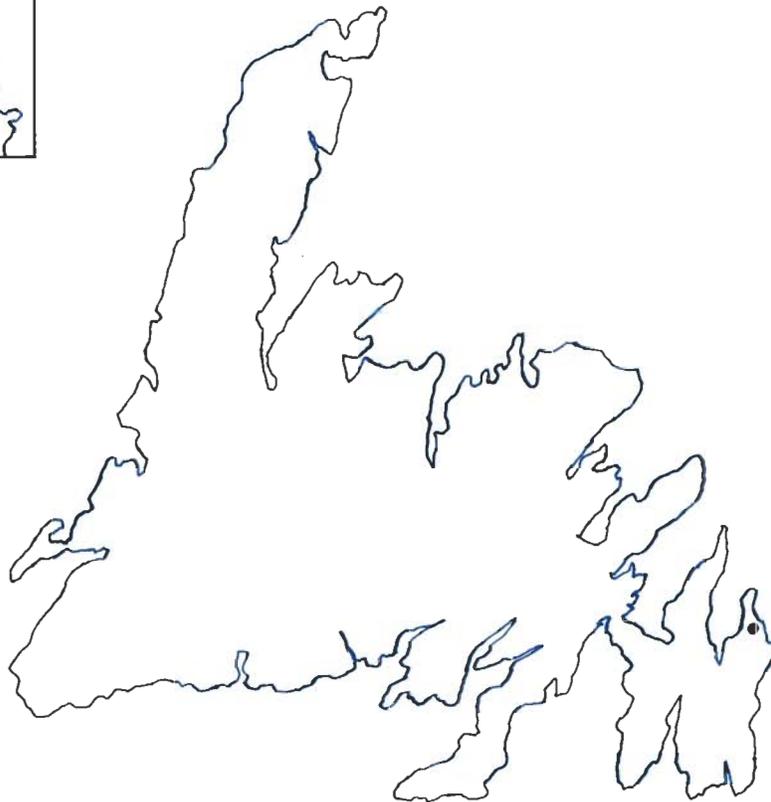
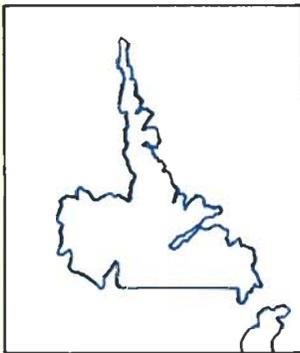




Canada - Newfoundland
**Flood
Damage
Reduction**
Program

Hydrotechnical Study of the Waterford River Area

TECHNICAL APPENDICES



Waterford River

**WRD
FO-124**

FENCO NEWFOUNDLAND LIMITED



Department of
Environment



Environment
Canada

Fenco Newfoundland

FENCO NEWFOUNDLAND LIMITED
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ST. JOHN'S, NEWFOUNDLAND, CANADA A1C 5J2 • TELEPHONE: (709) 754-1480
TELEX: 016-4936 • CABLE: FENCCENG

48160-C2-380000

June 6, 1988

Canada-Newfoundland Flood Damage
Reduction Program
c/o Department of Environment and Lands
Confederation Complex
4th Floor West Block
P.O. Box 4750
St. John's Newfoundland
A1C 5T7



Attention: Dr. W. Ullah, P. Eng.
Director, Water Resources Division

RE: WATERFORD RIVER AREA - HYDROTECHNICAL STUDY

Dear Dr. Ullah:

We are pleased to submit 50 copies of our final report of this study. Accompanying this submission are 10 copies of our technical appendix and a complete set of flood risk maps for the study area.

This report describes the results of field surveys and our studies to identify flood-prone areas and flood damage reduction alternatives in the study area - from St. John's Harbour to Donovans Industrial Park. The first Chapter presents a concise summary of our findings and subsequent chapters provide the details.

It has been a distinct pleasure to work with you and the other members of the Flood Damage Reduction Technical Committee during this project. We particularly wish to thank you, Ms. E. Langley, and Mr. R. Picco for your considerable assistance and constructive comments throughout the course of this study.

We look forward to being of service to you again in the near future.

Yours very truly,
FENCO Newfoundland Limited

A handwritten signature in cursive script, appearing to read 'Eric Gray'.

Eric Gray, P. Eng.
President

:hc
Encl.

Lavalin

VOLUME 2

TECHNICAL APPENDICES

- A Hydrometric Monitoring
- B Documentation of HEC-2 and QUALHYMO Files
- C Cross-Section Plots

WATERFORD RIVER HYDROTECHNICAL STUDY

**TECHNICAL APPENDIX A
HYDROMETRIC MONITORING**

- A-1 Crest Gauge Monitoring
(March 28 to Nov. 13, 1987)

- A-2 Snow Surveys
(March - April 1987)

APPENDIX A

A-1 Crest Gauge Monitoring

WATERFORD RIVER HYDROTECHNICAL STUDY
CREST - STAGE GAUGE DATA (March 28 - April 10/87)

DATE	Symes Bridge WSG #1	Brookfield WSG #2	MP 8 WSG #3	D6 WSG #4	D15 WSG #5
March 26/87	25.7	17.2	n/a	29.5	n/a
28	24.8	12.9	7.9	28.7	22.2
30	31.1	15.2	10.2	34.0	24.1
April 2/87	45.4	26.7	*97.2	45.7	33.3
3	117.5	59.7	*81.3	88.9	84.5
as read 6	46.4	26.0	*96.5	46.7	34.6
Max. 6	60.6	75.2		97.2	97.4
8	50.8	30.5	*98.7	49.9	39.4
as read 10	55.3	33.7	*92.7	53.3	40.6
Max. 10	92.7	55.9		71.4	63.5

Notes:

- Values indicated are read in "cm" height from stage gauge reference pin. (except *)
- * indicates values measured from top of reference stage gauge to water surface. (At site #3 only; due to stage gauge damage)
- All values considered maximum except where noted.
- As read indicates present water level at gauge.
- Max. indicates maximum water level recorded since last observation.

WATERFORD RIVER HYDROTECHNICAL STUDY

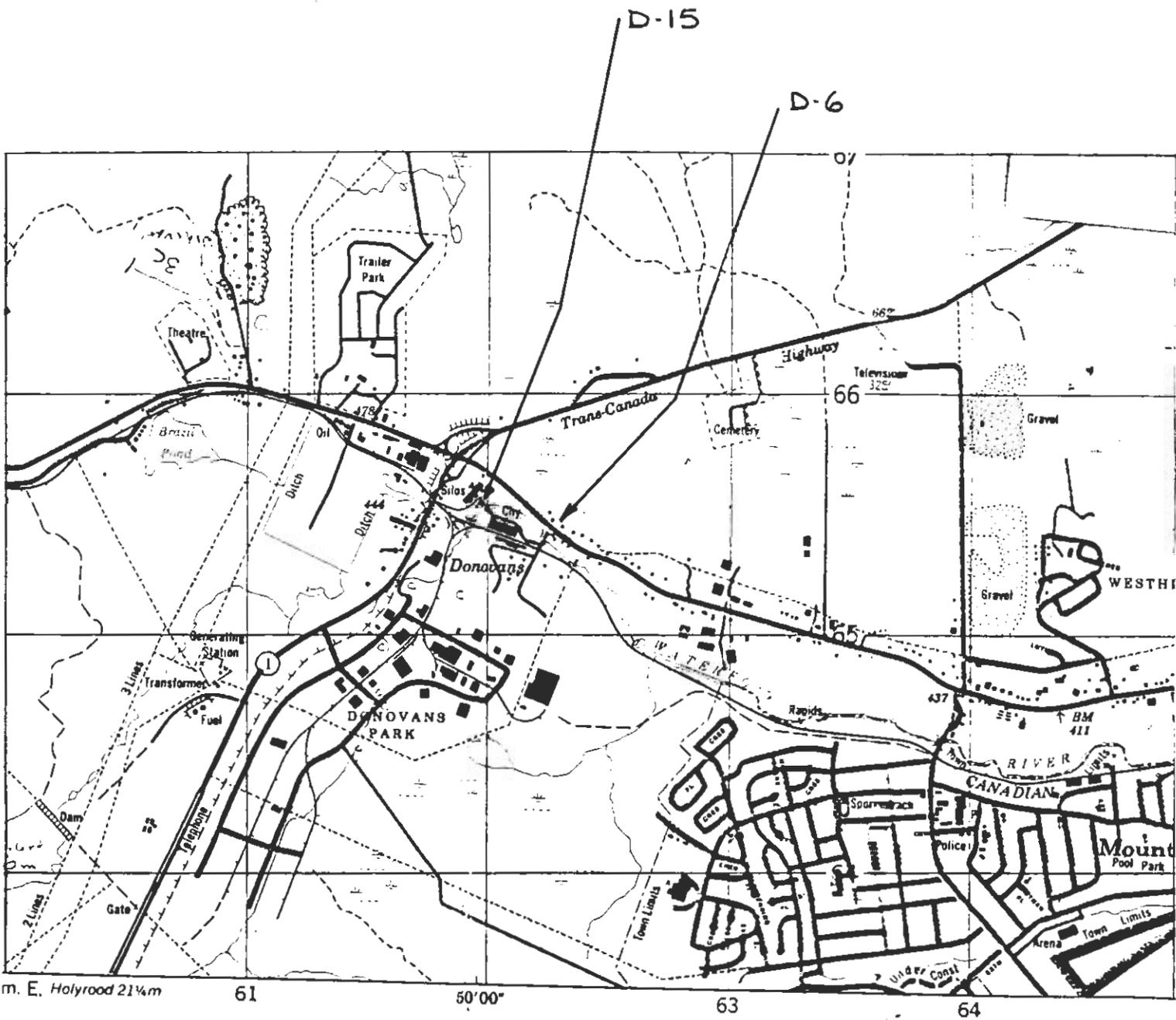
CREST - STAGE GAUGE OBSERVATIONS (APRIL 15 - NOVEMBER 13, 1987)

- April 15, 1987 - No significant increase in water level recorded.
- May 17, 1987 - Water level very low, no readings obtained.
- July 1, 1987 - Water level very low, no readings obtained.
- July 28, 1987 - WSG #1, Symes Bridge
recorded maximum = 17.2 cm
as read = 10 cm below reference pin.
- WSG #2, Brookfield Road Bridge
recorded maximum = 10.2 cm
as read = 5.1 cm below reference pin.
- WSG #3, Birch Avenue tracks water level well below guage. Dry ground under guage.
- WSG #4, Newfoundland Fibreply Bridge
recorded maximum = 23.5 cm
as read = 5 cm.
- WSG #5, Newfoundland Hardwoods Bridge
recorded maximum = 12.7 cm
as read = 0.0 cm (water level at reference pin).
- August 6, 1987 - No significant increase or change in water level recorded. Water levels below or at reference pin.
- September 10, 1987 - No significant increase or change in water level recorded.
- September 28, 1987 - No significant increase or change in water level recorded.

WATERFORD RIVER HYDROTECHNICAL STUDY

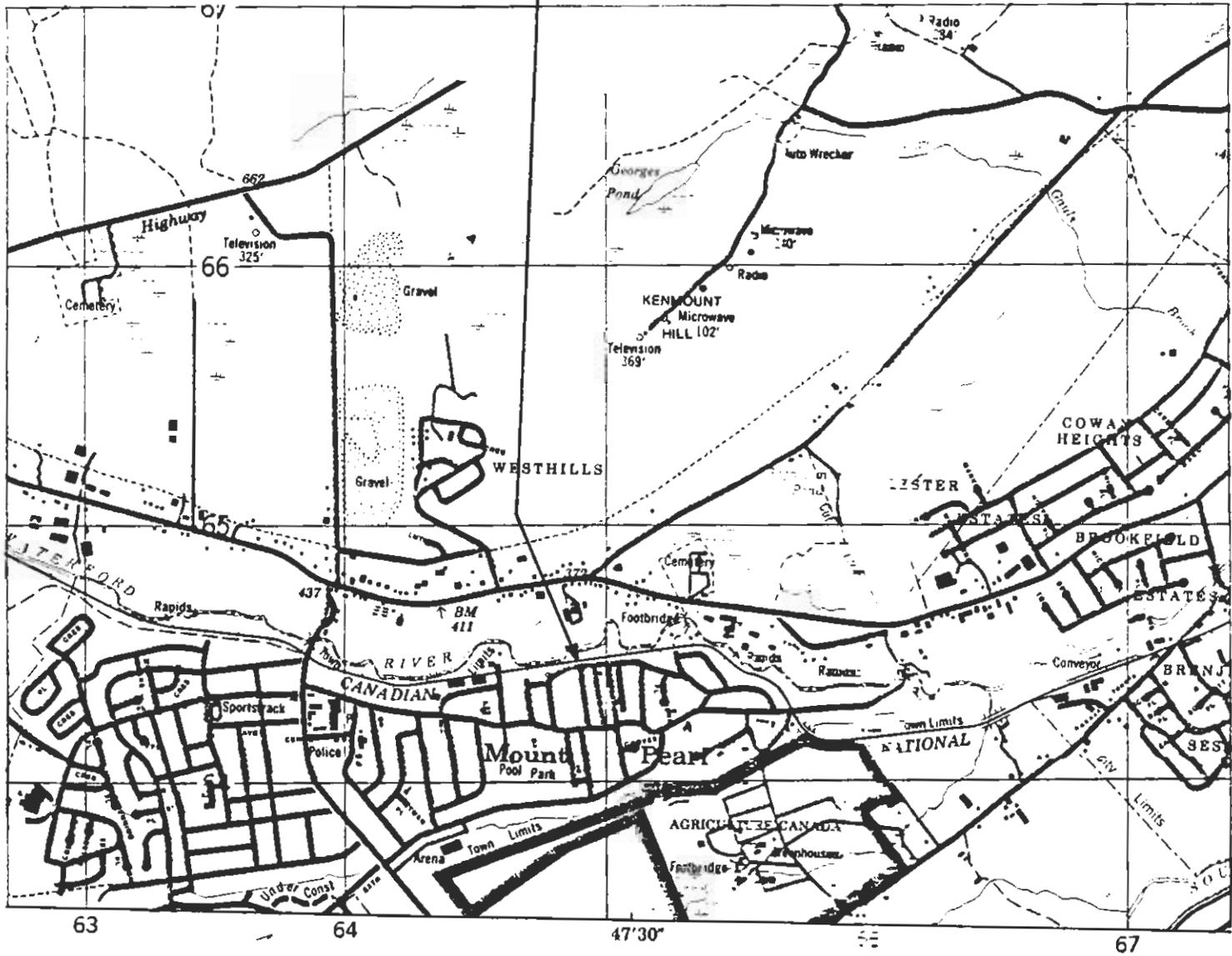
CREST - STAGE GAUGE OBSERVATIONS (APRIL 15 - NOVEMBER 13, 1987)

