DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

LAKE TOOLIBIN CONTROL WORKS

MARCH 1995

REF NO. J209L

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

In recent years surface flows into Lake Toolibin have been increasing in salinity, such that vegetation within the lake is likely to be adversely affected if trends continue. Jim Davies & Associates Pty. Ltd. has been commissioned by the Department of Conservation and Land Management (CALM) to design control works to allow high salinity surface flows to bypass Lake Toolibin with only fresher flows allowed to pass into the Lake.

This report details the proposed flow control structures and diversion drain.

2.0 DRAIN DESIGN

2.1 Drain Alignment

Figure 1 shows in plan the proposed drain alignment as recently surveyed by Brian Eckersley.

The drain will pass along the western edge of Lake Toolibin and around the northern side of Lake Walbyring to Nepowie Road, just upstream of Lake Taarblin. The alignment of the drain through the Lake was selected to avoid areas of healthy vegetation, generally passing through areas of decaying salt affected Casuarina Obesa. The drain will be kept at least 10 m from the bank of the Lake.

The general layout of the proposed Inlet Control Structure shown on Figure 13 indicates that the drain is displaced from the surveyed line between 0 m and 300 m distance downstream of the structure, as indicated also on Figure 3.

2.2 Design Flow

The diversion channel aims to divert flows of salinity greater than 1500 mg/L TDS from entering the main body of Lake Toolibin. Analysis by Jim Lane (CALM) of streamflow and salinity data collected at the Water Authority's Northern Arthur River gauging station (609010) indicates that for flows greater than 3.0 m^3/s salinity is less than 1500 mg/L TDS. The channel is to be sized to carry a flow of 6.0 m^3/s upstream of North West Creek (at a distance of 900 m from the Inlet Control Structure) and 7.0 m^3/s downstream of North West Creek allowing for future deterioration of surface flows.

2.3 Drain Gradient

Figure 2 is a long section showing the natural surface through Lake Toolibin and the downstream section to Nepowie Road and railway culverts as surveyed by Brian Eckersley. The survey can be divided into four sections, namely:

* Lake Toolibin (E to D)
* Outlet Drain (D to C)
* Drain along Fenceline (D to B), and
* Drain through Unnamed Lakes (B to A).

Also shown on Figure 2 is the invert level of the Lake Toolibin overflow channel to Lake Walbyring as surveyed previously by the Water Authority. The proposed drain invert level is indicated on Figure 2 with a constant gradient from the proposed upstream end of the separator drain at the inlet control structure through to 5,200 m distance at the Nepowie Road culverts. The gradient of the proposed invert is 0.00014. Several other gradients were investigated including those which provide a slightly steeper gradient down to the Nepowie Railway culvert and one which is less incised at the upstream end of the separator drain. The invert indicated on Figure 2 has been adopted as it causes least backwater effect in the reach upstream to the Wickepin/Harrismith Road crossing and minimises the depth of excavation in the reach downstream between Lake Toolibin and the unnamed lakes, which should reduce overall contract costs.

2.4 Drain Dimensions

The design flow is to be conveyed partially within an excavated drain and partially over natural surface, with the width of flow restricted to the west by the natural bank of Lake Toolibin and to the east by the bund formed from excavated material. Hence, the cross section of flow will vary along the drain and the water surface profile can be calculated using steady state, non-uniform flow hydraulics as included in the backwater model HEC-2. Table 1 presents various drain parameters at different distances along the drain including natural surface, drain invert, bed width and side batters as well as excavation volume and total width of flow and water surface elevation.

TABLE 1 PROPOSED DRAIN DIMENSIONS

Distance Downstream of Inlet Control Structure (m)	Surveyed Natural Surface Elevation (mAHD)	Proposed Invert (mAHD)	Proposed Bed Width (m)	Proposed Drain Batters X (1:X)	Excavation Volume (m^3/m)	Refer Figure No.	Total Flow Width (m)	Water Surface Elevation (mAHD)
0	297.52	297.52	43	3	0	N/A	N/A	297.82
50	297.62	297.14	28	3	6.3	3	N/A	297.76
100	297.53	296.79	11.6	3	10.3	3	75	297.75
150	297.51	296.78	11.6	3	10.1	4	65	297.74
350	297.35	296.75	11.6	3	8.0	4	70	297.72
700	297.30	296.70	11.6	3	8.0	5	55	297.67
950	297.33	296.67	13.8	3	10.5	5	55	297.64
1100	297.19	296.65	13.8	3	8.4	6	35	297.62
1300	296.90	296.62	13.8	3	4.1	6	30	297.60
1500	296.95	296.59	13.8	3	5.3	7	30	297.57
1700	296.97	296.56	13.8	3	6.1	7	30	297.55
2665	298.26	296.43	13.8	3	35.3	8	20	297.42
3185	298.13	296.36	13.8	3	33.9	8	20	297.34
3650	297.80	296.29	13.8	3	27.7	9	20	297.28
4150	297.35	296.22	13.8	3	19.4	9	20	297.20
4565	296.84	296.16	13.8	3	10.7	10	N/A	297.15
5065	297.14	296.09	13.8	3	17.7	10	20	297.08
5565	296.19	296.02	13.8	3	2.4	11	N/A	297.02

Note:

1. Design flow is 6 m^3/s between 0 m and 900 m, and 7 m^3/s between 900 m and 5565 m downstream of Inlet Control Structure.

Drain dimensions are shown on Figures 3 to 11 which represent conditions along the proposed drain at distances shown on Figure 1.

Drain invert will gradually converge to natural surface as the drain approaches Nepowie Road. The bottom width of the channel will remain at 13.8 m, with an increasing amount of flow spreading across the natural surface as the drain capacity diminishes.

The velocities during the design flow of 6.0 and 7.0 m^3/s are less than 0.50 m/s at all cross sections which is less than the threshold value of 1.0 m/s for movement of bed materials (WADA, 1989) so that no erosion of the drain or sedimentation is expected to occur.

2.5 Separator Bund Elevation

Figure 12 shows a flood frequency analysis of peak levels in Lake Toolibin compiled from data supplied by Jim Lane from information supplied by Peter Helsby, Water Authority Albany for a meeting in November 1994. This analysis indicates that the 10 year average recurrence interval (ARI) flood level is 298.25 mAHD. It is proposed that the separator bund will have a level final crest height of 298.55 mAHD, thus allowing 0.3 m freeboard above the 10 year flood level. The bund is to be constructed at a height of 0.35 m above the final crest height; that is 298.90 to allow for settlement after construction from the Inlet Control Structure to 2614 m distance.

2.6 Separator Bund Dimensions

The bund is to be compacted during construction by the excavation bulldozer and to allow this to be achieved bank batters are to be 1:3 with a 0.5 m crest width. The separator bund will extend through the length of the Lake and a further 300 m downstream of the Lake to 2614 m distance.

May not be necessary.

2.7 Cut and Fill Analysis

Table 2 presents a cut and fill analysis. It can be seen that the bund material will predominantly be sourced from the adjacent drain, with the excess being sourced from the excavated channel south of Lake Toolibin. Between distance 1100 m and 1950 m there is a shortfall in material, of total volume 3850 m^3. This material can be sourced between distances 2000 m and 2420 m. The total volume of earth to be excavated is approximately 98950 m^3.

2.8 Analysis of Soil Dispersion

Soil samples were obtained by CALM and analysed by the Chemistry Centre (W.A.). These samples were taken at depths of 10 cm and 50 cm below surface at eight sites along the route of the proposed diversion drain. Four sites were in the Lake bed and four downstream of the Lake.

Two dispersion tests were performed; the SCS Test (percent dispersion by method AS 1289.C82) and the Emersen Test (a 'crumb test'). Test results and associated literature are presented in Appendix A. Results suggest that soils will not be dispersive due to high salinity content. Soils may become dispersive if the salt is flushed from them by fresh water. However, it is considered that fresh water within the Lake will not have sufficient velocity to cause this flushing.

Treatment of the soils is considered unnecessary. Revegetation of the separator bund will increase the stability of the soil.

TABLE 2 CUT AND FILL VOLUMES

Distance (m)	Minimum Bund Fill Volume[1] (m^3/m)	Drain Cut Volume (m^3/m)	Excess (+) or Shortfall (-) (m^3/m)	Excess (+) or Shortfall (-) (m^3)
0	6	0	-6	0
50	5	14	9	457
100	6	10	5	230
150	6	10	4	212
200	6	11	5	242
250	6	11	5	247
300	7	9	2	109
350	7	8	1	42
400	7	8	1	59
450	6	10	3	173
500	7	8	0	22
550	6	11	6	281
600	6	11	5	275
650	6	10	4	208
700	8	8	0	19
750	8	7	-1	-49
800	8	8	0	17
850	6	12	6	302
900	8	9	1	55
950	7	10	3	155
1000	7	12	5	241
1050	7	11	4	194
1100	9	8	0	-14
1150	11	5	-6	-275
1200	11	4	-7	-363
1250	12	4	-8	-398
1300	12	4	-8	-379
1350	10	6	-4	-186
1400	11	5	-6	-288
1450	11	5	-6	-309
1500	11	5	-6	-290
1550	11	6	-5	-271
1600	11	6	-5	-238
1650	10	7	-3	-151
1700	10	7	-3	-159
1750	10	7	-4	-180
1800	10	7	-3	-161
1850	10	8	-2	-101
1900	10	9	-1	-54
1950	9	9	0	-7
2000	8	11	2	123
2050	9	11	2	88

TABLE 2 CUT AND FILL VOLUMES (Continued)

Distance (m)	Minimum Bund Fill Volume [1] (m^3/m)	Drain Cut Volume (m^3/m)	Excess (+) or Shortfall (-) (m^3/m)	Excess (+) or Shortfall (-) (m^3)
2100	9	10	1	53
2150	9	10	1	59
2200	8	12	4	204
2250	7	14	7	335
2264	7	15	8	118
2314	6	16	10	511
2364	3	28	26	1277
2414	3	28	26	1285
2464	3	28	26	1293
2514	3	29	26	1301
2564	3	29	26	1309
2614	3	29	26	1317
2664		35	35	1767
2704		34	34	1350
2754		30	30	1505
2804		27	27	1351

Notes:

1. Proposed finished height of bund between distances 0 and 2614 m is 298.9 mAHD.
2. Proposed top width of bund is 0.5 m.
3. Proposed batter slope on bund is 1:3.

3.0 CONTROL OF FLOW AT INLET

3.1 Inlet Control Structure

Control of flow will be achieved using a system of control bores into the diversion drain and an overflow weir across the main body of Lake Toolibin. Refer to Figure 13 for plan view of control system. Once the Inlet system is flowing at design capacity of $6m^3/s$ water level will be at 297.84 mAHD and flow will commence over the sill into the Lake. It will be possible to completely shut off the Inlet to the separator drain by inserting boards to pass all flow into the Lake. Figure 14 shows an analysis of the division of flow at the Inlet. For example, when the total flow s $6m^3/s$ the bypass flow is also $6m^3/s$ with no flow into the Lake. When the total flow is 17 m^3/s the flow is equally split (8.5 m^3/s) between the separator drain and the Lake. When the total flow is 29 m^3/s the flow is 10 m^3/s into the separator drain and 19 m^3/s into the Lake.

Figure 16 shows detail of a typical panel of the inlet control structure and Figure 17 shows detail of the inlet structure against the separator inlet bunds. The structure comprises a number of steel universal columns set 2 m vertically apart into the lake bed and finished with a concrete slab extending 1.0 m upstream and 5.0 m downstream. Concrete cut-off walls 0.5 m deep are to be set at both upstream and downstream ends of the concrete base slab. Wandoo planks will be used to control flow into the diversion channel. Planks will be permanently bolted between the columns from 0.3 to 0.9 m above top of slab (297.52 mAHD), with planks over the lowest 0.3 m within the I-beam removed or inserted as required. To pass $3m^3/s$ into the diversion channel a total length of 14 m at 0.3 m depth will be required; hence lower planks will be removed from 7 of the panels. To pass $6m^3/s$ into the diversion channel a total length of 42 m at 0.3 m depth will be required and hence planks will be removed from all 21 of the panels. At the higher flow of 6 m^3/s, the backwater effect from the downstream channel means that more than twice the flow width is required as compared with 3 m^3/s.

This structure has been analysed hydraulically as a culvert with inlet control. Figure 15 is graphical output from Culvert for Windows, showing upstream and downstream water level at the inlet structure for a range of flows.

3.2 Inlet Bund

A bund will extend from the inlet structure to the western bank of the Lake, a distance of approximately 250 m as shown on Figure 13. This bund will have a final height of 298.55 mAHD, constructed at a height of 298.90 mAHD to allow for 0.35 m settlement after construction. The volume of soil required is estimated to be 1200 m^3. The source of this material will be determined on-site by CALM to minimise disturbance to existing vegetation.

3.3 Convergence of Flow To Drain

The inlet structure will have a width of approximately 43 m. Excavation of the drain will begin immediately downstream of the structure, with excavated depth increasing from zero at the structure to design depth 100 m downstream with bottom width decreasing to 11.6 m. At a distance of 50 m, width of excavation will be 28 m at an elevation of 297.15 mAHD.

3.4 Overflow Sill into Lake Toolibin

The overflow sill into Lake Toolibin will be set at 297.84 mAHD with proposed dimensions as shown on Figure 18. The length of the overflow sill will extend from the inlet control structure for approximately 150 m to the north-east.

It is proposed that the sill will comprise compacted soil covered with a concrete mattress, supplied and installed by Revetment Systems Aust. Pty. Ltd. or equivalent. The source of soil will be determined on-site by CALM.

4.0 LAKE TOOLIBIN OUTLET

4.1 Overflow Spillway

The diversion channel to Lake Taarblin will be a separate drain from the natural overflow channel to Lake Walbyring, with a compacted bund keeping the two flows separate. The compacted bund will extend 300 m downstream of Lake Toolibin, to just upstream of the farm access crossing at distance 2614 m (refer Figures 1 and 2).

The spillway at Lake Toolibin outlet will be set at 297.56 mAHD with a constructed overflow sill at the exit from Lake Toolibin into the overflow channel. The length of the sill will be 36 m and has been sized to carry the 10 year ARI flow of 35 m^3/s, without causing a rise in lake water level. The 10 year ARI flood was determined using the Index Method. Figure 19 shows a Flood Frequency Analysis of annual maxima instantaneous peak flows at the Northern Arthur River Gauging Station (609010), along with Index Method flow values. Figure 20 shows a plan view of the outlet. The natural high point in the overflow channel will be lowered to maintain outlet control at the constructed sill.

Due to time constrictions it is suggested that construction of sill and lowering of the natural high point be delayed until channel excavation is complete. *

4.2 Farm Access Crossing

A minor floodway exists to allow machinery access across the natural overflow channel as indicated on Figure 20. A second crossing will be constructed across the diversion drain. The crossing is to be stabilised with rock and cement to a similar standard as the existing crossing over the natural overflow channel.

