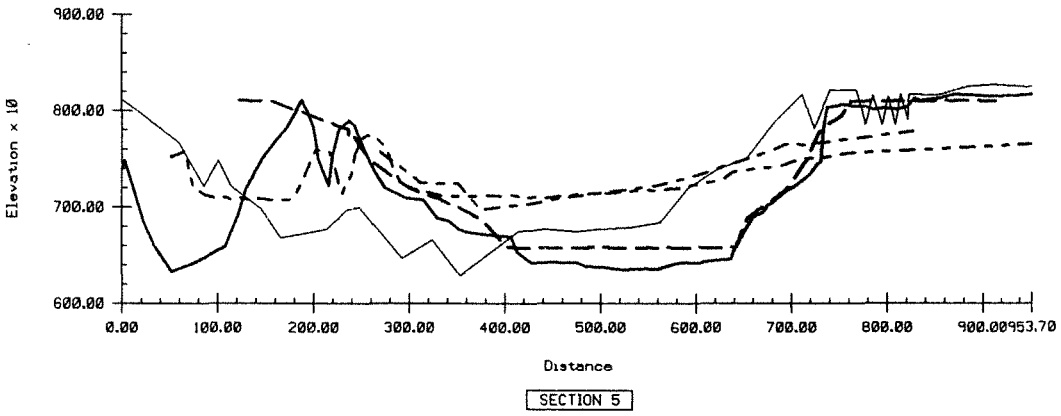
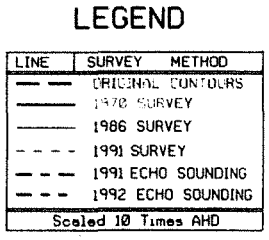


Figure 7: Sediment Volumes in Main Channel







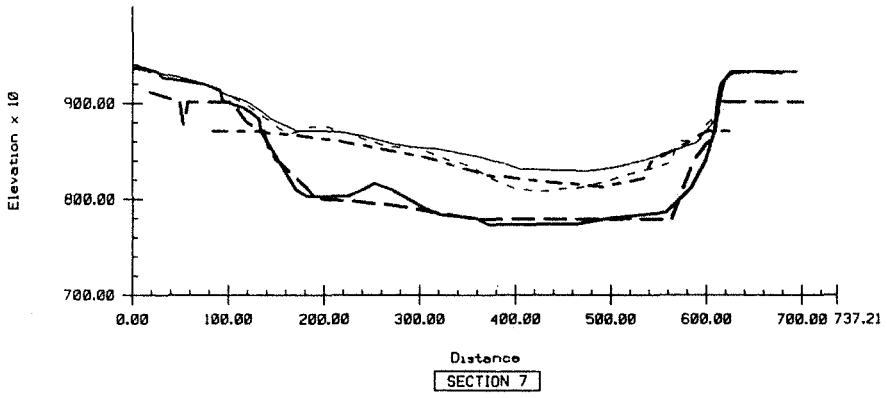


Figure 8: ECHO SOUNDING CROSS SECTIONS AND HISTORICAL SURVEYS AT SECTIONS 4, 5 & 7

ELEVATION AHD VERTICAL SCALE EXAGGERATED

FUTURE MEASUREMENTS

The Water Authority has made a commitment to resurvey the Ord River channel by echo sounding within Lake Argyle at 5 yearly intervals or after a flood event which obviously moves large volumes of sediment. It may be possible to extend the period between surveys when an understanding of the sediment's movement patterns has been acquired. The Water Authority will also continue to monitor the fine sediment load being discharged downstream through the offtake pipes and over the spillway, by sampling from these flows.

CONCLUSION

A variety of methods have been employed over the years to estimate the rate of erosion from the Ord River catchment and the consequent accumulation of sediment in Lake Argyle. The latest action has been to conduct a detailed hydrographic survey using echo-sounding over the old channel of the river under the lake. The survey has been recorded digitally and processed into the form of a digital terrain model. The contour plans of the channel before the Ord Dam was constructed were also digitised and used to generate a digital terrain model. Calculation of the volume between the two models estimates the total volume and distribution of coarse sediments in the channel from the dam to about 60km up the channel. The total volume is 64 million m^3 less than estimated before the echo-sounding, which means that the estimated mean sediment inflow should be revised to 20 million tonnes/year. Generation of graphic views of the models also gives a useful appreciation of the distribution of sediment. The detailed echo-sounding survey should form an accurate base to allow a future survey to study movement of sediment in the channel after significant flood events. Fine sediments discharged in released water are negligible compared to mean sediment inflow to the lake, but monitoring is continuing.

PART 2: DETAILS OF PROCESS AND RESULTS

COMPUTER DATA FILES

An objective of the base-line survey was to provide data that would allow a future survey to detect changes since 1992. Access to the computer data files generated as reported here, will be essential to achieve this. Files which are needed are named in the following sections, and can be found in the set of floppy disks on which they are archived in compressed form. The files are DOS compatible. Executing a compressed file will generate a group of some of the files named in this report, ready for use.

1992 ECHO-SOUNDING DATA

The raw data was collected by a hydrographic survey conducted by Don Shepherd of Sea & Land Surveying. A 7.2 m aluminium boat was fitted with a differential GPS facility and an echo-sounder which produced digital output. AMG coordinates from the GPS and depth values from the echo-sounder were merged in real time using Datacom's HYDRO software in a 386SX computer carried on the boat. Depths were recorded at about 5m intervals along run-lines as shown in Appendix A. The run-lines were planned to be positioned at 200m spacing on an even 200m multiple of AMG coordinates, either N-S or E-W, to be approximately perpendicular to the river channel. Actual positions are within 20m of this. The letter copied in Appendix E explains the deviations from the planned positions. Each run-line was long enough to cross the channel entirely, except where the tops of the channel banks were not deeply enough submerged for the boat to pass over. An additional run-line was recorded approximately along the centre line of the channel. Each data point was also labelled with a code identifying the run-line. In the data files handed over to the Water Authority, each point was listed as in Figure 9. The complete file of data comprised the concatenation of many points.

```
12069
472137.590
8215593.370
72.247
"ARN039                                    "
"1410                "
12068
472125.651
8215593.171
70.115
"ARN039                                    "
"1408                "
```

Figure 9: Example of data handed to Water Authority (2 points)

Before the data was handed to the Water Authority, it was reviewed in Mr Shepherd's office where clearly erroneous data was removed and plans of the run-lines were produced.

The data files which were accepted by the Water Authority still required editing before being suitable to enter a GIS. The author wrote some computer programs to assist this process. Some programs and parts of programs are specific for this project, while other parts are written within the framework of a larger system of programs and data structures called POLYANA (for 'Polygon Analysis'), also written by the author. The listings of the FORTRAN 77 code for the specialist programs written for this project are given in Appendix D. Copies of the programs which supplement Microstation (ASC2DGN, DGN2ASC, LIN_SCLE and SITEWORKS) are not provided, but all other programs needed are in the compressed file POLYANA.EXE on floppy disk.

Initially, the data was reformatted using program DS2XYZ (see Appendix D) so that each run-line was grouped, and coordinates and levels for each point were on one line, as shown in Figure 10. Note that a run-line is started with a record giving its label, a nominal scale for plotting the data, and the code '3D', indicating to Microstation that the data should be stored in a 3D design file. The end of the run-line is indicated by -1

in the position of the easting. Files with the format of Figure 10 are referred to as 'ASCII-formatted' files in this report.

```
ARN039                    20000.    3D
      472138.    8215594.              72.2470
      472126.    8215593.              70.1150
      472114.    8215594.              65.1420
      472102.    8215594.              66.2590
      472090.    8215594.              69.2020
      472078.    8215595.              69.6080
      472066.    8215595.              69.3040
      472054.    8215595.              65.2430
      472042.    8215594.              65.0410
      472030.    8215594.              64.6350
        -1.
```

Figure 10: Example showing data for run-line ARN039 reformatted

Only points labelled with a valid run-line code were accepted. There were then two types of error needing correction:

1. Some run-line labels were not changed until after several points were recorded on the next run-line. The FORTRAN program LINBRK (see Appendix D) was written to change the label to the label of the next run-line when the distance between adjacent points was greater than 100 metres.

2. Some sequences of points were displaced from their correct sequence in a run-line e.g. if the correct sequence was a,b,c,d,e,f,g,h, the sequence a,b,f,g,c,d,e,h would be incorrect, although the coordinates of each data point were true. When plotted with lines joining adjacent points, the appearance of the error would be as in Figure 11. Incorrect sequences were relocated in the data file by manual editing (cut & paste).

Correct sequence Incorrect sequence

Figure 11: Effect of displacing point sequences in data files

The data was then read into a new Microstation 3D design file, named OCES.DGN, using the Polygon Utility program ASC2DGN. The program SITEWORKS was then used to generate a digital terrain model (DTM) from the data. SITEWORKS stores each DTM it generates in a separate file with the name extension '.DTM'. These files can only be used by SITEWORKS running within Microstation. In generating the DTM, the run-line along the channel centre line was omitted due to difficulties in properly incorporating the data in the DTM. If used, it would have practically no influence on the sediment volume estimates.

Review of this DTM showed that the rules used by SITEWORKS to form a surface gave a poor result when run-lines were skewed to the channel alignment. Top of bank on one run-line would join directly to base of bank on the next run-line because that was the closest point. The solution was to reorganise the data points to create strings roughly parallel to the channel. Points were taken from successive run-lines to do this as shown in Figure 12. The reorganisation was performed by program XLORD (Appendix D).

Data processing commenced from the ASCII-formatted files because the labels on the run-lines were not preserved in the Microstation design file, and they were needed in the process. Preparatory steps necessary before running XLORD were:

a) conversion of the ASCII-formatted files, using program LIST3, into a random access format used by

the POLYANA system, for input to XLORD.

b) minor manual editing of run-lines where they crossed each other, to separate them. This was done by viewing the POLYANA files with program THREPAN to identify the records to be split and the point number where the split was to be made. The changes are then performed with program FIX3.

c) renaming the run-lines so that when the names were in their collating sequence, the run-lines were properly ordered from north to south. This was done mostly automatically with program ORDLAB (Appendix D), with one of the key changes being to reverse the numbering sequence. Minor changes to run-line names were done with program FIX3.

After running XLORD, the output files produced were converted to ASCII format using program POINT3, and the ASCII-formatted files were read into OCES.DGN using program ASC2DGN. Once in OCES.DGN, some minor editing of the new strings was done to break strings which crossed from one side of the channel to the other, and to resolve strings at one bend in the channel where cross-over of strings had occurred because adjacent run-lines almost formed a T shape. The revised strings were presented to SITEWORKS as 'breaklines' for generation of the DTM, which meant that all the lines defined by the strings had to be part of the surface of the DTM. Because the revised strings were reminiscent of a spider's web, the DTM generated was called WEB.DTM.

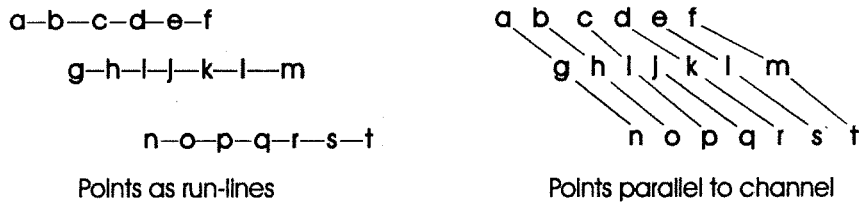


Figure 12: Reorganisation of point sequences

DIGITISED CONTOURS OF ORIGINAL ORD RIVER CHANNEL

Contour plans of the land covered by Lake Argyle were prepared for the PWD in 1965 before the Ord Dam was constructed. Cartography was by the Mapping Branch, Surveyor General's Division, Dept of Lands and Surveys, from photography in 1955 and 1961. Original drawing sheets are held by the Water Authority in Plan Book No. PWDWA 43333. The plans are drafted totally in Imperial Units: scale is 20 chains to 1 inch, grid reference crosses are in yards, and contours are in 10 ft intervals above Wyndham Low Water Mark Ordinary Spring Tide (LWOST). LWOST is 4.29 m below the Australian Height Datum (AHD). Contours were manually digitised from these plans, generally from enlarged prints for easier tracing of close contours. Only contours defining the shape of the original river channel were digitised. Digitising extends from Section 7 to the dam wall.

Contours were digitised into a Microstation design file. The Imperial units were transformed by computer into AMG coordinates and AHD levels. SITEWORKS was used to generate a DTM from the contours. Due to the quantity of data, the DTM was made in sections. Minor modifications were also made to the contours in the process of computing volumes, as described below.

1991 ECHO-SOUNDING DATA

An echo-sounding survey over the Ord River channel was conducted between Section 5 and Section 7 in 1991. Sensing and data collection systems were different from the 1992 survey, but the data was ultimately available in a Microstation design file. The 1991 echo sounding run-lines 'zig-zagged' along the channel from Section 5 to Section 7, as shown in Appendix A. Approaching Section 7, the coverage of the channel width was reduced due to low water level. To provide an interpolation between the survey area and the banks of the original channel, a suitable contour from the digitised channel contours was added to the this set of data. The

DTM generated by SITEWORKS from the zig-zag data and the extra contour on each side is saved in file ZZ.DTM.

MICROSTATION DESIGN FILE 'OCES.DGN'

OCES.DGN is the primary design file for the Ord Channel data. Digitised contours, echo-sounding run-lines, and the resequenced echo-sounding data are stored there. It also contains a line digitised roughly along the centre of the channel to guide cross-section generation, and camera position for perspective views. In addition, cross-sections previously surveyed along the numbered Sections have been digitised and stored in OCES.DGN for comparison with generated cross-sections. Figure 13 shows how the various types of data have been assigned to the different 'levels' in this file.

PROCESSING OF DTMs

1. Cross-Sections

A series of cross-sections were generated at 200 m spacing, perpendicular to a line digitised approximately along the centre of the channel. The cross-sections showed each surface that was defined at that position. The full set of these are plotted in Appendix B. In addition, cross-sections were constructed at the standard sites of Sections 4, 5 and 7. The surveyed sections for these sites from 1971 and 1986 were digitised and plotted on the DTM cross-sections for comparison. A key to the sections shown is included in the Appendix.

2. Perspective Views

Grid-mesh models of the DTMs were constructed with a 25m mesh size in a design file using SITEWORKS. Microstation's program FLYTRHU was then used to prepare a sequence of views of the original channel and present surfaces defined by the echo-sounding surveys. The digitised channel centreline was set on a grade from 97m AHD at Section 7 to 73m AHD at the dam, i.e generally about 20-30m above the river bed. This line then guided the 'camera' recording the views. The key parameters for the camera were: camera angle 65°, front clipping plane at 500m, and rear clipping plane at 4000m from the camera. The camera also had a 'floating target', which meant it was aimed tangential to the guide line at any point. One hundred views were made. The views were recorded in the 'PCX' file format with 256 colours, which allowed them to be imported into WINDOWS PAINTBRUSH. In PAINTBRUSH, the area of interest in each view was 'cut' to the clipboard, from whence it was 'pasted' into a slide show using Microsoft's POWERPOINT. This process minimised the amount of data stored in the slide show. The show is entitled 'The Ord Channel Under Lake Argyle'. The slides are in two files, ORDS.PPT and ORDN.PPT. If the POWERPOINT VIEWER is installed in WINDOWS, the slides can be displayed on the computer screen in the 'fly-through' style. A number of the key views have been printed and are shown in Appendix C. The views are preceded by a key to the segments of channel displayed and the viewing position.

3. Calculation of Sediment Volume

1. The objective was to calculate the volume between the original channel, as defined by the contours, and the present channel as defined by the echo-sounding, progressively along the channel. Initially, the DTM for the original channel was in two parts, NCT.DTM for the channel north of Section 5, and SCT.DTM for the remainder. To compute volumes of 'cut' and 'fill', (cut would mostly arise from mismatch of data, but should be included in total areas to compensate for mismatches which result in fill) the cross-section generation was run with each pair of surfaces separately i.e. WEB.DTM with NCT.DTM, then with SCT.DTM, and then ZZ.DTM with SCT.DTM. While doing these runs, the options to display areas and to generate a report of cut and fill areas, were turned on. The reports were imported into a LOTUS spreadsheet, named ORDSECVL.WK4, and the displayed areas were plotted to provide a visual verification of the computations.

2. The 'display areas' option overlays a red polygon around areas of fill, and a green polygon around areas of cut. Some of these polygons are not correctly formed, due to bugs in the SITEWORKS programming. However, from manual checks, the corresponding areas computed and reported are correct.

3. A visual inspection of the cross-sections suggested there were several stretches of the channel where there was significant mis-alignment of the 1992 echo sounding data and the digitised contours, in places up to 70m. It was considered justifiable to adjust the contours because there seemed to be more possible sources of error in generating these than in the echo sounding data. Consequently a graduated realignment of the contours was done. A set of positions was found where the alignment needed shifting 'x' metres east or west. A series of boxes were then placed in OCES.DGN such that the north and south ends of each box were at adjacent known positions. The contours lying within each box were then skewed using the LIN_SCLE Microstation application, which effectively adjusted all points in linear proportions between the known points. As LIN_SCLE only works on 2D design files, the process required copying of the section of contours to a new file using 'fence file'; converting that file to text using DGN2ASC; importing the text file to a new 2D design file using ASC2DGN (thereby preserving contour levels as 'tags' in the 2D file); running LIN_SCLE to produce a new, transformed, 2D file; export from there to text again using DGN2ASC; and finally import the text file to a new level in OCES.DGN.

4. The process of generating cross-sections and computing volumes was repeated using the modified contours. Possibly because a process was omitted that filters out points lying on straight lines between other points, the contours had to be divided into 3 DTM's. The DTM's were saved in files XNCT.DTM, XCCT.DTM and XSCT.DTM, being north, central and south sections of the transformed contours. The generated cross-sections were not stored in OCES.DGN, but were put in new design files to which OCES.DGN could be attached as a reference file. SECTPLT.DGN contains the set showing all surfaces in each cross-section. SECTCAL.DGN contains the 4 sets, one for each pair of surfaces to compute volumes and to display the areas of cut and fill. The surface combinations were:

   XNCT.DTM with WEB.DTM
   XCCT.DTM with WEB.DTM
   XSCT.DTM with WEB.DTM
   XSCT.DTM with ZZ.DTM

5. The computed areas were loaded into the same LOTUS spreadsheet as before transformation. Only chainage, cut area and fill area were used from the reports. Computed volumes were done by the spreadsheet. Additional columns were created as copies of the cut and fill areas, and designated as 'modified areas'. Any changes used in the final calculation of volumes can be detected by comparing the 'original' and 'modified' columns.

6. Sections showing major areas of 'cut' near chainage 2000 and chainage 19000 were zeroed because the error was due to definition of the banks. No sediment was accumulated at the sections. Net fill was computed manually at 24400, 24600, 24800, 27000, 27200, 27600, 28000, 28600, 29200 and 30400 due to doubt about the areas displayed. However there was negligible difference between generated and manual results for net areas at the sections. Sections from 6800 to 9000 inclusive, at 13800, 15400 and 15600 were well aligned before transformation and poorly aligned afterwards. The cut and fill areas from these sections before transformation was pasted into the 'modified' areas for final volume calculation.

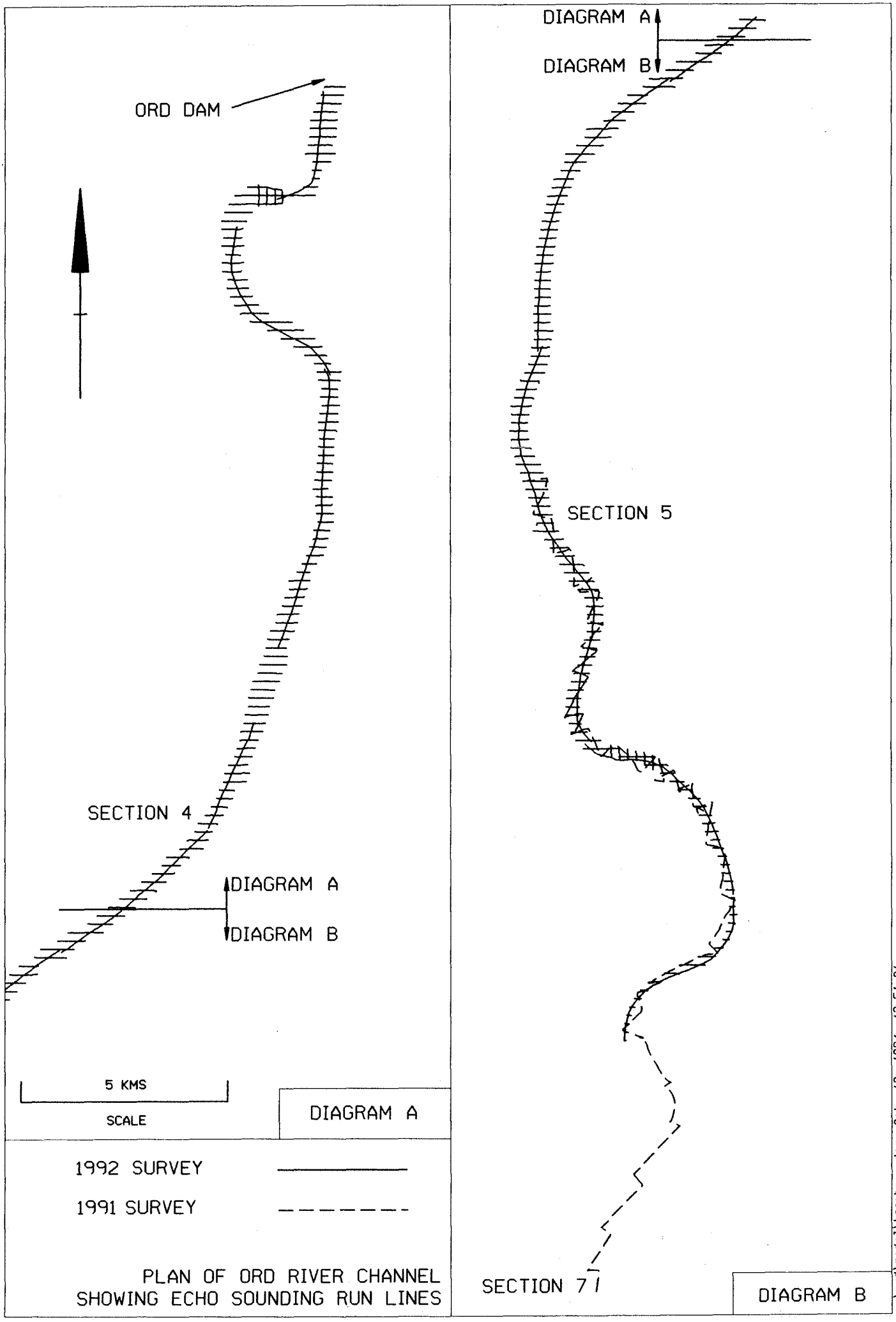
7. Aligning the digitised contours with the echo sounding data made negligible difference to net volumes summed along the channel. If total fill volume was summed, the alignment would have reduced the total for the full channel by about 15%. The difference in the sum of net volume was less than 1%. However, the improved alignment gives visual confirmation that computed areas are reasonable.