- October 13, 1987
- WSG #1, Symes Bridge
recorded maximum = 10.2 cm
as read = 2.5 cm below reference pin.
 - WSG #2, Brookfield Road Bridge
recorded maximum = 10.2 cm
as read = 5.1 cm below reference pin.
 - WSG #4, Newfoundland Fibreply Bridge
first recorded maximum = 37.5 cm
second recorded maximum = 26.7 cm
as read = 10.2cm.
 - WSG #5, Newfoundland Hardwoods Bridge
recorded maximum = 11.4 cm
as read = 0.0 cm (water level at reference pin).
- October 27, 1987
- Check WSG # 1 and WSG # 2; No. Max. level recorded. Present level below reference pin.
- November 13, 1987
- WSG #1, Symes Bridge
recorded maximum = 48.9 cm
as read = 27.9 cm
 - WSG #2, Brookfield Road Bridge
recorded maximum = 53.3 cm
as read = 15.2 cm
 - WSG #4, Newfoundland Fibreply Bridge
recorded maximum = 69.2 cm
as read = 45.7 cm.
 - WSG #5, Newfoundland Hardwoods Bridge
recorded maximum = 41.9 cm
as read = 20.3 cm

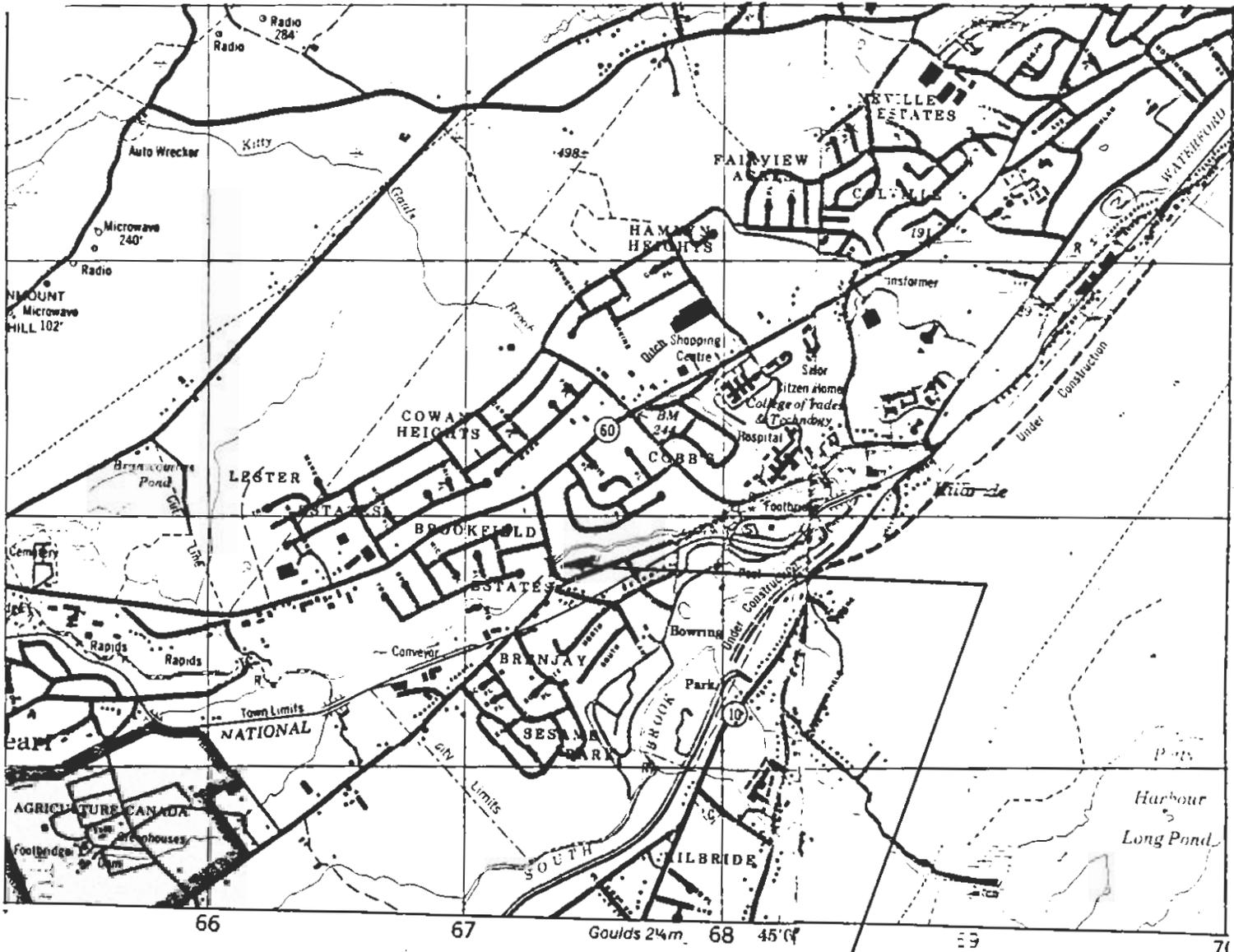


CREST GAUGES : D-6 , D-15

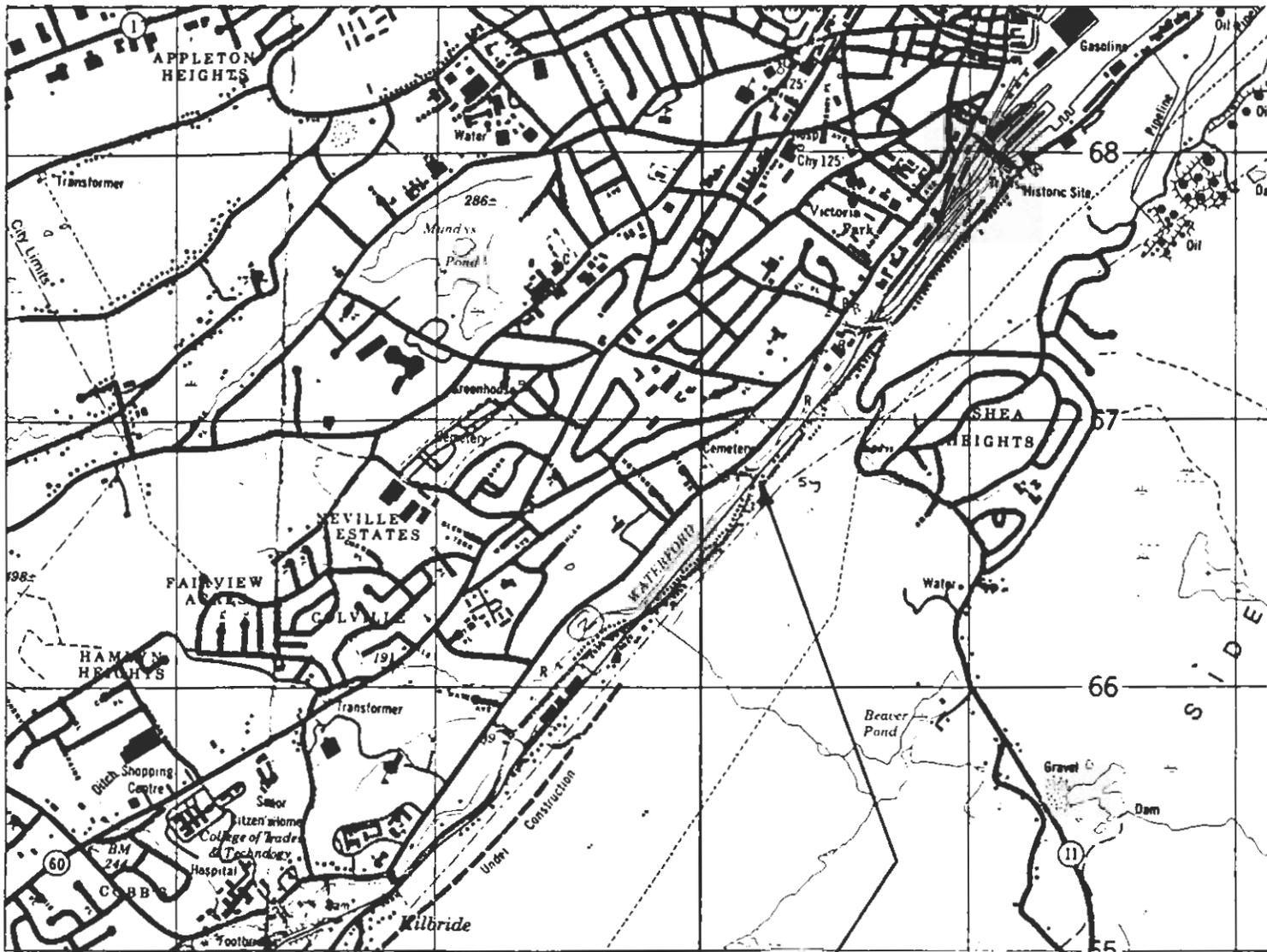
MP-8



CREST GAUGE MP 8



CREST GAUGE BROOKFIELD



CREST GAUGE: SYMES

TECHNICAL APPENDIX A

A.2 SNOW SURVEYS

Data on snow water equivalent was collected at three sites during the study period. The objective of these surveys was to obtain snowpack data for hydrologic modelling, in the event that runoff in 1987 was sufficiently high for inclusion in the process of model calibration or verification.

The three sampling sites cover the predominant land uses, and consider the elevation and slope variability in the watershed.

Site 1 Southwest St. John's

- Victoria Park at Water Street
- within built-up area
- in low elevation reach of the watershed (20 m)

Site 2 Blackmarsh Road and Frecker Drive

- built-up area - woodland transition
- site of previous snow course (No. 5)
- intermediate elevation (110 m)
- southward facing slope

Site 3 Harbour Arterial (0.5 km East of TransCanada Highway)

- woodland area (access via hydro corridor)
- near site of previous snow course (No. 1)
- high elevation (190 m)
- northward facing slope

The sites are shown on the enclosed figure. Three or four measurements were taken at each site at stations (e.g. A,B,C,D) which were separated by 20 m. The observation data are summarized in the Tables.

TABLE A-2

SNOW SURVEY - 1987
WATERFORD RIVER BASIN

Date: March 30, 1987

<u>Site</u>	<u>Location</u>	<u>Snow Depth (cm)</u>	<u>Water Equiv (cm and %)</u>	
1. Victoria Park and Water St.	A	63.3	22.4	35.4
	B	43.7		
	C	32.3		
2. Blackmarsh Rd at Frecker Dr	A	108.1	35.2	32.6
	B	116.5		
	C	101.7		
3. Arterial Road near TCH	A	147.3	58.6	39.8
	B	121.9		
	C	135.3		
	D	128.3		

Date: April 02, 1987

<u>Site</u>	<u>Location</u>	<u>Snow Depth (cm)</u>	<u>Water Equiv (cm and %)</u>	
1. Victoria Park and Water St.	A	54.6	19.0	34.9
	B	37.5		
	C	27.9		
2. Blackmarsh Rd at Frecker Dr	A	96.5	31.7	32.9
	B	102.2		
	C	91.4		
3. Arterial Road near TCH	A	134.0	55.3	41.2
	B	111.8		
	C	122.6		
	D	116.8		

TABLE A-2 (cont'd)

SNOW SURVEY - 1987
WATERFORD RIVER BASIN

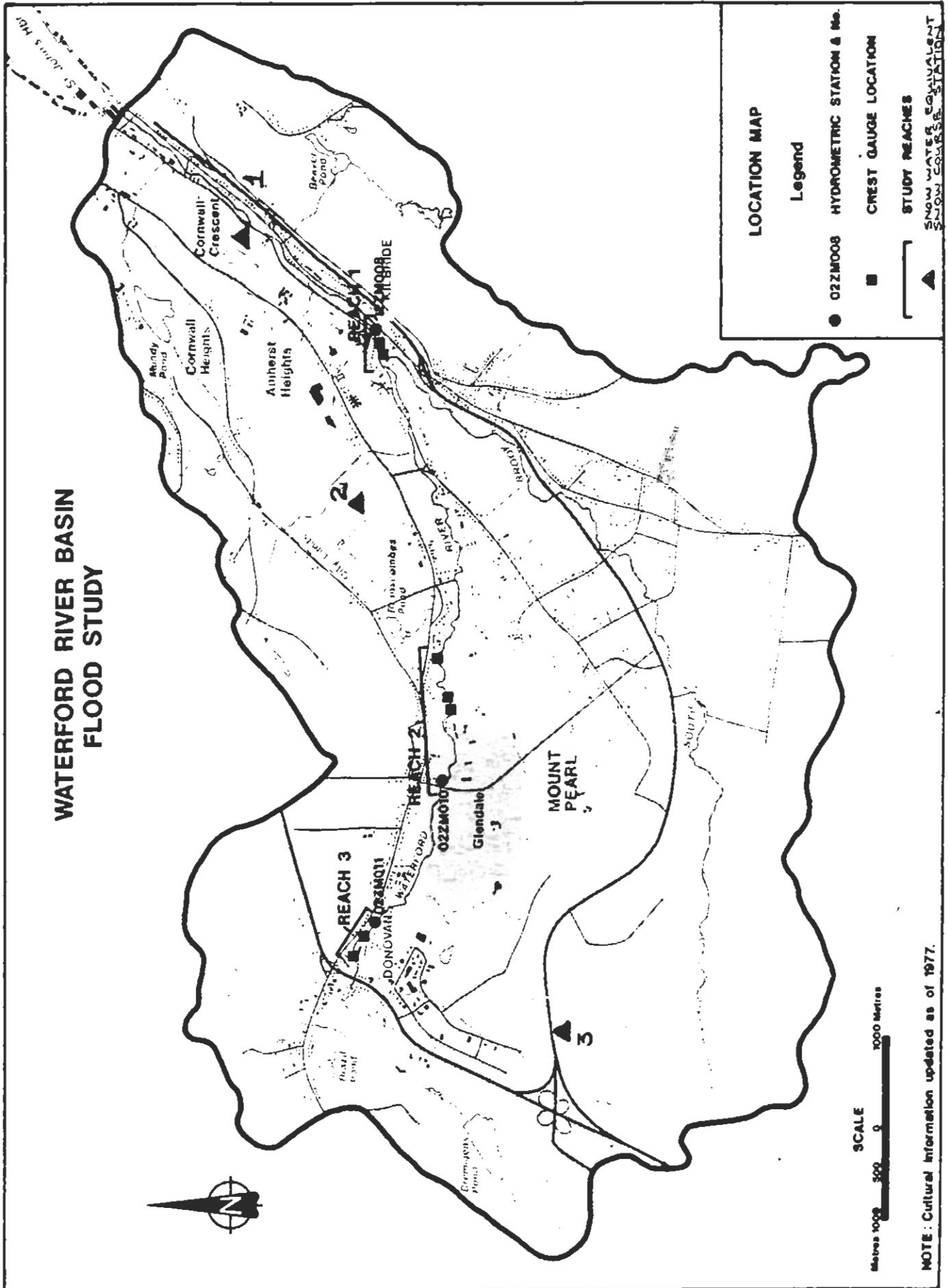
Date: April 03, 1987

<u>Site</u>	<u>Location</u>	<u>Snow Depth (cm)</u>	<u>Water Equiv (cm and %)</u>	
1. Victoria Park and Water St.	A	40.5	16.0	39.5
	B	28.2		
	C	20.1		
2. Blackmarsh Rd at Frecker Dr	A	84.0	29.8	35.5
	B	85.2		
	C	81.6		
3. Arterial Road near TCH	A	119.0	50.0	42.0
	B	98.9		
	C	93.7		

Date: April 15, 1987

<u>Site</u>	<u>Location</u>	<u>Snow Depth (cm)</u>	<u>Water Equiv (cm and %)</u>	
1. Victoria Park and Water St.	A	2 cm	not estimated	
	B	approx.		
	C	in pockets		
2. Blackmarsh Rd at Frecker Dr	A	5 cm	not estimated	
	B	approx.		
	C			
3. Arterial Road near TCH	A	8 cm	not estimated	
	B	approx.		
	C			

WATERFORD RIVER BASIN FLOOD STUDY



LOCATION MAP

Legend

- 022M008 HYDROMETRIC STATION & No.
- CREST GAUGE LOCATION
- STUDY REACHES
- ▲ SNOW WATER EQUIVALENT STATION COURSE

SCALE
Metres 1000 500 0 1000 Metres

NOTE: Cultural information updated as of 1977.