5.0 OVERFLOW FROM LAKE WALBYRING

The natural overflow path from Lake Walbyring crosses the diversion channel, as shown on Figure 1. To prevent backup of flows up the natural drainage line no bank is to be built on the southern side between distances 4125 and 4175 m.

6.0 MATERIALS COST ESTIMATE

The cost estimates given below are for the Inlet Control Structure and the Overflow Sill into and out of Lake Toolibin

1.	Concrete Base Slab: Require 35 m^2 at \$180/m^3	\$6300
2.	Concrete Reinforcement Mesh: Require 20 sheets (2.4m x 6m) at \$50.15/sheet	\$1,000
3.	Steel Universal Columns (100 UC 14.8): Require 24 x 3 m lengths at approx. \$19/m	\$1368
4.	Wandoo Planks: Require 96 of 2020 x 150 x 50 mm and 46 of 2000 x 150 x 50 mm	\$2047
5.	Concrete Mattress: Require total of approximately 690 m^2 at \$29.80/ m^2	\$20115
	Total	\$30830

Note: This cost estimate excludes transport costs and incidental items such as bolts and washers, etc.

CHEMISTRY CENTRE

Your Ref : Lake Toolibin/
Our Ref : 94A1554; 2.8.2
Enquiries to : Ivan Wilson
Telephone :

District Manager
Conservation & Land Management Authority
Narrogin District Headquarters
PO BOX 100
Narrogin WA 6312
Attention : T.Bowra

Report on:

16 samples of soil received on 16 March 1995

Analyte		EC (1:5)	pH (H2O)	SCS Disp	Clay
Unit		mS/m		%	%
CCWA ID	Client ID				
94A1554/001	1A	390	7.5	9	46.0
94A1554/002	1B	250	8.2	21	22.0
94A1554/003	2A	770	8.0	2	38.0
94A1554/004	2B	460	8.3	2	48.0
94A1554/005	3A	480	8.4	52	71.0
94A1554/006	3B	380	8.5	65	54.0
94A1554/007	4A	340	7.2	48	32.0
94A1554/008	4B	390	7.6	3	46.0
94A1554/009	5A	78	6.5	26	10.0
94A1554/010	5B	32	7.4	64	18.0
94A1554/011	6A	190	7.1	13	46.0
94A1554/012	6B	210	7.5	50	46.0
94A1554/013	7A	240	8.9	39	70.0
94A1554/014	7B	460	7.9	5	72.0
94A1554/015	8A	210	7.7	46	70.0
94A1554/016	8B	200	5.1	6	76.0

Analyte	Method	Description
EC (1:5)	S-EC	Electrical conductivity (1:5) at 25 deg C. ACL Method S02.
pH (H2O)	S-PHEC	pH (1:5) in water. ACL Method S01.
SCS Disp	S-DISP	Percent dispersion, by method AS 1289.C8.2 Also referred to as SCS Dispersion Test
Clay	S-CLAY	Clay, less than ~~0.002~~ mm. ACL Method S06. 0.005 IW.

Attachment to Report on Lake Toolibin soils, Lab Nos 94A1554/001-16

<u>Comments on samples and methods</u>

Samples were prepared to pass a 2.36 mm sieve.

Clay particle size was determined as <0.005mm. The percentage reported was obtained for the calculation of "Percent dispersion".

Most of these soils have very high salinities and dissolved salts can cause errors in clay measurements either by changes in buoyancy or causing flocculation of particles. Corrections for buoyancy due to soluble salts were made using data derived from EC (1:5) measurements. No samples appeared to flocculate during the "Clay %" determinations.

A soil with an EC (1:5) of 300 mS/m will contain approximately 1% dissolved solids.

<u>Observations on extracts (1:5, soil:water) used to measure pH and EC.</u>

It was noted that all but 2 samples (exceptions being 94A1554/009 and 010 - both low salinity) flocculated completely on standing 60 minutes, leaving a completely clear supernatant liquor.
It follows that a zero percent dispersion result would be obtained if measurements were made at this soil:water ratio (200g soil:1000mL water).
— The AS1289.C8.2 dispersion values were obtained at a soil:water ratio of 25g:1000mL.

The pH extracts flocculated because of high salt concentrations and, while AS1289.C8.2 indicates some soils are dispersive, they may not disperse in the presence of highly saline water. In the presence of non saline water their behaviour would be less predictable.

I R WILSON
CHEMIST AND RESEARCH OFFICER

*** END ***

FIGURES

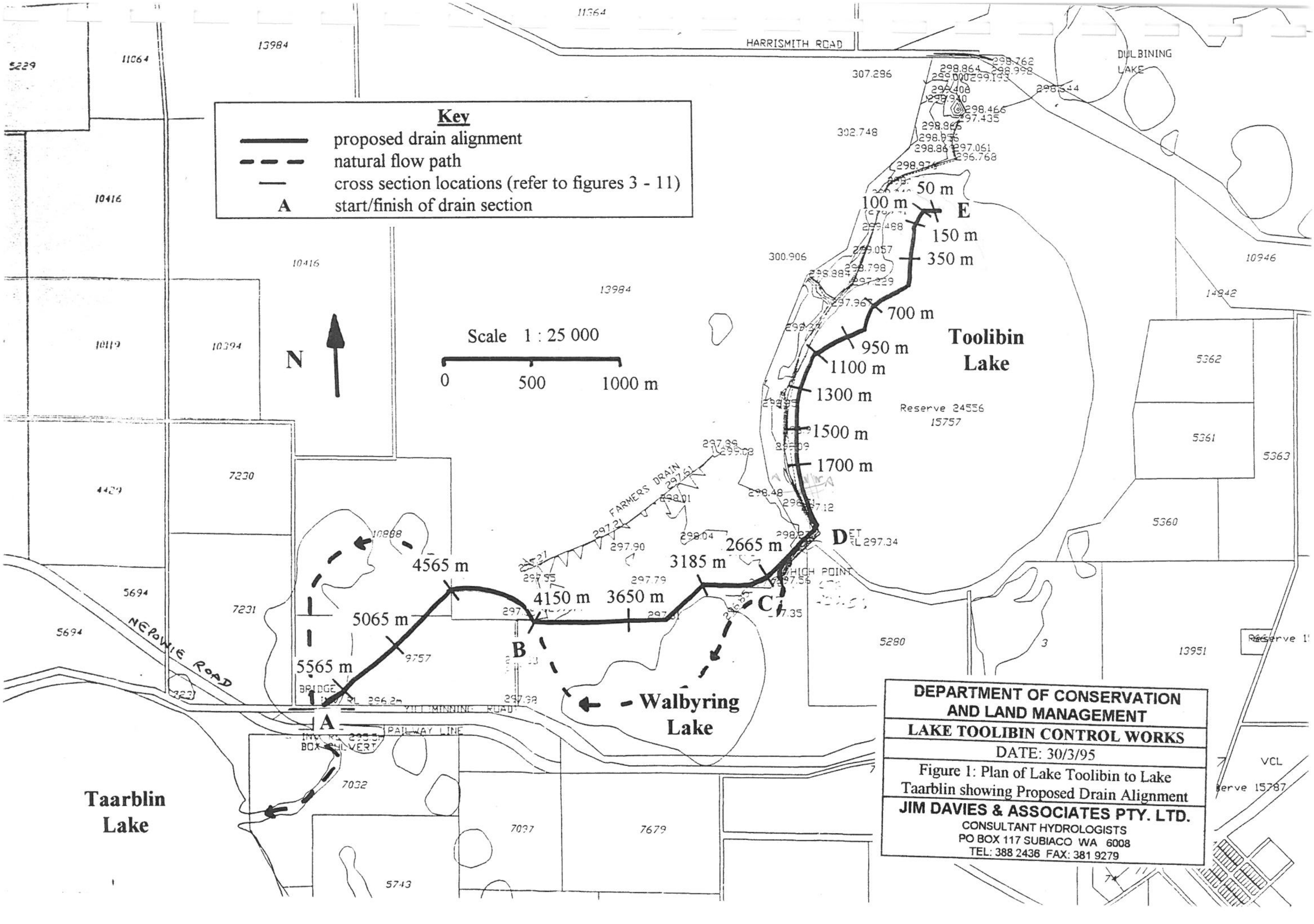

Figure 1: Plan of Lake Toolibin to Lake Taarblin showing Proposed Drain Alignment