Figure 13: Table of Levels and Contents for MicroStation File OCES.DGN

Level	Contents	Level	Contents
1	Upper bank boundaries	33	Contours transformed - part north
2	Boxes for contour transformations	34	Contours transformed - to Dam
3	Raised centreline for flythru camera	35	
4		36	Echo '91 Zig Zag course ES1991.ASC
5	Original channel contours	37	Southern centreline
6		38	
7		39	
8		40	Location of historical cross sections
9	Echo '92 broken runlines	41	
10	Echo '92 web for DTM	42	
11	Echo '92 runlines from ECXYZ.ASC	43	
12		44	
13	Portion of upstream centreline	45	Echo '92 - runlines for input to XLORD
14		46	
15		47	
16		48	
17		49	
18		50	Plots of cross sections at 4, 5 & 7
19		51	Plot window for Lv=50
20		52	Text for plot Lv=50
21	Channel centreline & bed definition lines	53	
22		54	Bank boundaries for US channel
23		55	Echo '91 Zig Zag course with contours
24		56	
25		57	
26	Model boundaries for DTM triangles	58	
27		59	Duplicated upper channel for plot
28		60	Plot boundary, text & ZZ course
29	Model boundaries for DTM triangles	61	
30		62	
31	Contours transformed - southern part	63	
32	Contours transformed - part north		

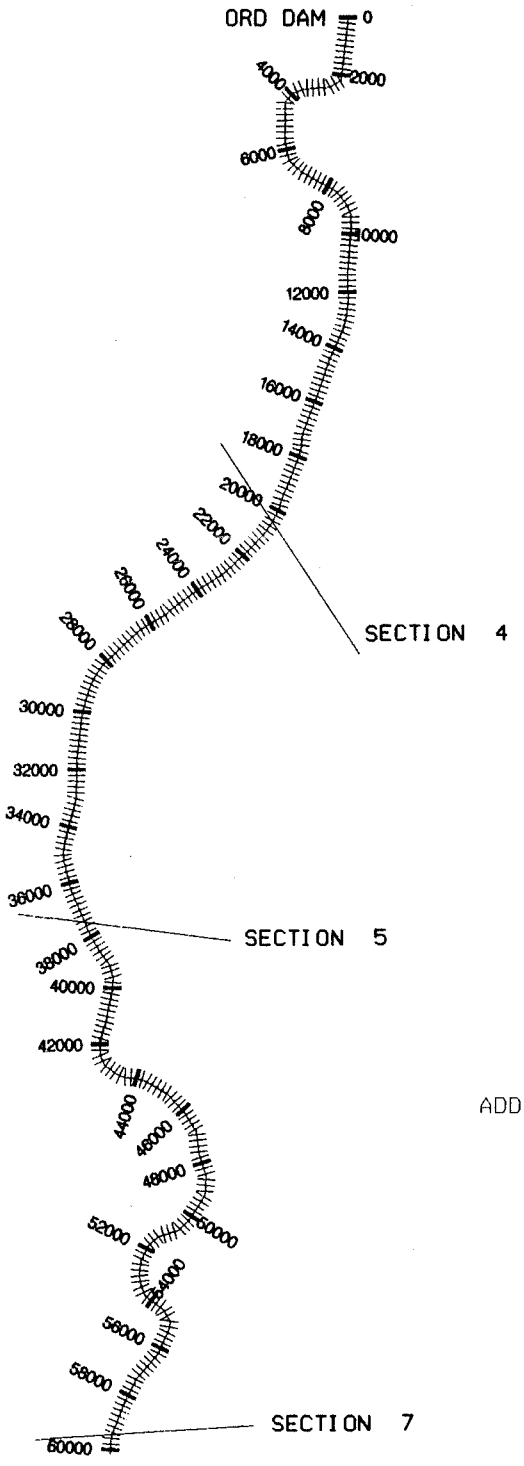
APPENDIX A

RUN-LINE LOCATIONS


ORD DAM
SECTION 4
DIAGRAM A
DIAGRAM B
5 KMS
SCALE
DIAGRAM A
1992 SURVEY
1991 SURVEY
PLAN OF ORD RIVER CHANNEL
SHOWING ECHO SOUNDING RUN LINES
DIAGRAM A
DIAGRAM B
SECTION 5
SECTION 7
DIAGRAM B
e:\ord\model\tranbase.dgn Oct. 13, 1994 13:51:21

APPENDIX B

CHANNEL CROSS-SECTIONS



5 KMS
SCALE

KEY TO CROSS SECTIONS

ORIGINAL CONTOURS

1991 ECHO SOUNDING

1992 ECHO SOUNDING

ADDITIONAL LEGEND ON HISTORICAL CROSS SECTIONS

PLAN SHOWING LOCATION OF FOLLOWING CROSS SECTIONS AND HISTORICAL SECTION ALIGNMENT

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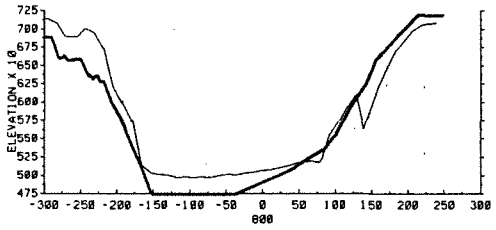
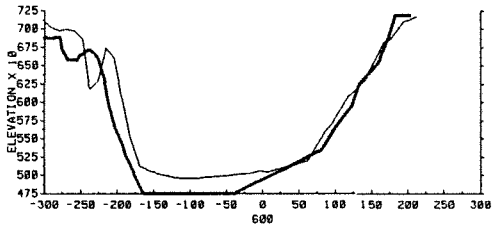
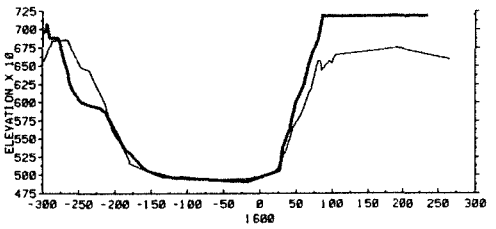
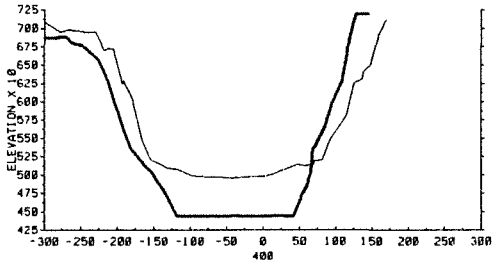
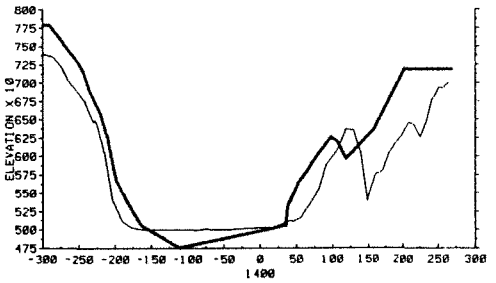
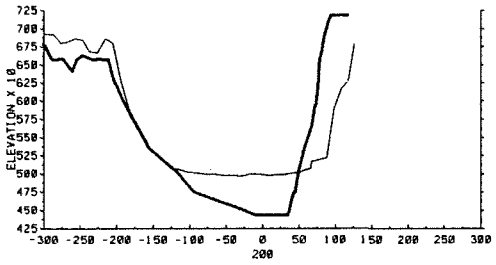