Figure

TECHNICAL APPENDIX B

DOCUMENTATION OF HEC-2 AND QUALHYMO FILES

WATERFORD HYDROTECHNICAL STUDY
DOCUMENTATION OF HEC-2 AND QUALHYMO FILES

FILENAME	DESCRIPTION
K75WFORD.DAT	LUMPED QUALHYMO MODEL FOR 23 AUG. 1975 EVENT
K76WFORD.DAT	LUMPED QUALHYMO MODEL FOR 9 JAN. 1976 EVENT
K77WFORD.DAT	LUMPED QUALHYMO MODEL FOR 27 DEC. 1977 EVENT
K78WFORD.DAT	LUMPED QUALHYMO MODEL FOR 27 JAN. 1978 EVENT
K79WFORD.DAT	LUMPED QUALHYMO MODEL FOR 29 JAN. 1979 EVENT
K80WFORD.DAT	LUMPED QUALHYMO MODEL FOR 7 OCT. 1980 EVENT
K81WFORD.DAT	LUMPED QUALHYMO MODEL FOR 26 NOV. 1981 EVENT
K82WFORD.DAT	LUMPED QUALHYMO MODEL FOR 4 OCT. 1982 EVENT
K83WFORD.DAT	LUMPED QUALHYMO MODEL FOR 26 OCT. 1983 EVENT
K84WFORD.DAT	LUMPED QUALHYMO MODEL FOR 7 FEB. 1984 EVENT
K85WFORD.DAT	LUMPED QUALHYMO MODEL FOR 25 MAY 1985 EVENT
K86WFORD.DAT	LUMPED QUALHYMO MODEL FOR 11 APR. 1986 EVENT
WDIS75.DAT	DISCR. QUALHYMO MODEL FOR 23 AUG. 1975 EVENT
WDIS76.DAT	DISCR. QUALHYMO MODEL FOR 9 JAN. 1976 EVENT
WDIS77.DAT	DISCR. QUALHYMO MODEL FOR 27 DEC. 1977 EVENT
WDIS78.DAT	DISCR. QUALHYMO MODEL FOR 27 JAN. 1978 EVENT
WDIS79.DAT	DISCR. QUALHYMO MODEL FOR 29 JAN. 1979 EVENT
WDIS80.DAT	DISCR. QUALHYMO MODEL FOR 7 OCT. 1980 EVENT
WDIS81.DAT	DISCR. QUALHYMO MODEL FOR 26 NOV. 1981 EVENT
WDIS82.DAT	DISCR. QUALHYMO MODEL FOR 4 OCT. 1982 EVENT
WDIS83.DAT	DISCR. QUALHYMO MODEL FOR 26 OCT. 1983 EVENT
WDIS84.DAT	DISCR. QUALHYMO MODEL FOR 7 FEB. 1984 EVENT
WDIS85.DAT	DISCR. QUALHYMO MODEL FOR 25 MAY 1985 EVENT
WDIS86.DAT	DISCR. QUALHYMO MODEL FOR 11 APR. 1986 EVENT
WDIS100.DAT	DISCR. QUALHYMO MODEL FOR 100 YEAR EVENT
RAIN20.DAT	HOURLY RAINFALL FOR 20 YEAR EVENT
RAIN100.DAT	HOURLY RAINFALL FOR 100 YEAR EVENT
RAIN75D.DAT	HOURLY RAINFALL FOR 20-30 AUG. 1975 EVENT
RAIN76D.DAT	HOURLY RAINFALL FOR 15 NOV. 1975-15 JAN 1976
RAIN77D.DAT	HOURLY RAINFALL FOR 15 NOV. 1977- 5 FEB 1978
RAIN78D.DAT	HOURLY RAINFALL FOR 10-25 DEC. 1978 EVENT
RAIN79D.DAT	HOURLY RAINFALL FOR 15 NOV. 1978- 5 FEB 1979
RAIN80D.DAT	HOURLY RAINFALL FOR 1-10 OCT. 1980 EVENT
RAIN81.DAT	HOURLY RAINFALL FOR 1-30 NOV. 1981 EVENT
RAIN82.DAT	HOURLY RAINFALL FOR 1 AUG. - 31 OCT. 1982
RAIN83.DAT	HOURLY RAINFALL FOR 1 JULY - 21 DEC 1983
RAIN84D.DAT	HOURLY RAINFALL FOR 15 NOV. 1983 -1 MAR 1984
RAIN85D.DAT	HOURLY RAINFALL FOR 20-28 MAY 1985
RAIN86D.DAT	HOURLY RAINFALL FOR 15 NOV. 1985-20 APR.1986
TEMP76D.DAT	HOURLY TEMPERATURE FOR 15 NOV 1975-15 JAN 1976
TEMP77D.DAT	HOURLY TEMPERATURE FOR 15 NOV. 1977-5 FEB 1978
TEMP79D.DAT	HOURLY TEMPERATURE FOR 15 NOV. 1978-5 FEB 1979
TEMP84D.DAT	HOURLY TEMPERATURE FOR 15 NOV. 1983-1 MAR 1984
TEMP86D.DAT	HOURLY TEMPERATURE FOR 15 NOV.1985-20 APR.1986
PACK.DAT	QUALHYMO SNOWMELT PARAMETERS
XQMAIN.EXE	QUALHYMO PROGRAM
WAT100.HEC	WATERFORD R. HEC-2 MODEL FOR 100 YEAR
WAT20.HEC	WATERFORD R. HEC-2 MODEL FOR 20 YEAR

TECHNICAL APPENDIX C

RIVER CROSS-SECTION DATA

C-1 Mannings Roughness Coefficients

C-2 Cross-Section Plots

APPENDIX C-1

TABLE C-1

WATERFORD RIVER

MANNINGS ROUGHNESS VALUES

SECTION	LB*	RB	CH	SECTION	LB*	RB	CH
0.100	.050	.050	.040**	4176.0	.040	.040	.025**
0.300	.050	.050	.030***	4356.0	.040	.040	.030***
120.0	.050	.050	.040	4608.0	.040	.040	.040
291.0	.045	.045	.035	4840.0	.040	.040	.025
765.0	.040	.040	.040	4865.0	.030	.030	.030
782.0	.040	.040	.020	4880.0	.045	.045	.035
816.0	.050	.050	.040	5405.0	.045	.045	.025
857.0	.065	.065	.055	5445.0	.045	.045	.035
900.0	.070	.070	.050	6970.0	.040	.040	.030
1575.0	.070	.070	.030	6984.0	.050	.050	.035
1590.0	.070	.070	.040	7363.0	.060	.060	.045
2954.0	.050	.050	.040	7585.0	.060	.060	.050
2965.0	.030	.030	.025	7963.0	.070	.070	.065
2980.0	.050	.050	.040	8232.0	.090	.090	.075
3008.0	.045	.045	.040	8508.0	.095	.095	.080
3694.0	.040	.040	.030	8629.0	.120	.090	.080
3698.0	.030	.030	.015	8842.0	.090	.080	.075
3702.3	.030	.030	.025	8988.0	.035	.035	.025
3722.0	.040	.040	.030	9836.0	.035	.035	.035
3764.0	.030	.030	.020	9870.0	.040	.040	.030
3883.0	.035	.035	.030	10,247.0	.045	.045	.035
3933.0	.035	.035	.025	10,582.0	.080	.080	.065
3945.0	.030	.030	.025	11,758.0	.080	.080	.025
3957.0	.030	.030	.020	11,767.0	.080	.080	.065
3957.2	.040	.040	.030	11,930.0	.080	.080	.030
3985.0	.030	.030	.030	11,942.0	.080	.080	.065
4028.0	.040	.040	.030	12,228.0	.080	.080	.025
4070.0	.040	.040	.040	12,233.0	.080	.080	.035
4158.0	.040	.040	.025	12,235.0	.080	.080	.070

* Mannings "n" for left bank (LB), right bank (RB) and channel (CH)

** values employed for this section and subsequent sections until revised

*** revised value employed for this and subsequent sections until next revision

APPENDIX C-1

TABLE C-1 (cont'd)

WATERFORD RIVER

MANNINGS ROUGHNESS VALUES

SECTION	LB*	RB	CH
12,312.0	.050	.050	.040**
12,323.0	.050	.050	.025***
12,330.0	.050	.050	.030
12,330.0	.050	.050	.025
12,354.0	.050	.050	.040
12,572.0	.040	.040	.035
12,593.0	.040	.040	.025
12,607.0	.040	.040	.030
12,735.0	.040	.040	.025
12,763.0	.045	.045	.035
13,117.0	.045	.045	.025
13,146.0	.045	.045	.035
13,244.0	.045	.045	.025
13,266.0	.045	.045	.035
13,470.0	.045	.045	.025
13,569.0	.045	.045	.035
12,355.0	.050	.050	.040
12,366.0	.050	.050	.020
12,384.0	.050	.050	.040
12,408.0	.050	.050	.020
12,429.0	.050	.050	.040

* Mannings "n" for left bank (LB), right bank (RB) and channel (CH)

** values employed for this section and subsequent sections until revised

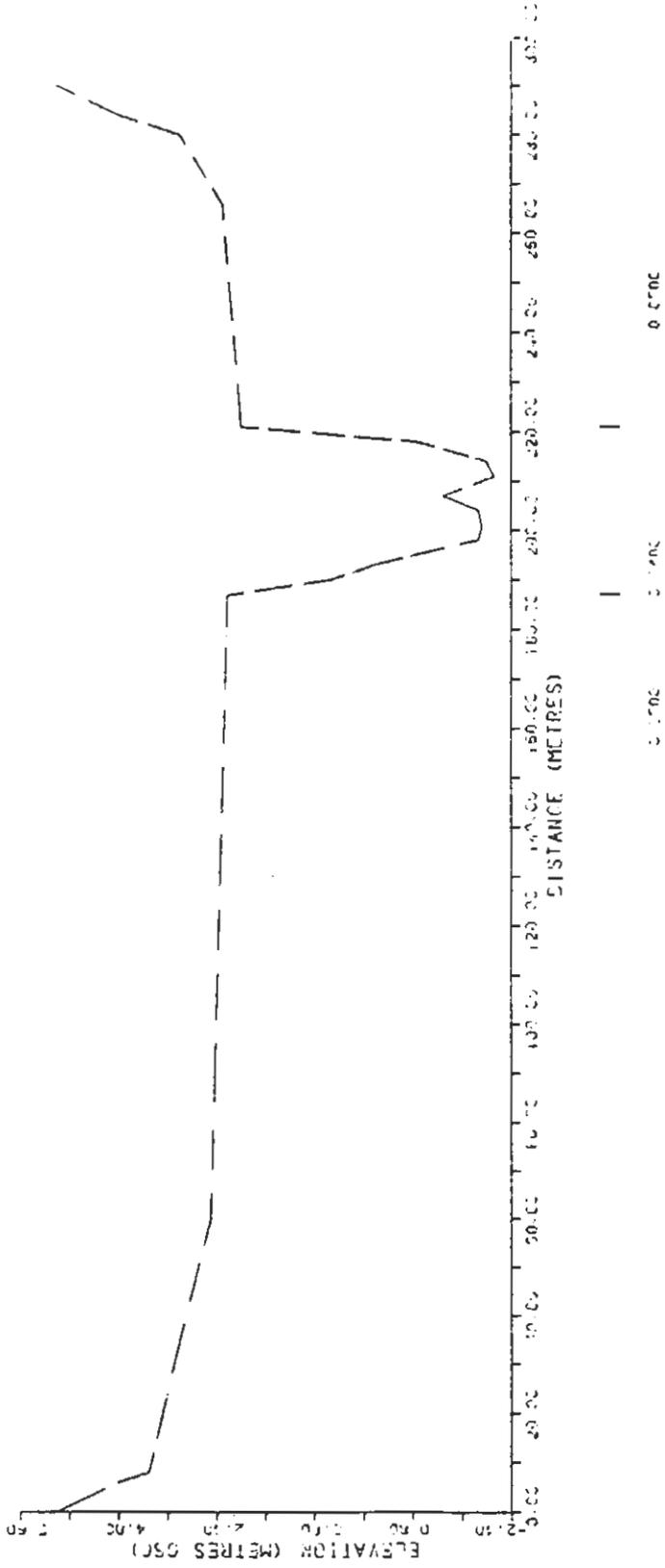
*** revised value employed for this and subsequent sections until next revision