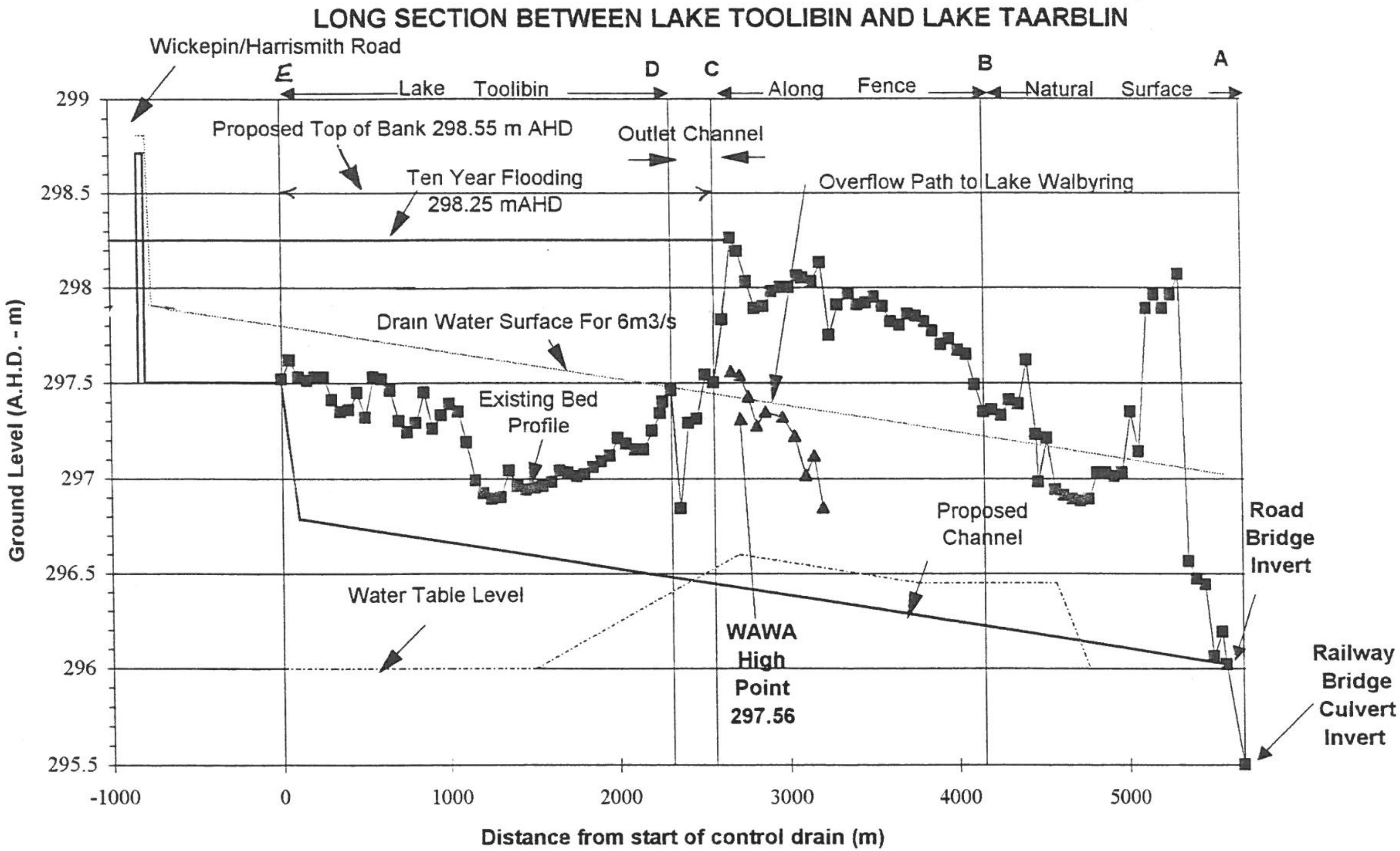

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Figure 2: Long Section between Lake Toolibin and Lake Taarblin
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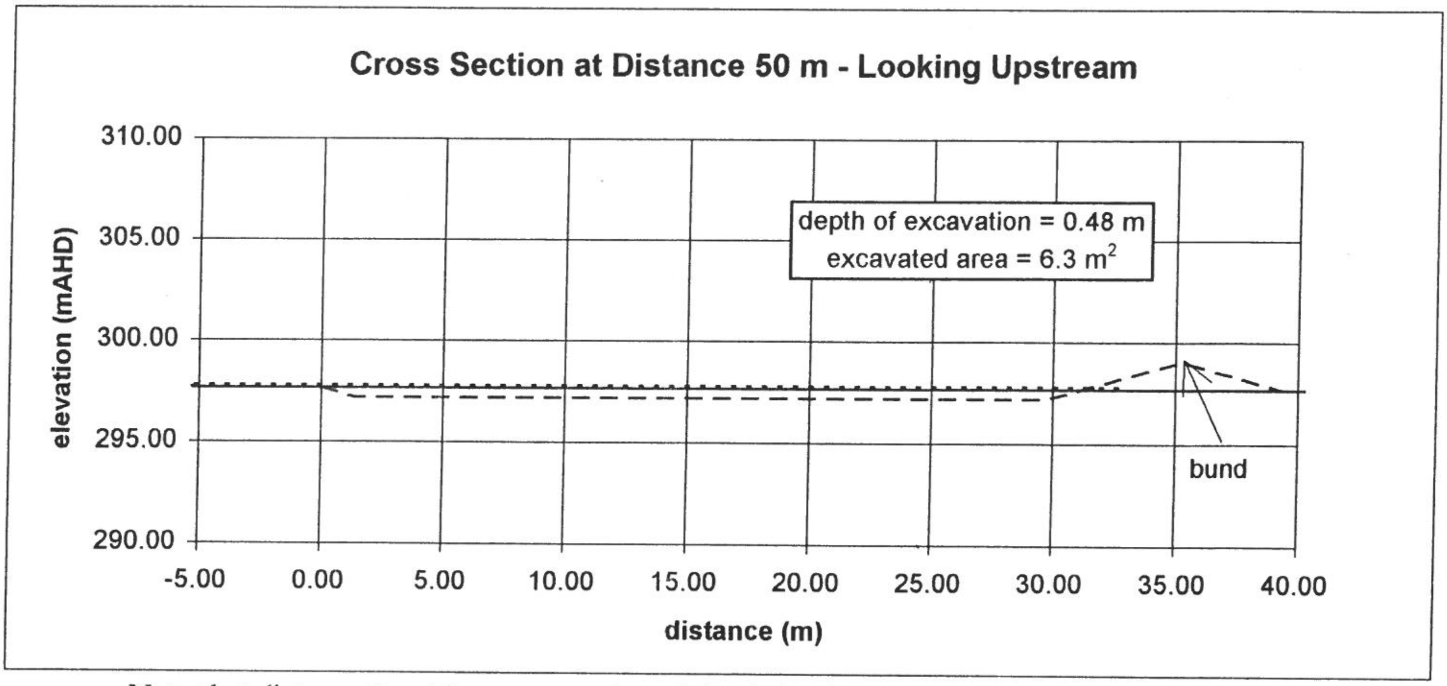
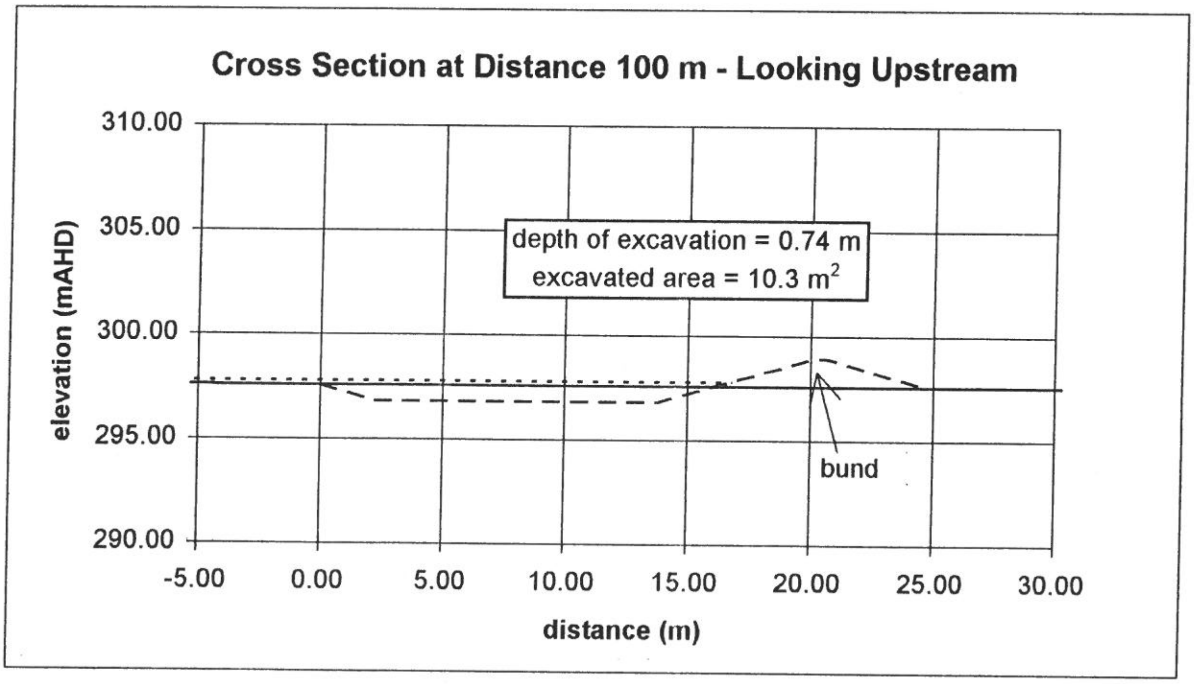


Note that distance 0 m (the western edge of the drain) is to be 40 m NNW of the survey location to provide a more gradual bend radius (see Fig. 13)



Note that distance 0 m (the western edge of the drain) is to be 20 m SE of the survey location to provide a more gradual bend radius (see Fig. 13)

Key to Figures 3 to 11

- - - - -	excavated drain and bund/bank
———	natural surface
....	water level (6 m^3/s)
■	surveyed location

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LAKE TOOLIBIN CONTROL WORKS

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Figure 3: Cross Sections of Drain Alignment showing Natural Surface - Proposed Drain and Bund

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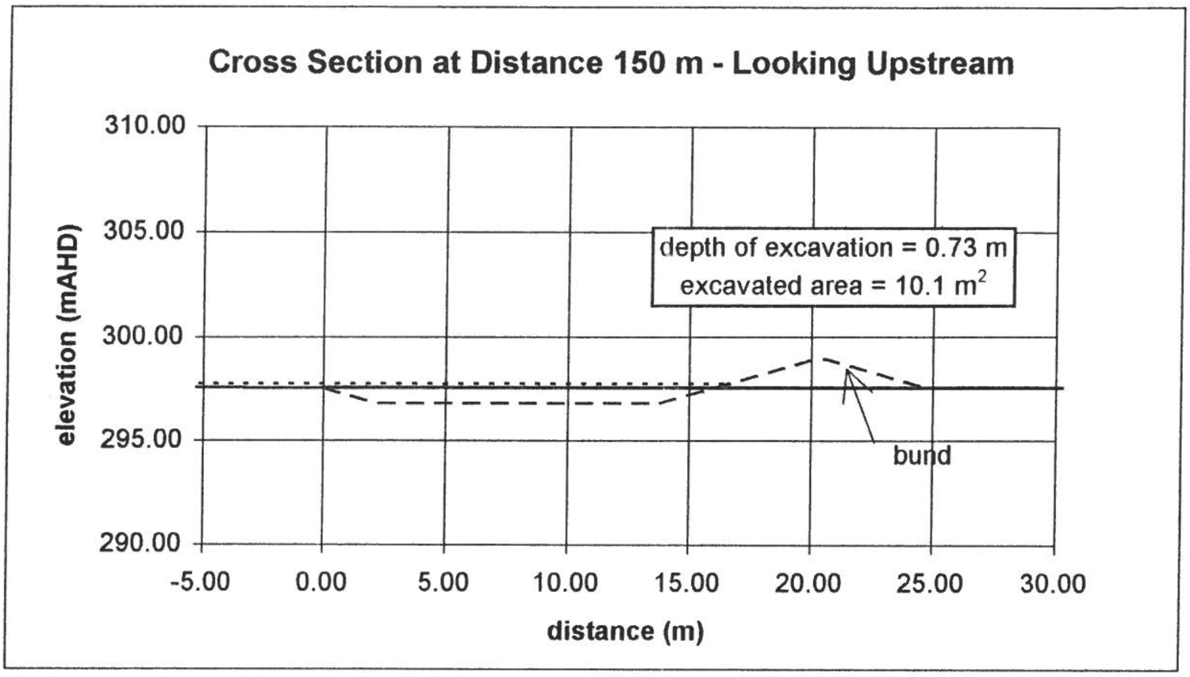

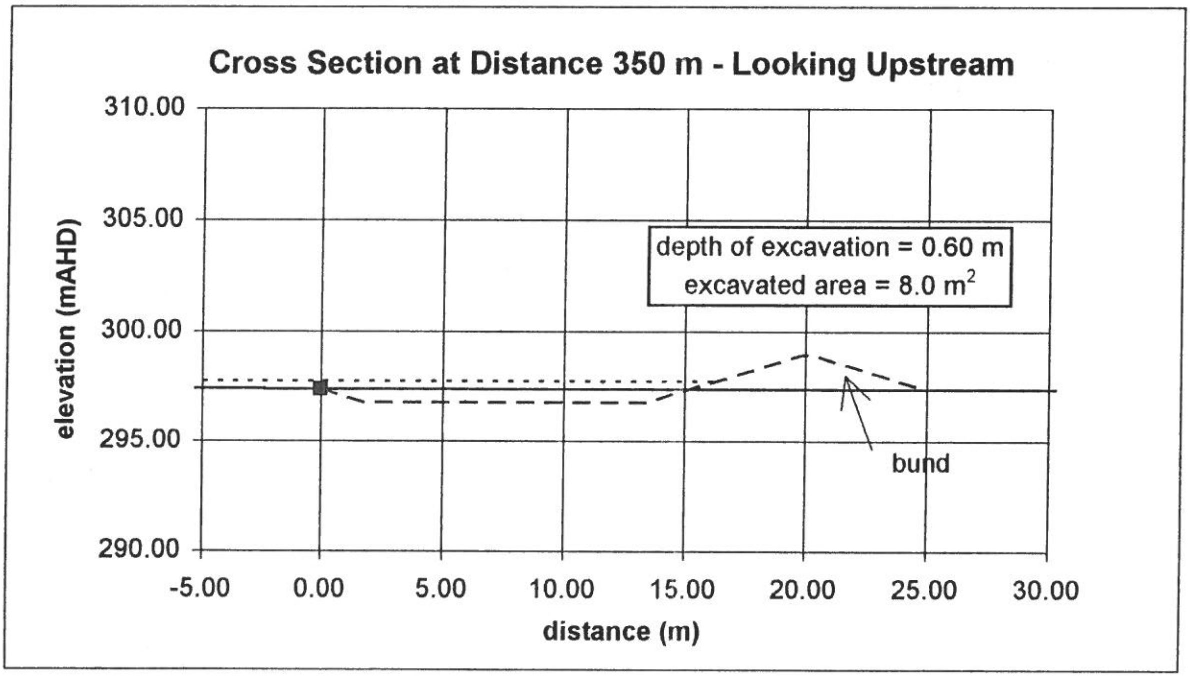

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LAKE TOOLIBIN CONTROL WORKS

DATE: 30/3/95

Figure 4: Cross Sections of Drain Alignment showing Natural Surface - Proposed Drain and Bund

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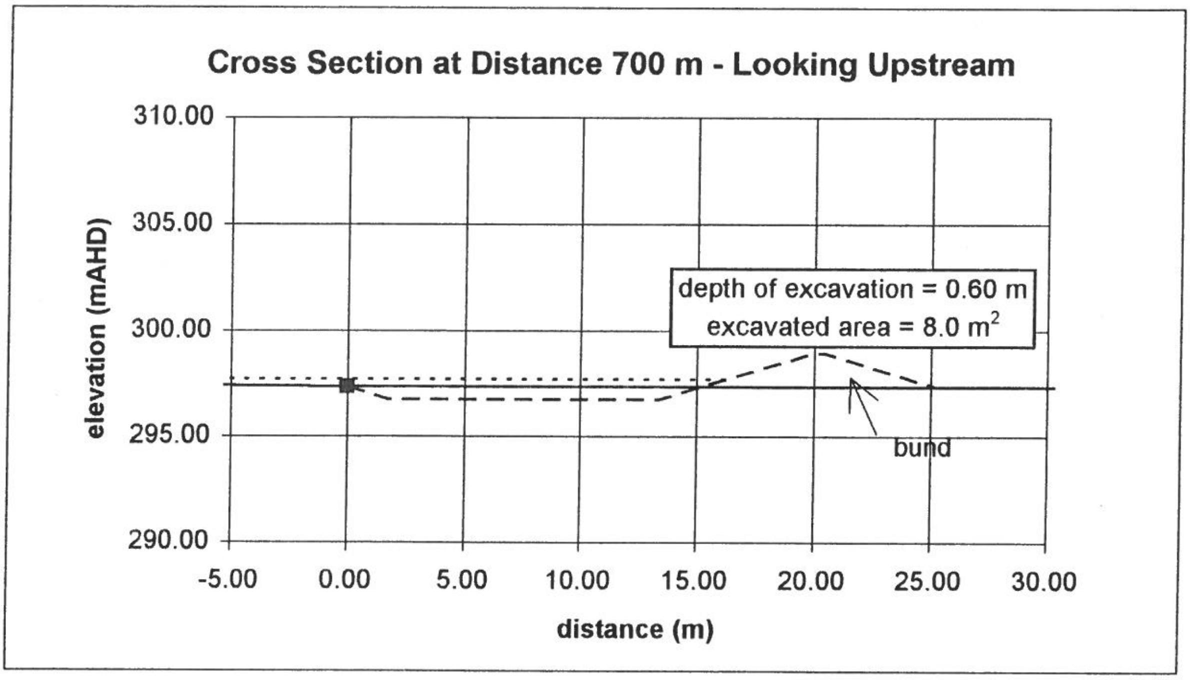