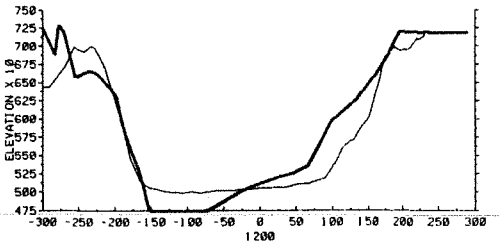


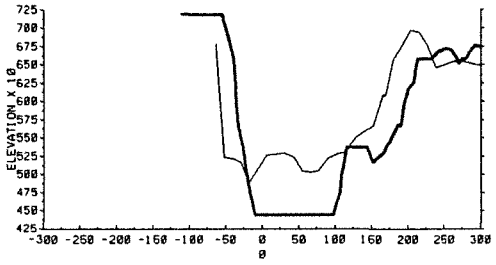


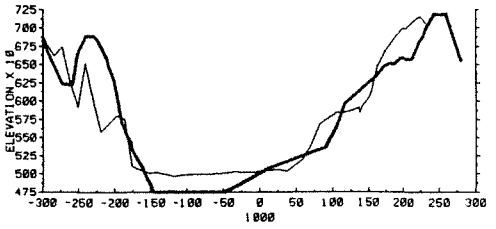












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

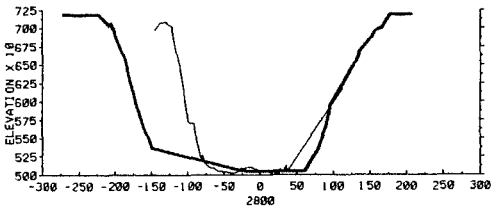
ELEVATION IS AHD EXAGGERATED 10 TIMES

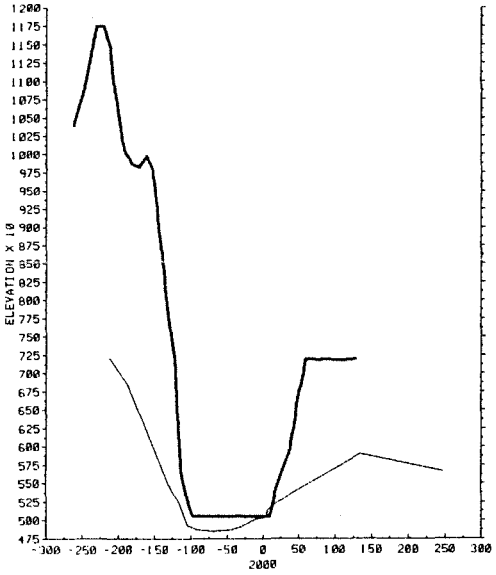
KEY TO CROSS SECTIONS

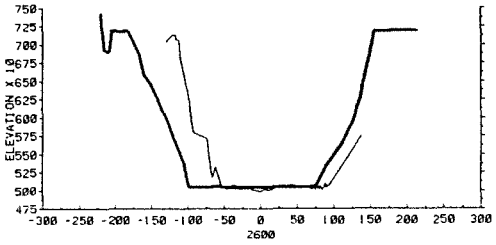
ORIGINAL CONTOURS

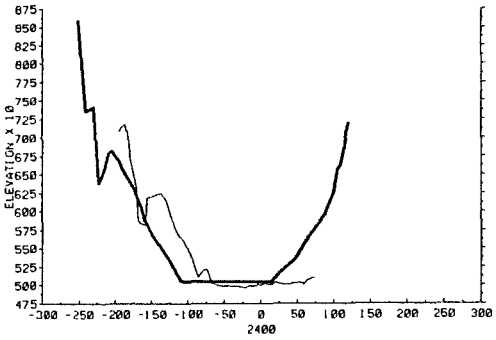
1992 ECHO SOUNDING

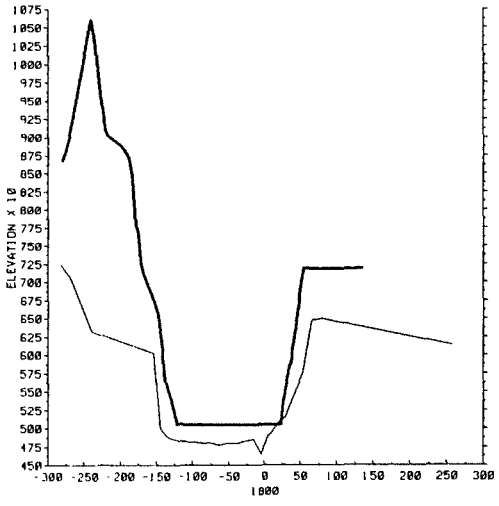
1991 ECHO SOUNDING

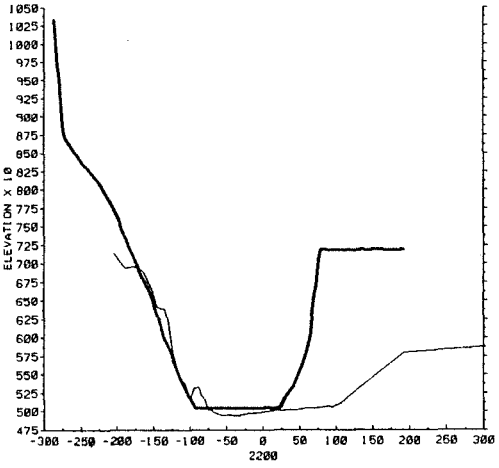












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

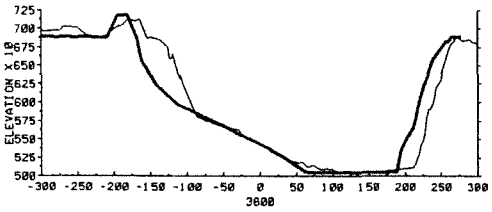
ELEVATION IS AHD EXAGGERATED 10 TIMES

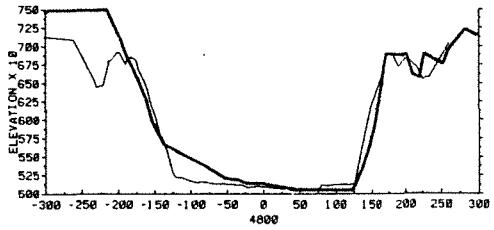
KEY TO CROSS SECTIONS

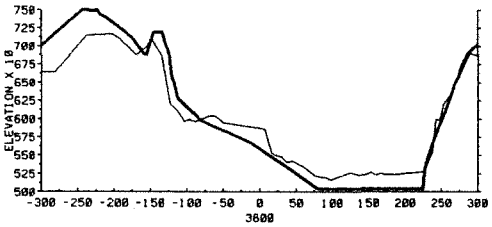
ORIGINAL CONTOURS

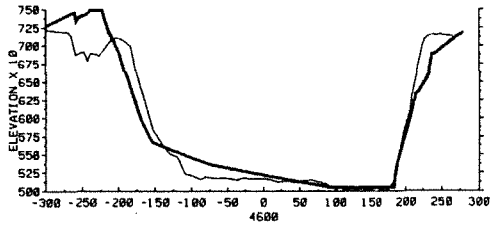
1992 ECHO SOUNDING

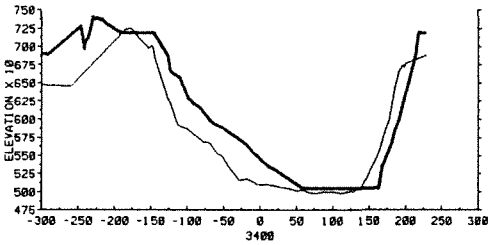
1991 ECHO SOUNDING

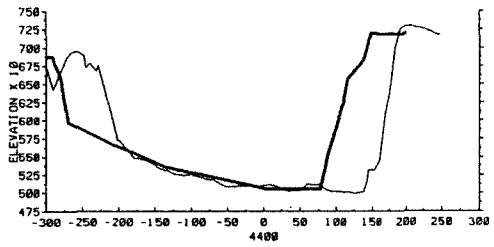


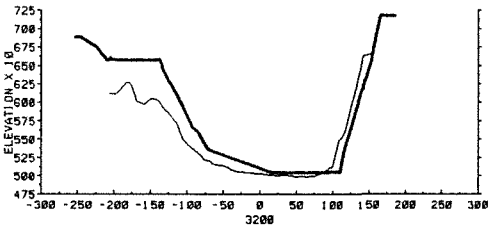


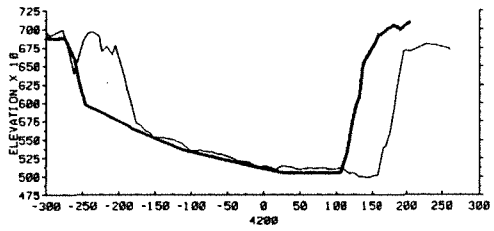


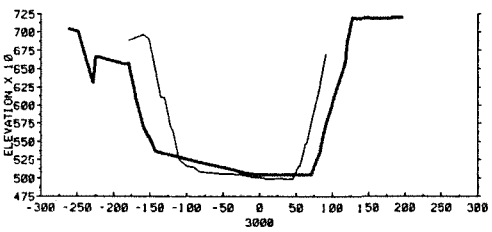


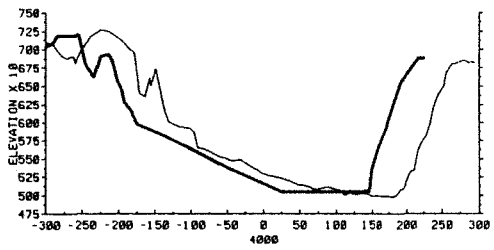












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

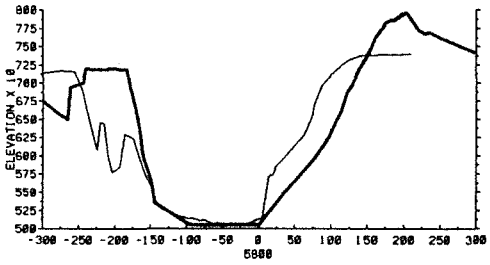
ELEVATION IS AHD EXAGGERATED 10 TIMES

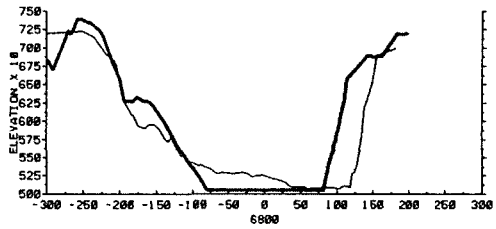
KEY TO CROSS SECTIONS

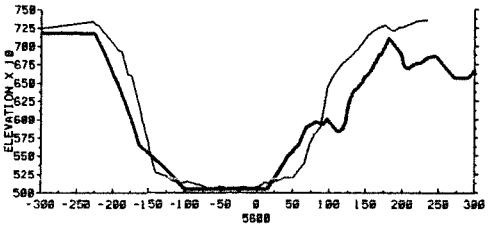
ORIGINAL CONTOURS

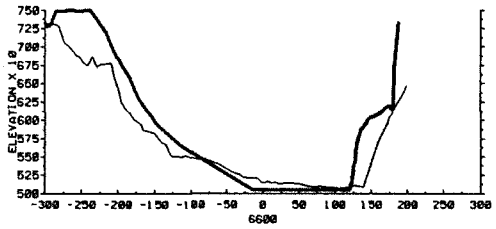
1992 ECHO SOUNDING

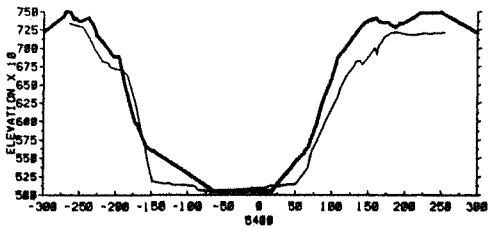
1991 ECHO SOUNDING

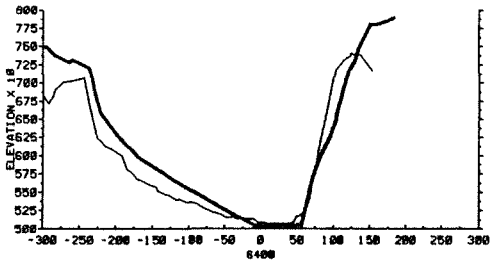


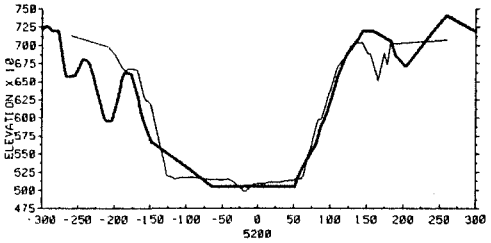


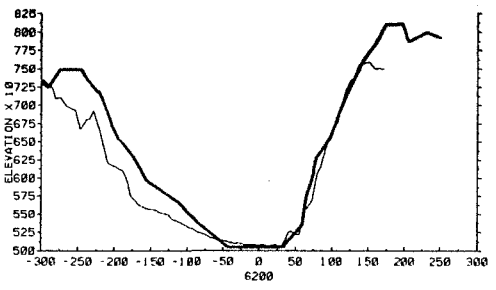


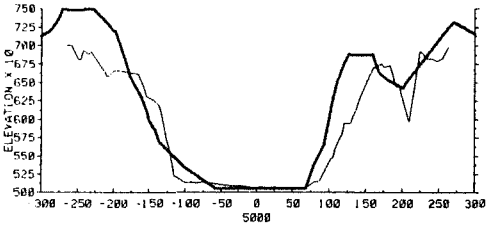


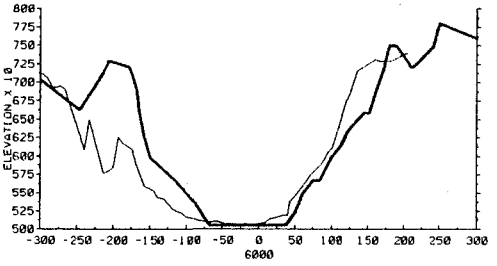












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

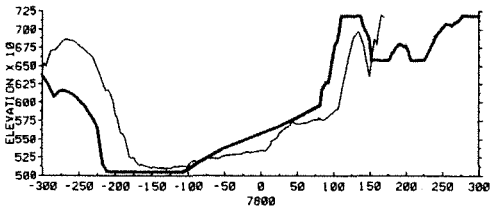
ELEVATION IS AHD EXAGGERATED 10 TIMES

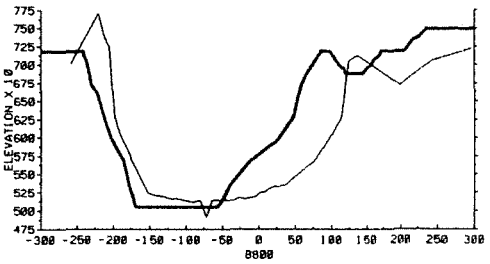
KEY TO CROSS SECTIONS

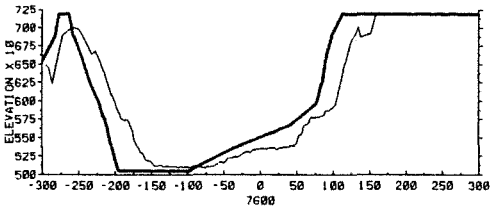
ORIGINAL CONTOURS

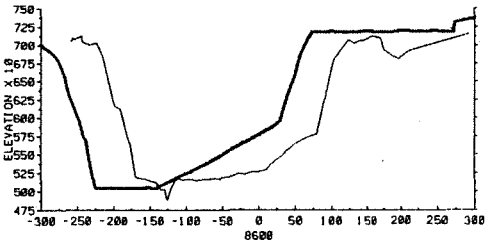
1992 ECHO SOUNDING

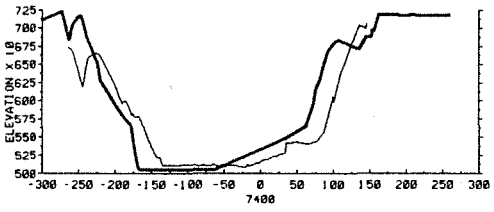
1991 ECHO SOUNDING

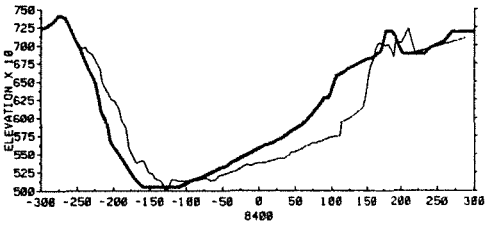


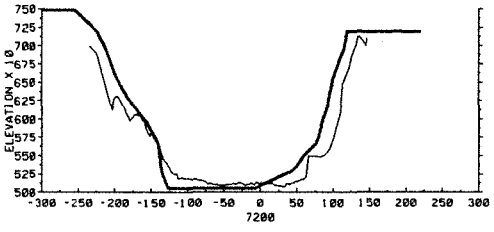


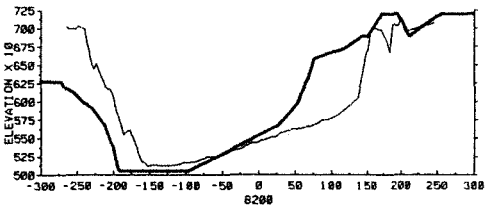


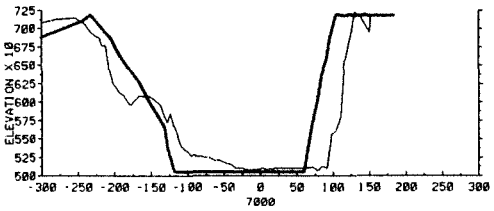


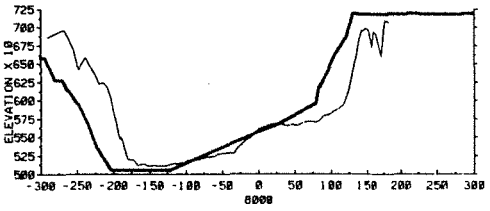












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

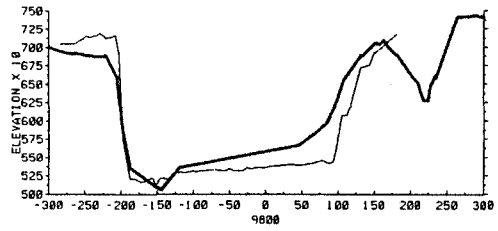
ELEVATION IS AHD EXAGGERATED 10 TIMES

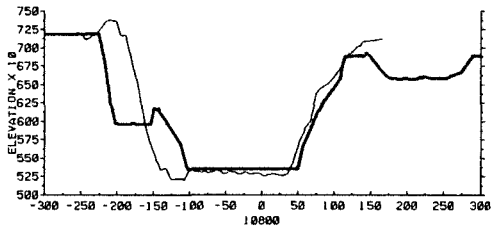
KEY TO CROSS SECTIONS

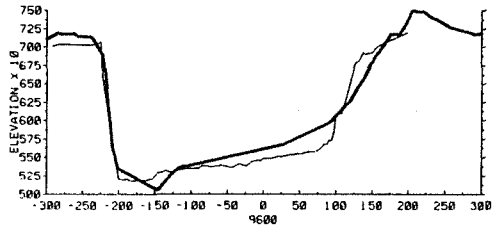
ORIGINAL CONTOURS

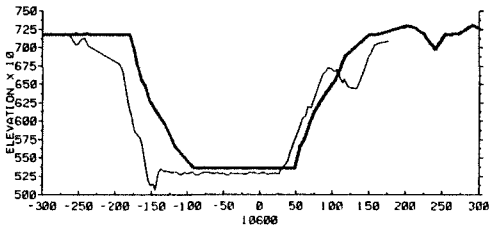
1992 ECHO SOUNDING

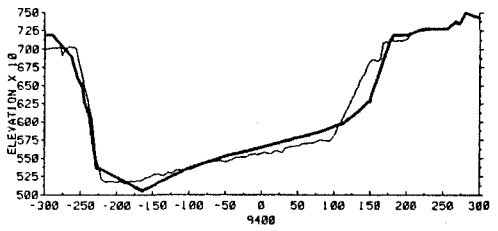
1991 ECHO SOUNDING

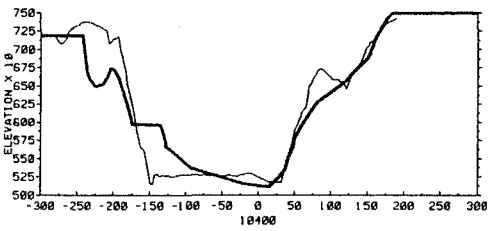


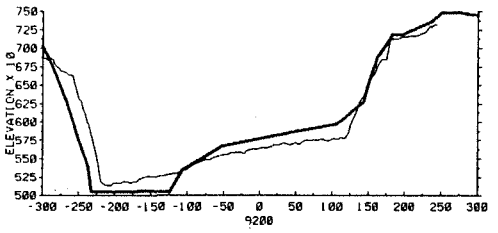


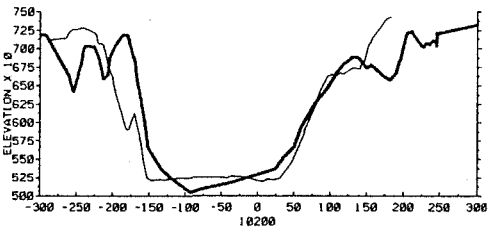


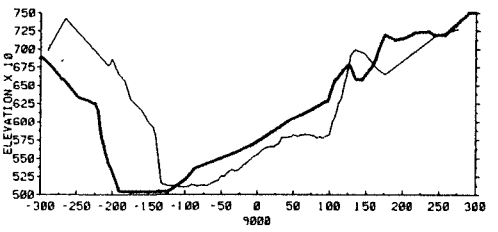


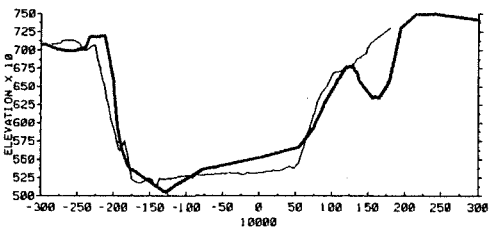












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

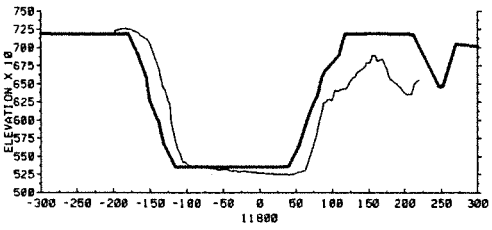
ELEVATION IS AHD EXAGGERATED 10 TIMES

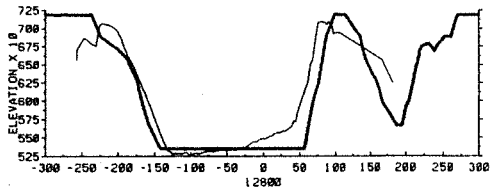
KEY TO CROSS SECTIONS

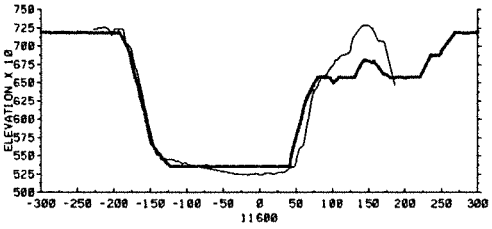
ORIGINAL CONTOURS

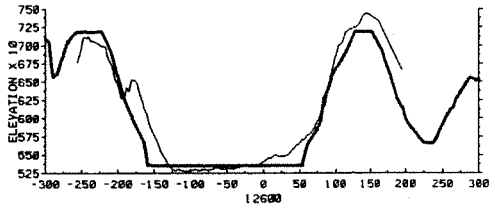
1992 ECHO SOUNDING

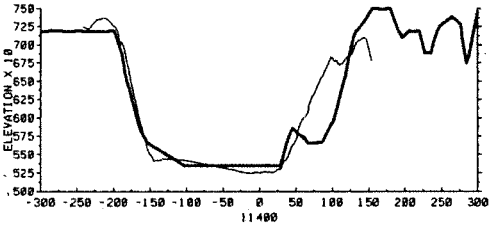
1991 ECHO SOUNDING

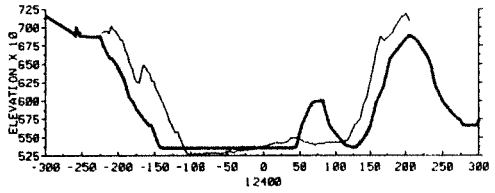


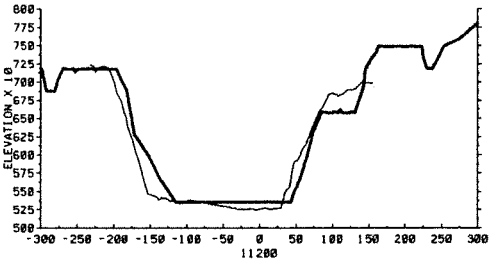


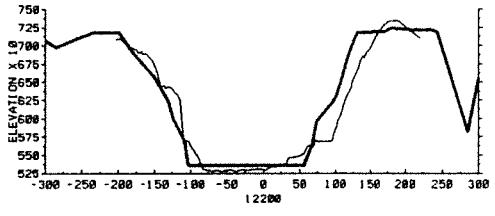


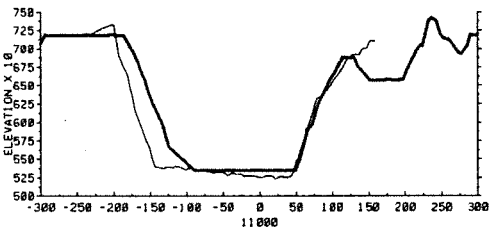


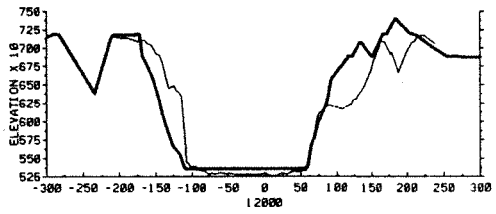












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

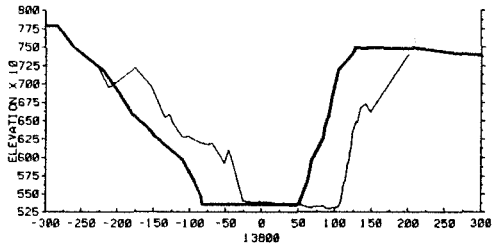
ELEVATION IS AHD EXAGGERATED 10 TIMES

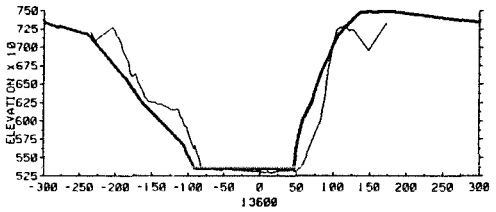
KEY TO CROSS SECTIONS

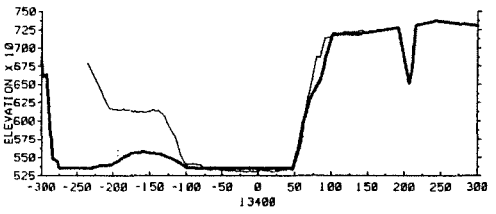
ORIGINAL CONTOURS

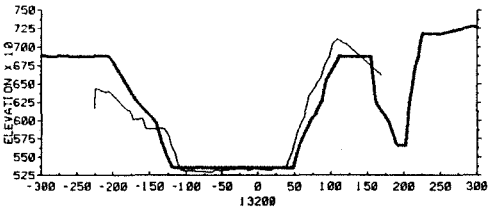
1992 ECHO SOUNDING

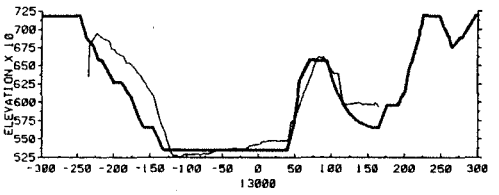
1991 ECHO SOUNDING

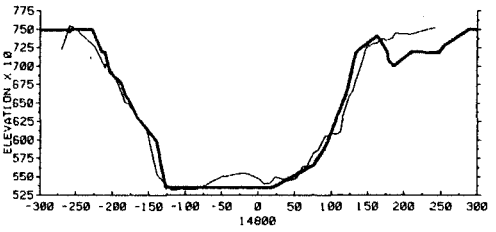


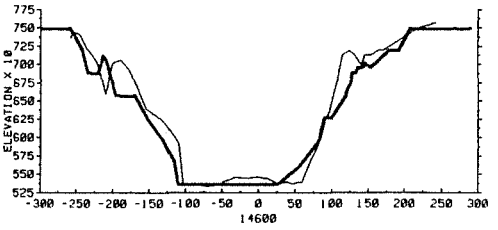


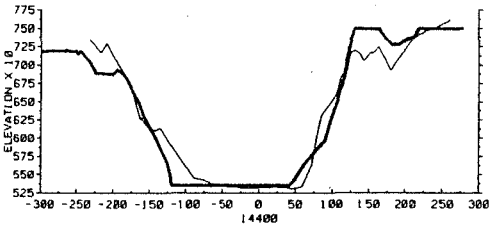


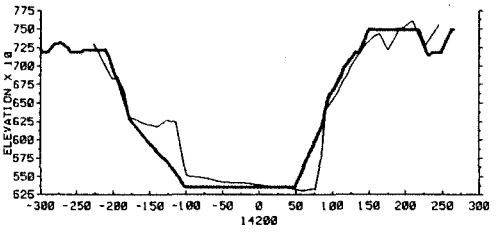


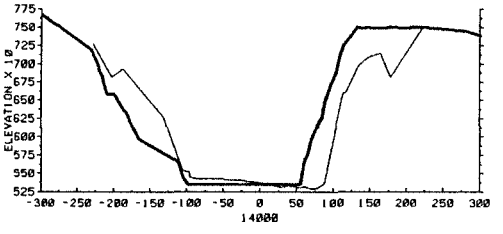












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

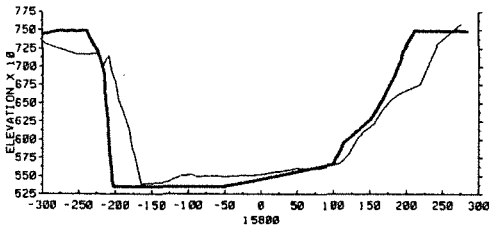
ELEVATION IS AHD EXAGGERATED 10 TIMES

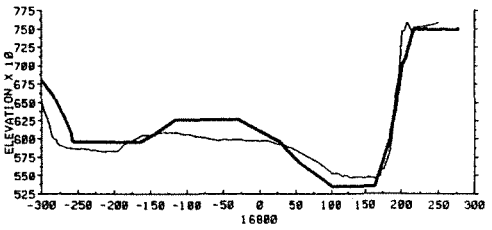
KEY TO CROSS SECTIONS

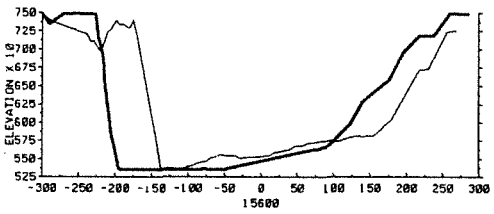
ORIGINAL CONTOURS

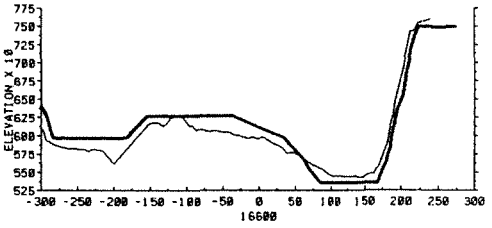
1992 ECHO SOUNDING

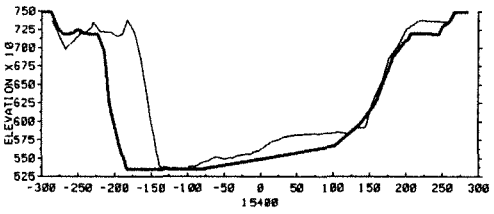
1991 ECHO SOUNDING

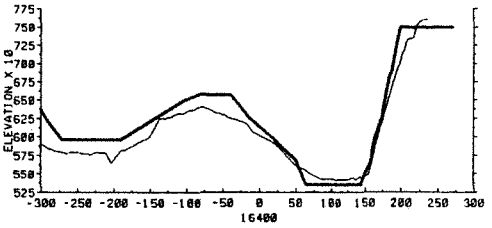


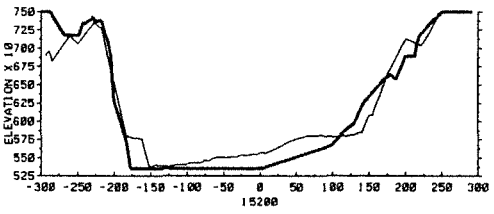


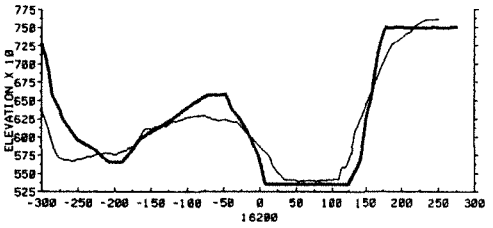


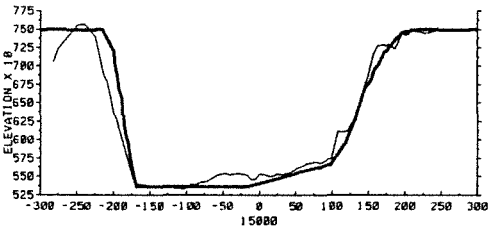


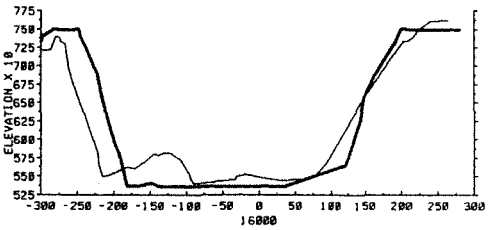












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

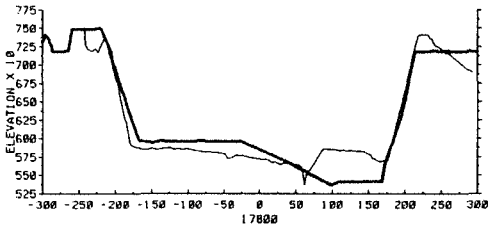
ELEVATION IS AHD EXAGGERATED 10 TIMES

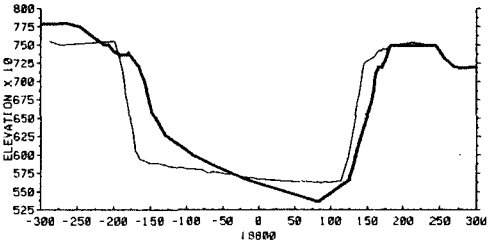
KEY TO CROSS SECTIONS

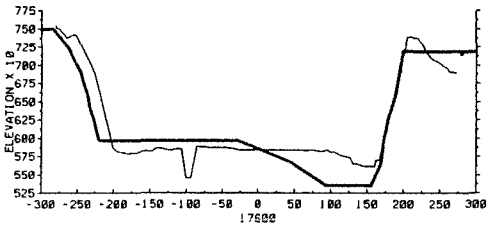
ORIGINAL CONTOURS

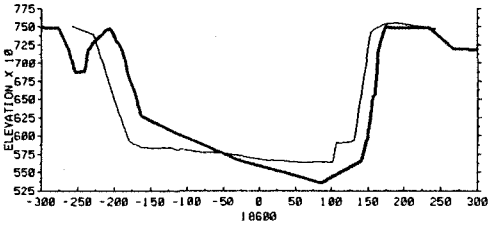
1992 ECHO SOUNDING

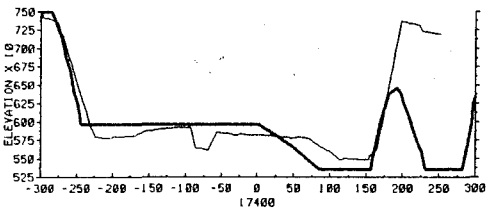
1991 ECHO SOUNDING

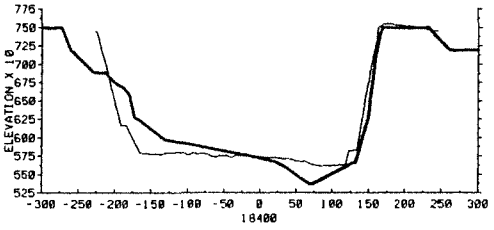


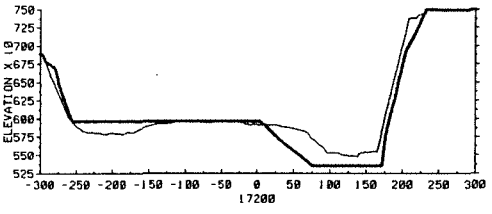


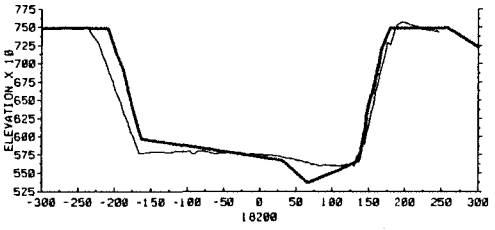


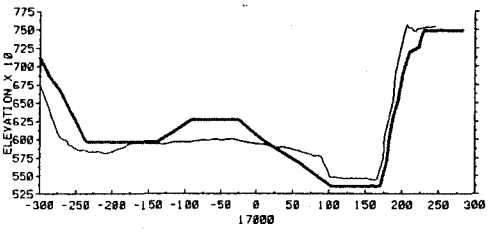


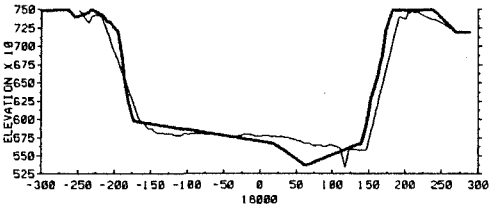












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

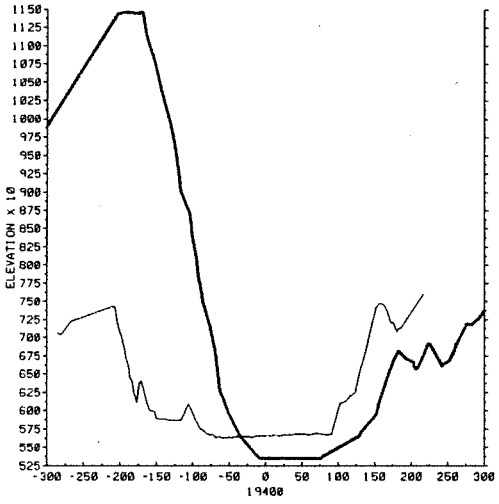
ELEVATION IS AHD EXAGGERATED 10 TIMES

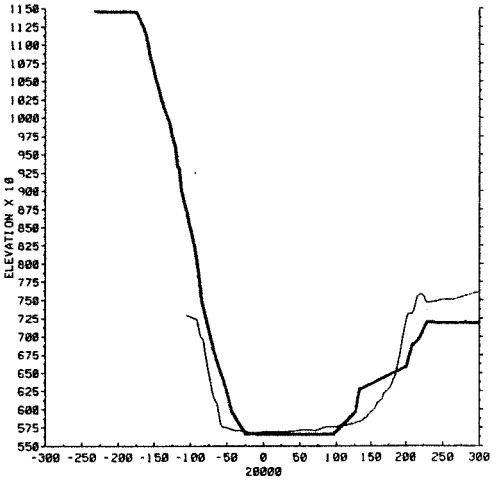
KEY TO CROSS SECTIONS

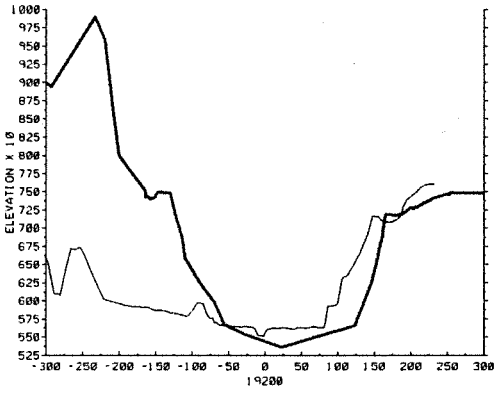
ORIGINAL CONTOURS

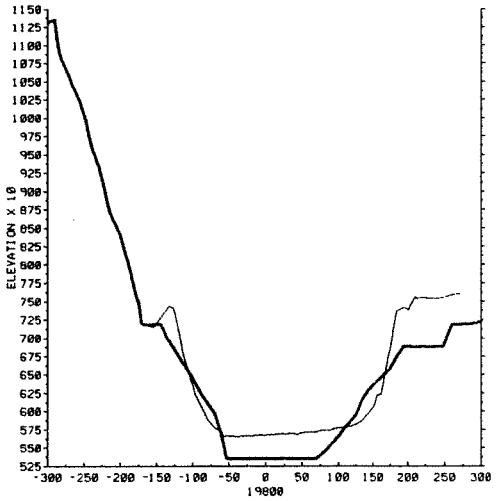
1992 ECHO SOUNDING

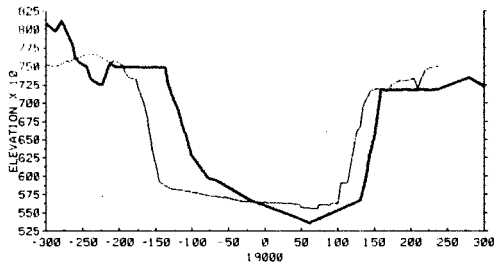
1991 ECHO SOUNDING

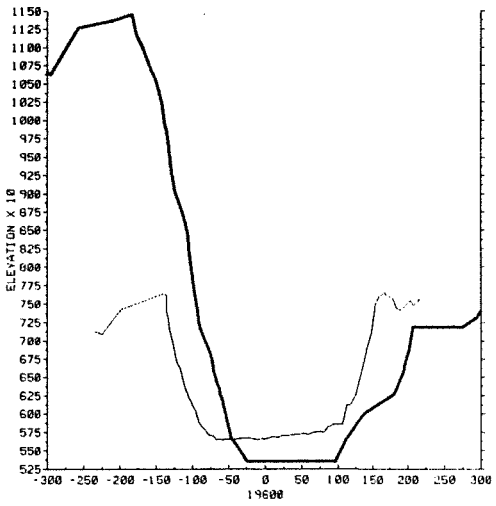












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

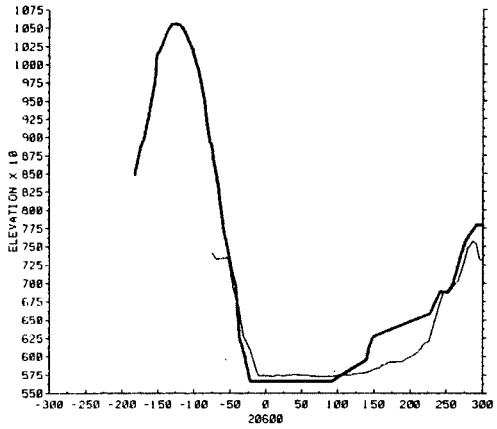
ELEVATION IS AHD EXAGGERATED 10 TIMES

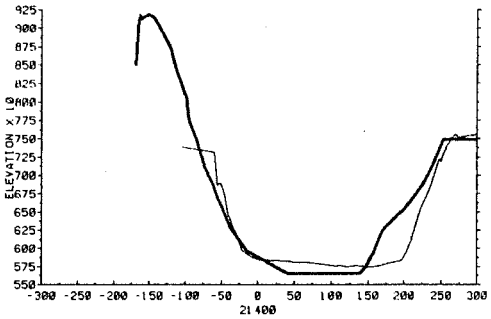
KEY TO CROSS SECTIONS

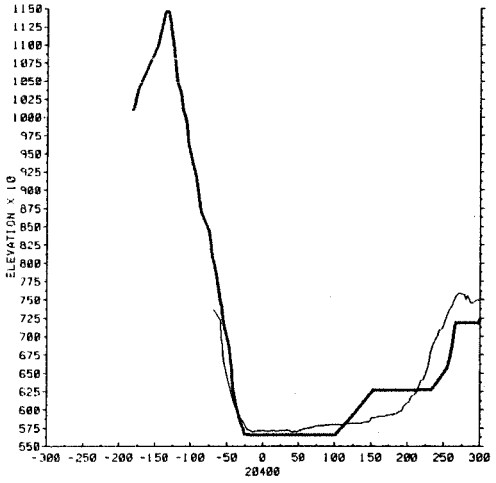
ORIGINAL CONTOURS

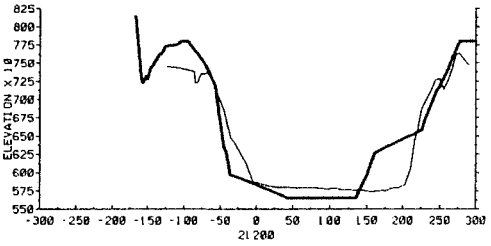
1992 ECHO SOUNDING

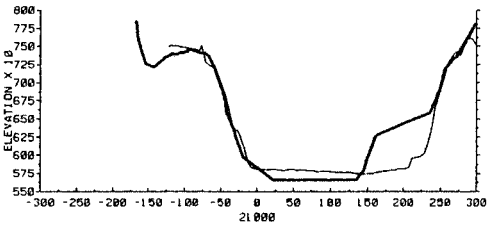
1991 ECHO SOUNDING

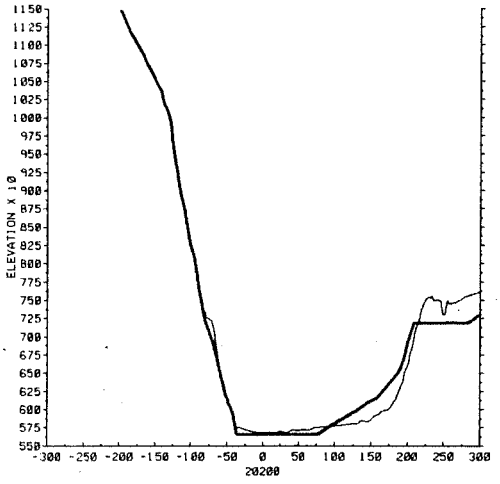


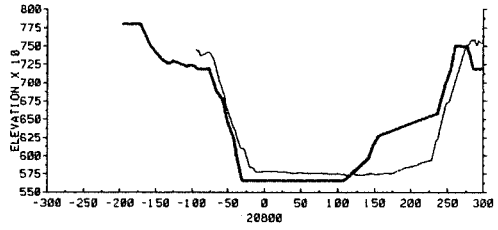












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

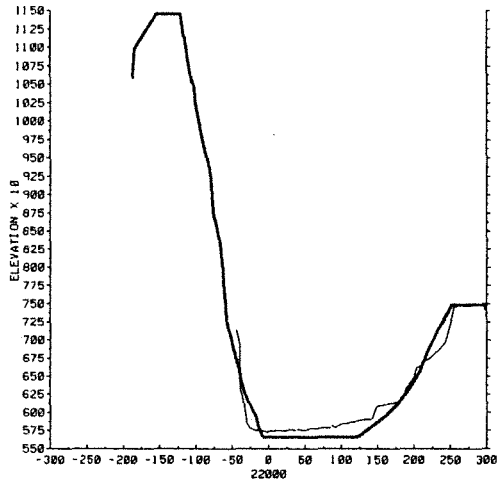
ELEVATION IS AHD EXAGGERATED 10 TIMES

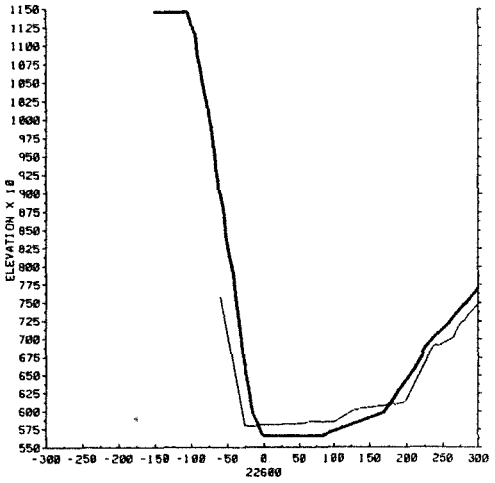
KEY TO CROSS SECTIONS

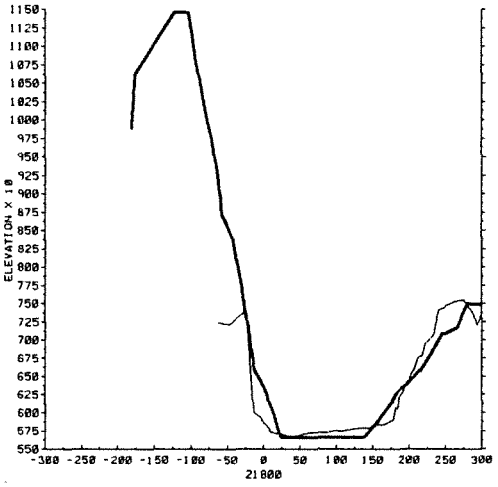
ORIGINAL CONTOURS

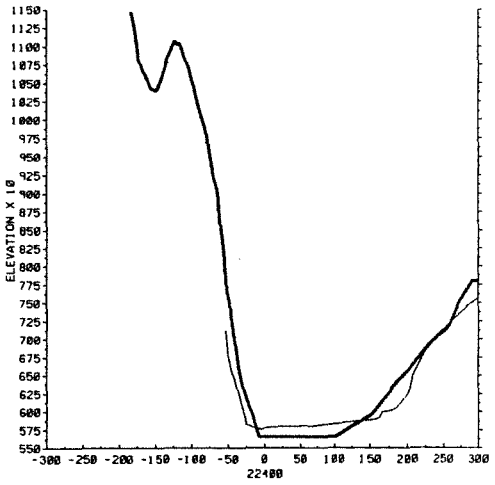
1992 ECHO SOUNDING

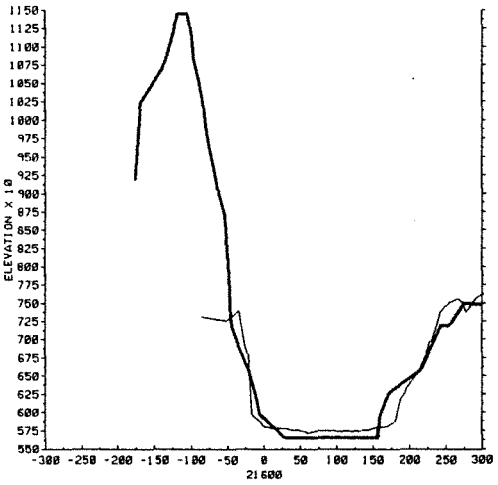
1991 ECHO SOUNDING

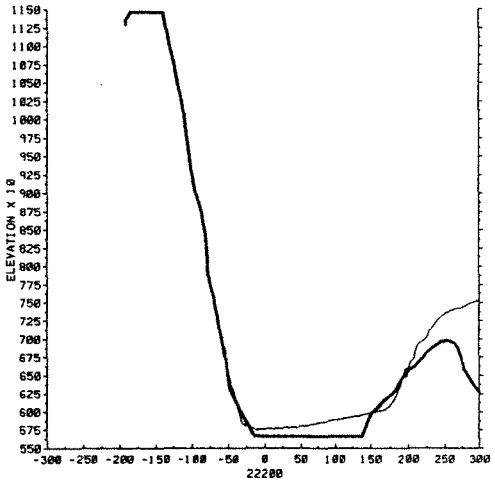












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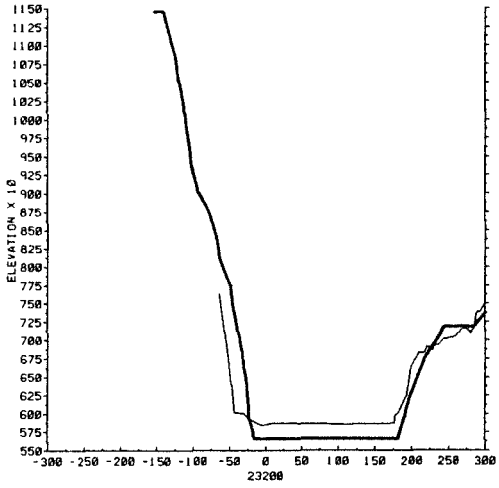