APPENDIX C-1
CROSS-SECTION PLOTS

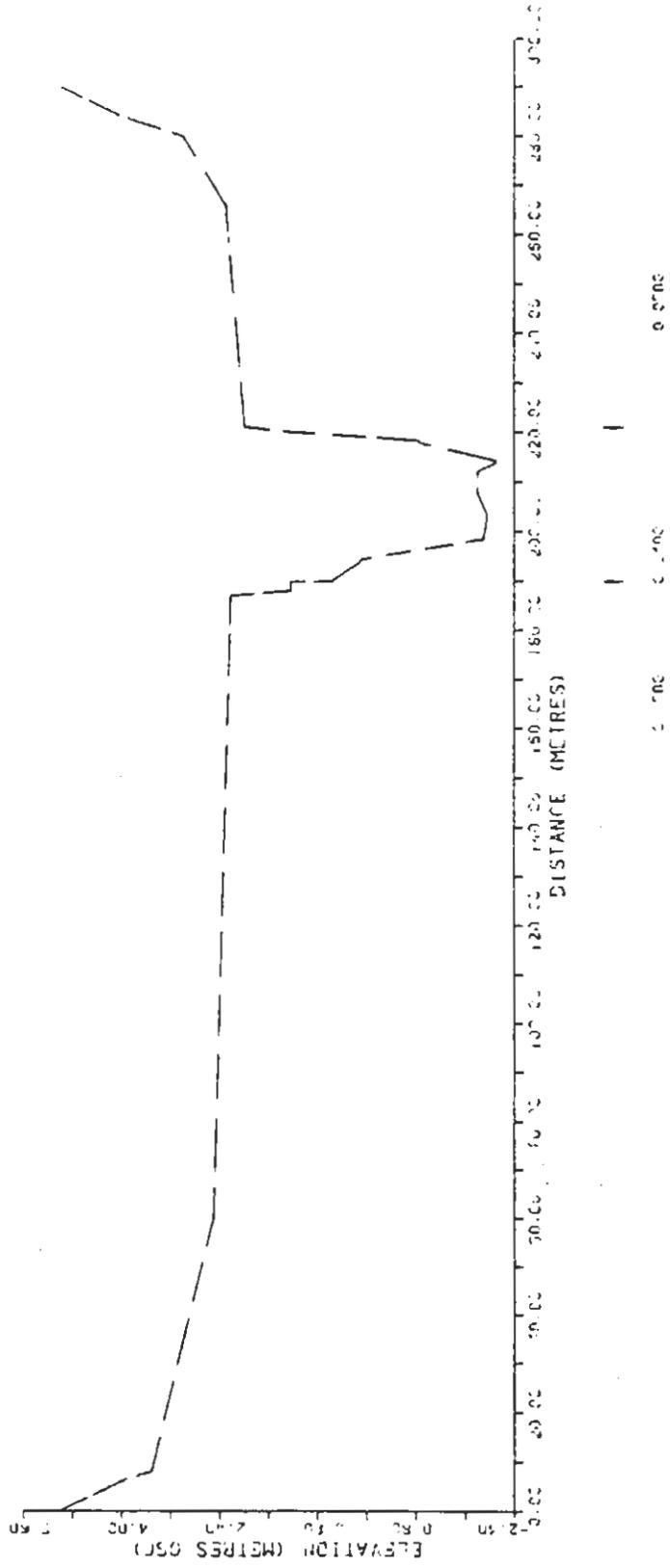
NOTES:

- 1) All sections are coded viewing the section from upstream looking downstream
- 2) Measured elevations by field survey are drawn by a solid line _____
- 3) Cross-section data from topographic mapping and charts are designated by a broken line -----

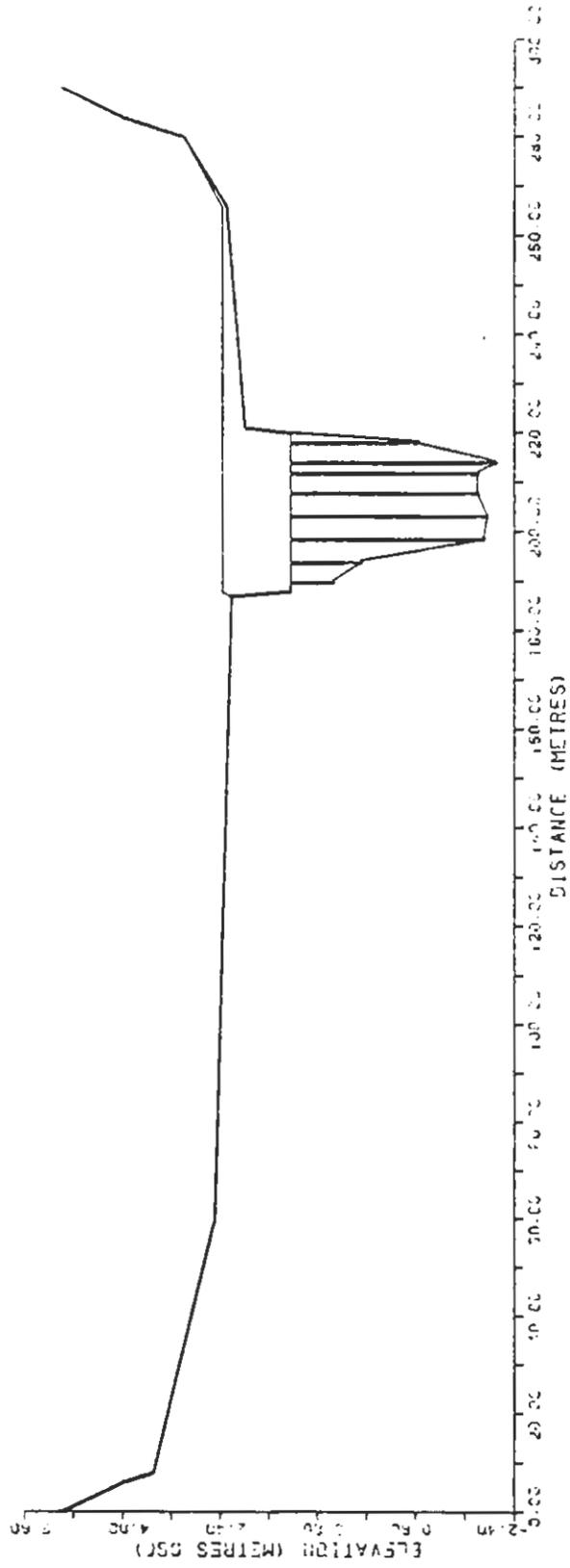
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 0.1



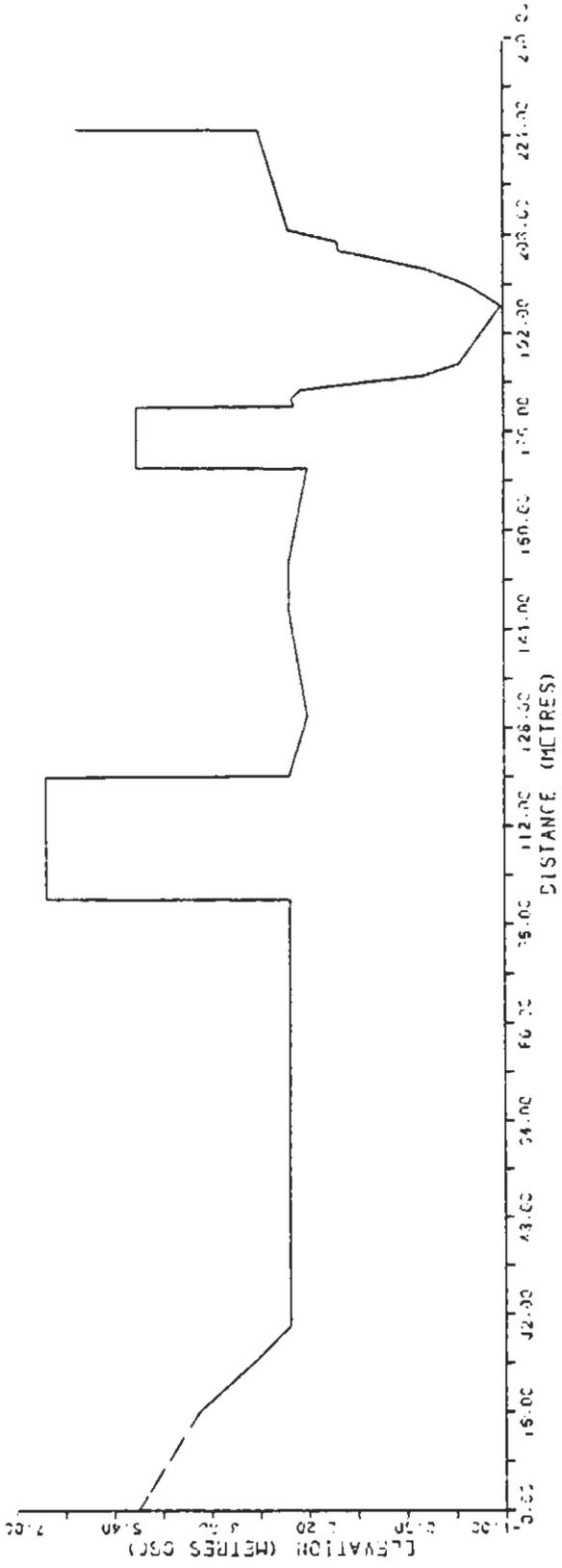
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 0.2



WATRFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 0.3

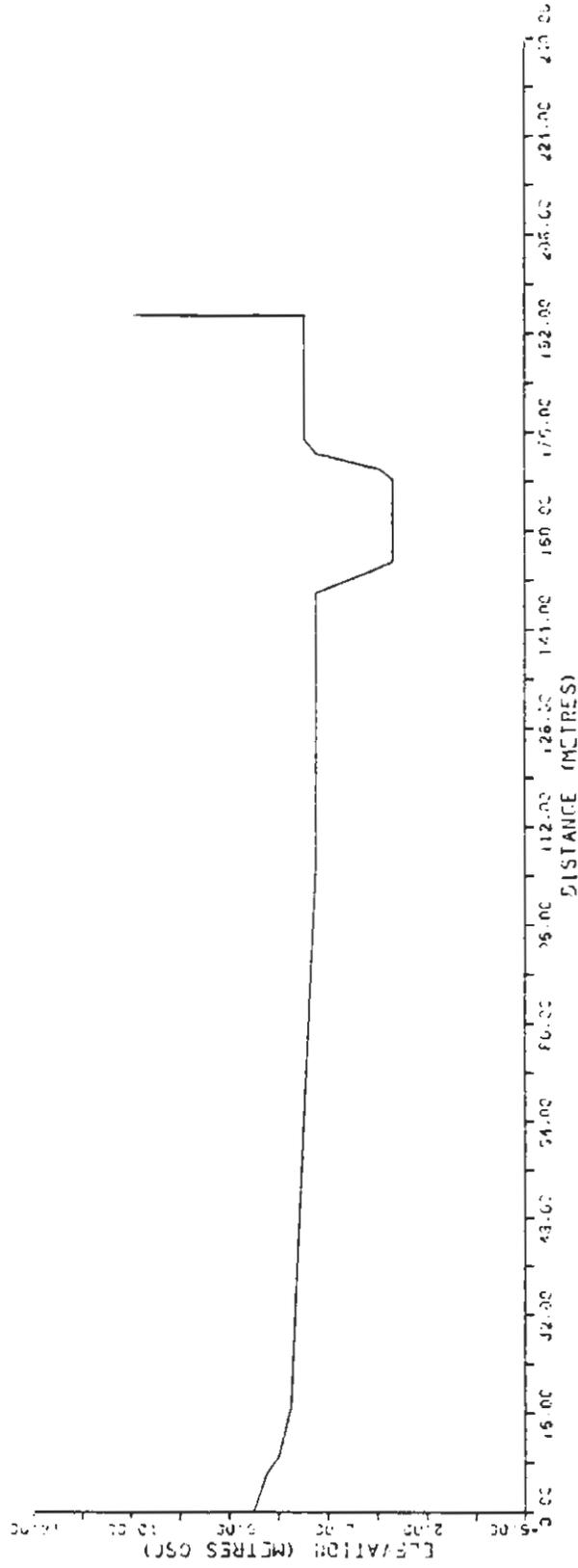


WATERFORD RIVER HEC-2 MODEL
 CROSS SECTION NUMBER 120.



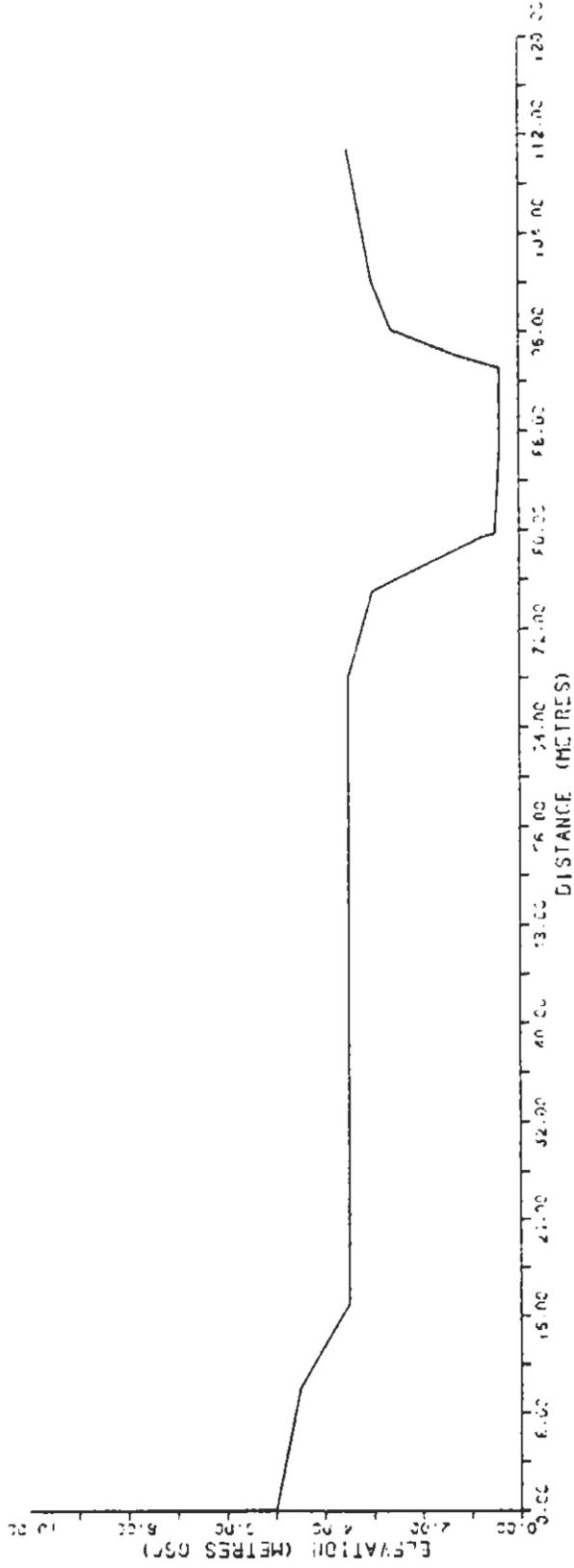
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 4.5000 4.5000
 5.0000 5.0000
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 6.0000 6.0000
 6.5000 6.5000
 7.0000 7.0000