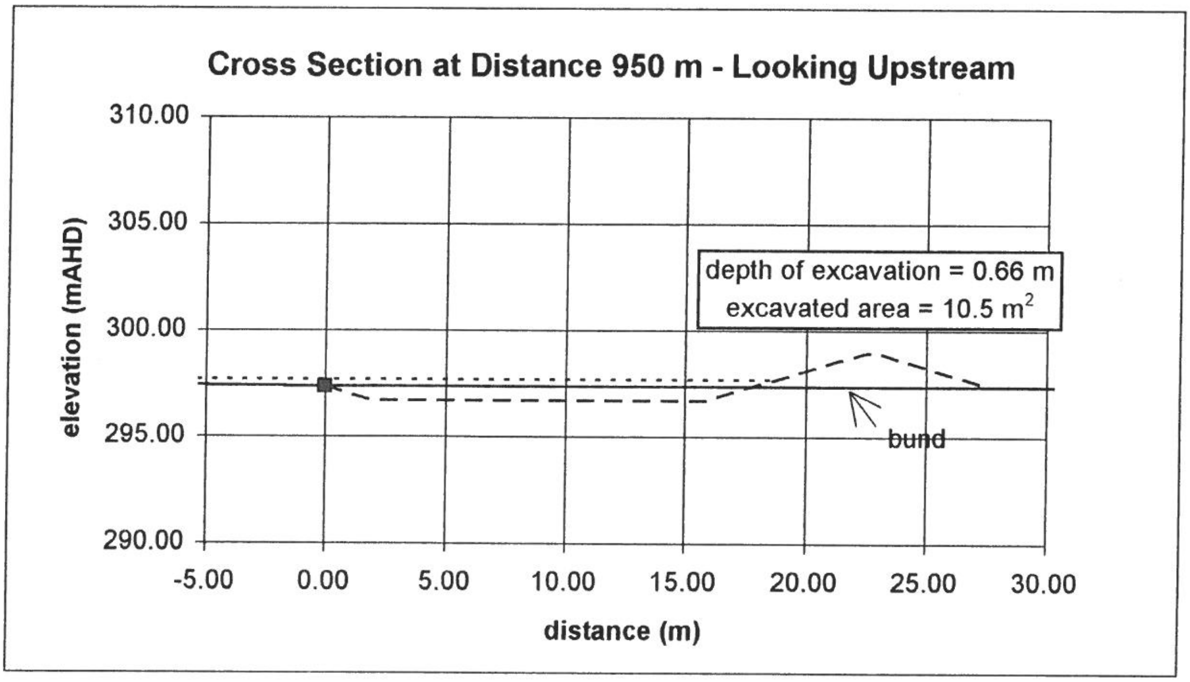

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Figure 5: Cross Sections of Drain Alignment showing Natural Surface - Proposed Drain and Bund
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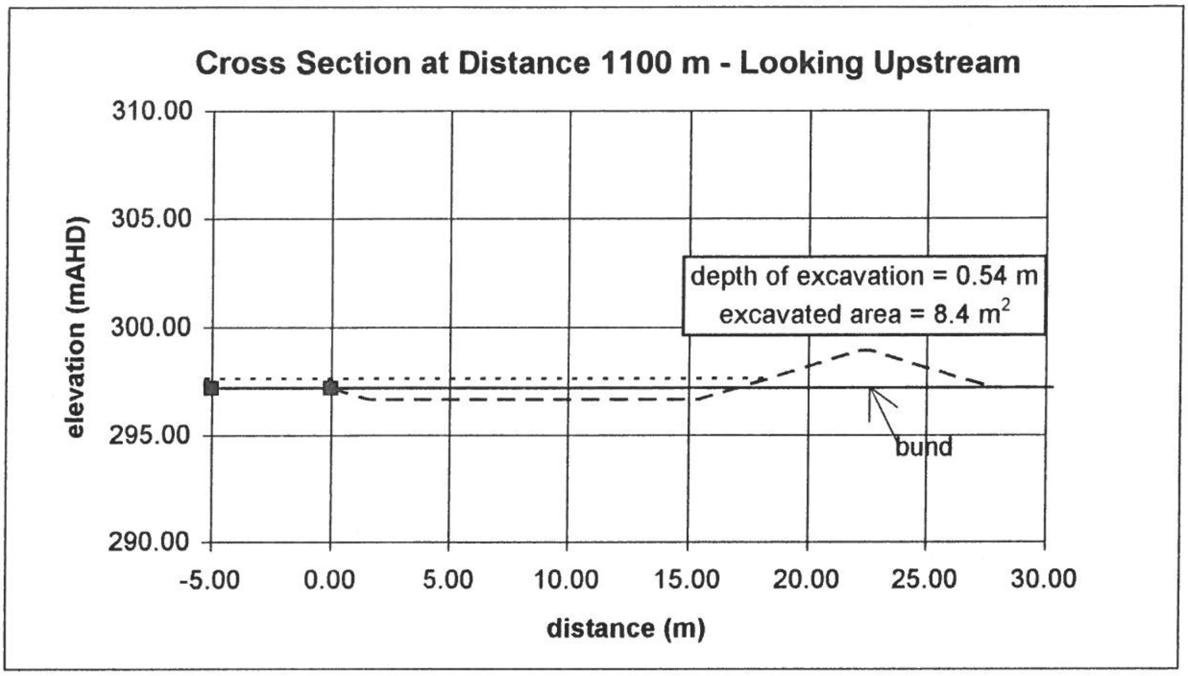

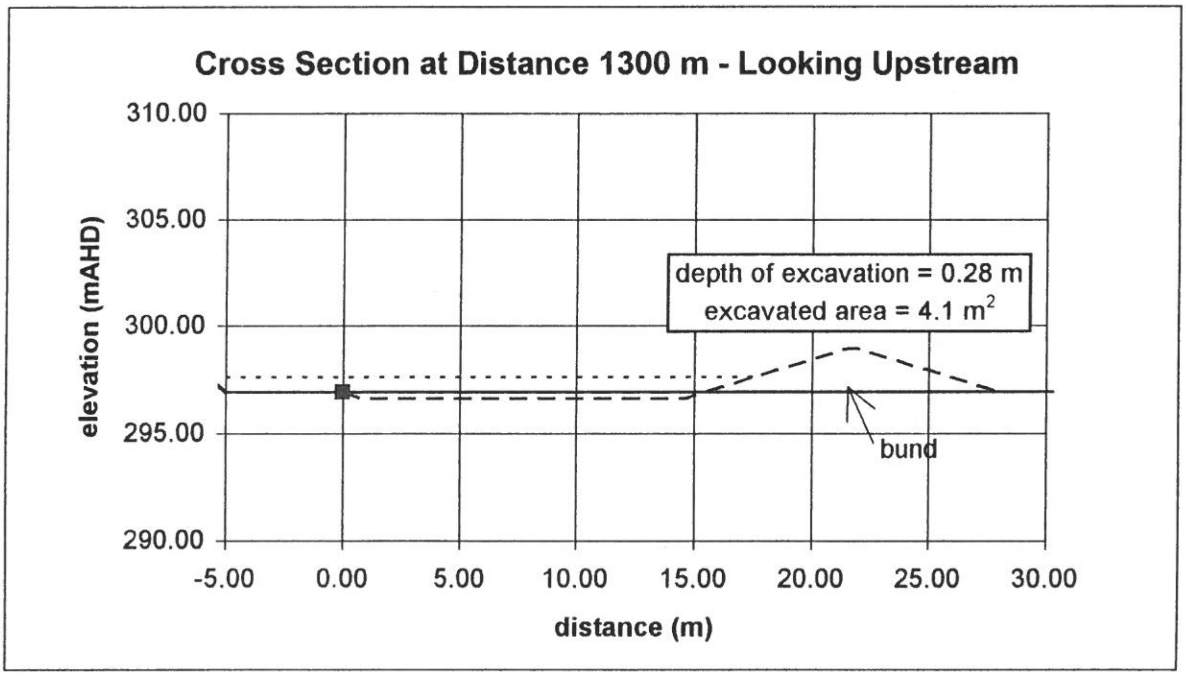

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Figure 6: Cross Sections of Drain Alignment showing Natural Surface - Proposed Drain and Bund
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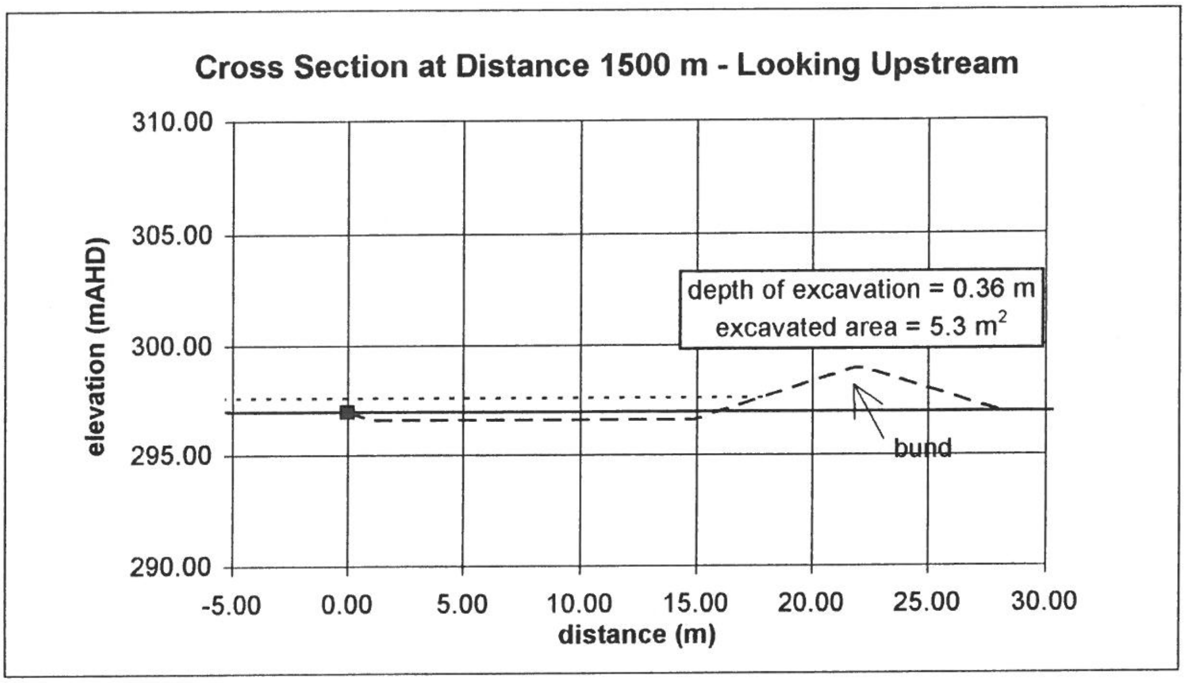

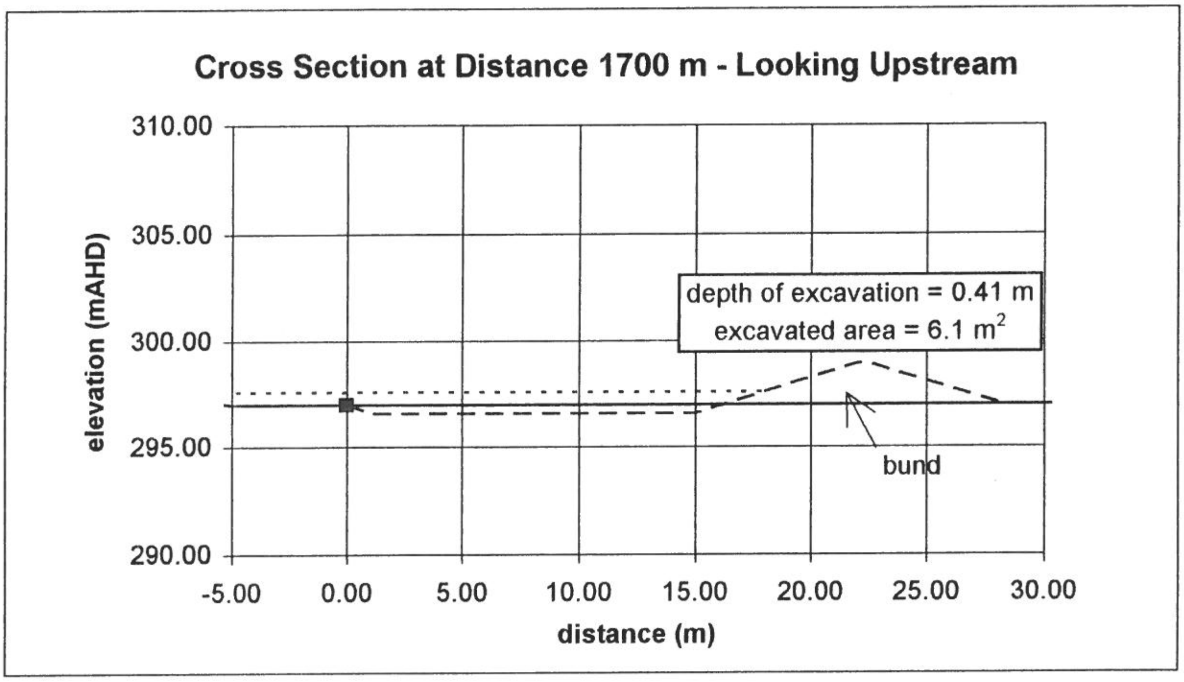

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Figure 7: Cross Sections of Drain Alignment showing Natural Surface - Proposed Drain and Bund
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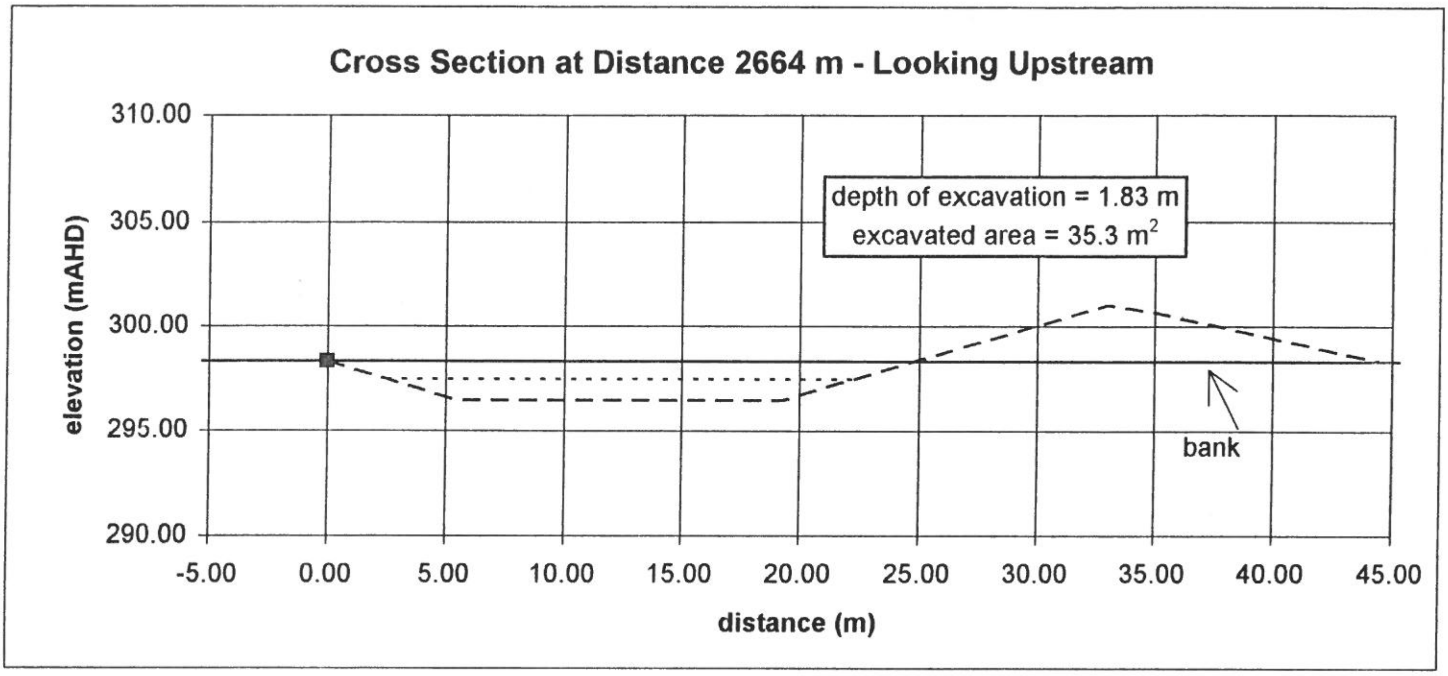