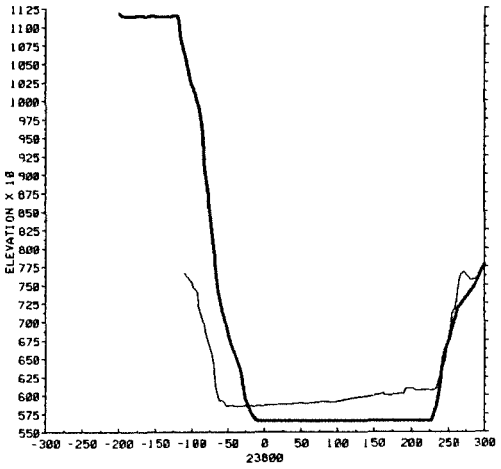

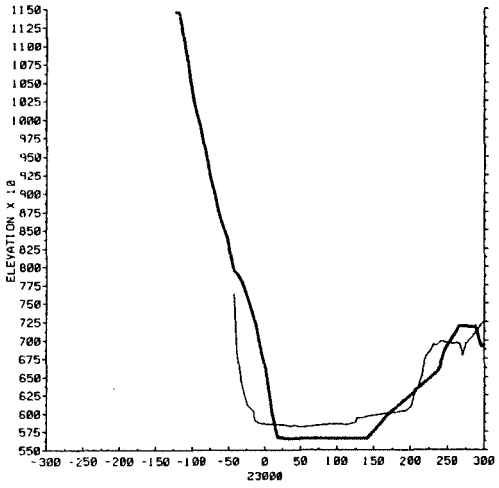

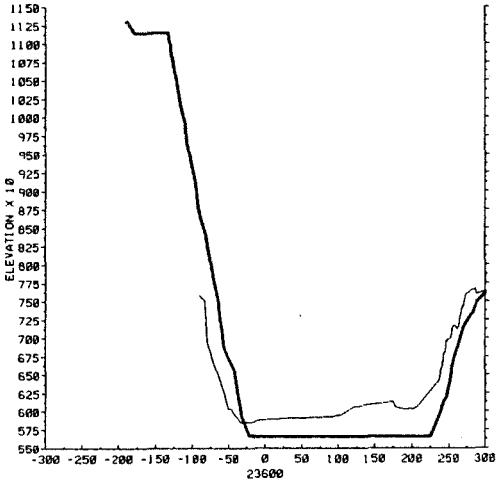

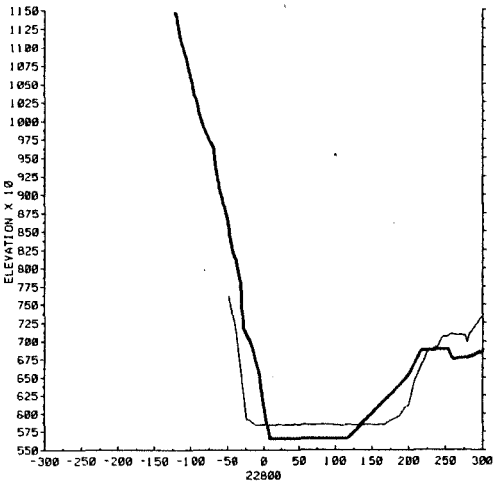

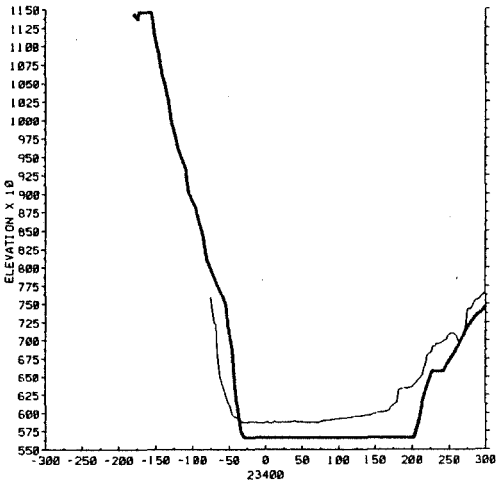

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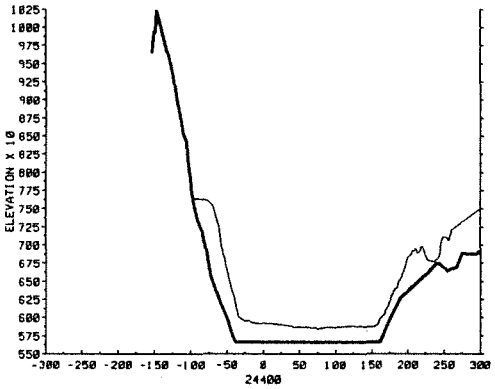

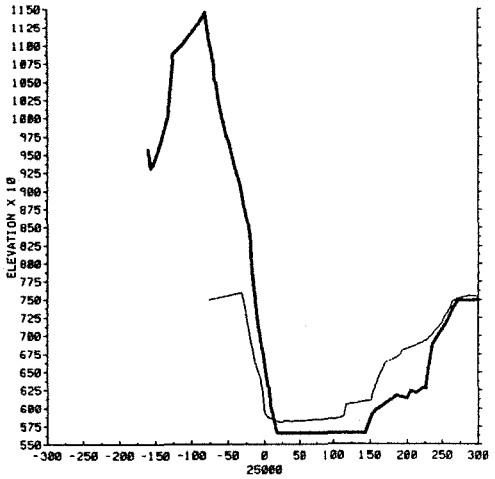

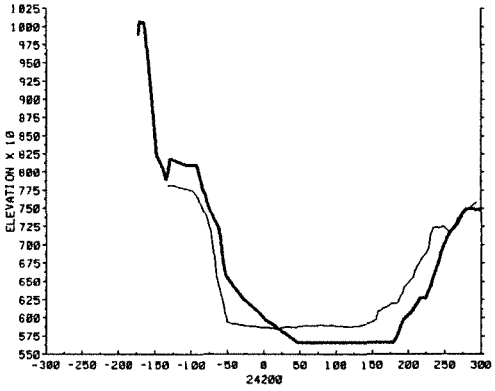

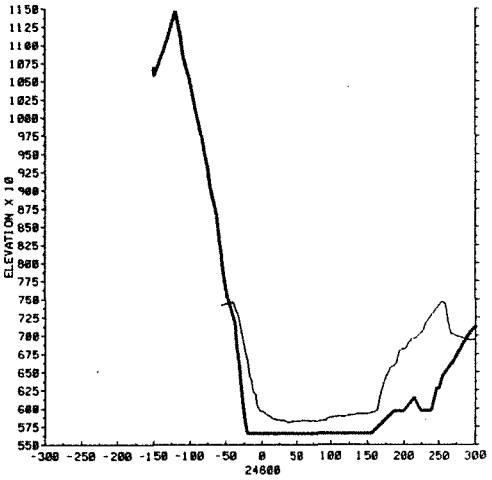

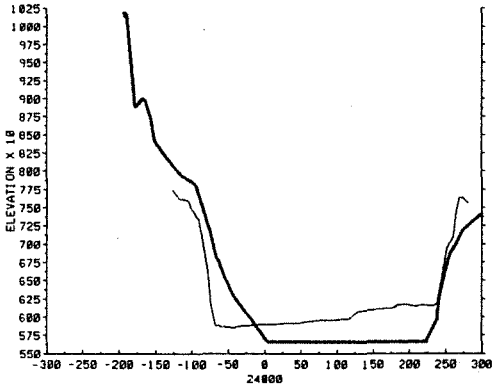

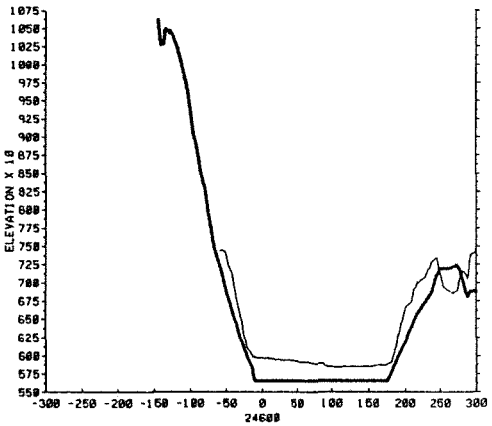

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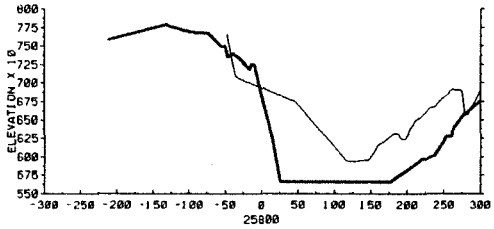
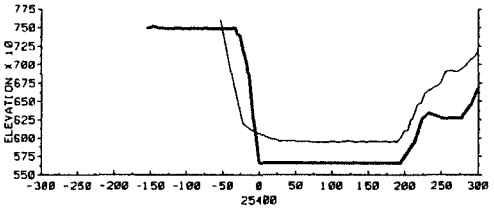
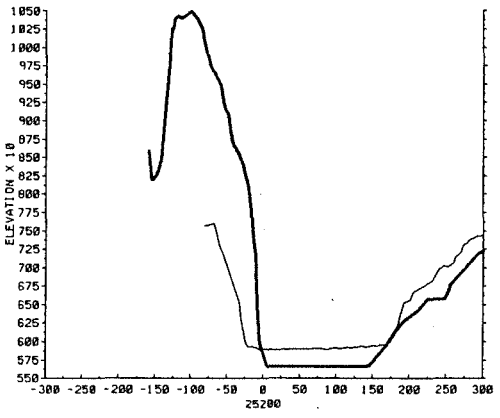
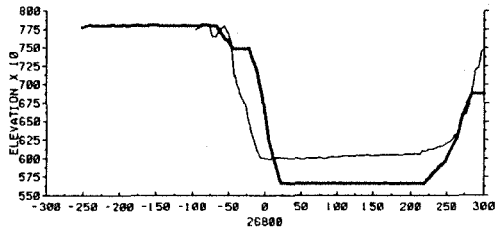
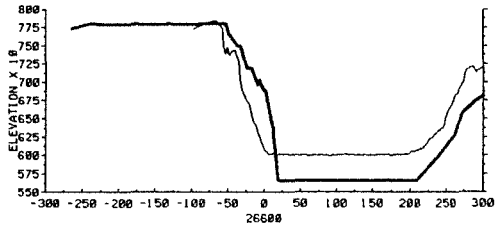
1991 ECHO SOUNDING

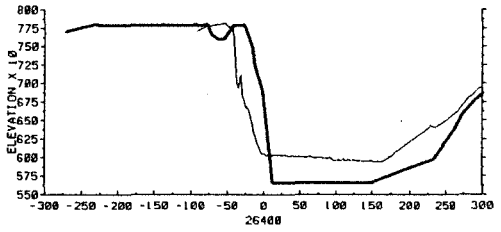


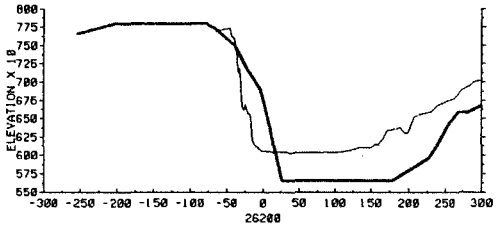


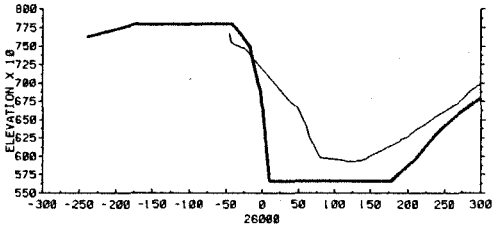












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

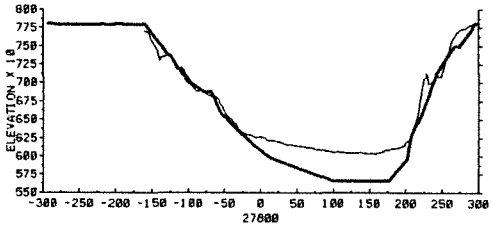
ELEVATION IS AHD EXAGGERATED 10 TIMES

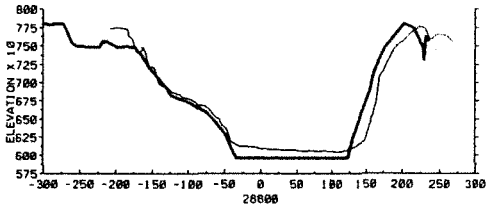
KEY TO CROSS SECTIONS

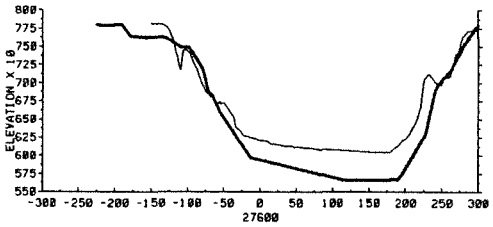
ORIGINAL CONTOURS

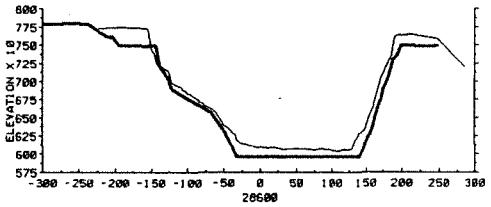
1992 ECHO SOUNDING

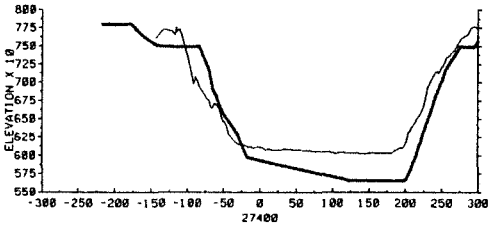
1991 ECHO SOUNDING

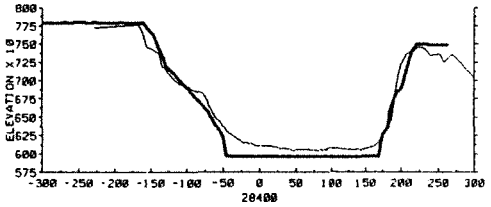


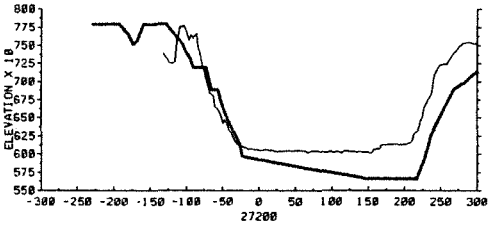


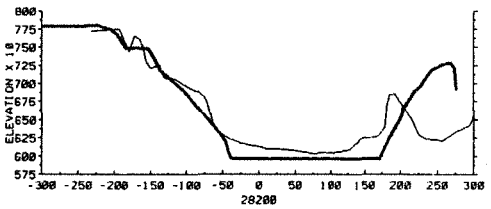


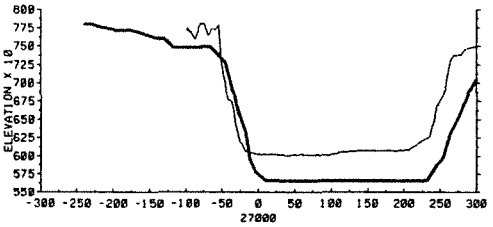


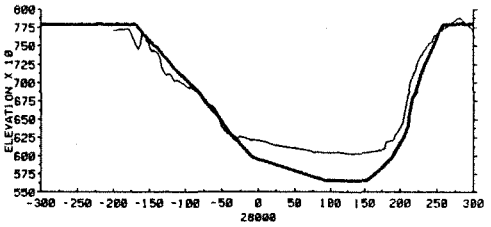












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

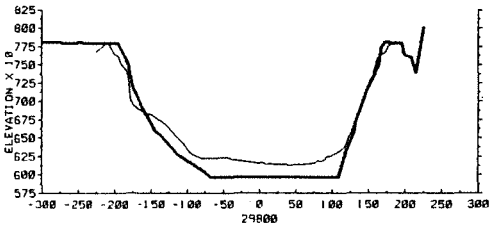
ELEVATION IS AHD EXAGGERATED 10 TIMES

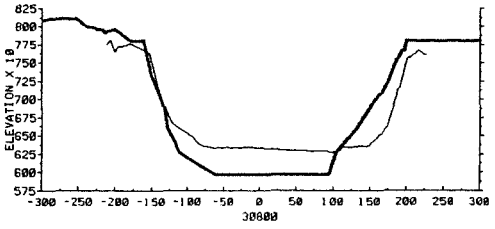
KEY TO CROSS SECTIONS

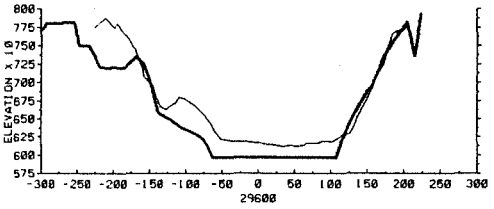
ORIGINAL CONTOURS

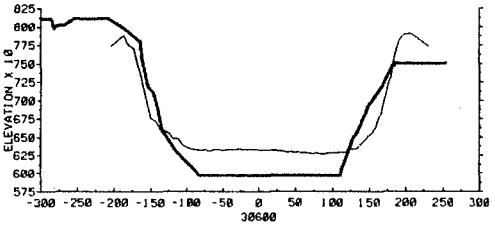
1992 ECHO SOUNDING

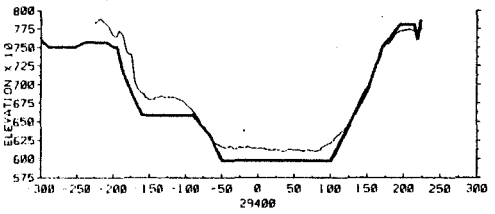
1991 ECHO SOUNDING

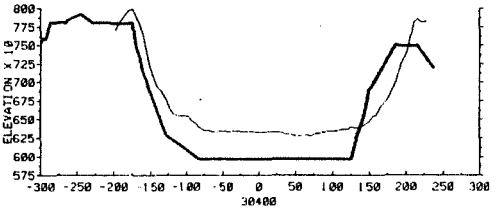


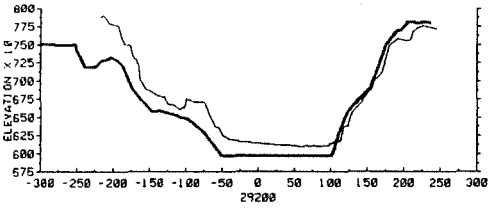


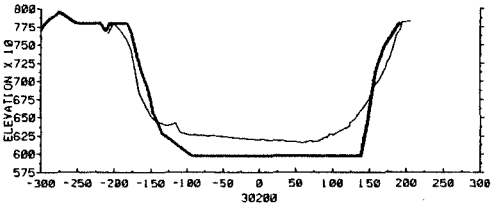


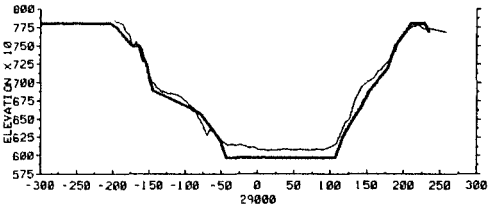


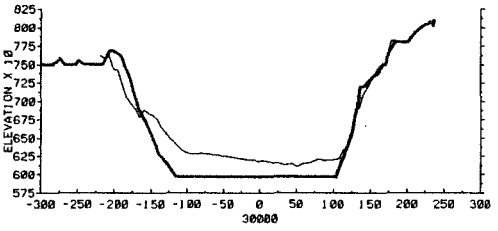












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

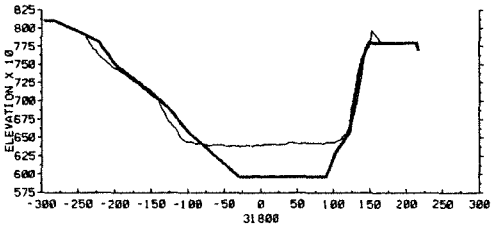
ELEVATION IS AHD EXAGGERATED 10 TIMES

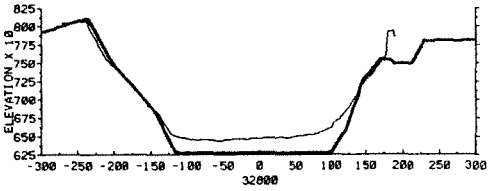
KEY TO CROSS SECTIONS

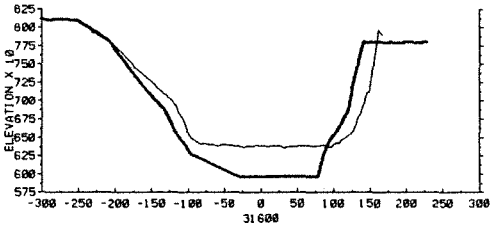
ORIGINAL CONTOURS

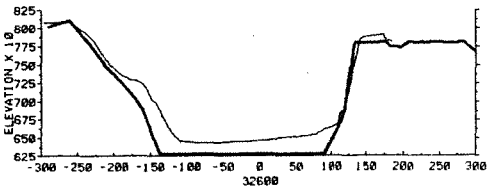
1992 ECHO SOUNDING

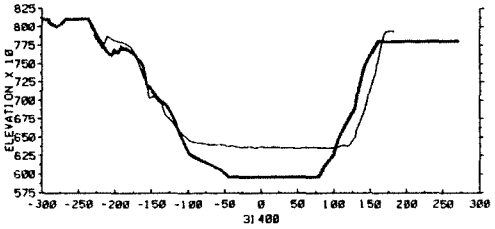
1991 ECHO SOUNDING

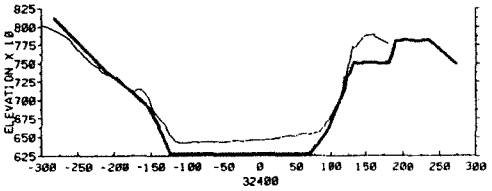


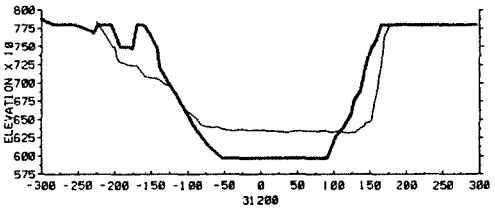


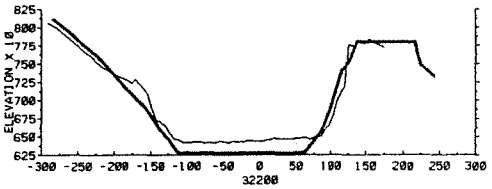


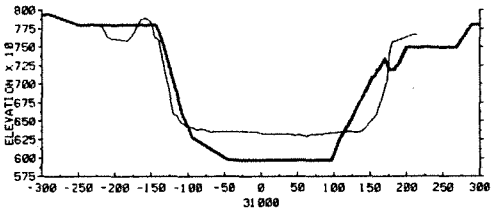


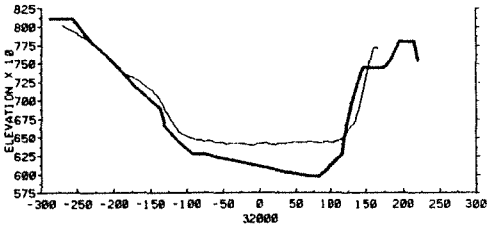












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

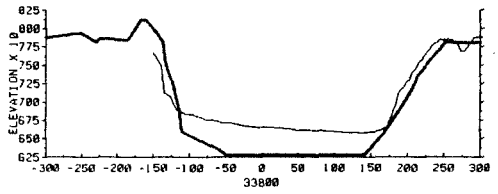
ELEVATION IS AHD EXAGGERATED 10 TIMES

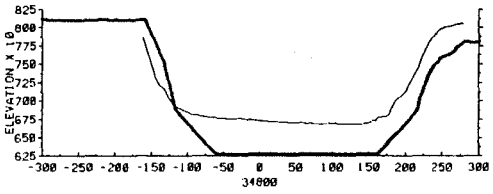
KEY TO CROSS SECTIONS

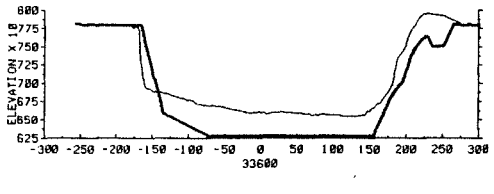
ORIGINAL CONTOURS

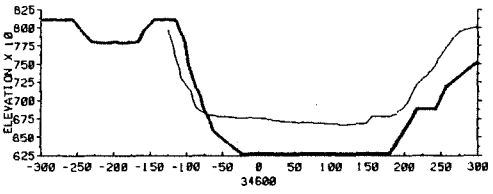
1992 ECHO SOUNDING

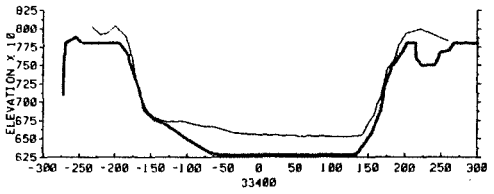
1991 ECHO SOUNDING

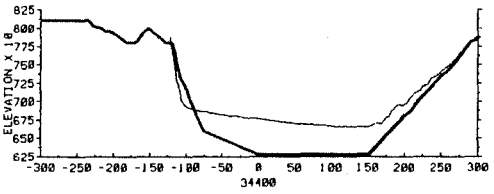


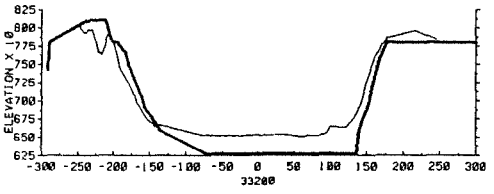


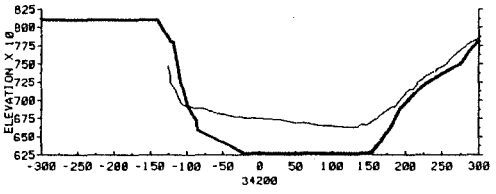


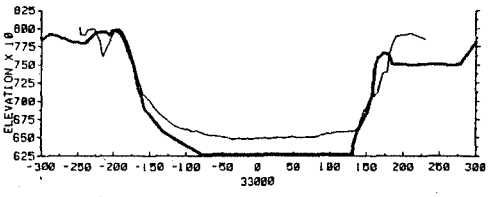


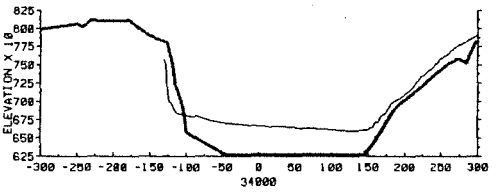












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

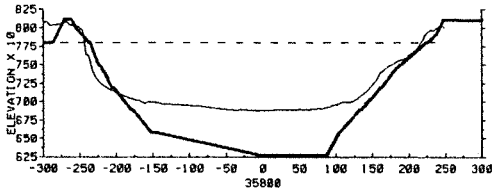
ELEVATION IS AHD EXAGGERATED 10 TIMES

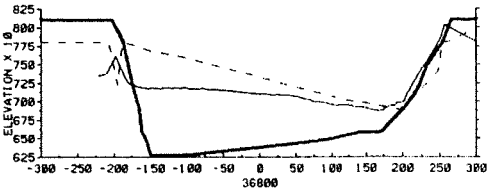
KEY TO CROSS SECTIONS

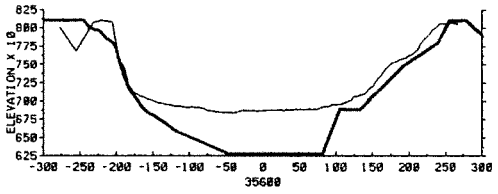
———— ORIGINAL CONTOURS

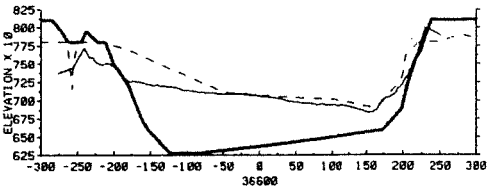
———— 1992 ECHO SOUNDING

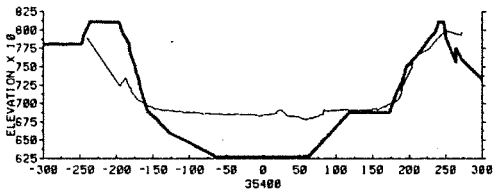
- - - - - - - - - - - - - - 1991 ECHO SOUNDING