WATERFORD RIVER HEC-2 MODEL
 CROSS SECTION NUMBER 291.0



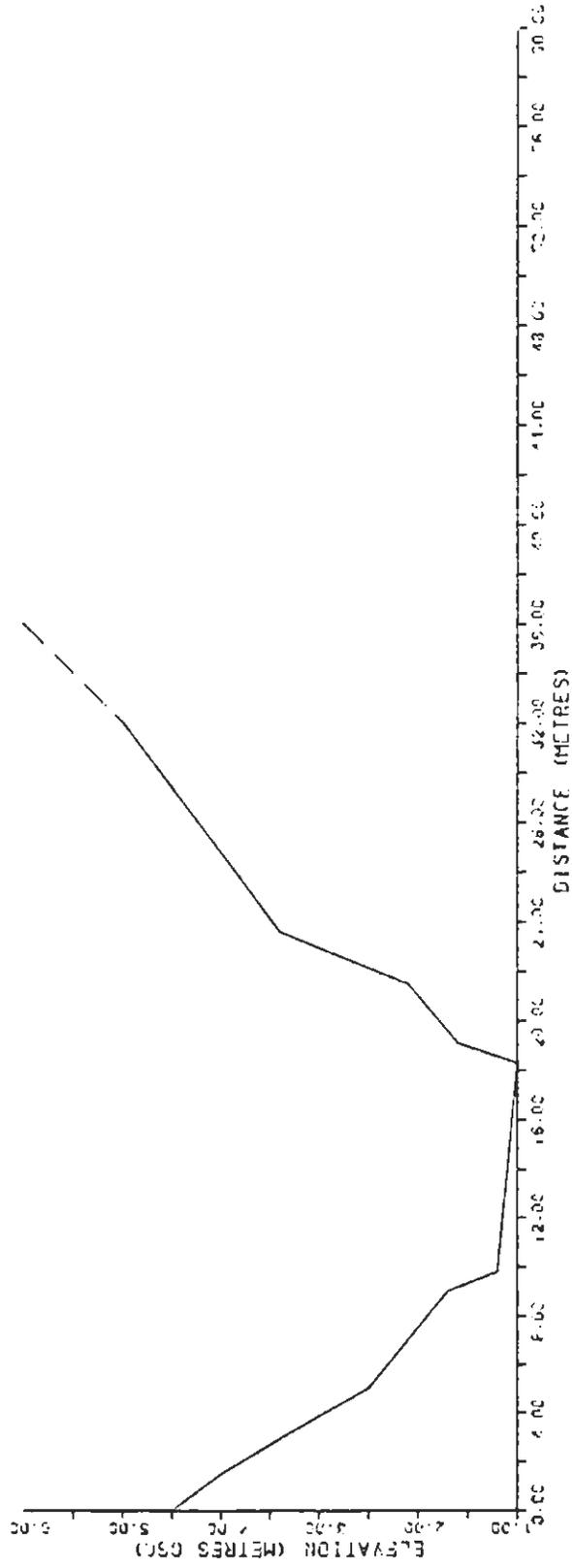
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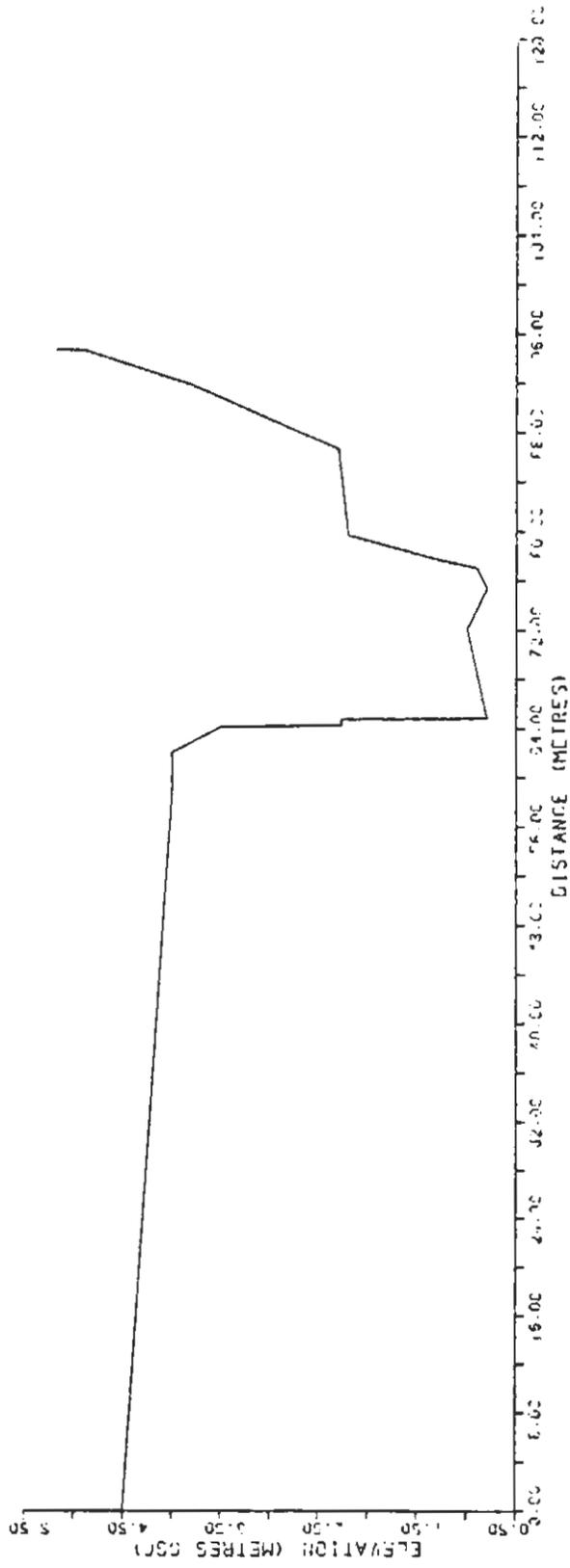
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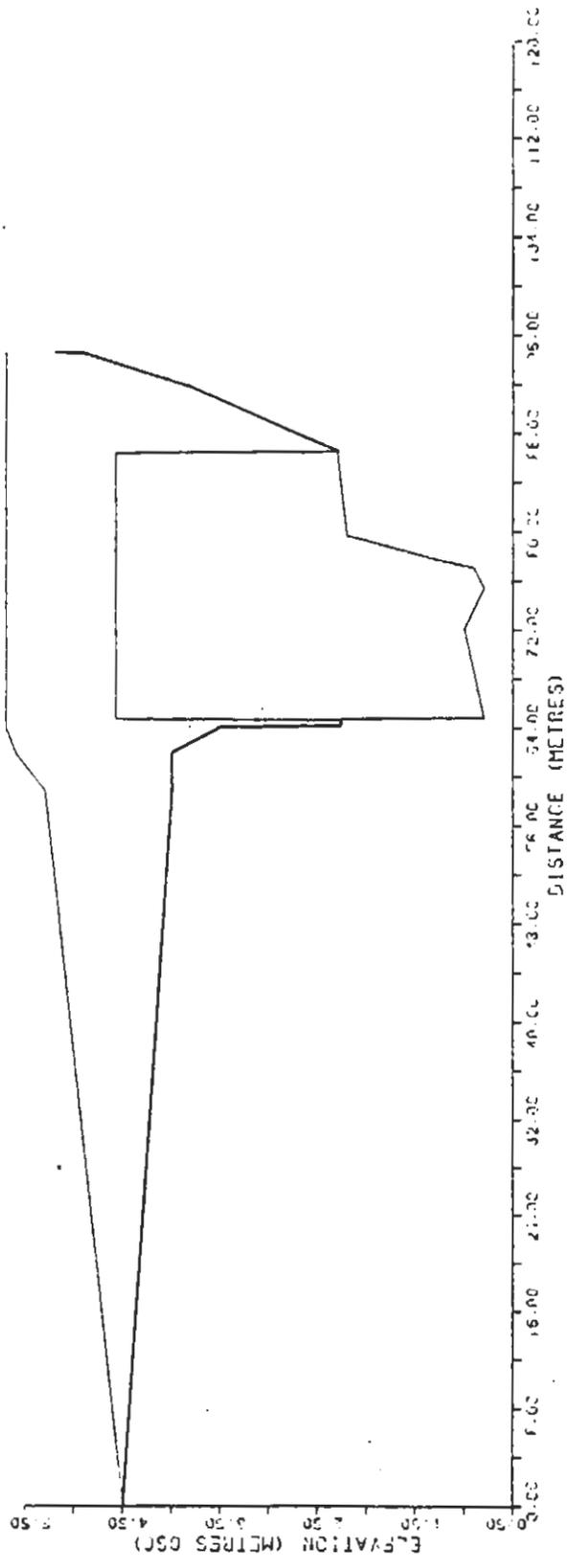


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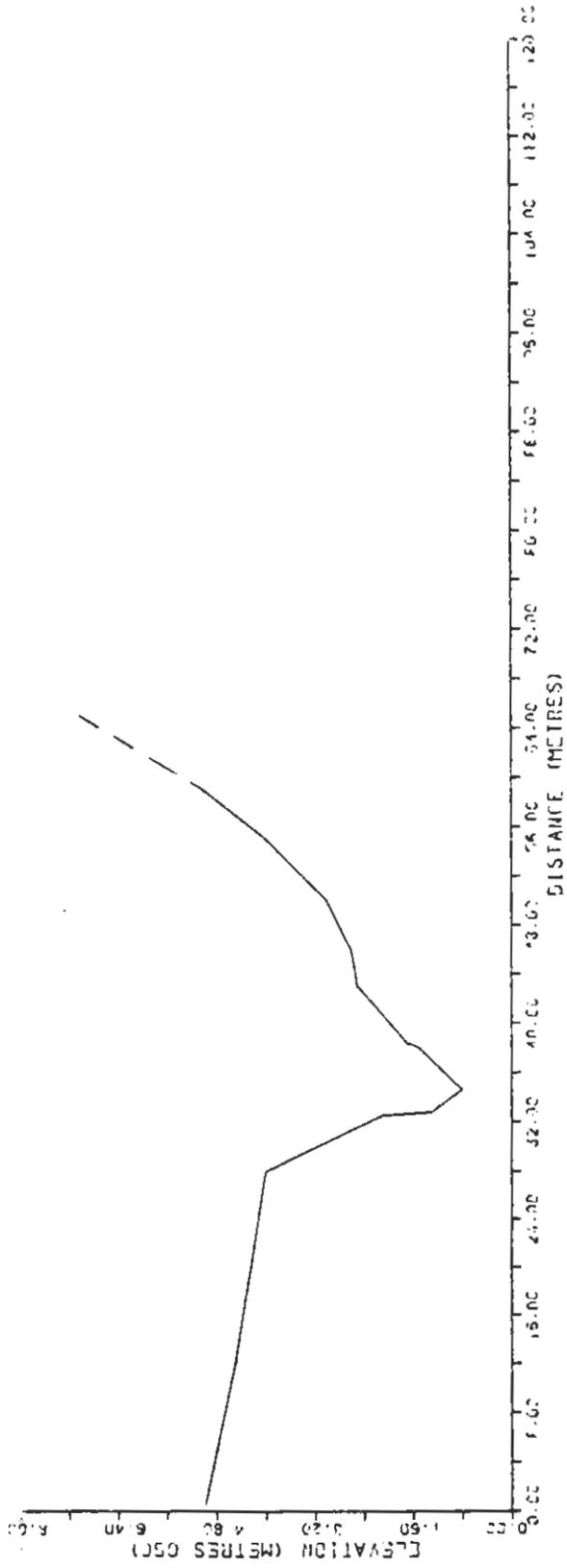
WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 765.



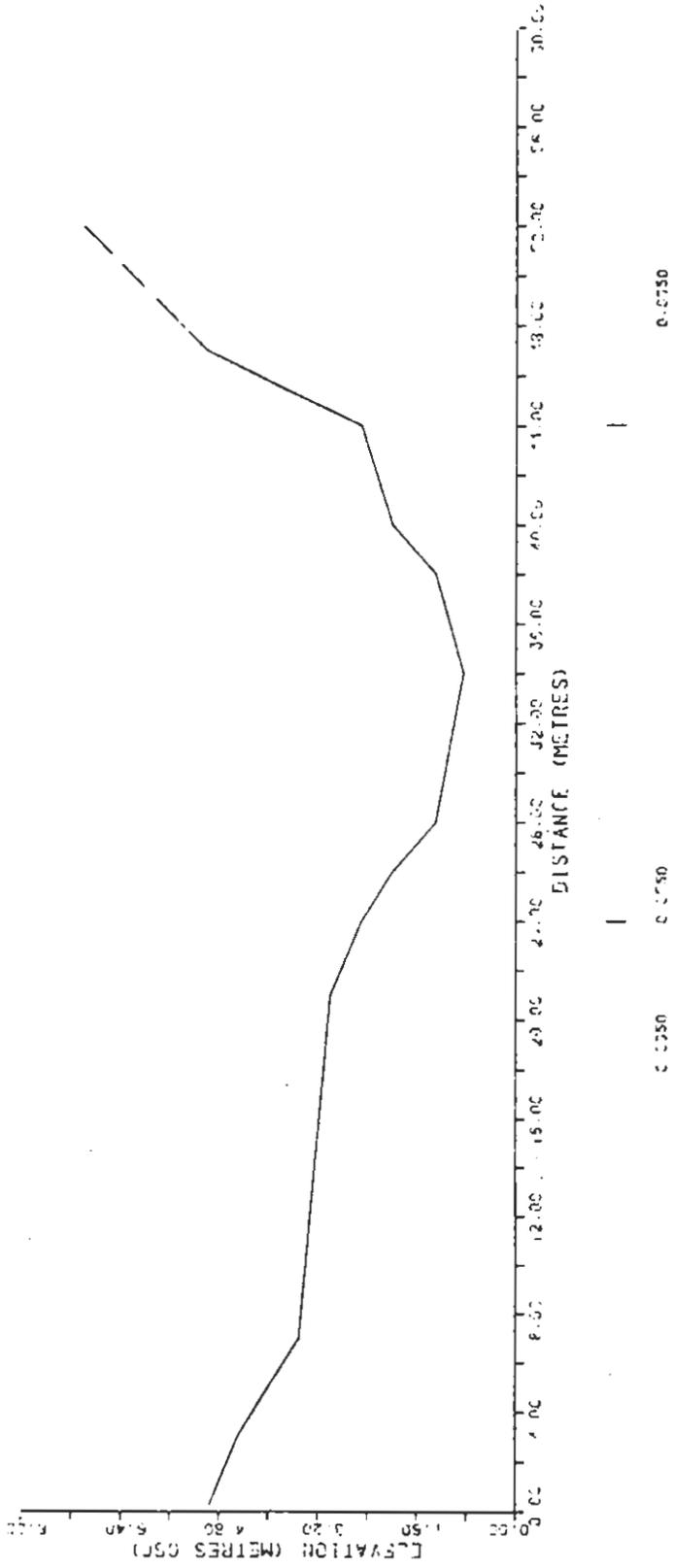
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 782.0