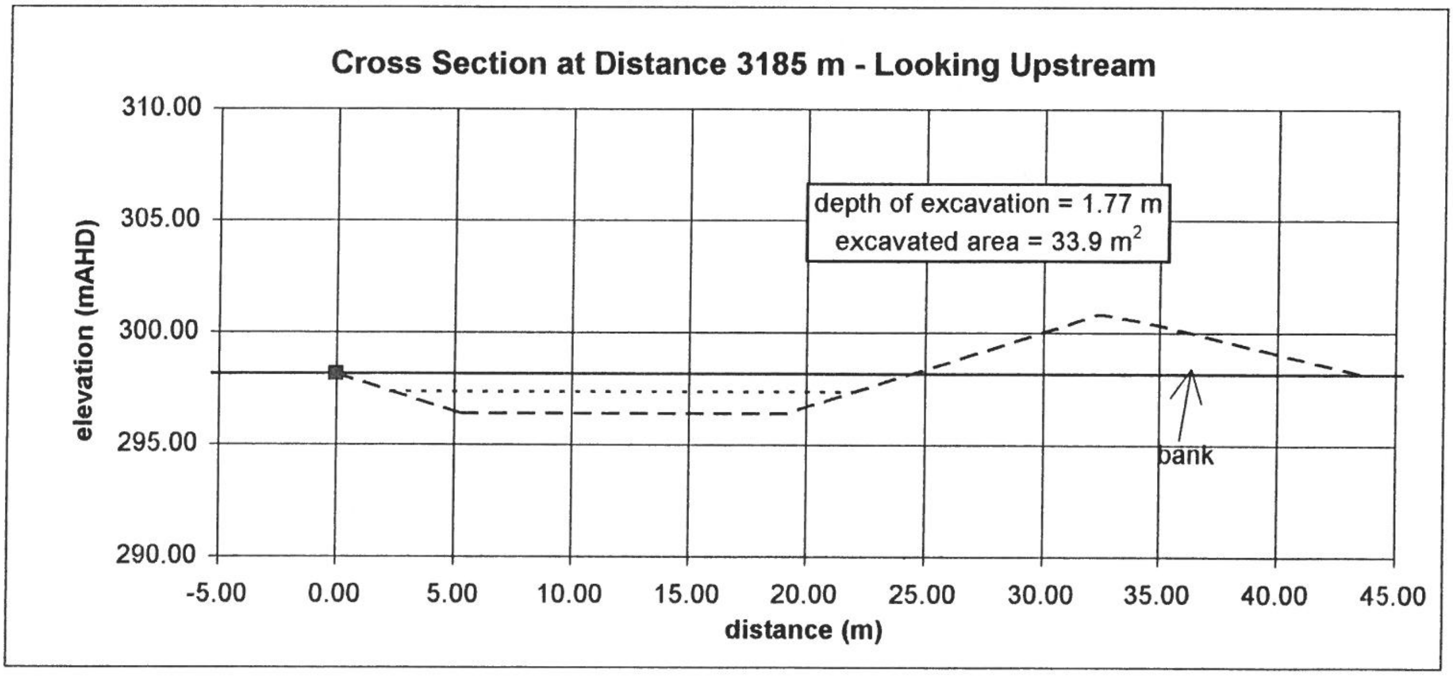

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LAKE TOOLIBIN CONTROL WORKS
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Figure 8: Cross Sections of Drain Alignment showing Natural Surface - Proposed Drain and Bund
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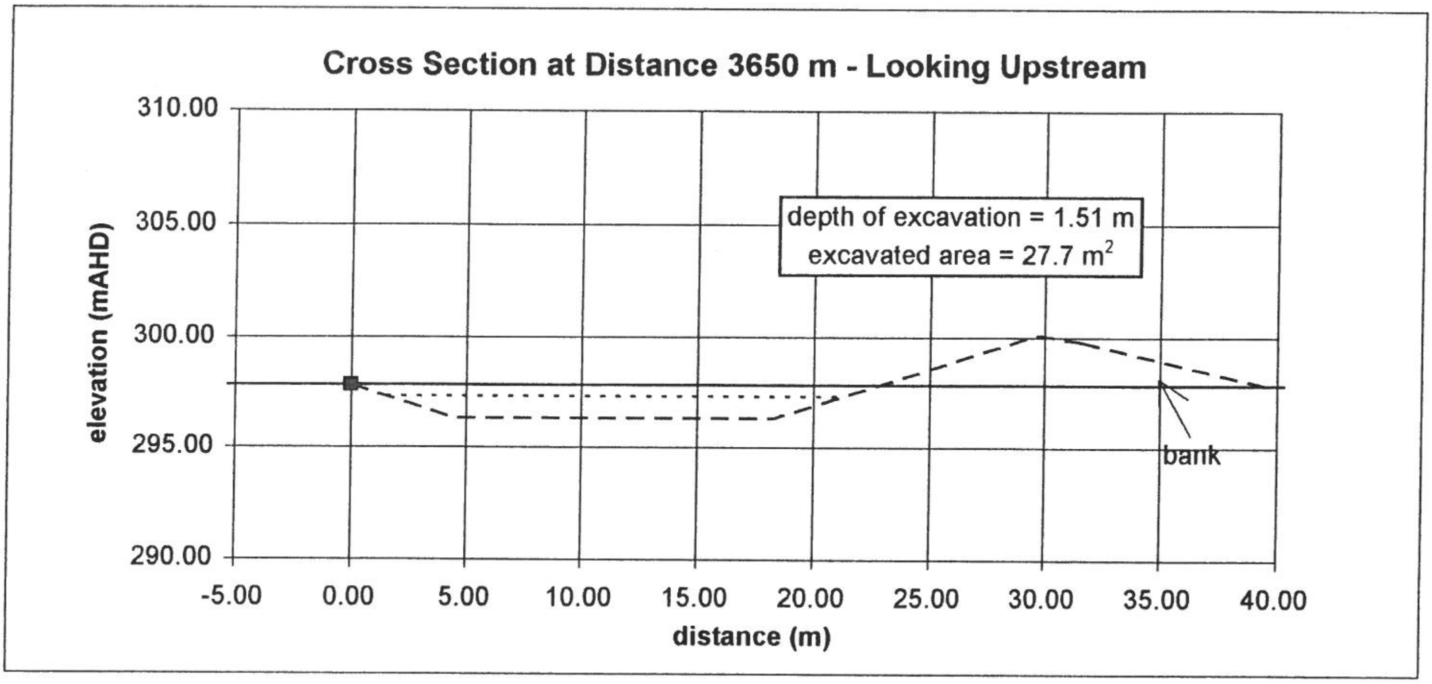

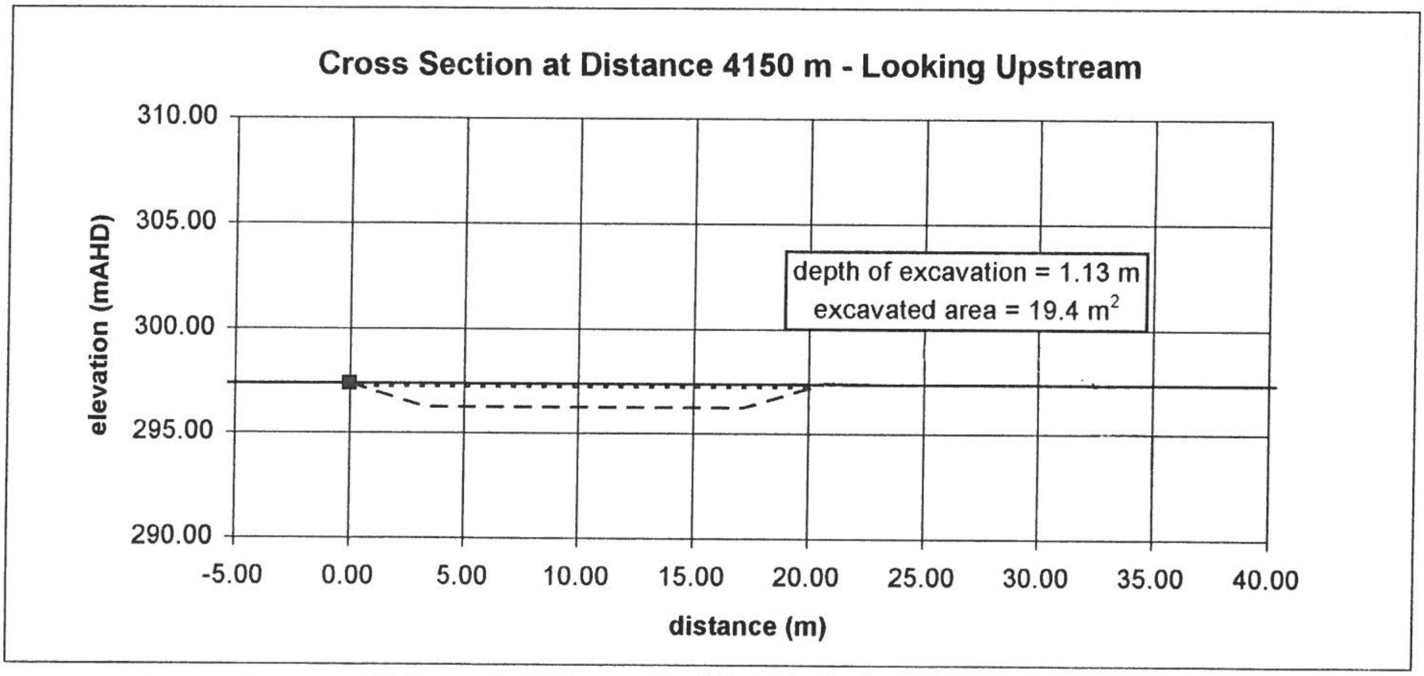

Notes: 1. Between 4125 m and 4175 m no bank is to be built on the southern side to allow natural overflow to flow into the drain.

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Figure 9: Cross Sections of Drain Alignment showing Natural Surface - Proposed Drain and Bund
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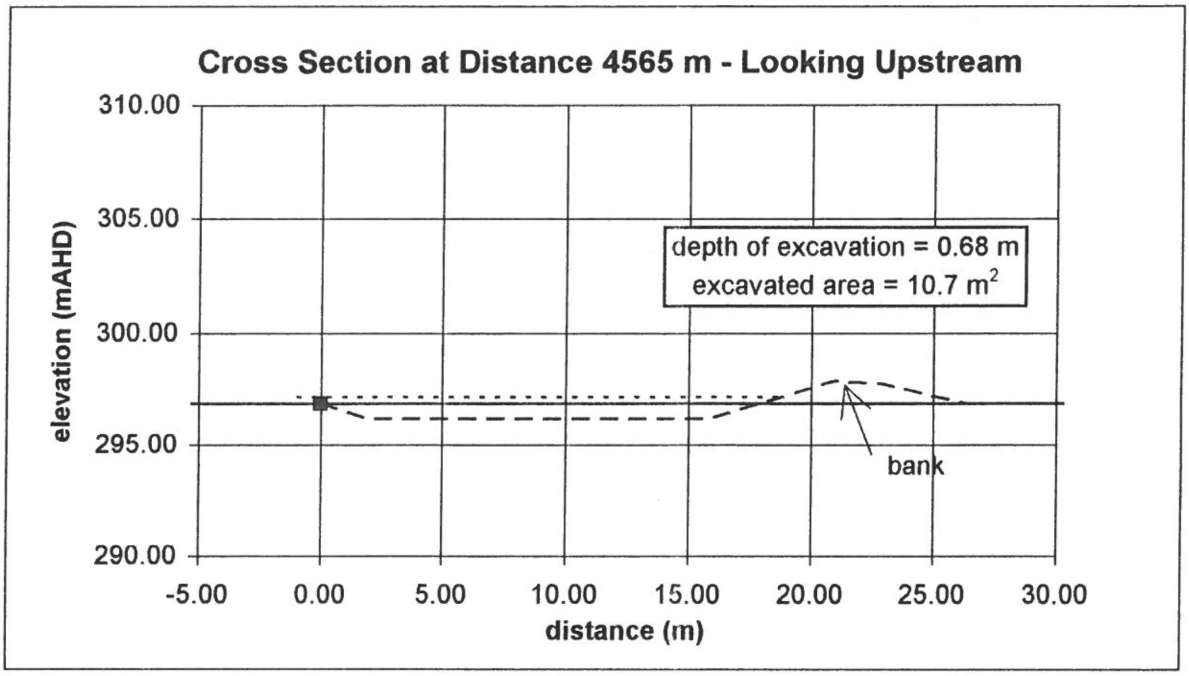