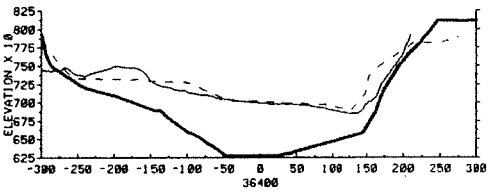


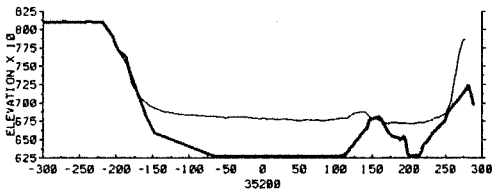


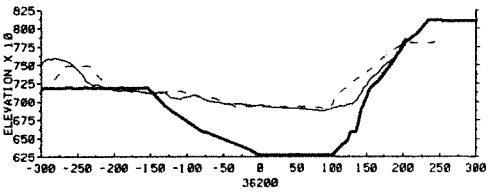


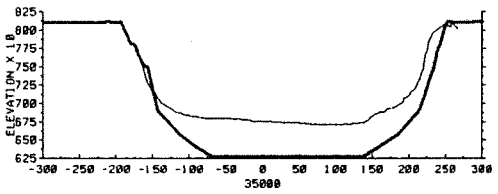


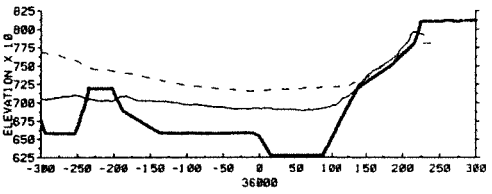












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

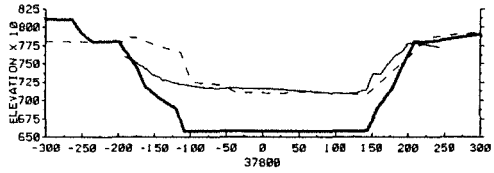
ELEVATION IS AHD EXAGGERATED 10 TIMES

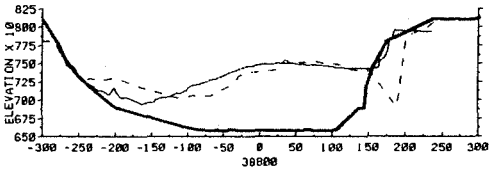
KEY TO CROSS SECTIONS

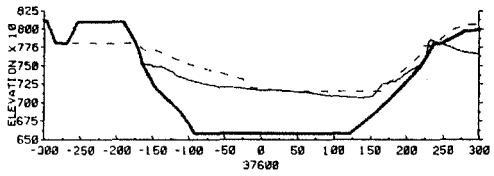
ORIGINAL CONTOURS

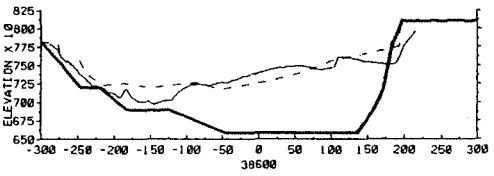
1992 ECHO SOUNDING

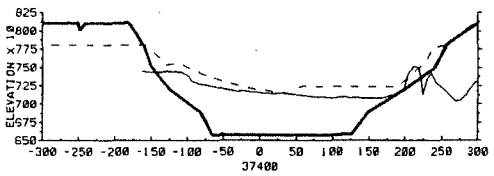
1991 ECHO SOUNDING

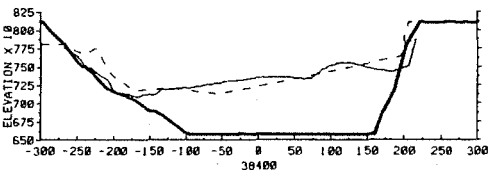


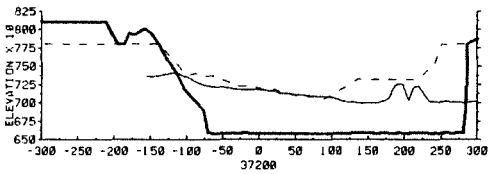


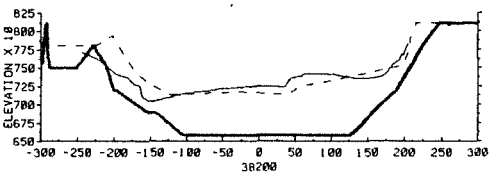


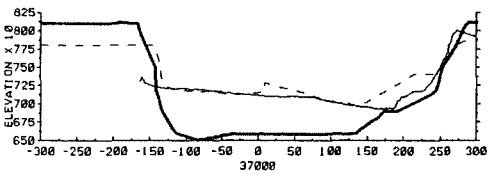


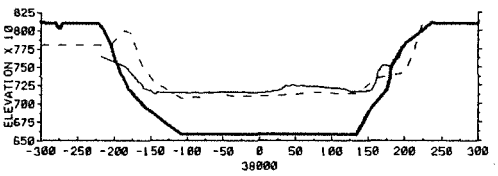












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

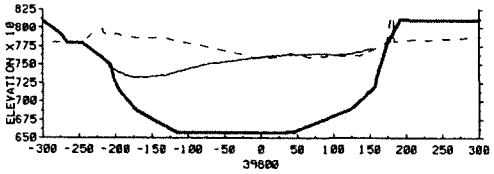
ELEVATION IS AHD EXAGGERATED 10 TIMES

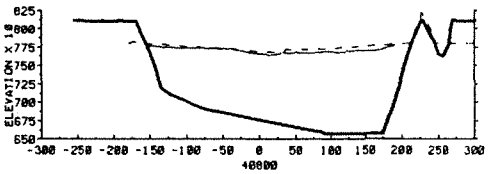
KEY TO CROSS SECTIONS

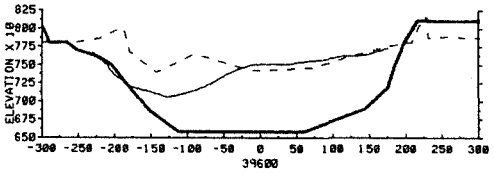
ORIGINAL CONTOURS

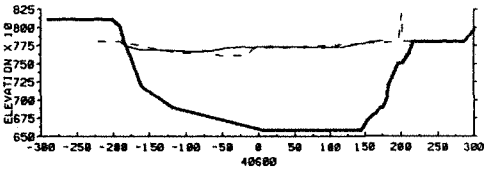
1992 ECHO SOUNDING

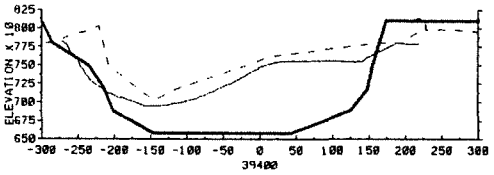
1991 ECHO SOUNDING

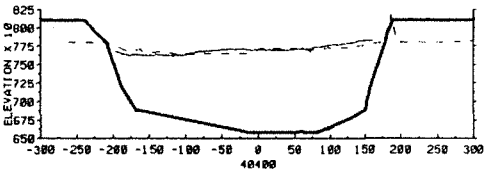


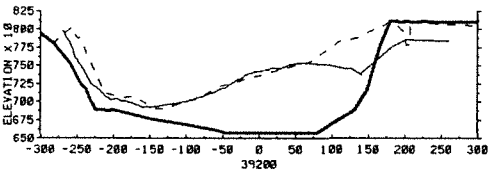


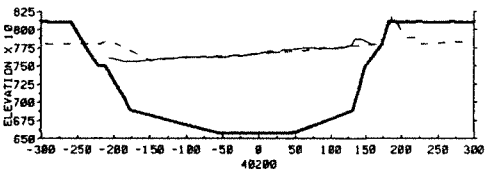


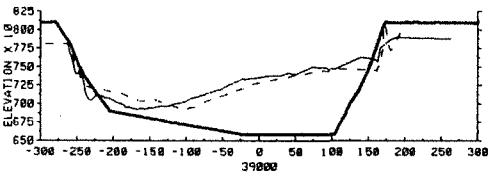


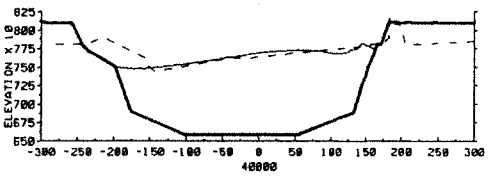












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

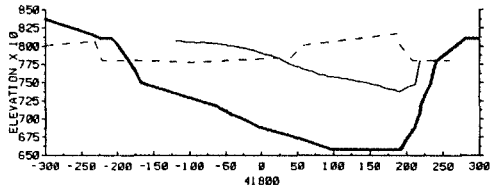
ELEVATION IS AHD EXAGGERATED 10 TIMES

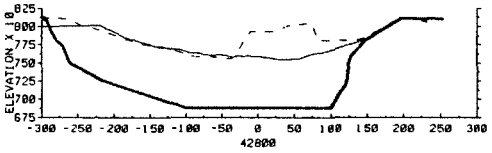
KEY TO CROSS SECTIONS

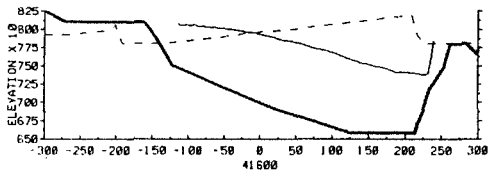
ORIGINAL CONTOURS

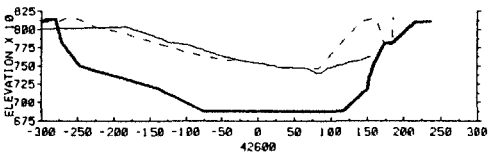
1992 ECHO SOUNDING

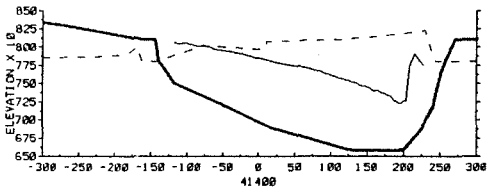
1991 ECHO SOUNDING

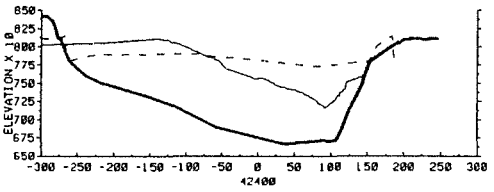


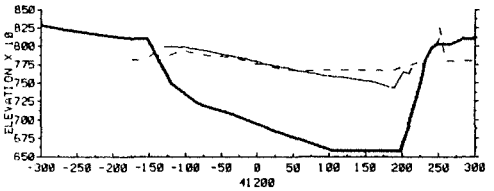


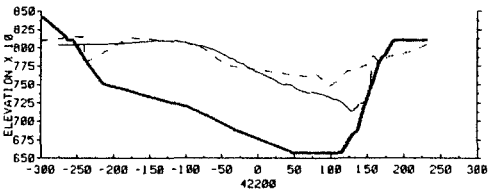


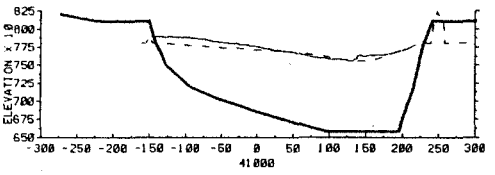


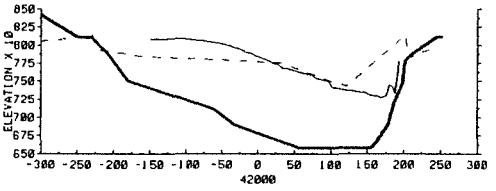












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

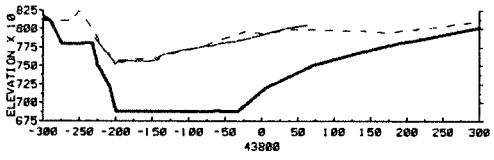
ELEVATION IS AHD EXAGGERATED 10 TIMES

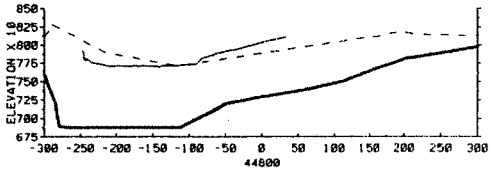
KEY TO CROSS SECTIONS

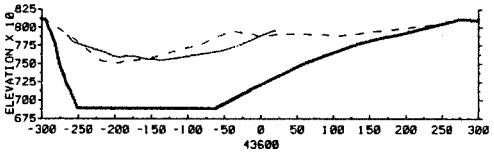
ORIGINAL CONTOURS

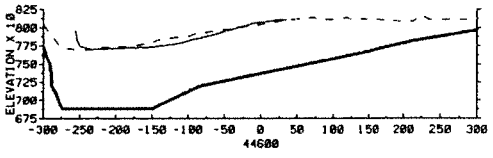
1992 ECHO SOUNDING

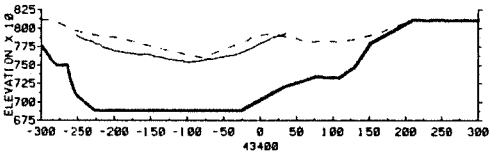
1991 ECHO SOUNDING

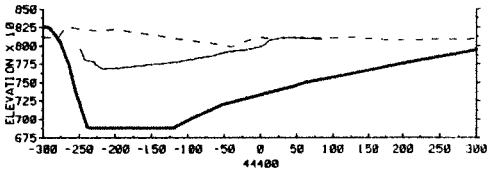


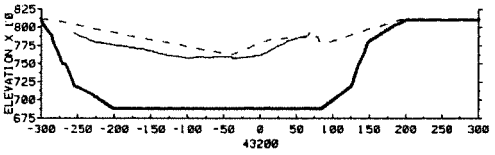


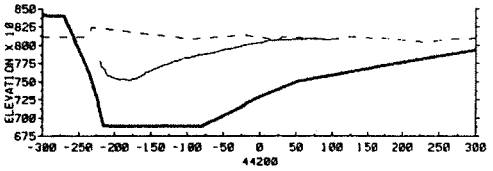


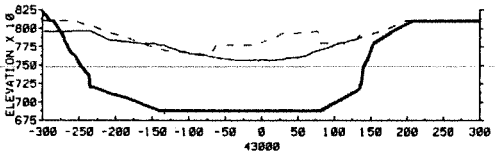


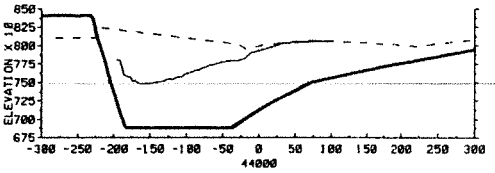












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

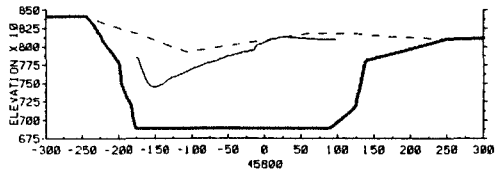
ELEVATION IS AHD EXAGGERATED 10 TIMES

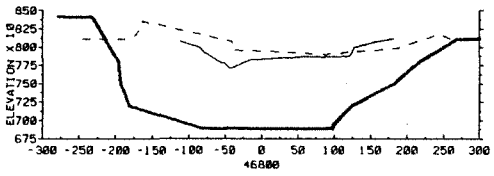
KEY TO CROSS SECTIONS

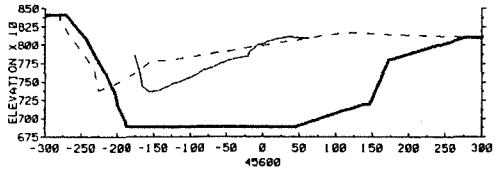
ORIGINAL CONTOURS

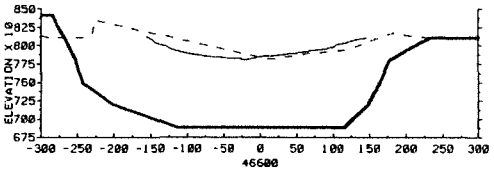
1992 ECHO SOUNDING

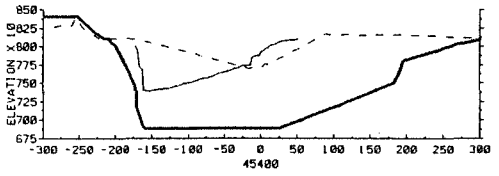
1991 ECHO SOUNDING

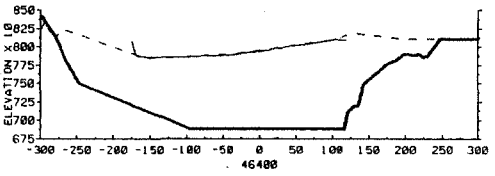


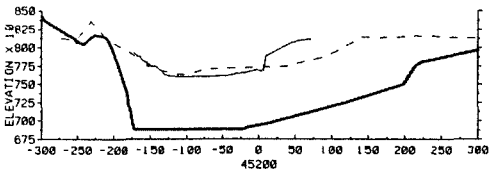


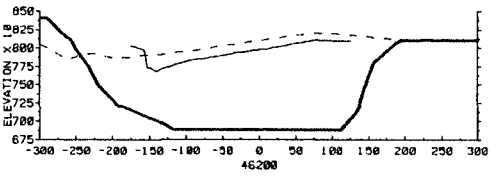


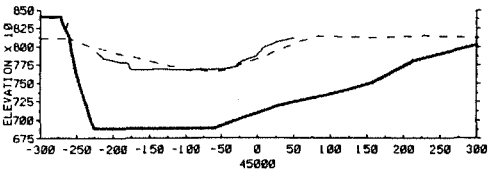


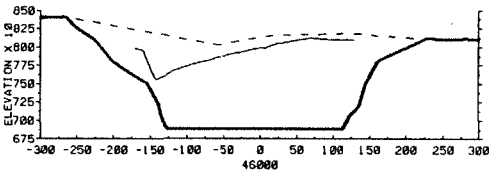












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

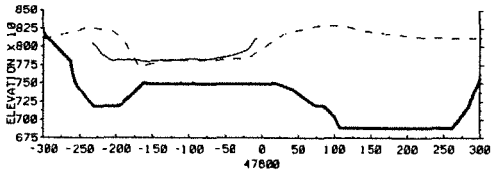
ELEVATION IS AHD EXAGGERATED 10 TIMES

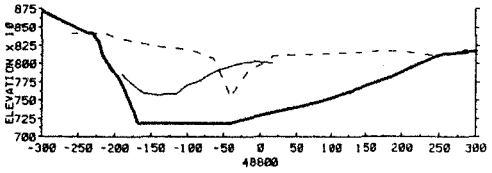
KEY TO CROSS SECTIONS

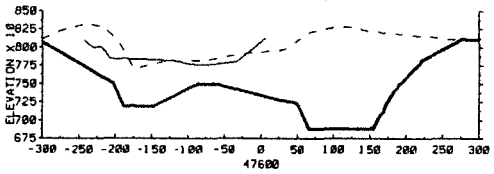
ORIGINAL CONTOURS

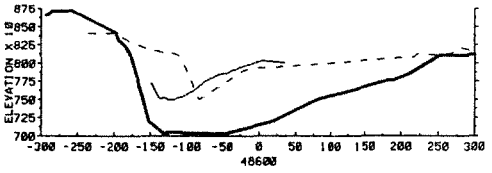
1992 ECHO SOUNDING

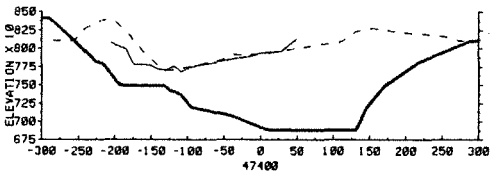
1991 ECHO SOUNDING

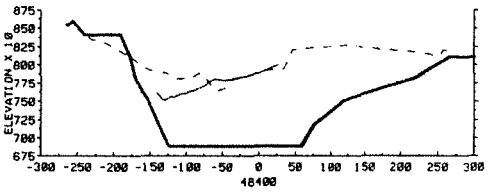


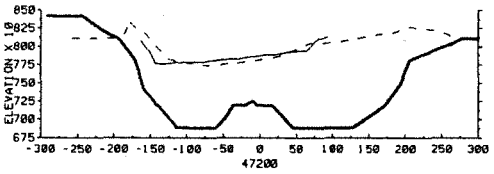


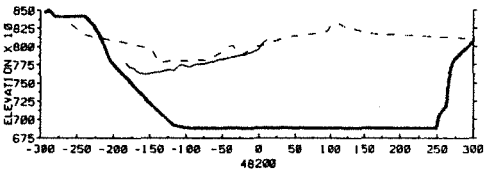


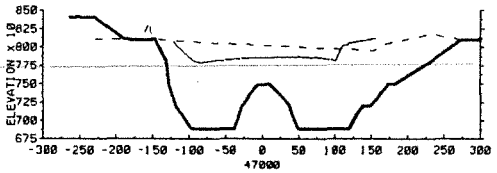


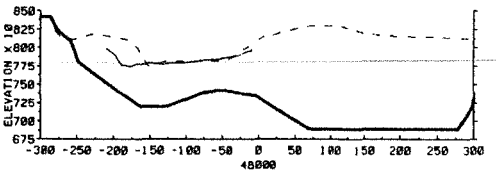












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

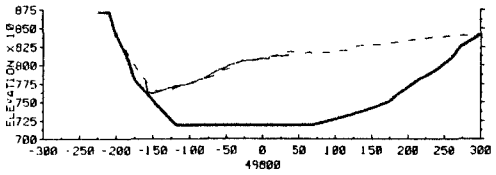
ELEVATION IS AHD EXAGGERATED 10 TIMES

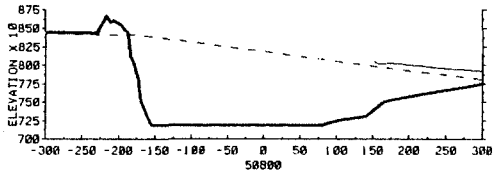
KEY TO CROSS SECTIONS

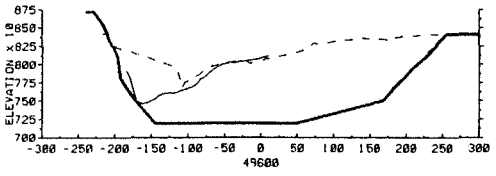
ORIGINAL CONTOURS

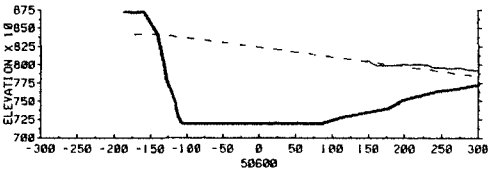
1992 ECHO SOUNDING

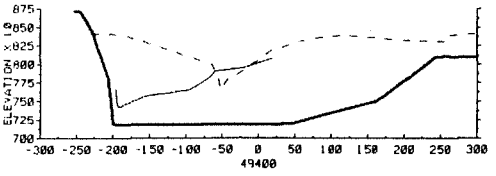
1991 ECHO SOUNDING

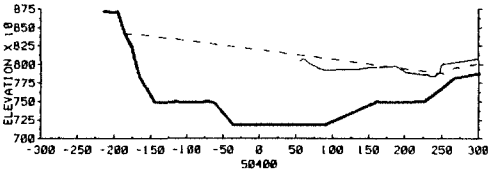


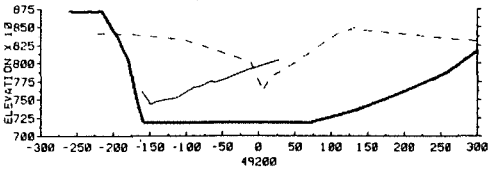


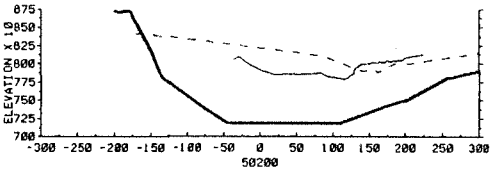


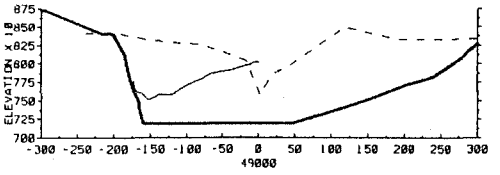


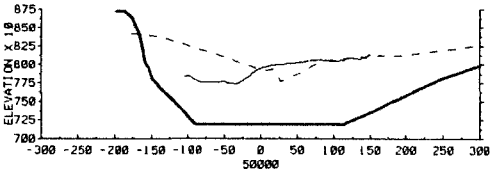












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

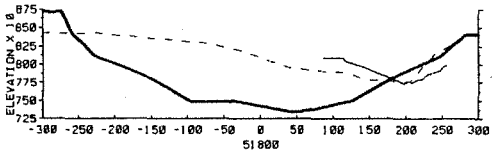
ELEVATION IS AHD EXAGGERATED 10 TIMES

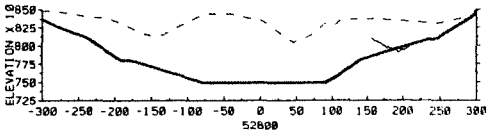
KEY TO CROSS SECTIONS

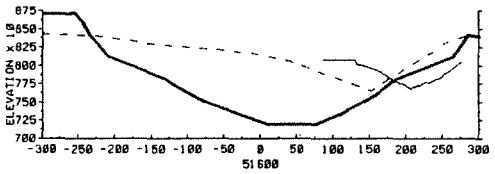
———— ORIGINAL CONTOURS

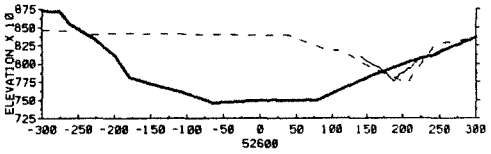
———— 1992 ECHO SOUNDING

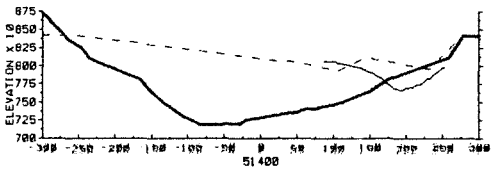
- - - - - - - - - - - - - - 1991 ECHO SOUNDING