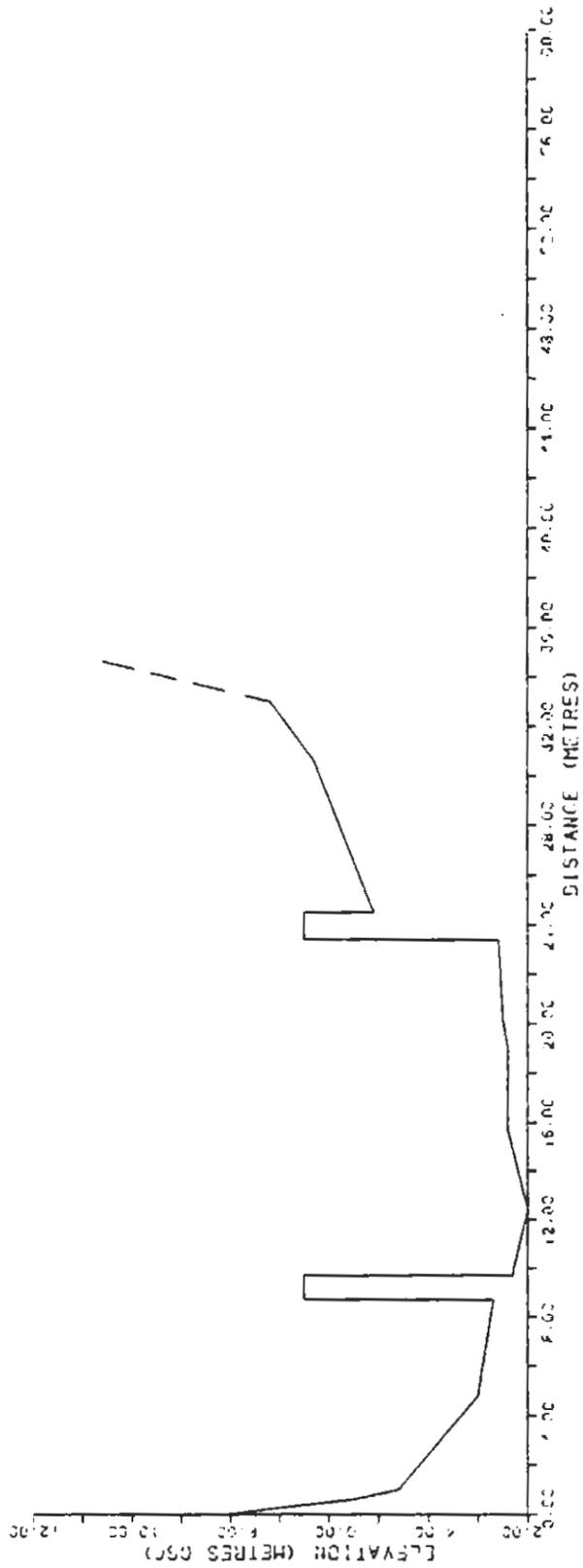
WATERFORD RIVER
CROSS SECTION NUMBER 816.
HEC-2 MODEL



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 857.

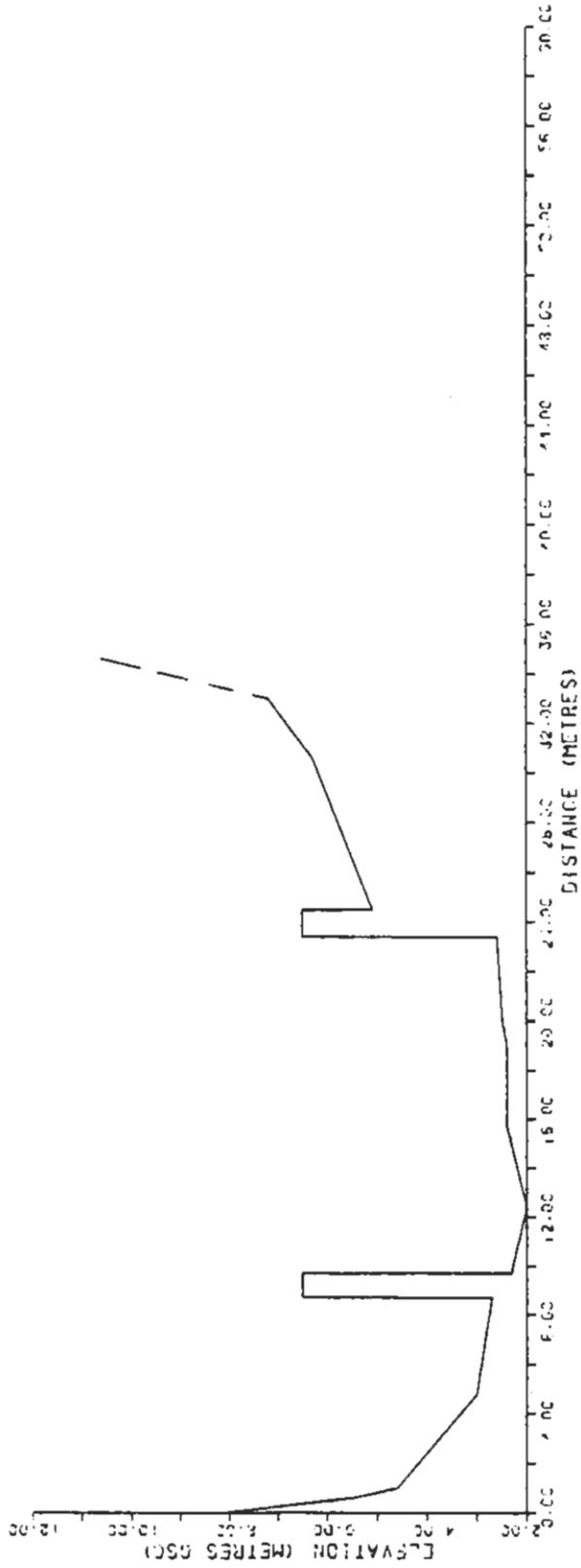


WATERFORD RIVER HEC-2 MODEL
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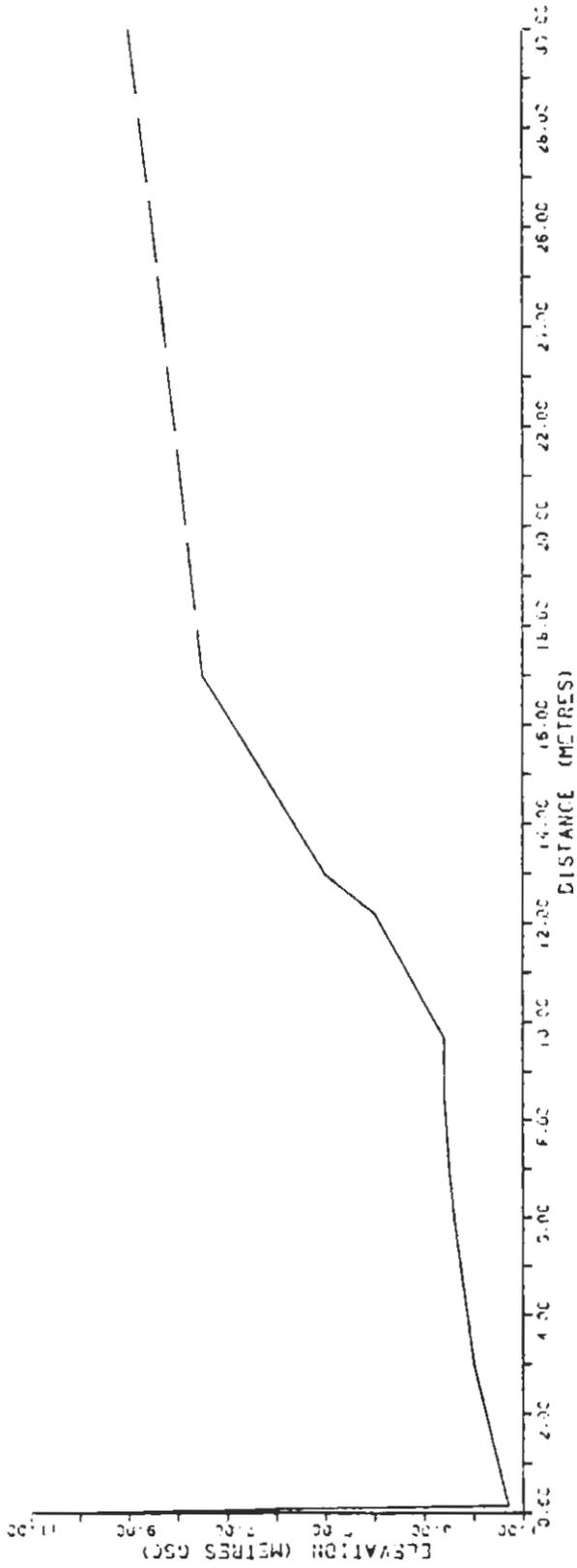
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 900.0



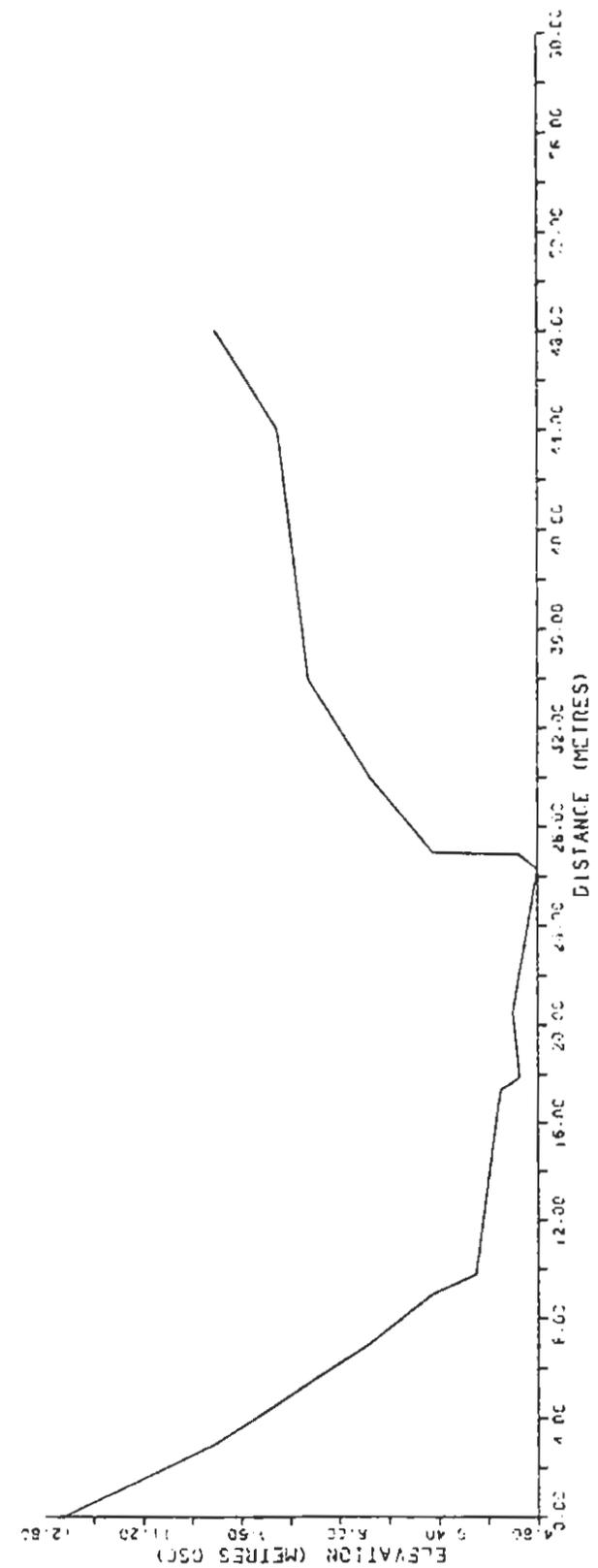
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 928.0



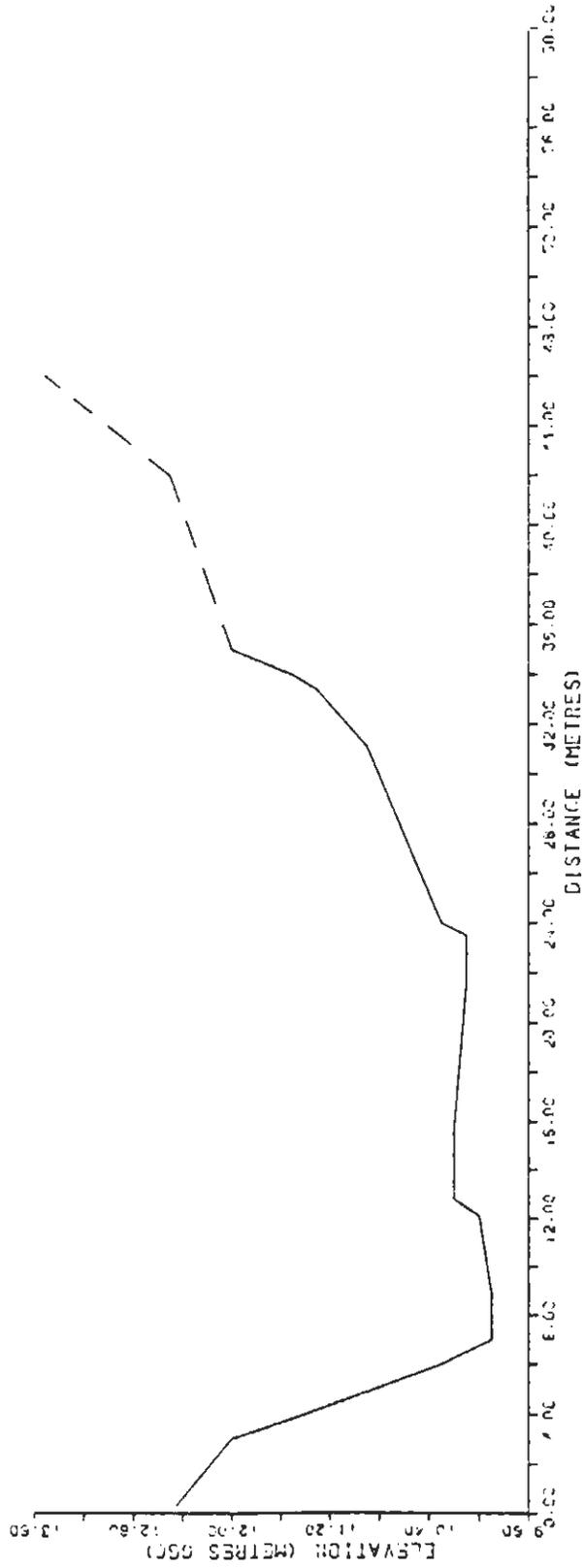
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1050.0