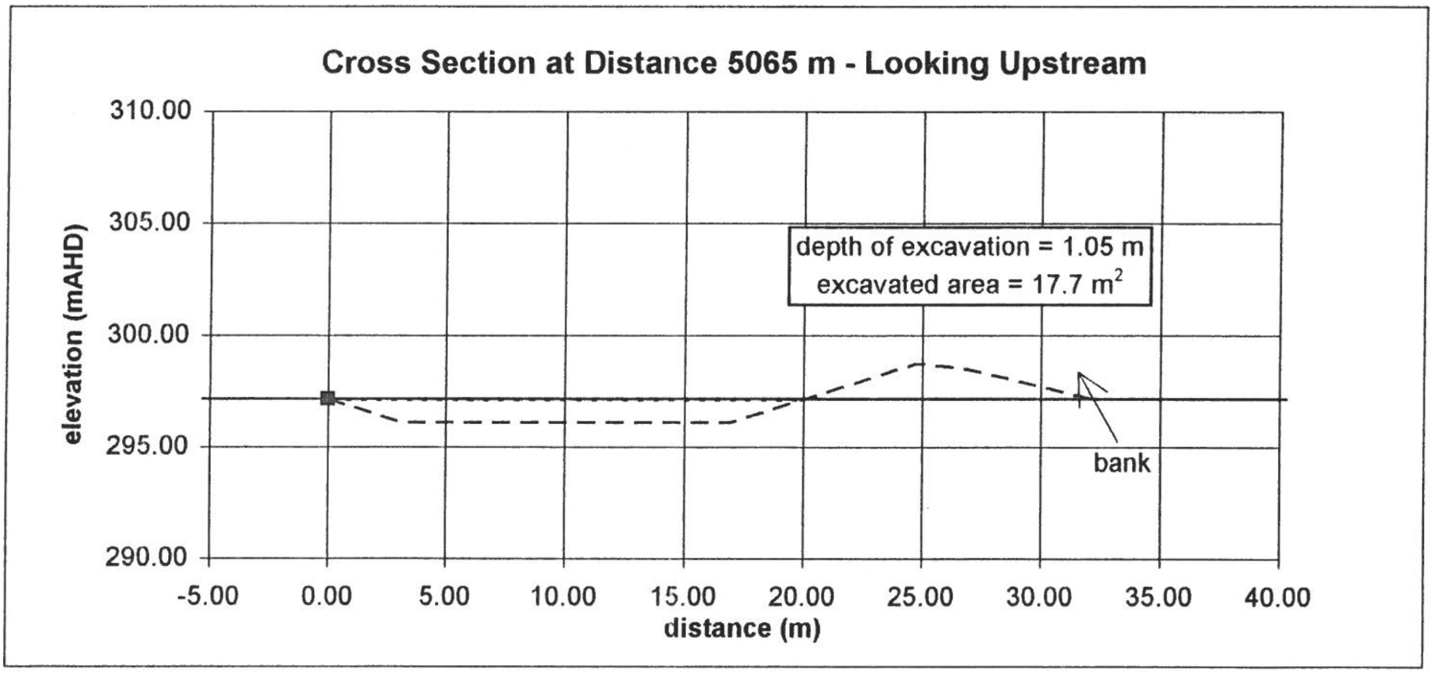

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Figure 10: Cross Sections of Drain Alignment showing Natural Surface - Proposed Drain and Bund
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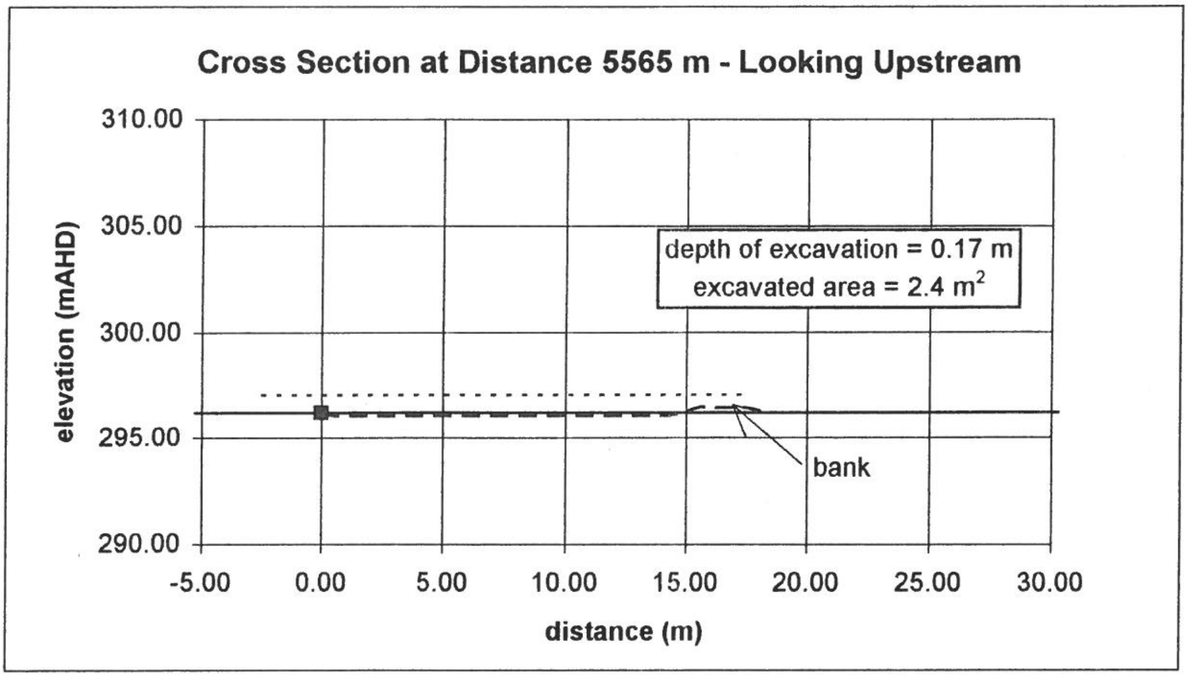

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Figure 11: Cross Section of Drain Alignment showing Natural Surface - Proposed Drain and Bund

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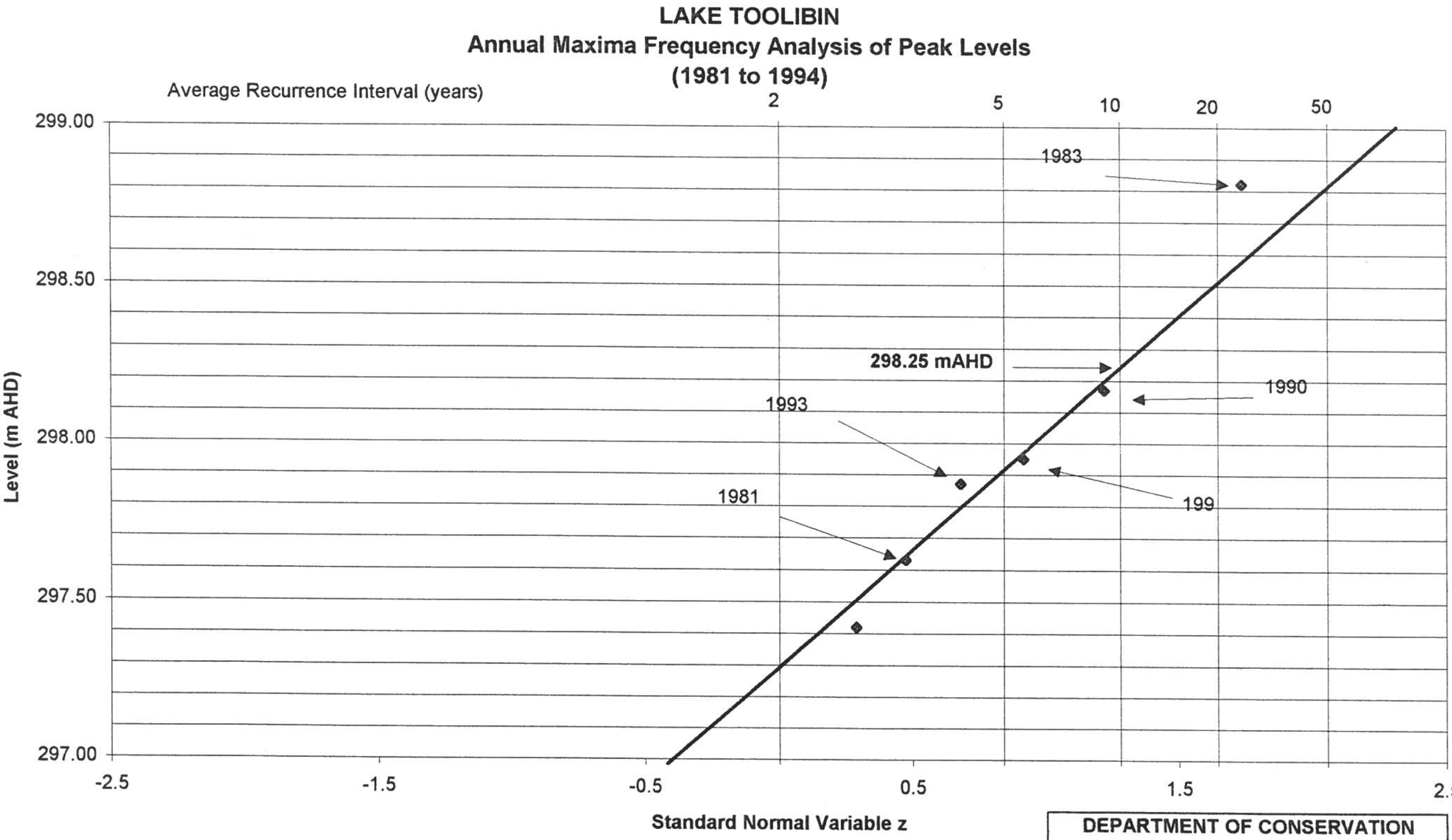

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Figure 12: Lake Toolibin Water Level Frequency Analysis
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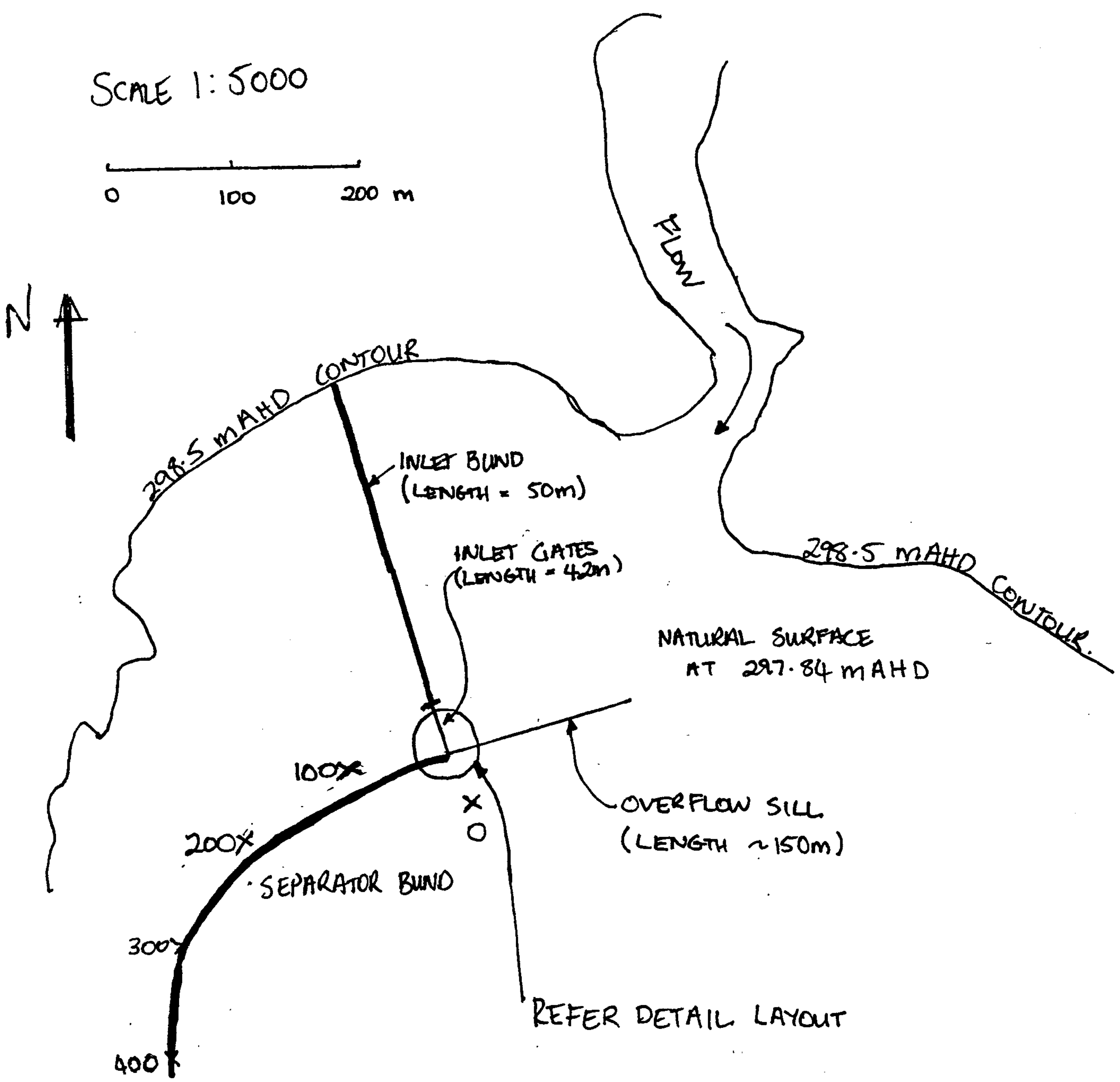
INLET DESIGN

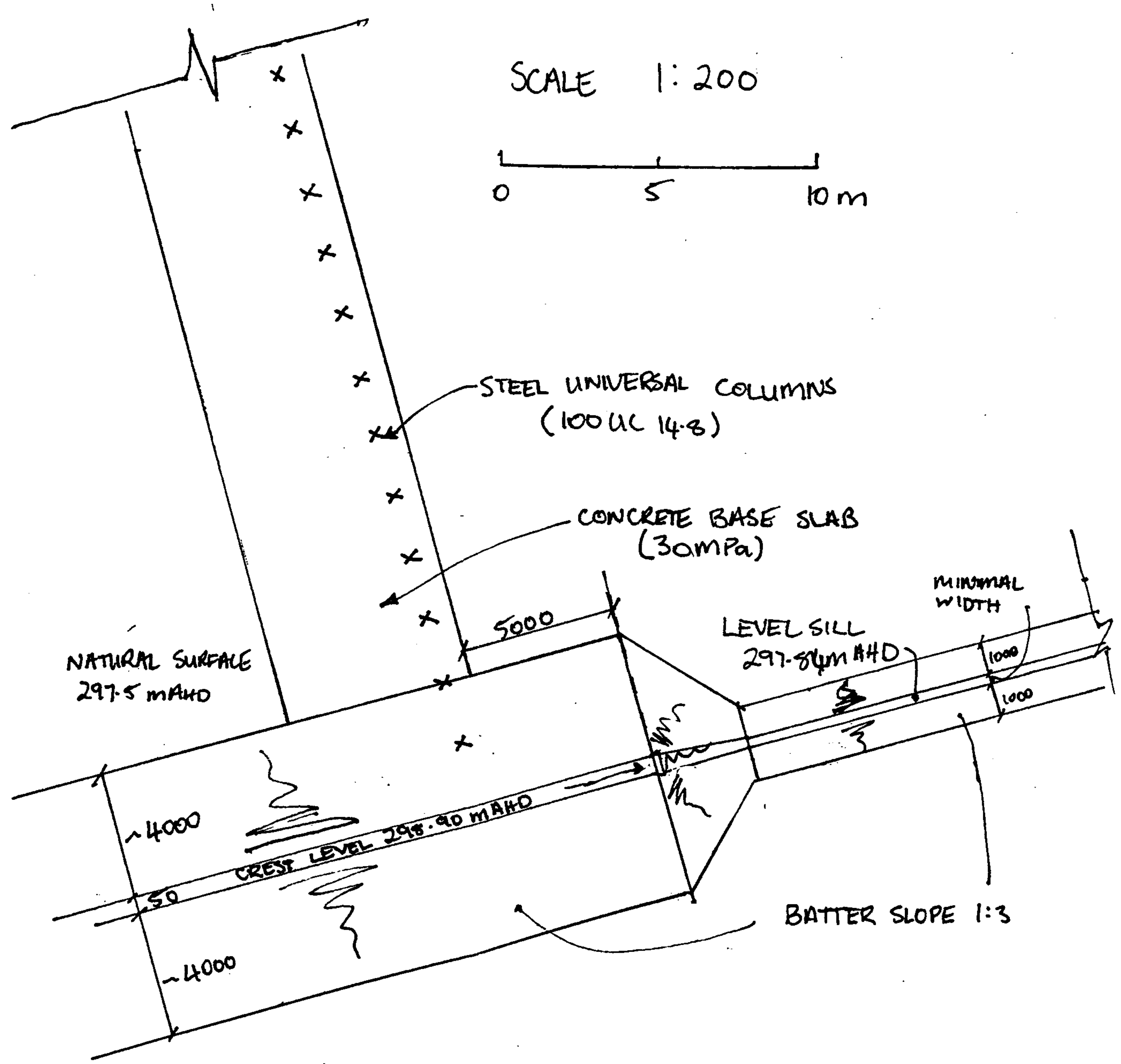
GENERAL LAYOUT



KEY:

X SURVEY POINT.