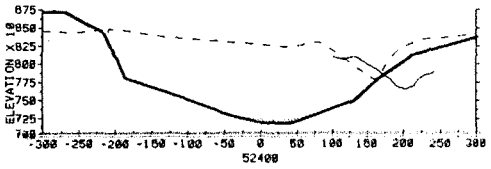


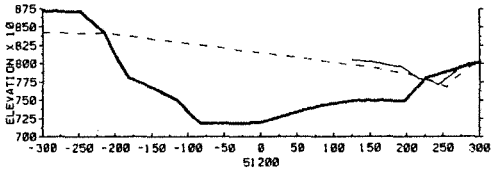


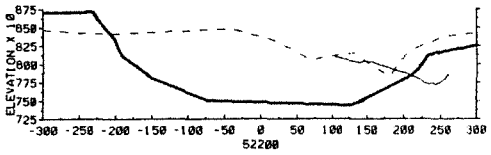


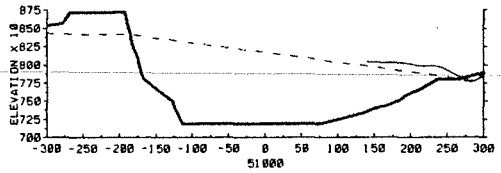


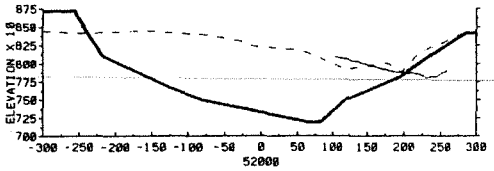












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

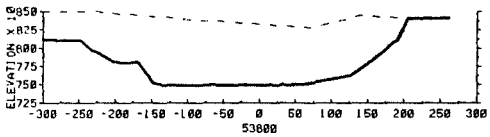
ELEVATION IS AHD EXAGGERATED 10 TIMES

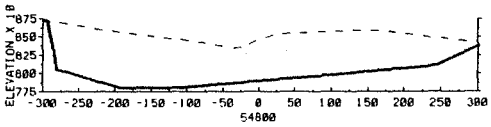
KEY TO CROSS SECTIONS

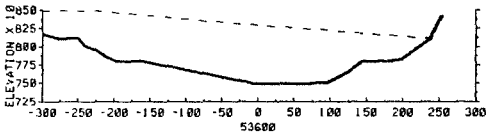
ORIGINAL CONTOURS

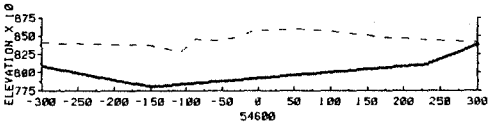
1992 ECHO SOUNDING

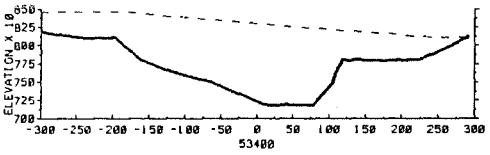
1991 ECHO SOUNDING

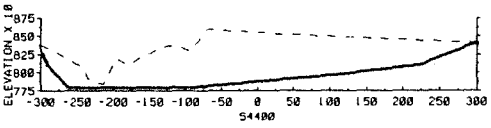


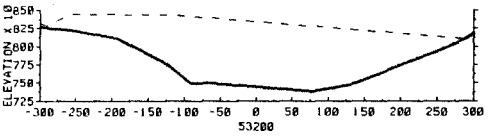


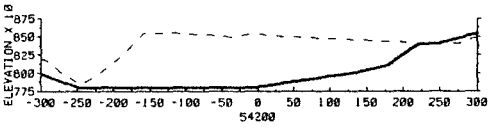


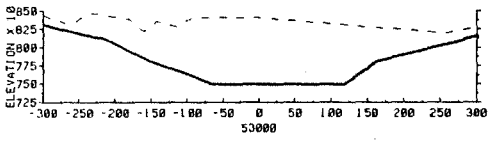


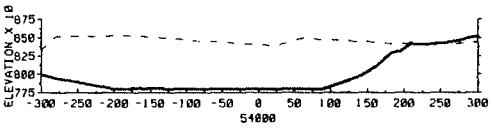












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

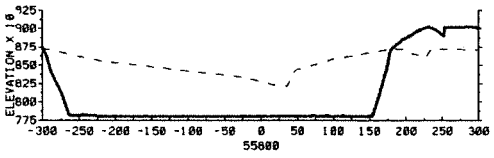
ELEVATION IS AHD EXAGGERATED 10 TIMES

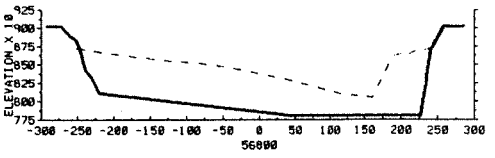
KEY TO CROSS SECTIONS

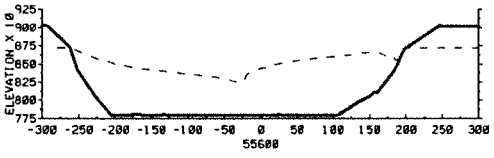
ORIGINAL CONTOURS

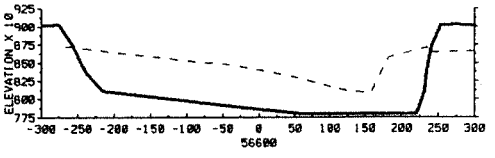
1992 ECHO SOUNDING

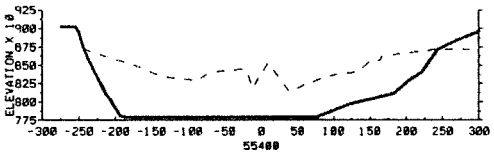
1991 ECHO SOUNDING

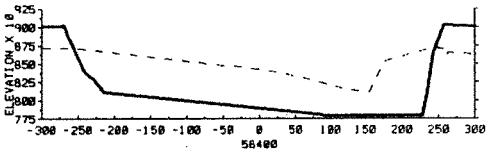


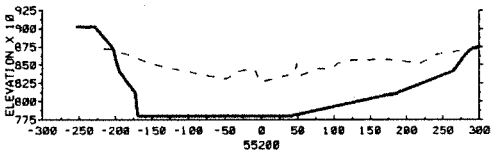


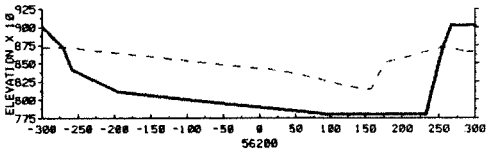


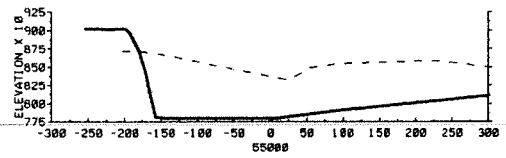


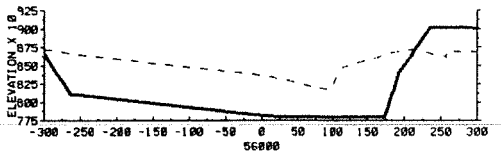












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

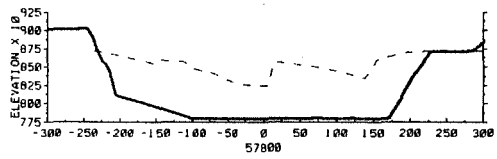
ELEVATION IS AHD EXAGGERATED 10 TIMES

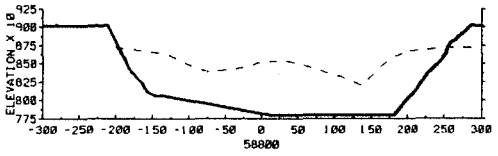
KEY TO CROSS SECTIONS

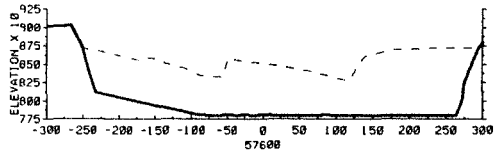
ORIGINAL CONTOURS

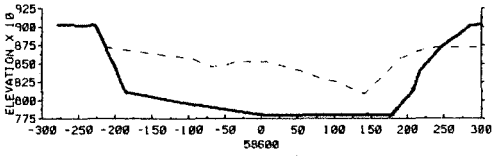
1992 ECHO SOUNDING

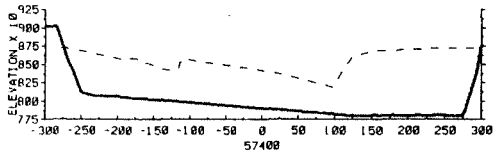
1991 ECHO SOUNDING

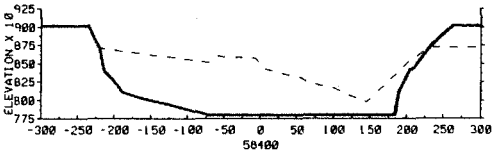


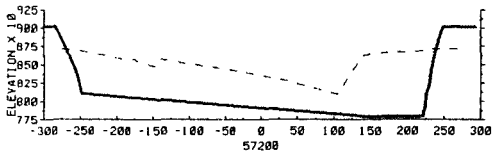


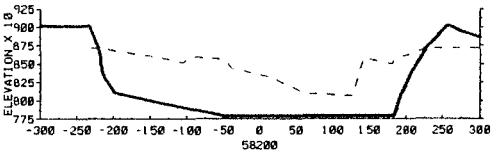


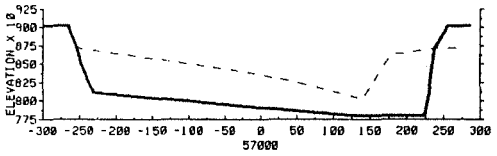


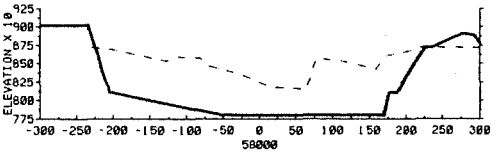












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

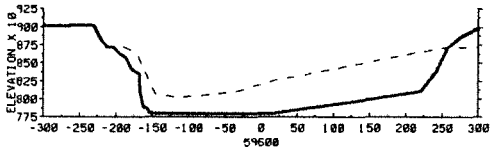
ELEVATION IS AHD EXAGGERATED 10 TIMES

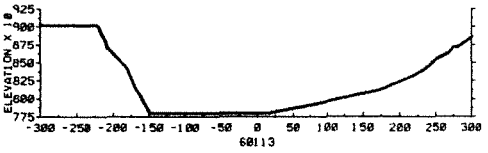
KEY TO CROSS SECTIONS

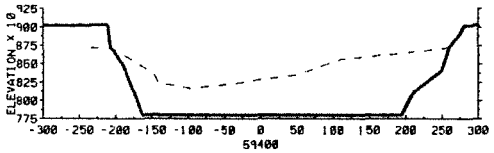
ORIGINAL CONTOURS

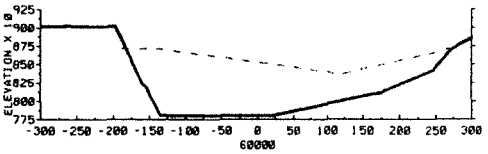
1992 ECHO SOUNDING

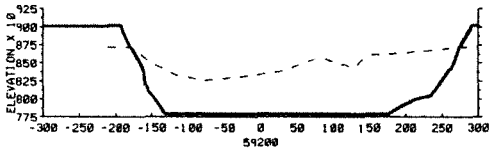
1991 ECHO SOUNDING

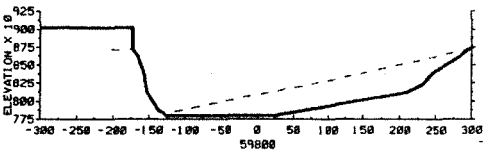


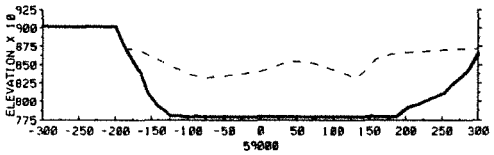












CROSS SECTIONS OF THE ORD RIVER

DISTANCES ARE METRES UPSTREAM FROM THE DAM

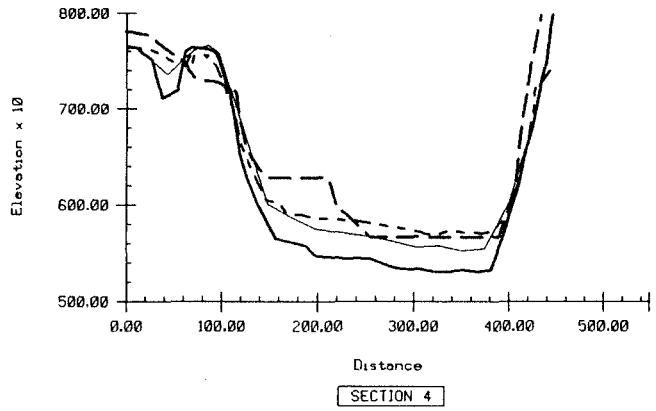
ELEVATION IS AHD EXAGGERATED 10 TIMES

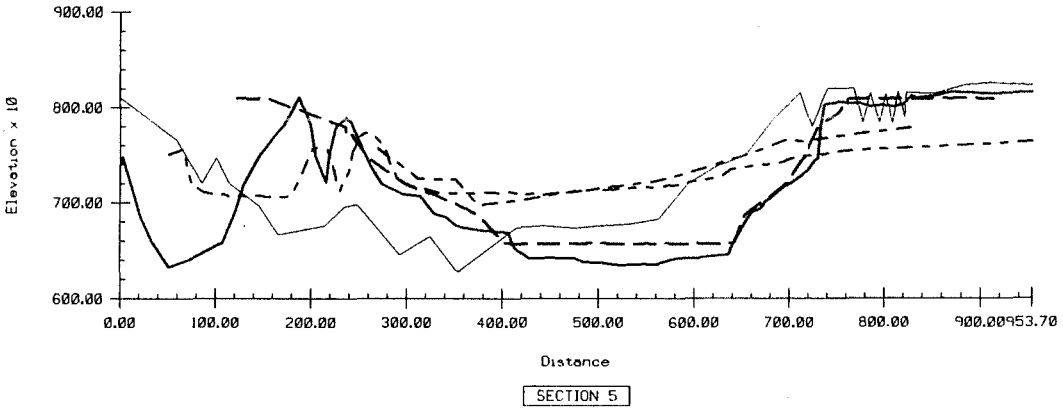
KEY TO CROSS SECTIONS

ORIGINAL CONTOURS

1992 ECHO SOUNDING

1991 ECHO SOUNDING

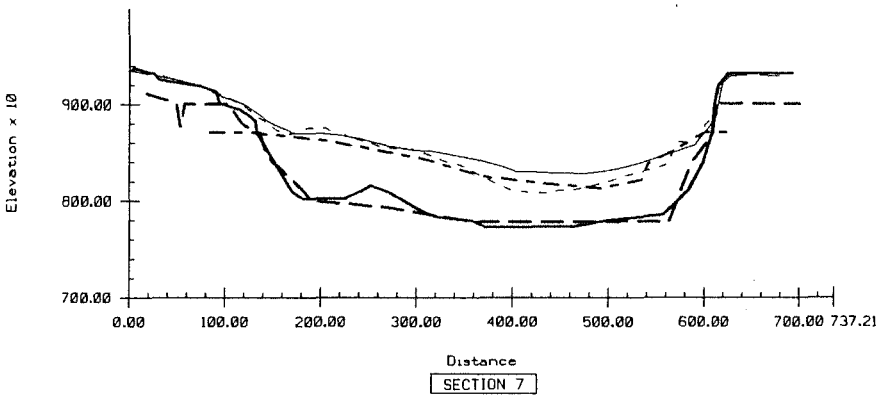




LEGEND

LINE	SURVEY METHOD
- - -	ORIGINAL CONTOURS
———	1985 SURVEY
———	1986 SURVEY
- - - -	1991 SURVEY
— - —	1991 ECHO SOUNDING
— - -	1992 ECHO SOUNDING

Scaled 10 Times AHD



ECHO SOUNDING CROSS SECTIONS AND HISTORICAL SURVEYS AT SECTIONS 4, 5 & 7

ELEVATION AHD VERTICAL SCALE EXAGGERATED

e:\ord\model\tranbase.dgn Oct. 13, 1994 14:09:53

APPENDIX C

PERSPECTIVE VIEWS OF CHANNEL AND SEDIMENT

Perspective Views of Digital Terrain Models of

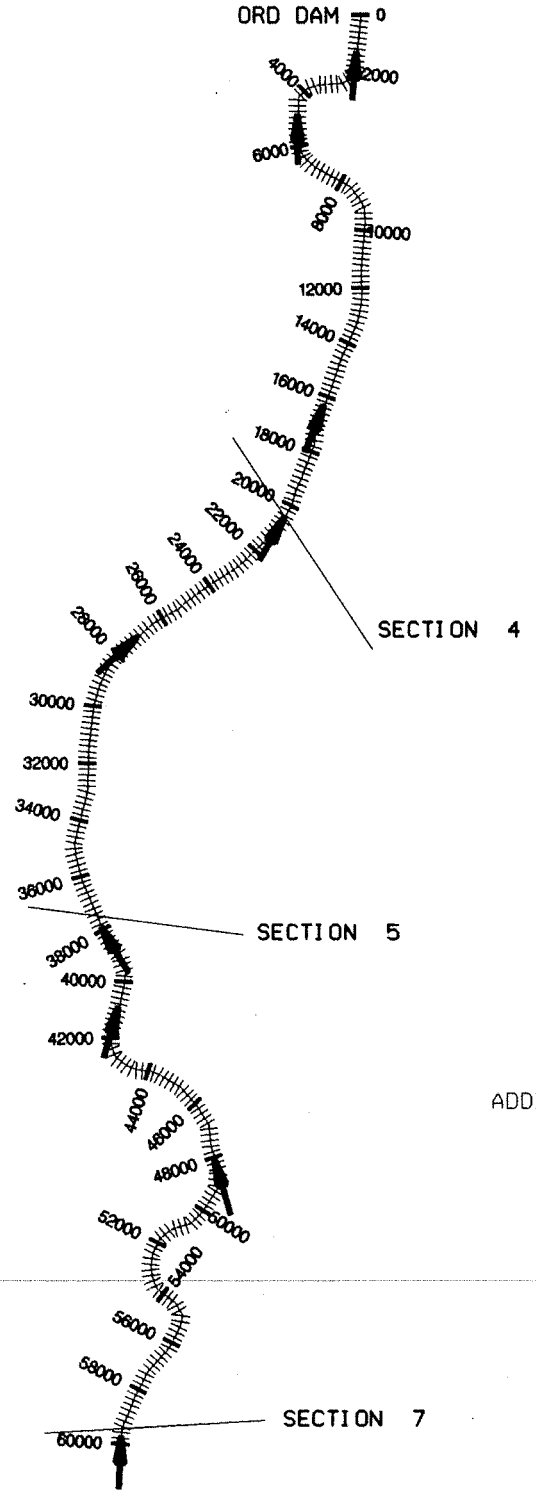
THE ORD RIVER CHANNEL UNDER LAKE ARGYLE

In all views:
Vertical scale is 10 times horizontal scale
Squares have 25 metre sideshorizontally
Observer is facing generally North (downstream)

3 models are shown, identified by colour:
- **Original channel from contours**
- **Channel in 1991 from echo-sounding**
- **Channel in 1992 from echo-sounding**

Views progress towards dam from upstream end of lake.

Prepared by Geoff Mauger and Bernie Hawkins
Water Authority of Western Australia, Oct 1994



5 KMS
SCALE

KEY TO CROSS SECTIONS

ORIGINAL CONTOURS

1991 ECHO SOUNDING

1992 ECHO SOUNDING

ADDITIONAL LEGEND ON HISTORICAL CROSS SECTIONS

PERSPECTIVE VIEW

PLAN SHOWING LOCATION OF FOLLOWING CROSS SECTIONS, HISTORICAL SECTIONS AND PERSPECTIVE VIEWS.

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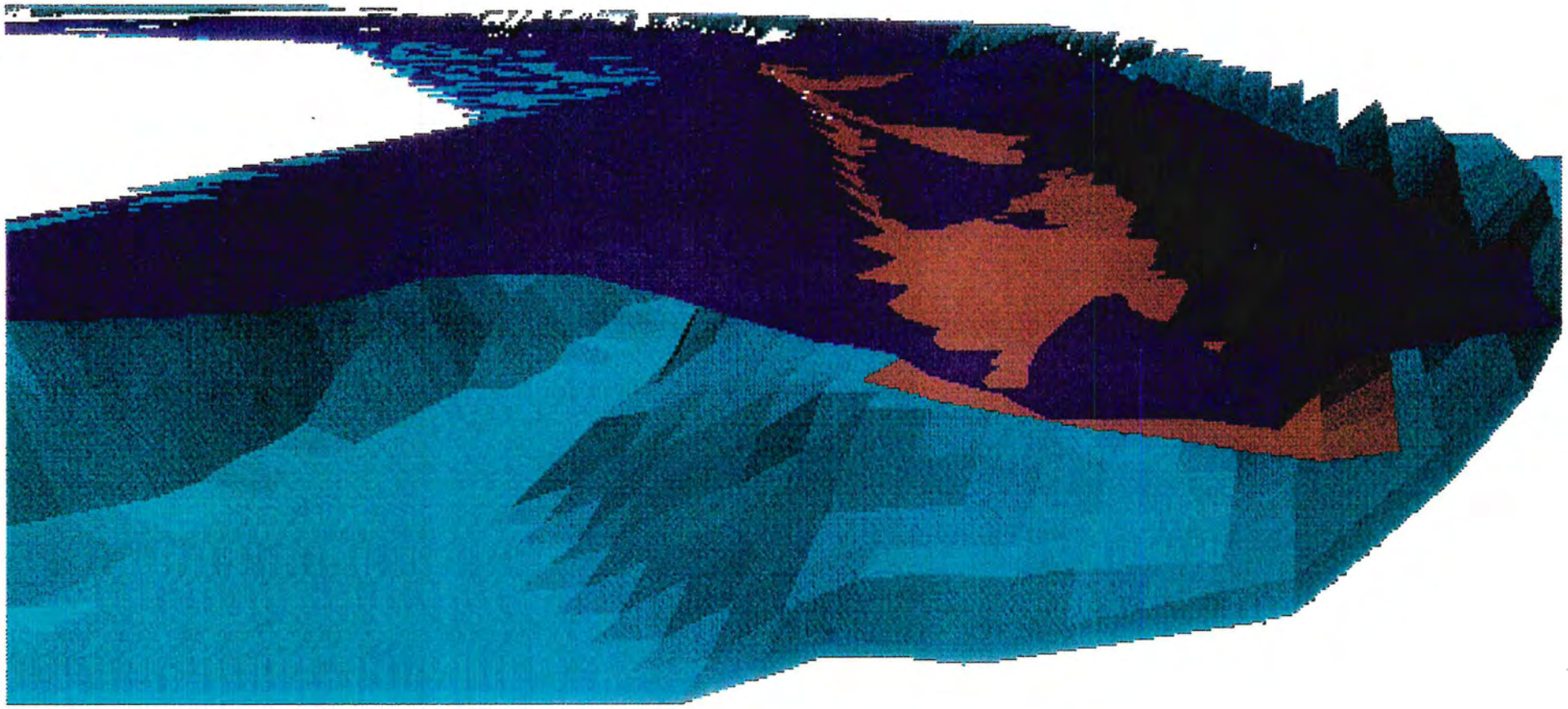
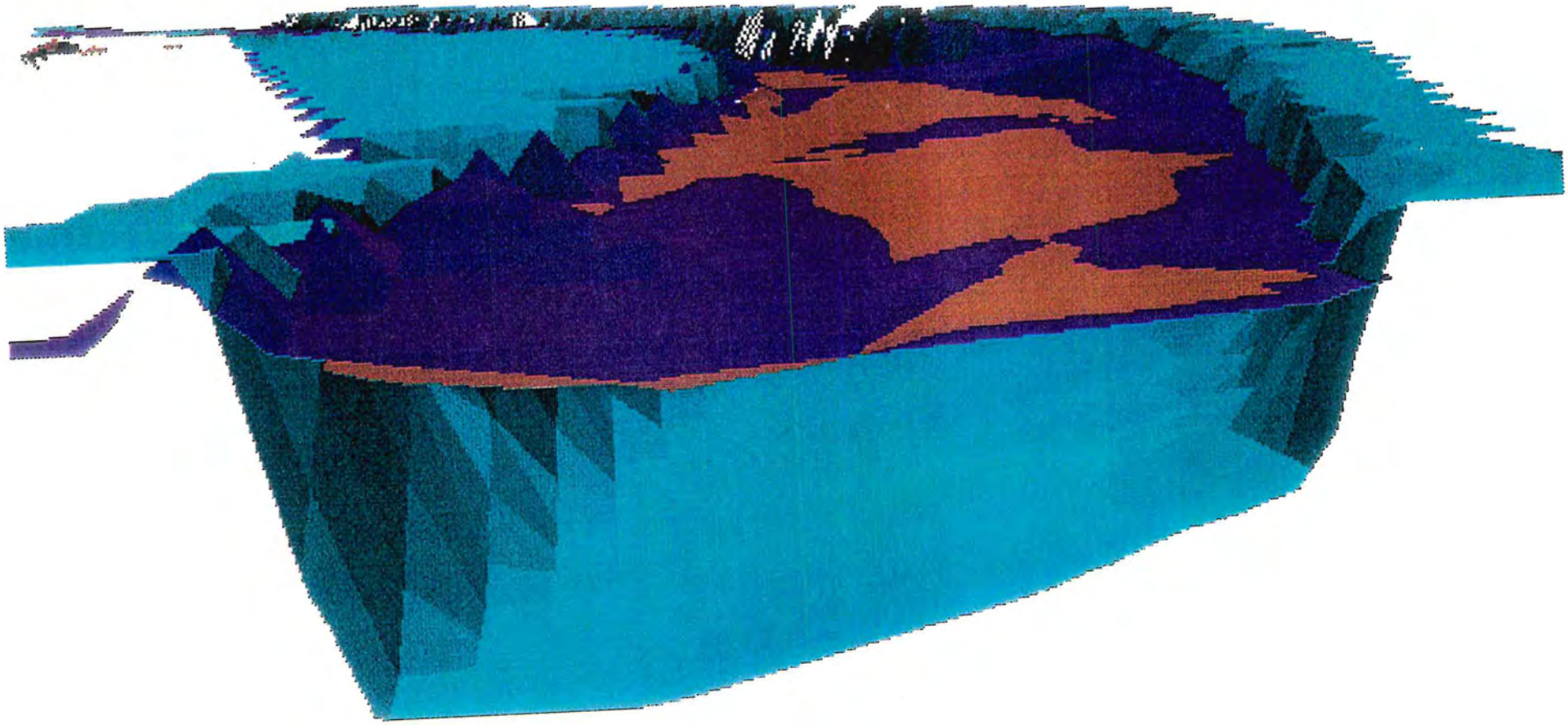
59.5 km from dam (Section 7)