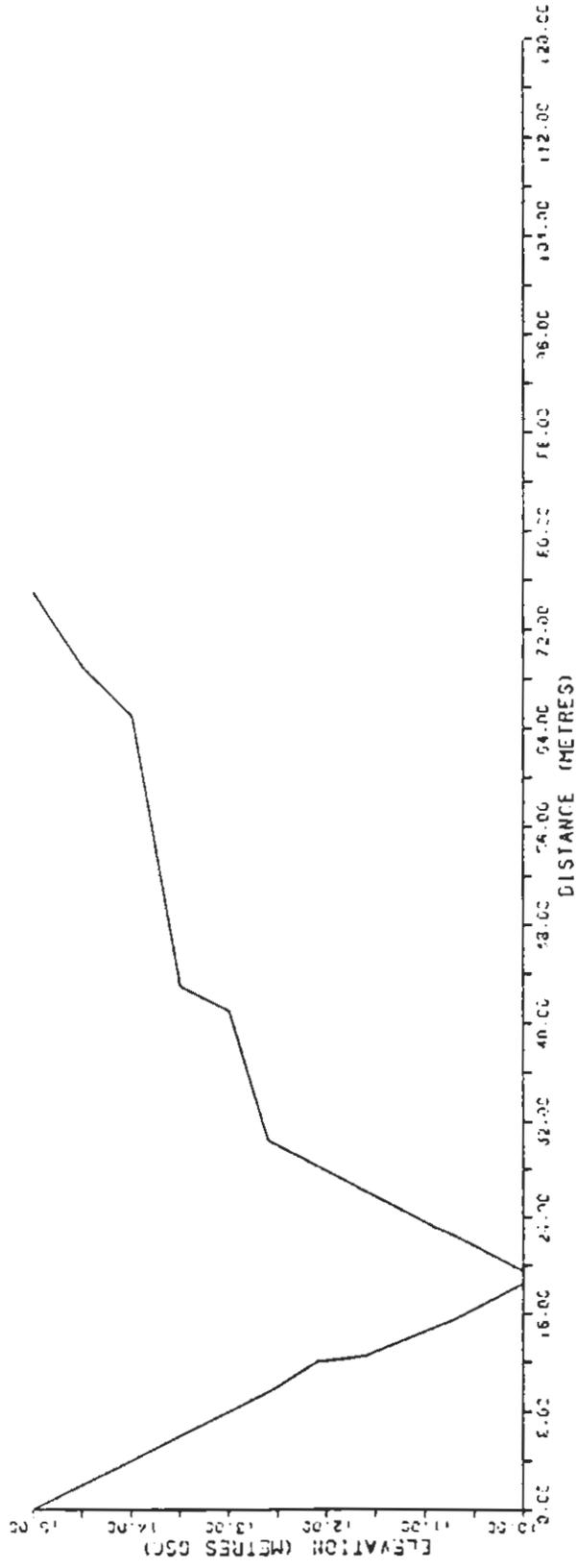
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1325.0



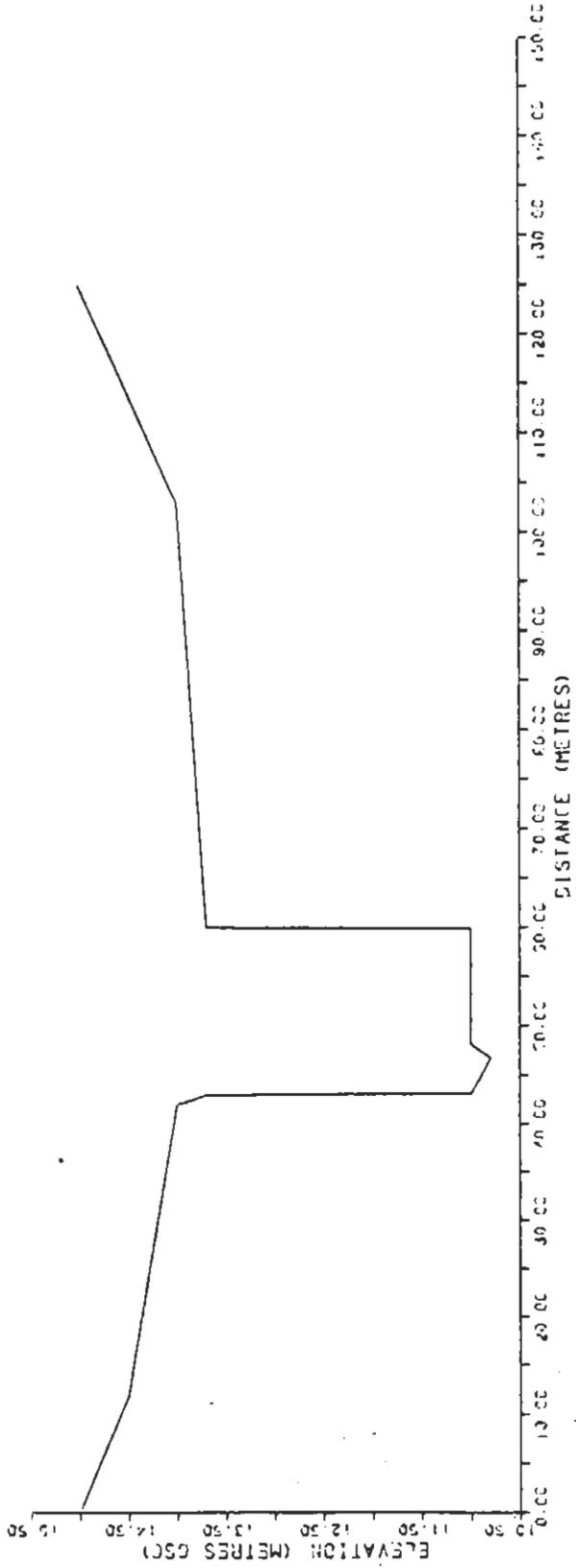
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1555.0

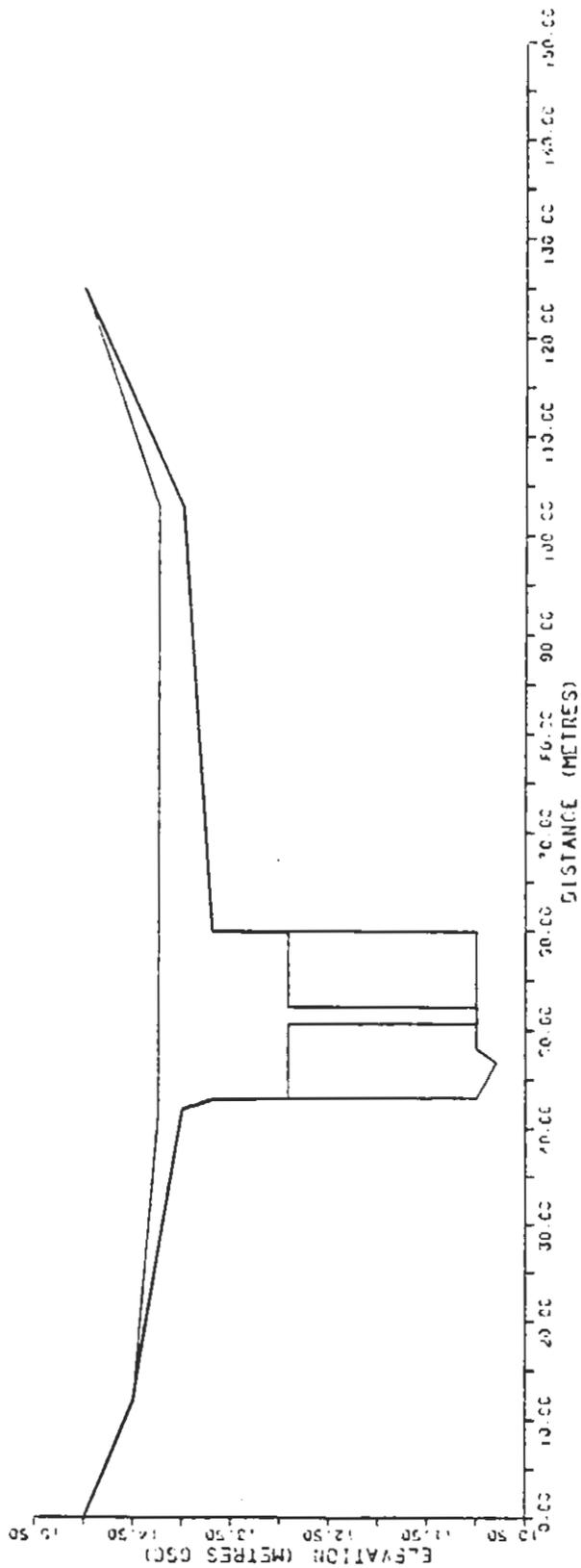


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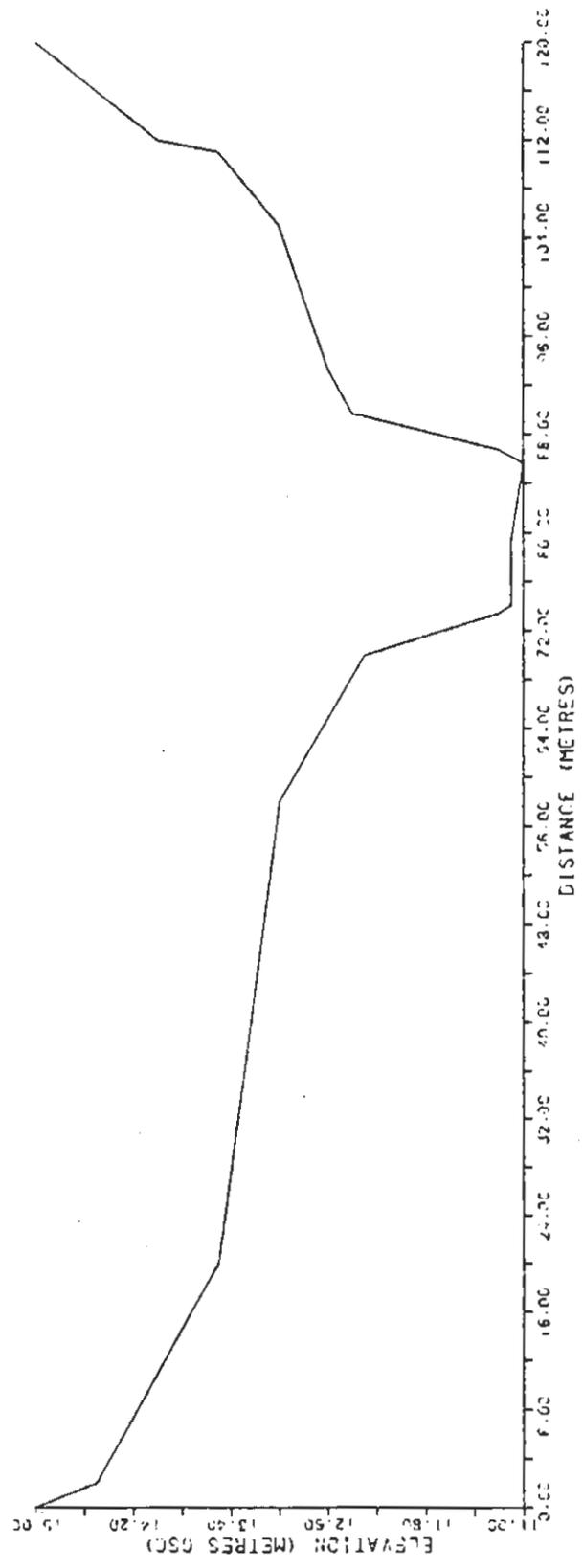
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1570.0



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1575.0

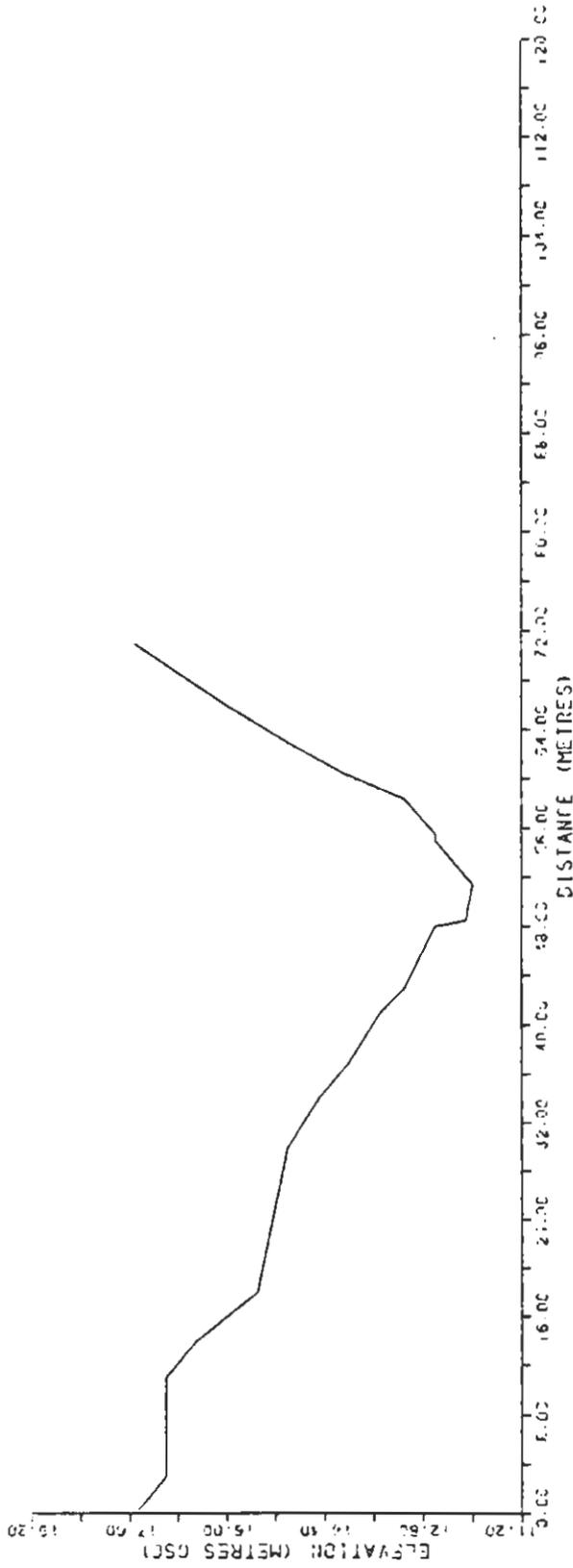


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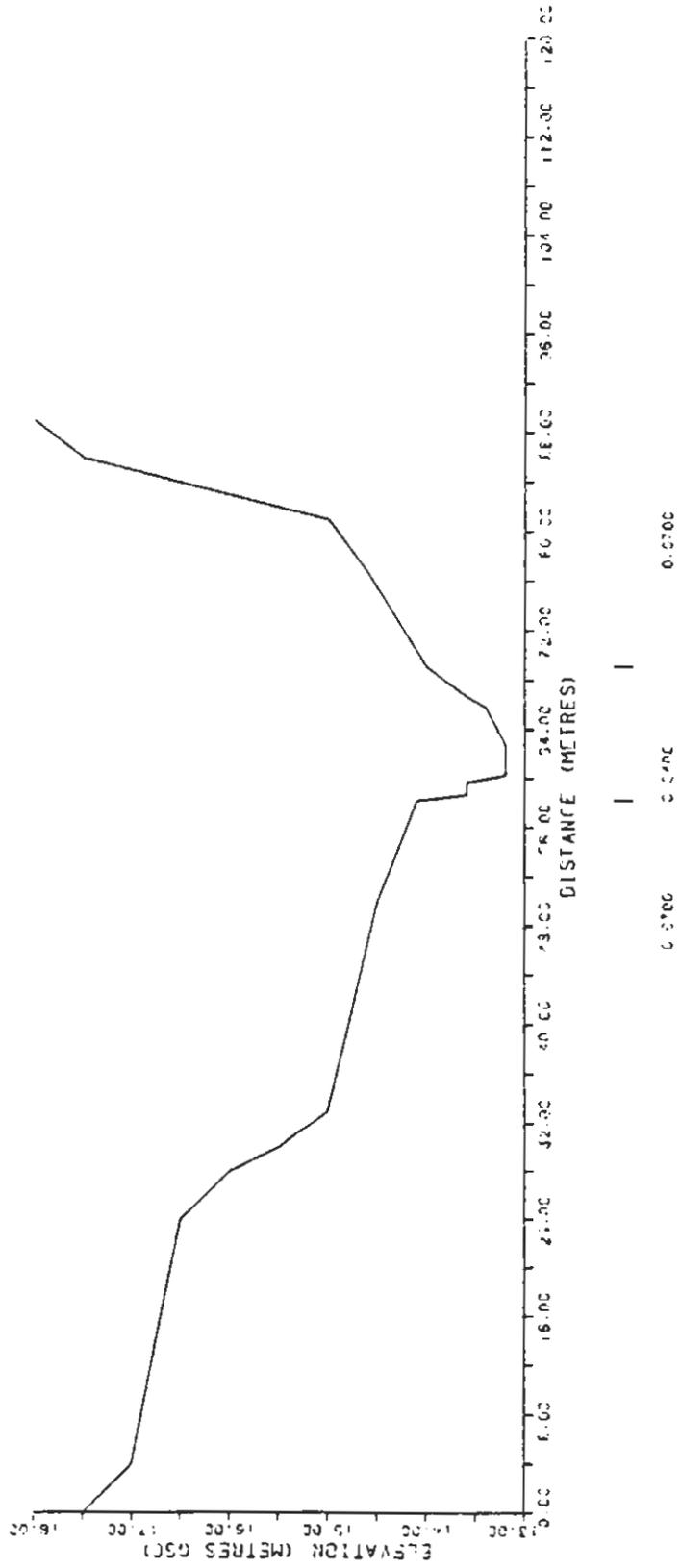