DETAIL LAYOUT



NOTE

1. ALL DIMENSIONS IN mm

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Figure 13: Plan of Proposed Inlet Control Structures

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Qtot m3/s	Qchan m3/s	Qweir m3/s	uswsl mAHD
3	3	0	297.66
6	6	0	297.84
9	7	2	297.88
14	8	6	297.93
21	9	12	297.98
29	10	19	298.03

weir level	298 mAHD
weir length	150 m

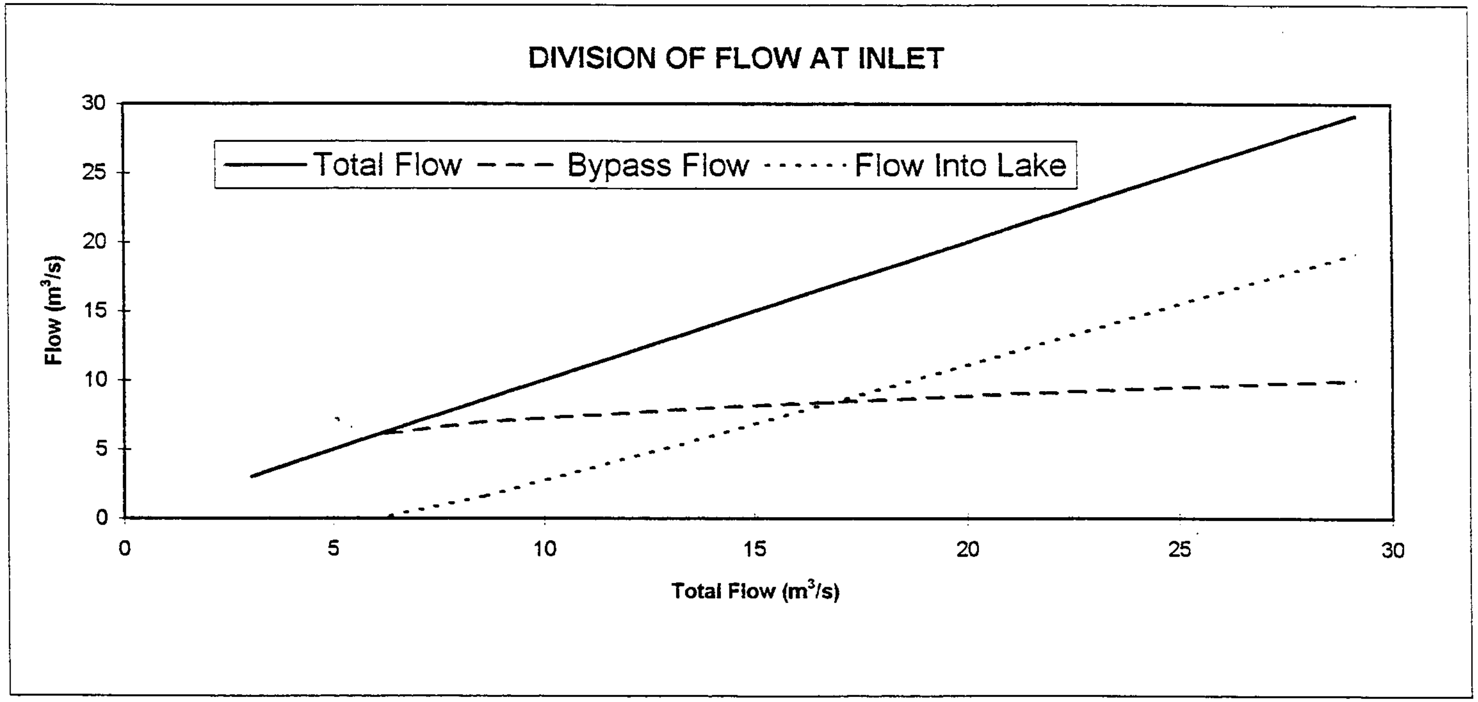

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Figure 14: Division of Flow at Inlet

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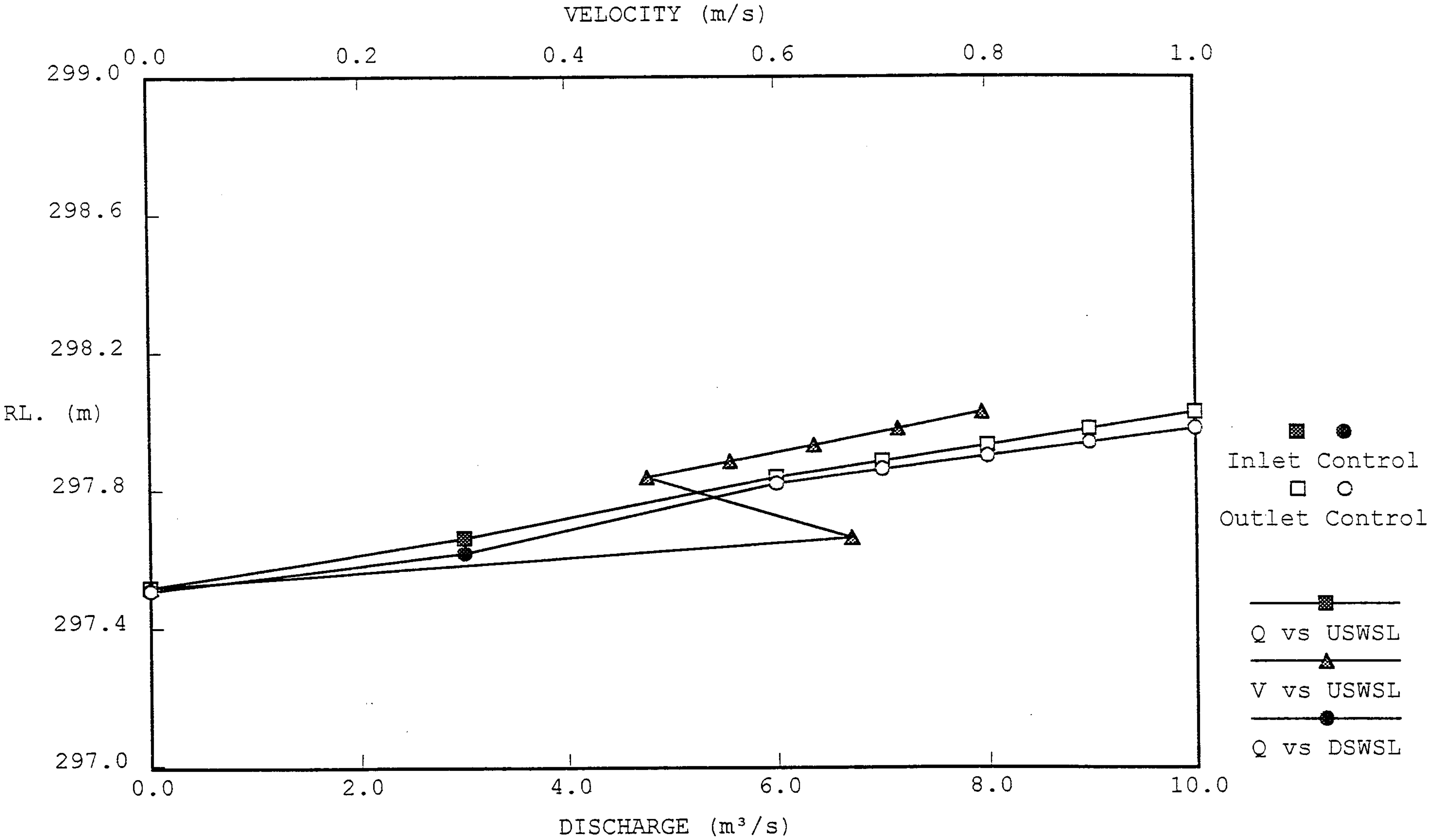

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Figure 15: Output from Culvert for Windows
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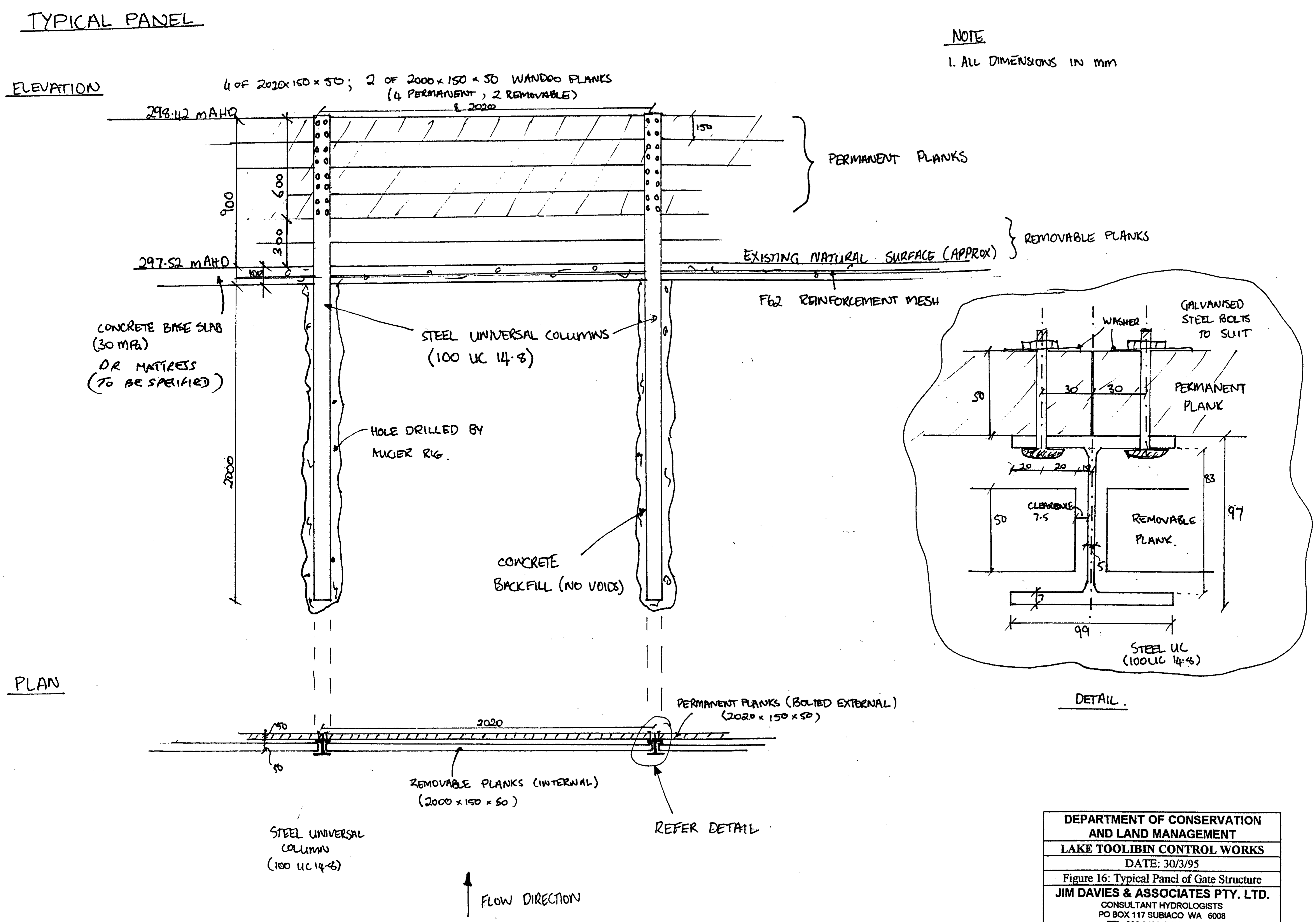

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Figure 16: Typical Panel of Gate Structure

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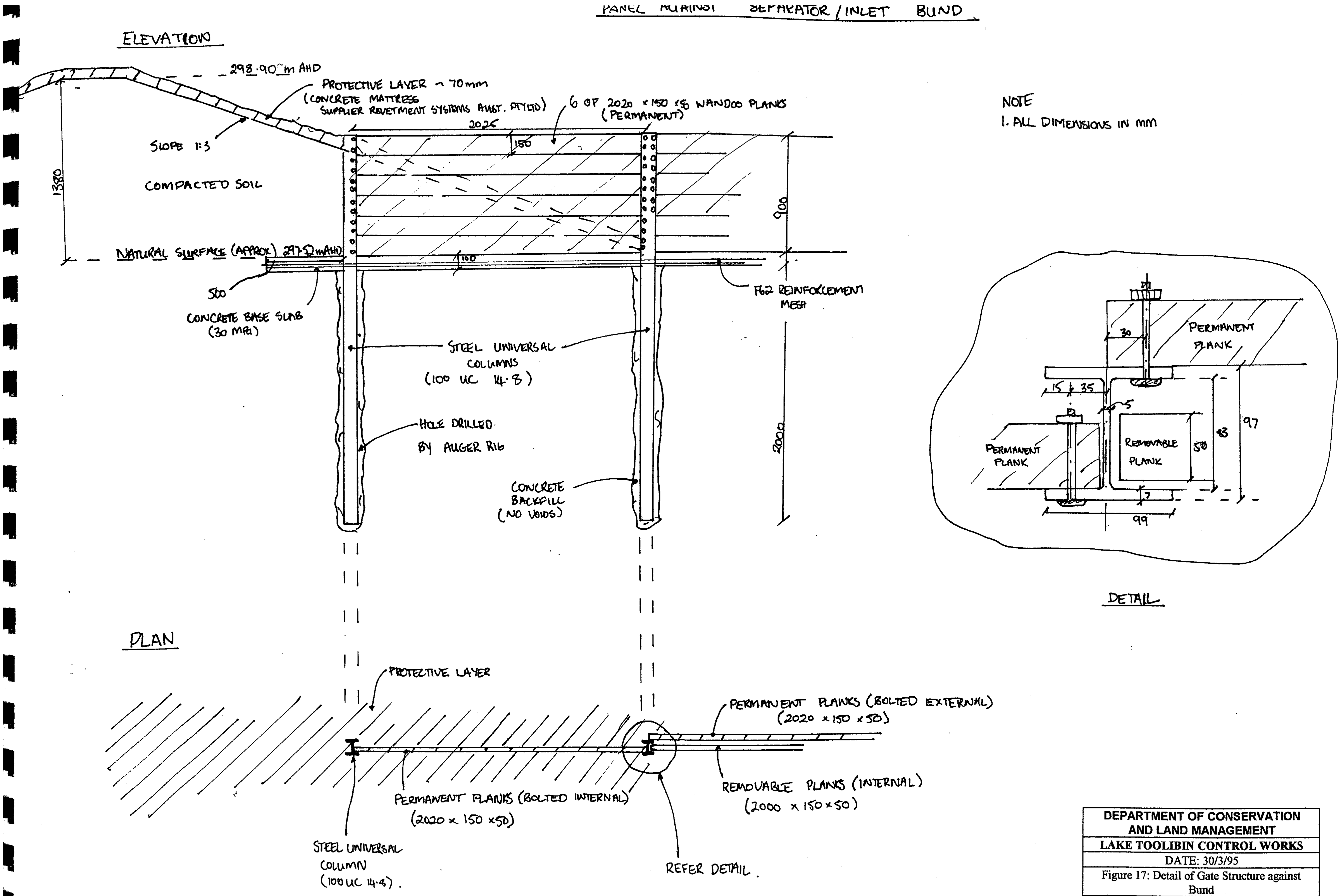