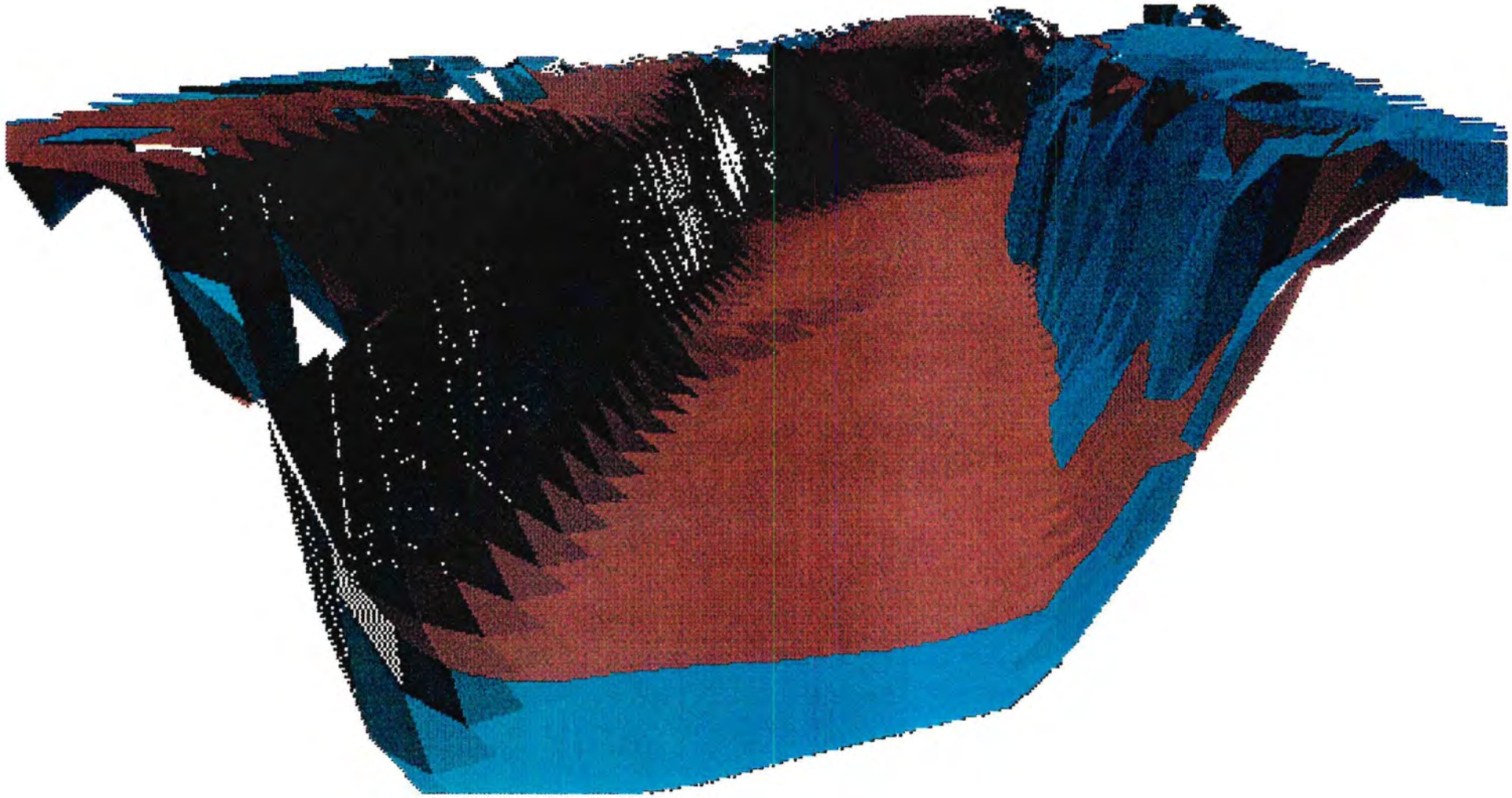


48.1 km from dam

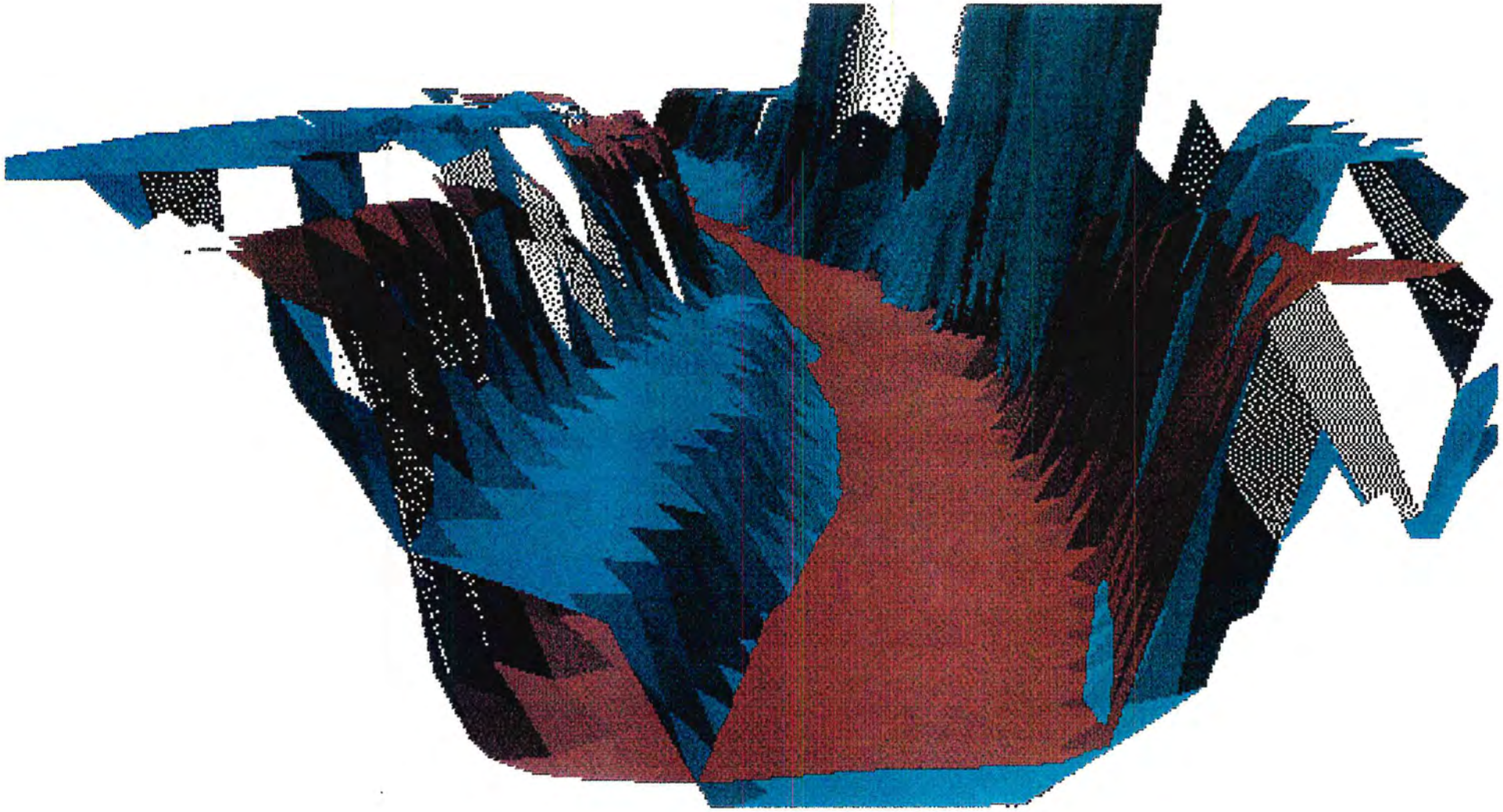


40.9 km from dam

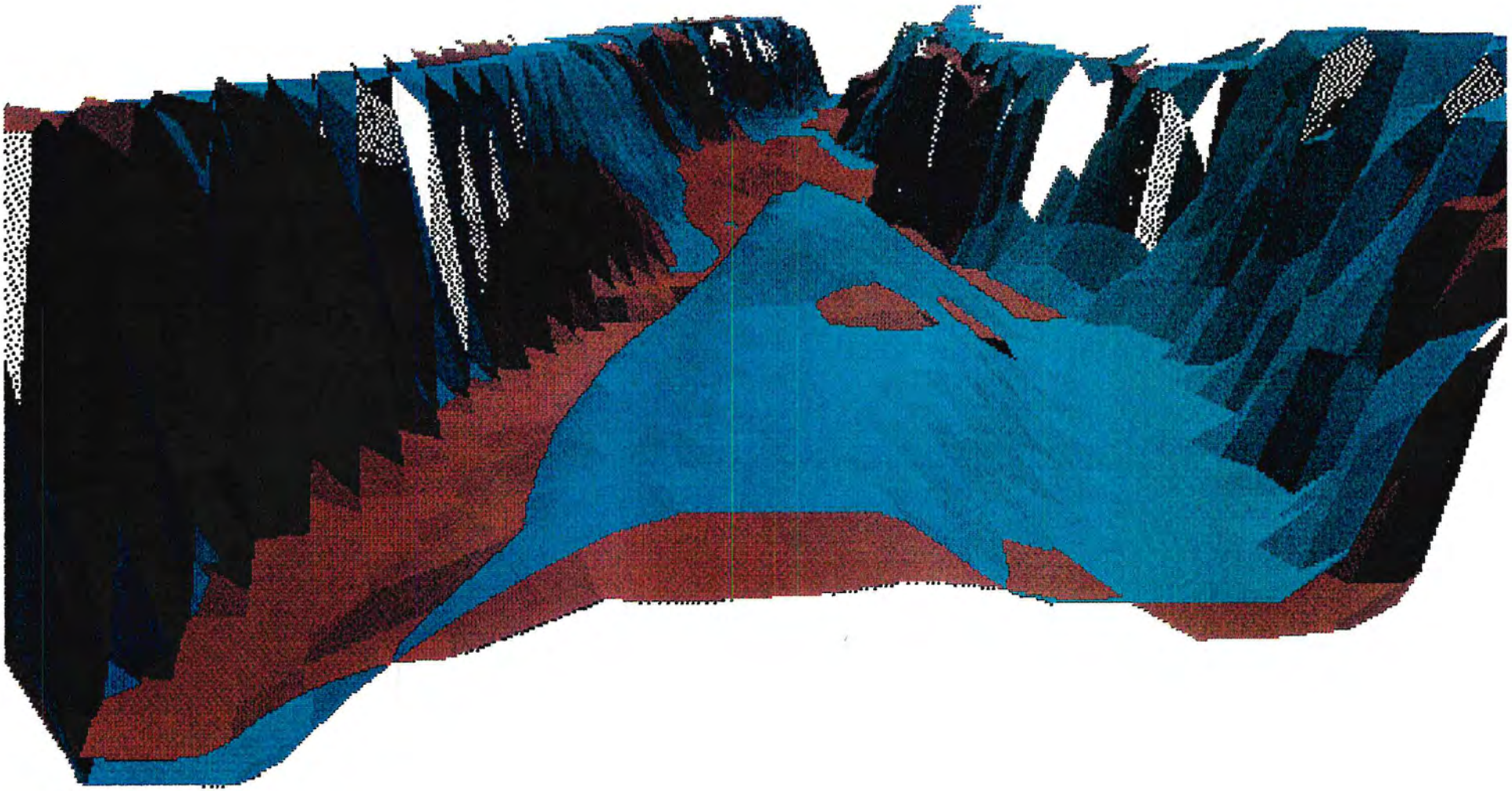
37.9 km from dam (Section 5)



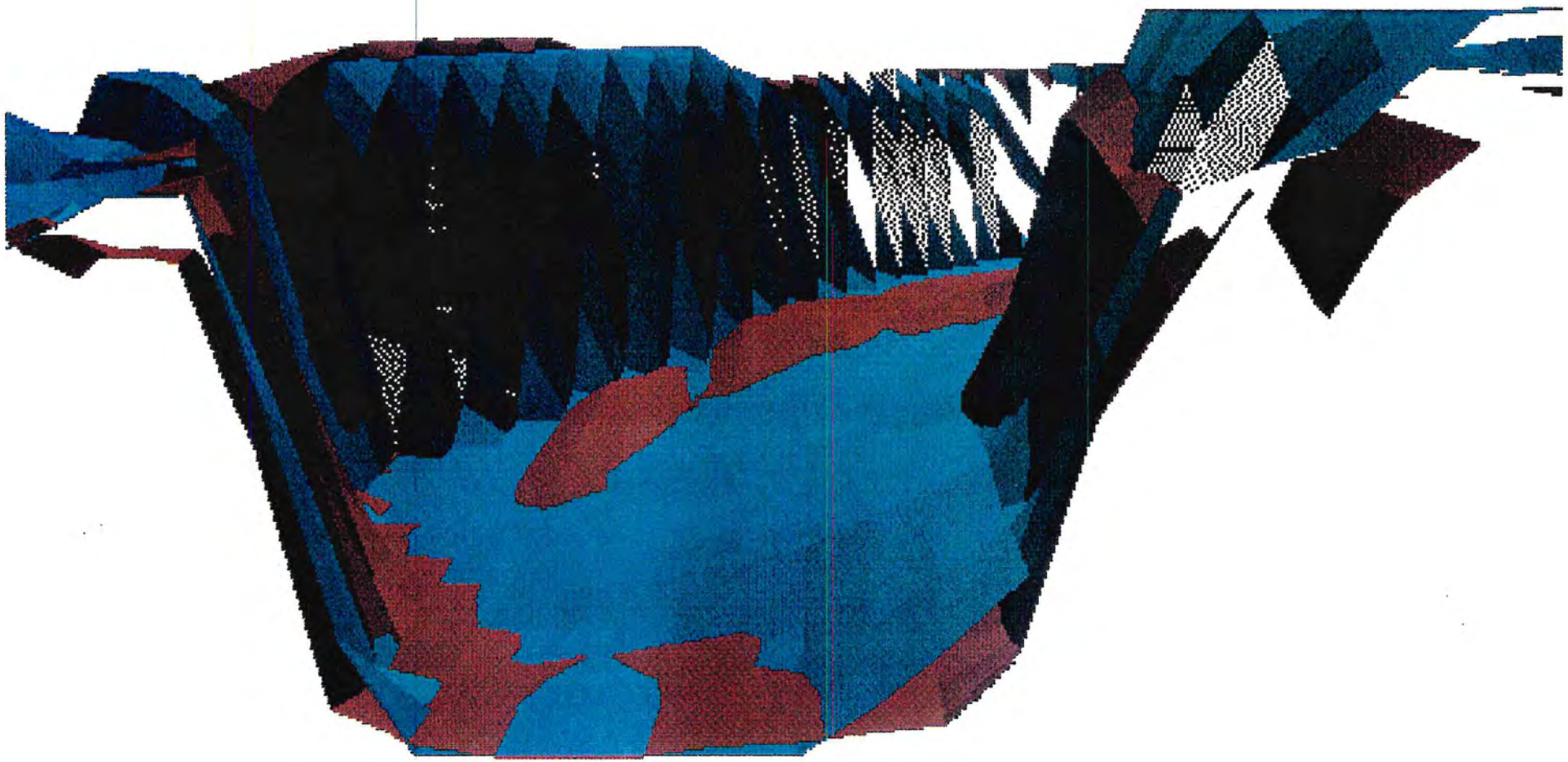
27.1 km upstream of dam



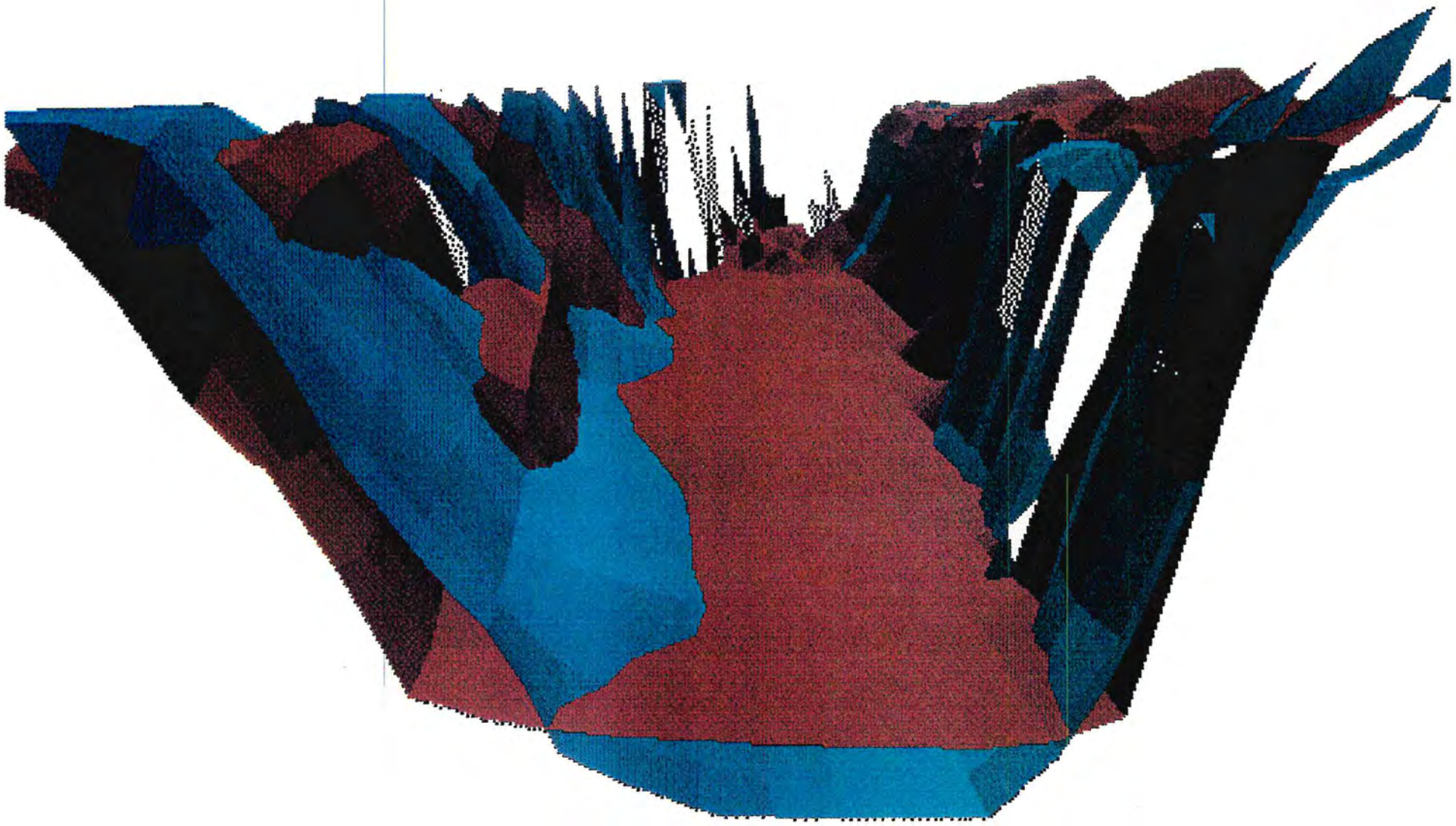
20.5 km upstream of dam (Section 4)