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Figure 17: Detail of Gate Structure against Bund

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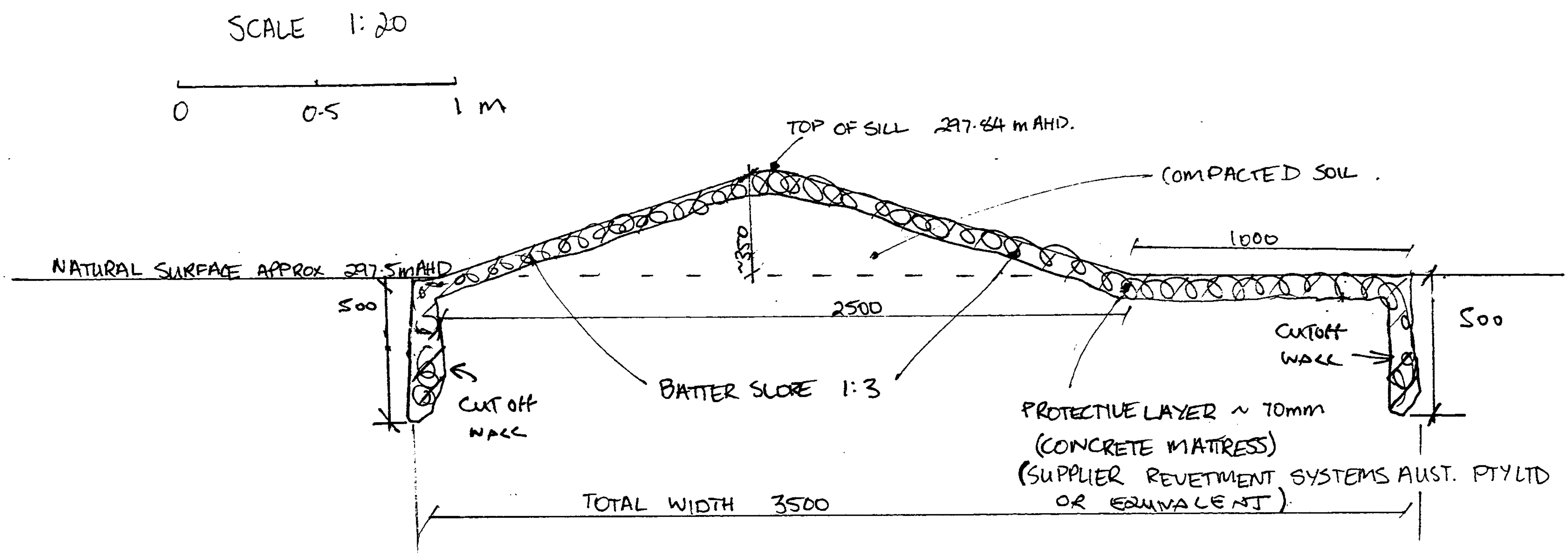
OVERFLOW SILL



NOTE

1. ALL DIMENSIONS IN MM
2. SOURCE OF SILL MATERIAL TO BE DETERMINED ON SITE BY CALM OR REPRESENTATIVE

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Figure 18: Cross Section of Overflow Sill into Lake Toolibin
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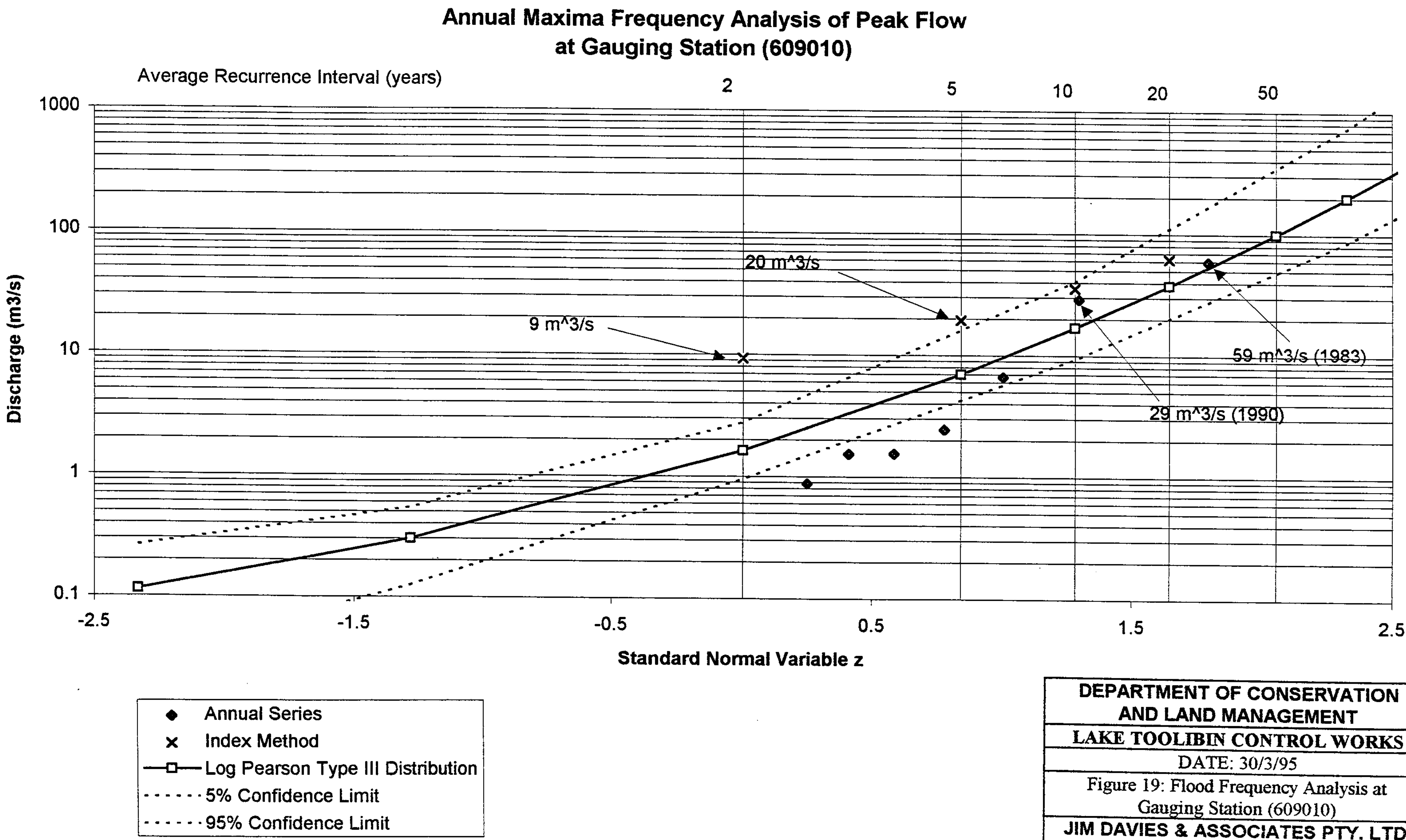

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Figure 19: Flood Frequency Analysis at Gauging Station (609010)

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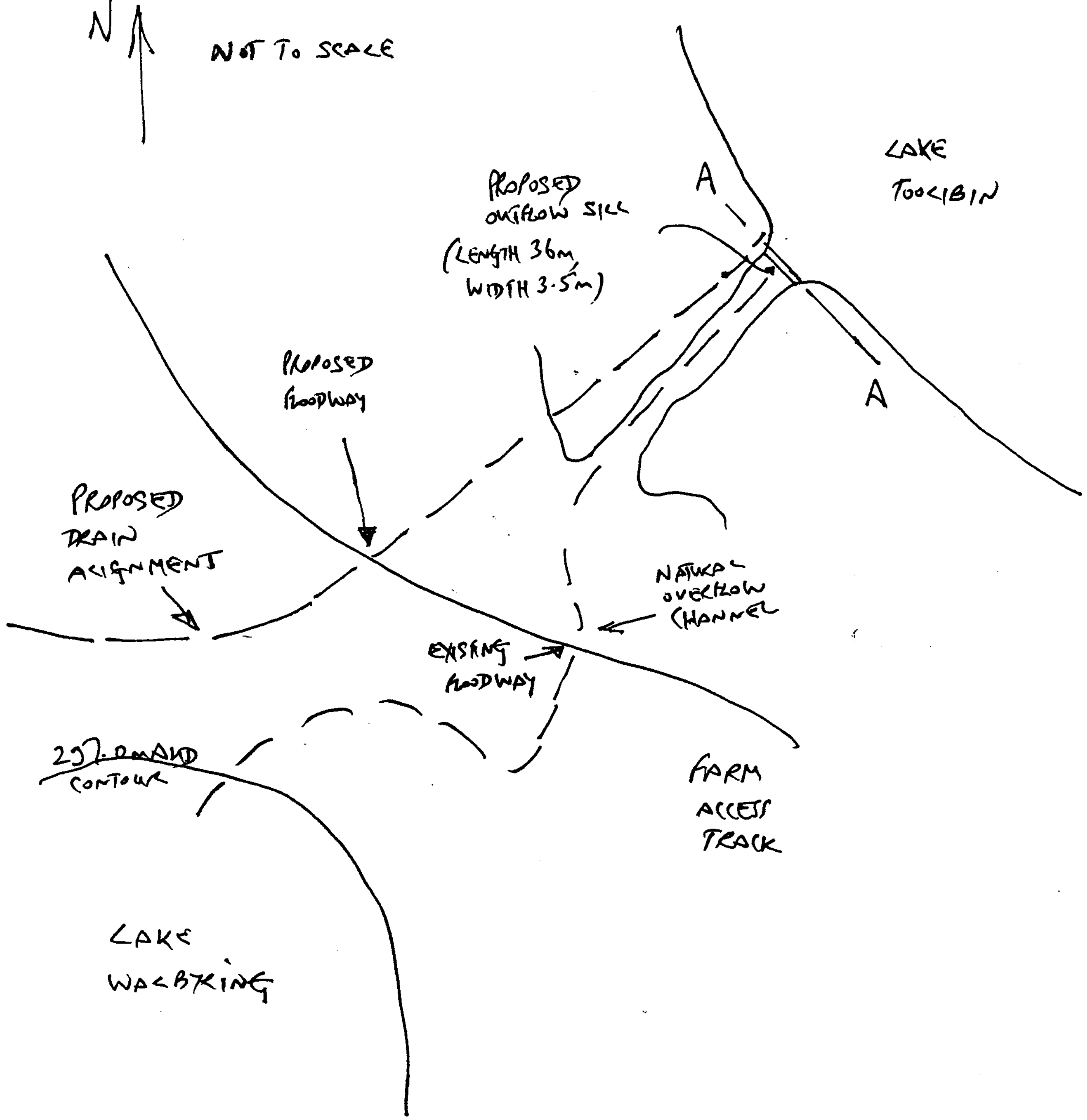
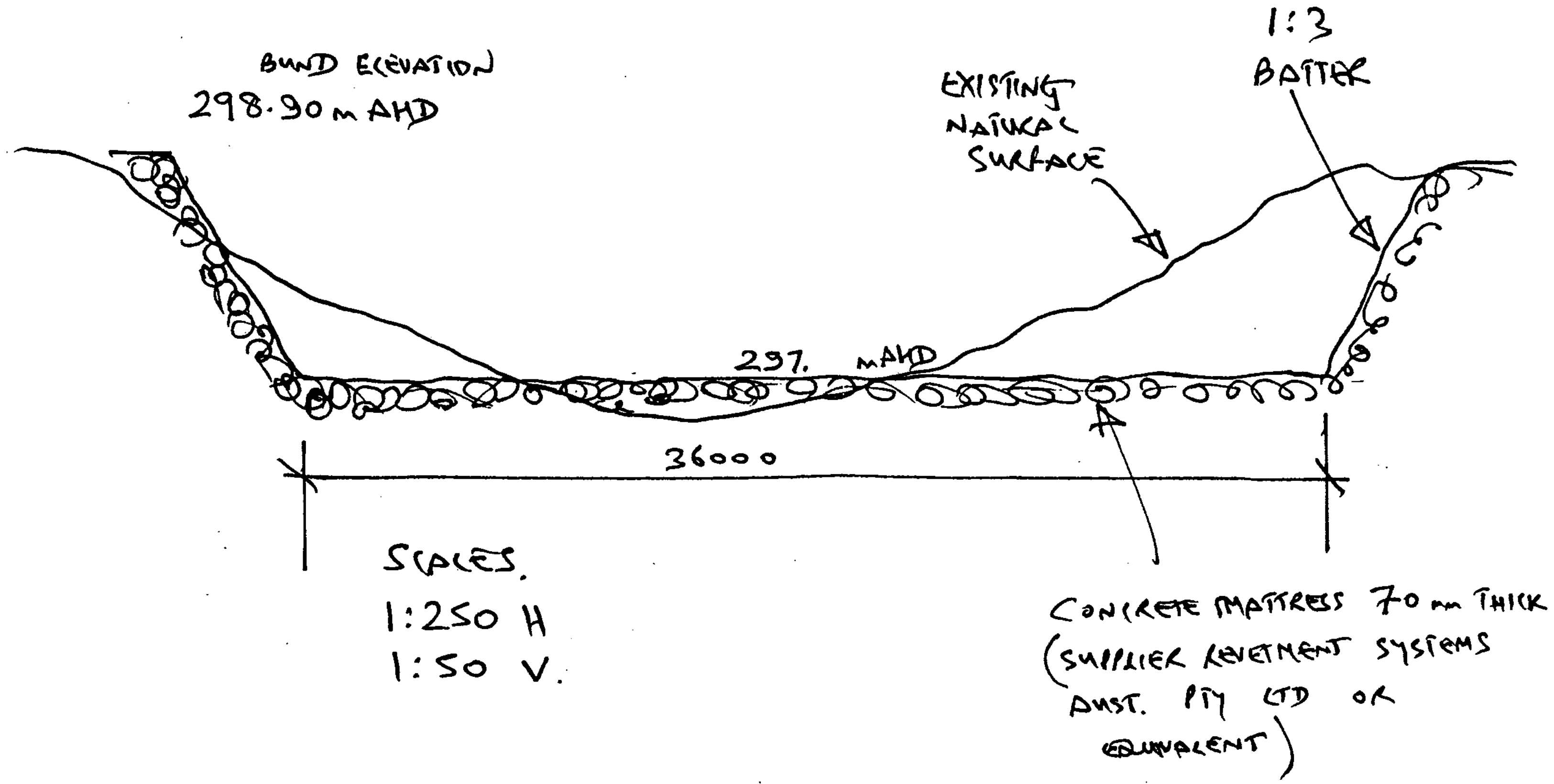
GENERAL LAYOUT





SECTION AA.

Notes

1. Refer to figure 18 for details of mattress batters and cut off wall design dimensions.

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Figure 20: Outlet Detail
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