16.3 km upstream of dam



4.9 km upstream of dam



1.3 km upstream of dam

APPENDIX D

FORTRAN PROGRAMS TO PROCESS ORD RIVER SEDIMENT SURVEY DATA

APPENDIX D: FORTRAN PROGRAMS TO PROCESS ORD RIVER SEDIMENT SURVEY DATA

DS2XYZ	Change HYDRO format data to ASCII format
LINBRK	Break run-line records at end of run-line
XLORD	Resequence run-line data from cross-section to longitudinal lines
ORDLAB	Relabel run-lines to give collating sequence north to south

```
      PROGRAM DS2XYZ
C REFORMAT ECHO SOUNDING DATA FROM DON SHEPHERD INTO ASCII X,Y,Z DATA
C FOR INPUT TO MICROSTATION USING ASC2DGN
      CHARACTER*40 FIN,FOUT,LAB,NAB,SEQ
      REAL*8 X,Y,Z
      ISEQ=0
      LSEQ=0
      MO=0
C NAMES OF OUTPUT FILE AND LIST OF INPUT FILES WILL BE READ FROM STANDARD INPUT
C IF FILE NAMES ARE LISTED IN AN EDIT FILE, USE DOS REDIRECTION '<' TO GET THEM
C READ AS STANDARD INPUT.
C OPEN FILE FOR WRITING REFORMATTED DATA
      READ(*,10,END=99) FOUT
      OPEN(UNIT=2,FILE=FOUT)
10    FORMAT(A40)
C OPEN A NEW FILE OF INPUT DATA
1     READ(*,10,END=99) FIN
      OPEN(UNIT=1,FILE=FIN)
C READ DATA FOR ONE POINT, DOWN TO LEVEL VALUE
2     READ(1,*,END=88) IT
      READ(1,*,END=88) X
      READ(1,*,END=88) Y
      READ(1,*,END=88) LAB
C TEST LEVEL VALUE TO SEE IF POINT IS REALLY PART OF RUN-LINE
      IF(LAB.EQ.'NULL') THEN
C IF NOT, READ OVER NEXT TWO LINES OF INPUT
       READ(1,*,END=88) SEQ
        READ(1,*,END=88) SEQ
        GO TO 2
      ELSE
C READ LEVEL OUT OF 'LAB'
       READ(LAB,*) Z
      ENDIF
C READ RUN-LINE LABEL
      READ(1,*,END=88) LAB
      IF(LAB(1:1).EQ.' ') LAB=LAB(2:40)
      NAB=LAB
C IF 4TH CHARACTER IS A LETTER, NEED TO SHIFT LABEL 1 CHARACTER LEFT
C SO THAT RUN-LINE DIGITS CAN BE READ FROM POSITIONS 4-6
      IF(ICHAR(LAB(4:4)).GT.57) LAB=LAB(2:40)
C      WRITE(*,*) IT,'=',LAB,'='
C TAKE POINT SEQUENCE NO. OFF NEXT RECORD (NO FURTHER USE)
      READ(1,*,END=88) SEQ
C READ TENTATIVE VALUE OF RUN-LINE DIGITS
      READ(LAB,30) NSEQ
30    FORMAT(3X,I3)
C IF > 0, UPDATE CURRENT RUN-INE DIGITS
      IF(NSEQ.GT.0) ISEQ=NSEQ
C IF NOT THE SAME AS AT LAST POINT, END RUN-LINE IN OUTPUT AND START
C NEW LINE WITH RUN-LINE LABEL AND ARBITRARY SCALE OF 1:20000
      IF(ISEQ.NE.LSEQ) THEN
        IF(LSEQ.NE.0) WRITE(2,20) -1.
        WRITE(2,25) NAB(1:20)
25      FORMAT(A20,' 20000.')
        LSEQ=ISEQ
      ENDIF
C WRITE NEW POINT TO OUTPUT
     WRITE(2,20) X,Y,Z
C SET FLAG TO SHOW A POINT WAS FOUND IN INPUT FILE
      MO=0
20  FORMAT(2F15.0,F15.4,I5)
      GO TO 2
C IF ANY POINTS FOUND IN INPUT FILE, WRITE END OF RUN-LINE
88    IF(MO.EQ.0) THEN
        WRITE(2,20)  -1.
        WRITE(*,20)  -1.
        MO=1
      ENDIF
      WRITE(*,*) 'CLOSING FILE',FIN
      CLOSE(1)
C GO AND SEE IF MORE INPUT FILES TO READ
      GO TO 1
99    STOP
      END
```

```
      PROGRAM LINBRK
C REGROUP POINTS WHERE NEW LABEL WAS STARTED BEFORE ACTUAL END OF LINE
C I.E. TAKE NEW LINE ONLY WHEN DISTANCE BETWEEN CONSECUTIVE POINTS
C EXCEEDS TOLERANCE.
C REPORT WHEN NEW LINE STARTS WITHOUT FIRST FINDING A NEW LABEL (**)
C OR WHEN A NEW LABEL IS NOT USED DUE TO NO GAPS IN DATA (++)
      CHARACTER*33 FIN,FOUT,LAB,LABO
      REAL*8 X,Y,Z,XO,YO,ZO
      WRITE(*,*) 'OUTPUT FILE ->'
      READ(*,10,END=99) FOUT
      OPEN(UNIT=2,FILE=FOUT)
10    FORMAT(A33,A2)
      WRITE(*,*) 'INPUT FILE ->'
      READ(*,10,END=99) FIN
      OPEN(UNIT=1,FILE=FIN)
      WRITE(*,*) 'BREAK LINE IF DISTANCE EXCEEDS (M) ->'
      READ(*,*) TOL
      DIST=-1
      LR=0
C LC COUNTS POSITION IN DATA FILE TO LOCATE MANUAL CHECKS
      LC=1
C LCL MARKS POSITION OF LABEL WHEN IT IS FOUND TO BE UNUSED
      LCL=1
      LABO=' '
      READ(1,10,END=99)LAB
1     READ(1,20)X,Y,Z
      LC=LC+1
      IF(X.LT.0) THEN
C INPUT DATA SAYS RUN-LINE ENDS HERE.  DOES IT?
        IDO=0
        IF(LR.EQ.0.AND.LAB.NE.LABO) THEN
C NEW LABEL OCCURS WITHOUT PREVIOUS ONE BEING WRITTEN. MANUAL CHECK NEEDED
          WRITE(*,*) '**',LABO,'**',LCL
C IDO FLAGS THAT NEW LABEL WAS ENCOUNTERED, BUT LINE MAY CONTINUE
          IDO=1
        ENDIF
C SAVE OLD LABEL FOR CHECK WHEN REAL END OF LINE FOUND
        LABO=LAB
        READ(1,10,END=99)LAB
        IF(IDO.EQ.1) THEN
C NO NEW LINE WAS STARTED SINCE LAST LABEL CHANGE. MANUAL CHECK NEEDED
          WRITE(*,*) '++',LAB,'++ AT ',LC
        ENDIF
        LC=LC+1
        LR=0
        LCL=LC
        GO TO 1
      ENDIF
C CHECK THAT DISTANCE FROM PREVIOUS POINT IS LESS THAN TOLERANCE
      IF(DIST.LT.0) THEN
C FIRST TIME HERE IN PROGRAM, ALWAYS START NEW RUN-LINE
      WRITE(2,10) LAB,'3D'
C LR=1 SAYS CURRENT RUN-LINE HAS LABL 'LAB'
        LR=1
        XO=X
        YO=Y
        DIST=0
      ELSE
        DIST=SQRT((XO-X)*(XO-X)+(YO-Y)*(YO-Y))
        IF(DIST.GT.TOL) THEN
C IF TOL EXCEEDED, START NEW LINE
          WRITE(2,20) -1
          WRITE(2,10) LAB,'3D'
          LR=1
        ENDIF
C UPDATE LAST X,Y FOR TESTING DISTANCE TO NEXT X,Y
        XO=X
        YO=Y
        WRITE(2,20) X,Y,Z
      ENDIF
      GO TO 1
20    FORMAT(2F15.0,F15.4)
99    WRITE(2,20) -1
      END
```

```
      PROGRAM XLORD
C FROM AN INPUT OF CROSS-SECTIONS, CONSTRUCT RECORDS WHICH ARE LONGITUDINAL
C TAKE RECORDS FROM 'INPUT' FILE, SELECT POINTS, THEN WRITE TO 'OUTPUT' FILE.
      INCLUDE 'REWRMS.FOR'
      INCLUDE 'FNCMN.FOR'
      INCLUDE 'OPTIONS.FOR'
      COMMON/I/NDC
      COMMON/C/FNAME
      CHARACTER * 40 FNAME
      REAL           CROSS(714),LONG(714),SIXTN,MNN,RIC
      INTEGER   *  4 CRS45(2),LNG45(2),NNN(232)
      EQUIVALENCE    (CROSS(4),CRS45(1)),(LONG(4),LNG45(1))
      CHARACTER * 20 HEAD,HDIND(LNINDX)
      INTEGER*2 LP(LNINDX)
      CHARACTER * 40 ANS
      LOGICAL        OPT3ST,EX
      DATA           HEAD,FORM/'UNLABELLED ','(I )'/
      SIXTN=16
      MNN=-100
C     INTIALISE ARRAYS
      DO 333,I=1,LNINDX
         CLEV(I,1)=0.
         CLEV(I,2)=0.
         IPNT(I,1)=0
         IPNT(I,2)=0
333   CONTINUE
         HDIND(1)=HEAD

      WRITE(*,*)' INPUT FILE      '
      CALL OPENMS(1,INDX,LNINDX,0,FNAMEI,EX)
100   WRITE(*,*)' OUTPUT FILE        '
      CALL OPNFIL(2,INDX,LNINDX,0,FNAMEO,EX)
      IF (EX) THEN
C       PROMPT FOR ANOTHER FILE NAME
        WRITE(*,*)FNAMEO,' EXISTS. MUST WRITE TO NEW FILE.'
        GO TO 100
      ENDIF
      WRITE(*,*) ' REPORT FILE [',CHARNB(FNAMER),']'
      READ(*,*) ANS
      IF(ANS.NE.'Z'.AND.ANS.NE.'z') FNAMER=ANS
      OPEN(UNIT=9,FILE=FNAMER)
C LOAD INDEXES FROM DONOR FILE
      CALL READM3(1,CLEV(1,1),LNINDX,1)
      CALL READM3(1,IPNT(1,1),LNINDX,2)
      DO 202,K=3,LNINDX
         IF(IPNT(K,1).GT.0) THEN
          READ(1,REC=IPNT(K,1)) (RMN(J,1),J=1,5)
          HDIND(K)=RMN(1,1)//RMN(2,1)//RMN(3,1)//RMN(4,1)//RMN(5,1)
         ENDIF
 202  CONTINUE
C START RECORD COUNT FOR NEW FILE
      NCL=3
C SET SELECTION OPTIONS
      CALL SETOPT(1,FNAMEI)
C
C ASSUME ORDER OF PRESENTATION IN INDEX IS DESIRED ORDER
C SET TOLERANCE OF LEVEL (Z-VALUE) THAT CAN BE JOINED TO PREVIOUS POINT
      WRITE(*,*) 'ENTER TOLERANCE TO FIT LEVEL ->'
      READ(*,*) GTOL
C SET TOLERANCE OF HOW MANY POINTS CAN BE SKIPPED TO FIND NEXT POINT
C      WRITE(*,*) 'ENTER MAX MISMATCH IN DISTANCE FROM EDGE ->'
C      READ(*,*) GAP
C SQUARE GAP FOR EASY COMPARISON
C       GAP=GAP*GAP
C (IF 1ST LEVEL CHANGE IS ZERO, PRESUME DOWNHILL)
      OTOL=TOL
C SET STARTING POSITION IN INDEX
      ICB=1
      DO 22 I=3,LNINDX
      IF(INDX(I,1).EQ.0) GO TO 4
      CALL READM3(1,CROSS,714,I)
         NWC=CRS45(2)*3+15
C FIND POSITION OF LOWEST POINT
C POINTS BEFORE LOWEST PT WILL NOT BE JOINED TO PTS AFTER, & VICE VERSA
         DO 36 J=21,NWC,3
36       IF(CROSS(J).EQ.CROSS(18)) GO TO 37
37       LP(I)=J-2
22    CONTINUE
```

```
4     DO 2 I=3,LNINDX
      IF(INDX(I,1).EQ.0) GO TO 3
C USE 'VALUE' WORD TO TRACK STARTING POINT IN RECORD
2     WRITE(1,REC=INDX(I,1)+5) SIXTN
3     IL=19
      NNN(1)=-100
C EXTRACT RECORDS FROM INDEX
      DO 1 I=ICB,LNINDX
      NCC=IPNT(I,1)
C IF WE RUN OUT OF RECORDS TO READ AND SOME NEW RECORD IS GENERATED,
C  WRITE IT
      IF(NCC.EQ.0.AND.IL.GT.19)GO TO 130
5     IF(NCC.EQ.0) GO TO 1
35       CALL READM3(1,CROSS,714,NCC)
C       WRITE(9,*)'NCC',NCC, (J,CROSS(J),J=3,6)
C LEAVE OUT REPEAT OF 1ST POINT IN COMPUTING RECORD LENGTH
         NWC=CRS45(2)*3+15
C        CHECK OPTIONS
         IF(OPT3ST(1,HEAD,CROSS,NCC)) GO TO 6
C  SET SEARCH LIMITS IN POINT SEQUENCES
           IF(CROSS(6).GT.0) THEN
             IP1=19
             IPB=CROSS(3)+3
             IPE=NWC-2
             IPI=3
           ELSE
             IPE=19
             IF(CROSS(3).EQ.16) CROSS(3)=NWC+1
             IP1=NWC-2
             IPB=CROSS(3)-3
             IPI=-3
           ENDIF
         IF(IL.EQ.19) THEN
           WRITE(9,*) '1..B,E,I,NCL',IPB,IPE,IPI,NCL
C START NEW RECORD IN OUTPUT
C MAKE STACK OF RECORDS USING POINTS FROM LAST STARTING POINT TO
C NEXT FREE POINT
           NST=0
           IOK=0
           DO 10 IC=IP1,IPE,IPI
           IF(IC.NE.IP1) THEN
             IF(CROSS(IC-IPI+2).LT.-100) THEN
               NST=NST+1
               NNN(NST)=CROSS(IC-IPI+2)
             ENDIF
           ENDIF
           IF(IC.EQ.IPB) IOK=1
10         IF(IOK.EQ.1.AND.CROSS(IC+2).GT.0) GO TO 11
C IF HERE, THIS RECORD USED UP.
           ICB=ICB+1
C           WRITE(9,*) 'ICB',ICB
           IF(IPNT(ICB,1).GT.0) GO TO 4
C IF NO MORE IN INDEX, FINISH JOB
           GO TO 160
11         REF=CROSS(IC+2)
C           WRITE(9,*) 'IP1,IPB,IPE,IPI,IC',IP1,IPB,IPE,IPI,IC
C SET TOLERANCE BY NEXT CHANGE IN LEVEL, WITH SIGN SHOWING UP OR DOWN
C USE PREVIOUS TOL IF AT END OF LINE OR ZERO LEVEL CHANGE
C           IF(IC.NE.IPE) THEN
C             TOL=(CROSS(IC+2+IPI)-CROSS(IC+2))/2
C           ELSE
C             TOL=OTOL
C           ENDIF
           IF(TOL.EQ.0) TOL=OTOL
           IF(ABS(TOL).LT.GTOL) TOL=SIGN(GTOL,TOL)
           OTOL=TOL
           LONG(6)=ABS(CROSS(6))
           HEAD=RMN(1,1)//RMN(2,1)//RMN(3,1)//RMN(4,1)//RMN(5,1)
           WRITE(9,*)'REF,TOL,OTOL,HEAD',REF,TOL,OTOL,HEAD
           SX=CROSS(IC)
           SY=CROSS(IC+1)
           SZ=CROSS(IC+2)
           NCCS=NCC
           ICSV=IC
           LPS=LP(NCC)-IC
           IPS=IPI
C           GAPS=(CROSS(IP1)-CROSS(IC))**2+(CROSS(IP1+1)-CROSS(IC+1))**2
         ELSE
```

```
C FIND NEXT POINT ALONG CROSS RECORD TO GO IN LONG RECORD
        WRITE(9,*) 'IL..B,E,I',IL,IPB,IPE,IPI,'TOL,REF',TOL,REF
C CHECK DOWN STACK FROM PREVIOUS CROSS-SECTION UNTIL ONE OF THE RECORDS
C IS FOUND ON THIS CROSS-SECTION. SET SEARCH START AFTER THAT POINT.
          INST=NST
          IF(NST.EQ.0) GO TO 17
C          WRITE(9,*)'NNN',(NNN(IC),IC=1,INST)
16        DO 19 IC=IPB,IPE,IPI
19        IF(CROSS(IC+2).EQ.NNN(INST)) GO TO 18
          IF(INST.EQ.1) GO TO 17
          INST=INST-1
          GO TO 16
18        IPB=IC+IPI
17        IF(INST.EQ.0) INST=1
C SHOULD ONLY JOIN POINTS WHICH ARE IN A COMPARABLE POSITION ALONG C/S
C I.E. ON THE SAME SIDE OF CROSS-SECTION LOW POINT
          IF((LP(NCC)-IPB)*IPI*LPS*IPS.GT.0) THEN
            IF(LPS*IPS.GT.0) THEN
              IPE=LP(NCC)
            ENDIF
          ELSE
            IF(LPS*IPS.LT.0) THEN
              IPB=LP(NCC)
            ENDIF
          ENDIF
          WRITE(9,*) 'LPS,IPS,IPI,LP,IPB,IPE',
     1     LPS,IPS,IPI,LP(NCC),IPB,IPE
          IF(IPE*IPI.LT.IPB*IPI) GO TO 14
C CHECK IF ELIGIBLE POINTS MEET ACCEPTABILITY CRITERIA
C START AFTER PREVIOUS LONG RECORD
          DO 12 IC=IPB,IPE,IPI
          WRITE(9,*)'IC,CROSS(IC+2)',IC,CROSS(IC+2)
C POINT POSITION IN CROSS RECORD
C           IF(ABS((CROSS(IP1)-CROSS(IC))**2+(CROSS(IP1+1)-CROSS(IC+1))
C     1      **2 -GAPS).GT.GAP) GO TO 12
C DON'T CROSS NEXT LONG RECORD AHEAD IN CROSS-SECTION
          IF(CROSS(IC+2).LT.-100) GO TO 14
C LEVEL WITHIN TOLERANCE RANGE
          IF(ABS(CROSS(IC+2)-REF).LE.TOL)    GO TO 13
12        CONTINUE
C IF HERE, NO POINTS IN THIS RECORD MATCHED. WRITE LONG
14        CONTINUE
          WRITE(9,*) 'NO MATCH..WRITE REC',NCL,'NNN',NNN(INST)
          GO TO 130
13        CONTINUE
        ENDIF
          RIC=IC
C WRITE POINT START IN 'VALUE' (CROSS(3)) TO MARK BEGINNING OF NEXT SEARCH
          WRITE(1,REC=INDX(NCC,1)+5) RIC
          WRITE(9,*) 'RIC,NCC',RIC,NCC
C SAVE THIS POINT AND WRITE PREVIOUS POINT
        IF(IL.GT.19) THEN
          LONG(IL-3)=SX
          LONG(IL-2)=SY
          LONG(IL-1)=SZ
          MNN=-100-NCL
          WRITE(1,REC=INDX(NCCS,1)+ICSV+4) MNN
C          WRITE(9,*) 'OK AT ',IL-3 ,SX,SY,SZ,MNN
          SX=CROSS(IC)
          SY=CROSS(IC+1)
          SZ=CROSS(IC+2)
          NCCS=NCC
          ICSV=IC
          IPS=IPI
          LPS=LP(NCC)-IC
          REF=SZ
C          GAPS=(CROSS(IP1)-CROSS(IC))**2+(CROSS(IP1+1)-CROSS(IC+1))**2
        ENDIF
          IL=IL+3
C GET NEXT RECORD FOR NEXT POINT
          GO TO 6
C
C       WRITE NEW RECORD TO OUTPUT FILE IF MORE THAN 1 POINT
130     IF(IL.GT.24) THEN
          NDC=1
140       IF(HDIND(NDC).NE.HEAD .AND. IPNT(NDC,2).NE.0) THEN
            NDC=NDC+1
            IF(NDC.GT.LNINDX) CALL NXTFIL(NCL,HDIND)
```

```
            GO TO 140
          ENDIF
          RMN(1,2)=HEAD( 1: 4)
          RMN(2,2)=HEAD( 5: 8)
          RMN(3,2)=HEAD( 9:12)
          RMN(4,2)=HEAD(13:16)
          RMN(5,2)=HEAD(17:20)
          HDIND(NDC)=HEAD
          LONG(3)=NDC
          CLEV(NDC,2)=NDC
          LNG45(1)=IPNT(NDC,2)
          IPNT(NDC,2)=NCL
C WRITE IN SAVED PREVIOUS POINT
          LONG(IL-3)=SX
          LONG(IL-2)=SY
          LONG(IL-1)=SZ
          MNN=-100-NCL
          WRITE(1,REC=INDX(NCCS,1)+ICSV+4) MNN
C          WRITE(9,*) 'LAST OK AT ',IL
C        ADD COPY OF 1ST POINT AS LAST POINT.
          NWL=IL+2
          LONG(NWL-2)=LONG(19)
          LONG(NWL-1)=LONG(20)
          LONG(NWL)=LONG(21)
          LNG45(2)=NWL/3-6
          CALL S3TLIM(LONG,NWL)
C        WRITE(9,*)'NCC',NCC, (J,CROSS(J),J=3,6)
          CALL WRITMS(2,LONG,NWL,NCL,0)
          NCL=NCL+1
          IF(NCL.GT.LNINDX) CALL NXTFIL(NCL,HDIND)
        ENDIF
C START ANOTHER LONG RECORD
        GO TO 3
C       GO BACK FOR MORE INPUT RECORDS
6       NCC=CRS45(1)
        GO TO 5
1     CONTINUE
C
C GO THROUGH INPUT FILE AND WRITE OUT UNUSED POINTS AS SEPARATE RECORDS
C
160   DO 50 I=1,LNINDX
      NCC=IPNT(I,1)
      IF(NCC.EQ.0) GO TO 150
51    IF(NCC.EQ.0) GO TO 50
      CALL READM3(1,CROSS,714,NCC)
C     CHECK OPTIONS
      IF(OPT3ST(1,HEAD,CROSS,NCC)) GO TO 63
      HEAD=RMN(1,1)//RMN(2,1)//RMN(3,1)//RMN(4,1)//RMN(5,1)
C LEAVE OUT REPEAT OF 1ST POINT IN COMPUTING RECORD LENGTH
      NWC=CRS45(2)*3+15
      IPB=21
55    IS=0
      DO 60 IC=IPB,NWC,3
      IF(CROSS(IC).GT.0.AND.IS.EQ.0) IS=IC
60    IF(CROSS(IC).LT.0.AND.IS.NE.0) GO TO 65
      IC=NWC+3
      IF(IS.NE.0) GO TO 65
C     NO MORE POINTS IN THIS RECORD.. GET THE NEXT
63    NCC=CRS45(1)
      GO TO 51
C MAKE NEW RECORD FROM SEQUENCE OF POINTS 'IS' TO 'IC'
65    NDC=1
67    IF(HDIND(NDC).NE.HEAD .AND. IPNT(NDC,2).NE.0) THEN
        NDC=NDC+1
        IF(NDC.GT.LNINDX) CALL NXTFIL(NCL,HDIND)
        GO TO 67
      ENDIF
      HDIND(NDC)=HEAD
      RMN(1,2)=HEAD( 1: 4)
      RMN(2,2)=HEAD( 5: 8)
      RMN(3,2)=HEAD( 9:12)
      RMN(4,2)=HEAD(13:16)
      RMN(5,2)=HEAD(17:20)
      CLEV(NDC,2)=NDC
      ICRS=CRS45(1)
      CRS45(1)=IPNT(NDC,2)
      IPNT(NDC,2)=NCL
      DO 70 K=IS,IC-3,3
```

```
      CROSS(19+K-IS)=CROSS(K-2)
      CROSS(20+K-IS)=CROSS(K-1)
70    CROSS(21+K-IS)=CROSS(K)
      NWL=IC-IS+21
      CROSS(NWL-2)=CROSS(19)
      CROSS(NWL-1)=CROSS(20)
      CROSS(NWL)=CROSS(21)
      CRS45(2)=NWL/3-6
      CALL S3TLIM(CROSS,NWL)
      CALL WRITMS(2,CROSS,NWL,NCL,0)
      WRITE(9,*)'NCC,NCL',NCC,NCL,'CROSS', (J,CROSS(J),J=3,21)
      CRS45(1)=ICRS
      NCL=NCL+1
      IF(NCL.GT.LNINDX) CALL NXTFIL(NCL,HDIND)
C LOOK FOR MORE POINTS IN THIS RECORD
      IPB=IC+3
      IF(IC.LE.NWC) GO TO 55
50    CONTINUE
C
150   DO 212,NDC=1,LNINDX-1
212   IF(IPNT(NDC+1,2).EQ.0) GO TO 213
      NDC=LNINDX
213         WRITE(*,2002) (CLEV(K,2),IPNT(K,2),K=1,NDC)
2002        FORMAT(1X,5(F10.1,I5))
      CALL SHUT3(2,1,HDIND)
      END

      PROGRAM ORDLAB
C BASIC PROGRAM TO READ AND WRITE 3D POLYANA FILES
C TAKE RECORDS FROM 'DONOR' FILE, MODIFY IF DESIRED, THEN WRITE TO
C 'RECEIVING' FILE, IF DESIRED.
C IN THIS PROGRAM, CHANGE LABELS OF RECORDS (I.E. RUN-LINES) SO THAT ORDER
C OF RECORDS FROM NORTH TO SOUTH IS ALSO ALPHABETIC ORDER OF LABELS.
C TESTS APPLY TO LABELS SUPPLIED WITH 1992 ECHO-SOUNDING DATA
      INCLUDE 'REWRMS.FOR'
      INCLUDE 'FNCMN.FOR'
      INCLUDE 'OPTIONS.FOR'
      REAL            CROSS(714),LONG(714)
      INTEGER   *  4 CRS45(2),LNG45(2),NDC
      EQUIVALENCE    (CROSS(4),CRS45(1)),(LONG(4),LNG45(1))
      CHARACTER * 20 HEAD,HDIND(LNINDX)
      CHARACTER *  3 AA
      CHARACTER * 14 BB
      LOGICAL        OPT3ST,EX
      DATA           HEAD,FORM/'UNLABELLED ','(I )'/
      CALL FILEIN

C     INTIALISE ARRAYS
      DO 333,I=1,LNINDX
         CLEV(I,1)=0.
         CLEV(I,2)=0.
         IPNT(I,1)=0
         IPNT(I,2)=0
333   CONTINUE
         HDIND(1)=HEAD

      WRITE(*,*)' INPUT FILE      '
      CALL OPENMS(1,INDX,LNINDX,0,FNAMEI,EX)
100   WRITE(*,*)' OUTPUT FILE        '
      CALL OPNFIL(2,INDX,LNINDX,0,FNAMEO,EX)
      IF (EX) THEN
C       PROMPT FOR ANOTHER FILE NAME
        WRITE(*,*)FNAMEO,' EXISTS. MUST WRITE TO NEW FILE.'
        GO TO 100
      ENDIF
C LOAD INDEXES FROM DONOR FILE
      CALL READM3(1,CLEV(1,1),LNINDX,1)
      CALL READM3(1,IPNT(1,1),LNINDX,2)
      DO 202,K=3,LNINDX
         IF(IPNT(K,1).GT.0) THEN
          READ(1,REC=IPNT(K,1)) (RMN(J,1),J=1,5)
          HDIND(K)=RMN(1,1)//RMN(2,1)//RMN(3,1)//RMN(4,1)//RMN(5,1)
         ENDIF
 202  CONTINUE
C START RECORD COUNT FOR NEW FILE
      NCL=3
C SET SELECTION OPTIONS
      CALL SETOPT(1,FNAMEI)
```

```
C EXTRACT RECORDS FROM INDEX
      DO 1 I=1,LNINDX
      NCC=IPNT(I,1)
5     IF(NCC.EQ.0) GO TO 1
35       CALL READM3(1,CROSS,714,NCC)
         HEAD=RMN(1,1)//RMN(2,1)//RMN(3,1)//RMN(4,1)//RMN(5,1)
         NWC=CRS45(2)*3+18
         NCN=CRS45(1)
C        CHECK OPTIONS
         IF(OPT3ST(1,HEAD,CROSS,NCC)) GO TO 6
C
C  MODIFY LABEL OF ORD CHANNEL RUN-LINES TO GIVE COLLATING SEQUENCE N-S
C
C 'ARG' SHOULG BECOME 'ARN'
         IF(HEAD(3:3).EQ.'G') HEAD(3:3)='N'
C IF 4TH A LETTER (NOT 0 OR 1), MOVE 1 CHARACTER RIGHT TO READ NUMBER
         IF(HEAD(4:4).GT.'2') THEN
           READ(HEAD,1002) AA,NN,BB
1002       FORMAT(A3,1X,I3,A13)
           BB(14:14)=' '
         ELSE
           READ(HEAD,1001) AA,NN,BB
         ENDIF
1001     FORMAT(A3,I3,A14)
C ALL 'ARN' WILL COLLATE BEFORE 'ARS'
C CHANGE NUMBER SO THAT ORDER IS NORTH TO SOUTH
         NN=200-NN
         WRITE(HEAD,1001) AA,NN,BB
C
C        WRITE NEW RECORD TO OUTPUT FILE
         NDC=1
140      IF(HDIND(NDC).NE.HEAD .AND. IPNT(NDC,2).NE.0) THEN
            NDC=NDC+1
            IF(NDC.LE.LNINDX) GO TO 140
            WRITE(*,*) 'INDEX',I
            GO TO 160
         ENDIF
         RMN(1,2)=HEAD( 1: 4)
         RMN(2,2)=HEAD( 5: 8)
         RMN(3,2)=HEAD( 9:12)
         RMN(4,2)=HEAD(13:16)
         RMN(5,2)=HEAD(17:20)
         HDIND(NDC)=HEAD
         CROSS(3)=NDC
         CLEV(NDC,2)=NDC
         CRS45(1)=IPNT(NDC,2)
         IPNT(NDC,2)=NCL
         CALL WRITMS(2,CROSS,NWC,NCL,0)
         NCL=NCL+1
C        GO BACK FOR MORE INPUT RECORDS
6        NCC=NCN
         GO TO 5
1     CONTINUE

160   DO 212,NDC=1,LNINDX-1
212   IF(IPNT(NDC+1,2).EQ.0) GO TO 213
      NDC=LNINDX
213         WRITE(*,2002) (CLEV(K,2),IPNT(K,2),K=1,NDC)
2002        FORMAT(1X,5(F10.1,I5))
C SORT INDEX RECORDS BY CHARACTER COLLATING SEQUENCE
            CALL CHARST(HDIND,IPNT(1,2),NDC)
            WRITE(*,2002) (CLEV(K,2),IPNT(K,2),K=1,NDC)
            CALL WRITMS(2,INDX(1,2),LNINDX,0,-1)
            CALL WRITMS(2,CLEV(1,2),LNINDX,1,-1)
            CALL WRITMS(2,IPNT(1,2),LNINDX,2,-1)

      CLOSE(2,STATUS='KEEP')
      CALL FILEUP
      END
```

APPENDIX E

LETTER EXPLAINING LOCATION OF RUN-LINES

Sea & Land Surveying

14 Langdale Street
Wembley Downs W.A. 6019 Ph: (09) 341 6462
Principal: D.M. Shepherd L.S. MIS Dip Eng Surv
Master Class 5

Chief Engineering Surveyor
Water Authority of WA.
PO Box 100
Leederville WA 6007
Att. Mr Barry McNally

Re: Lake Argyle Siltation Monitoring Survey, September 1992.

During the course of the survey all differential GPS positions were processed on the WGS 84 spheroid instead of the AMG 84.

The resultant error at that latitude requires a coordinate shift of -6.2m North, and 0.2m East. Where translocated base stations were used, the effect was cumulative.

The northing values in the processed digital data have accordingly been corrected as per the following schedule:

LINE	NORTH CORRECTION	INTENDED NORTHING	ACTUAL NORTHING
ARN 048		8 217 400	8 217 394
to	-6m		
ARN 036E inc.		8 215 000	8 214 994
ARN 036W		8 215 000	8 214 988
to	-12m		
ARN 001 inc.		8 208 000	8 207 988
ARS 200		8 207 800	8 207 788
to	-12m		
ARS 143 inc.		8 196 400	8 196 388
ARS 142		8 196 200	8 196 194
to	-6m		
ARS 067 inc.		8 181 200	8 181 194
ARS 066		8 181 000	8 180 988
to	-12m		
ARS 051 inc.		8 178 000	8 177 988
ARS 050		8 177 800	8 177 782
to	-18m		
ARS 034 inc.		8 172 000	8 171 982

The long lines have also been corrected by similar block shifts, according to their positions relative to the run lines.

The corrected processed digital data is returned. Using PKZIP, the full data base is written in ARGYLE.ZIP, which contains ASCII files ORDX01.ASC - ORDX16.ASC, LASX.ASC, and LANX.ASC. Again, the ASCII format is for SDRMAP.

Please accept my apologies for any inconvenience caused.

Don Shepherd.

D M Shepherd
15/03/93