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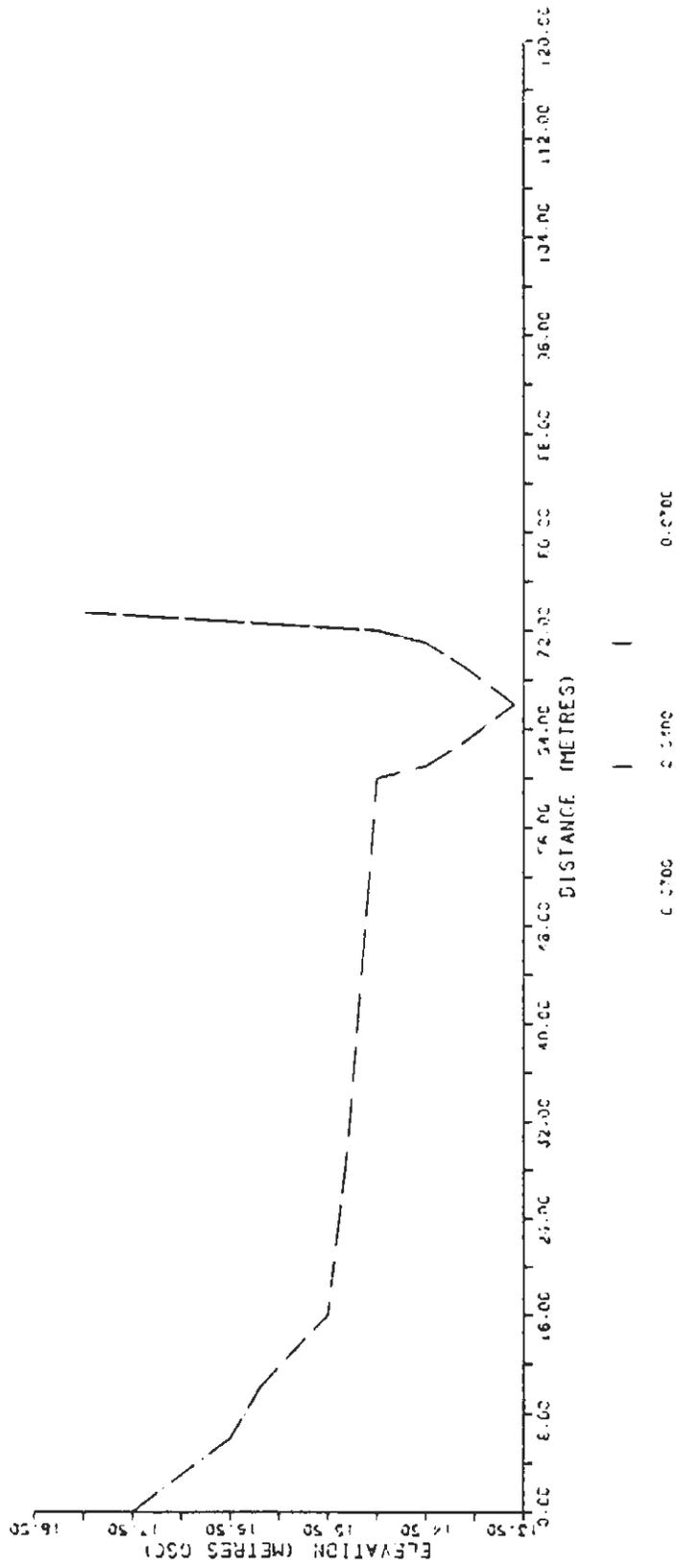
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CROSS SECTION NUMBER 1895.0



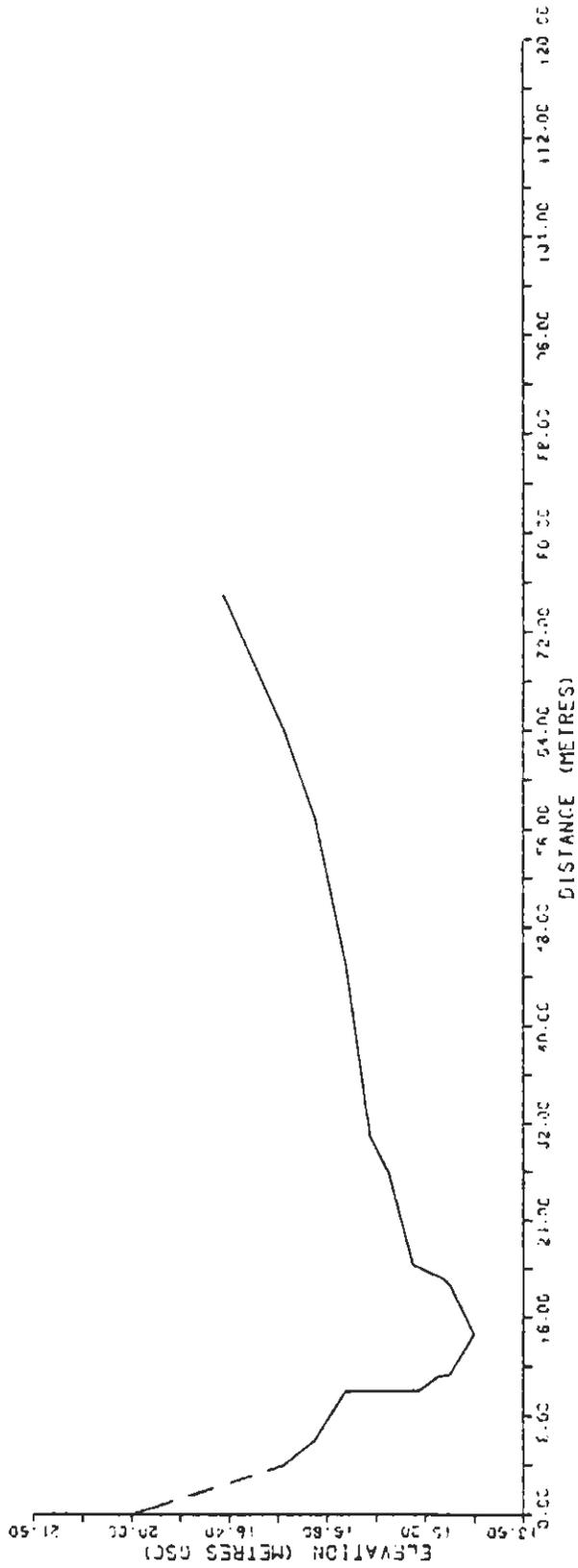
WATERFORD RIVER HEC-2 MODEL
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WATERFORD RIVER HEC-2 MODEL
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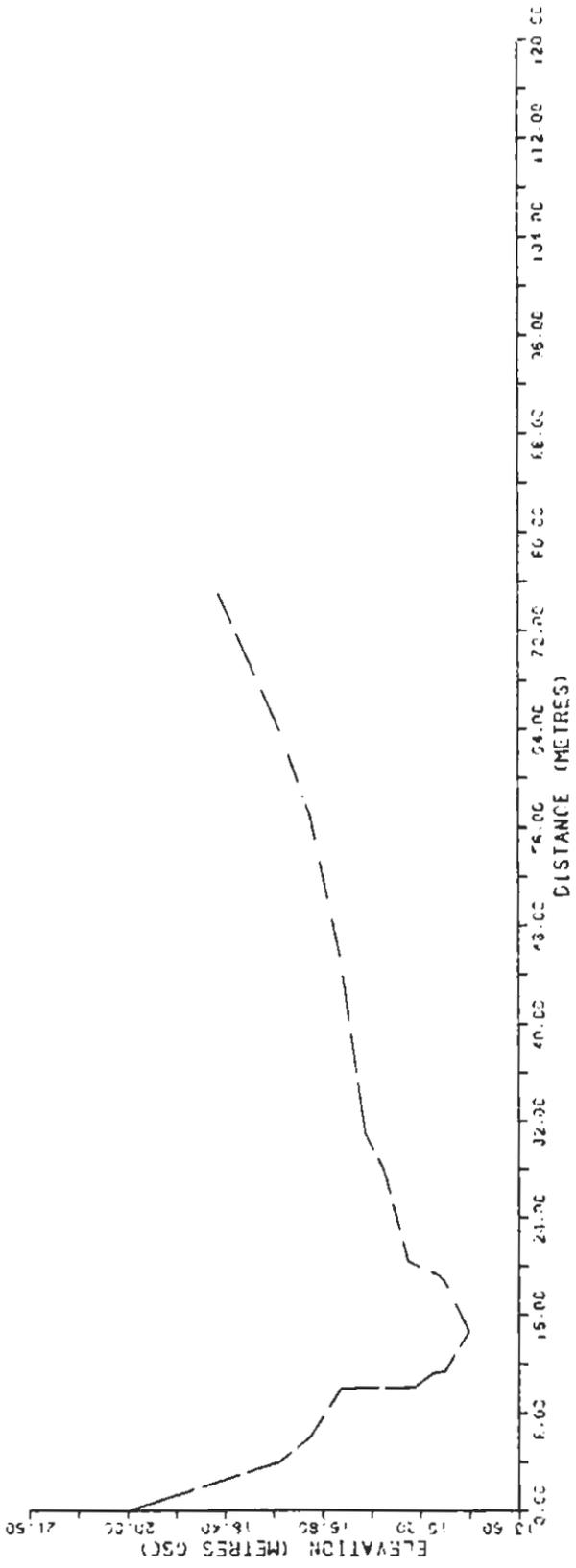


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 2391.0



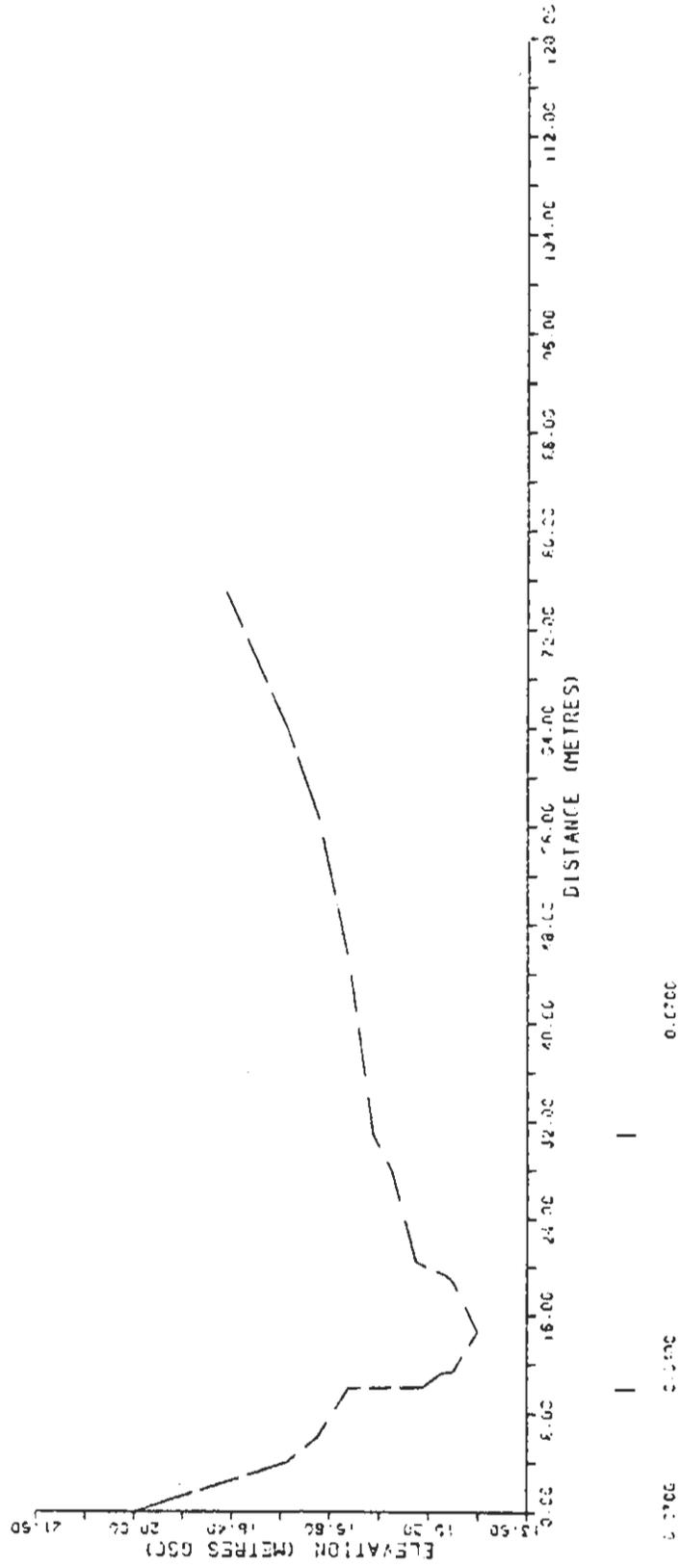
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WATERFORD RIVER HEC-2 MODEL
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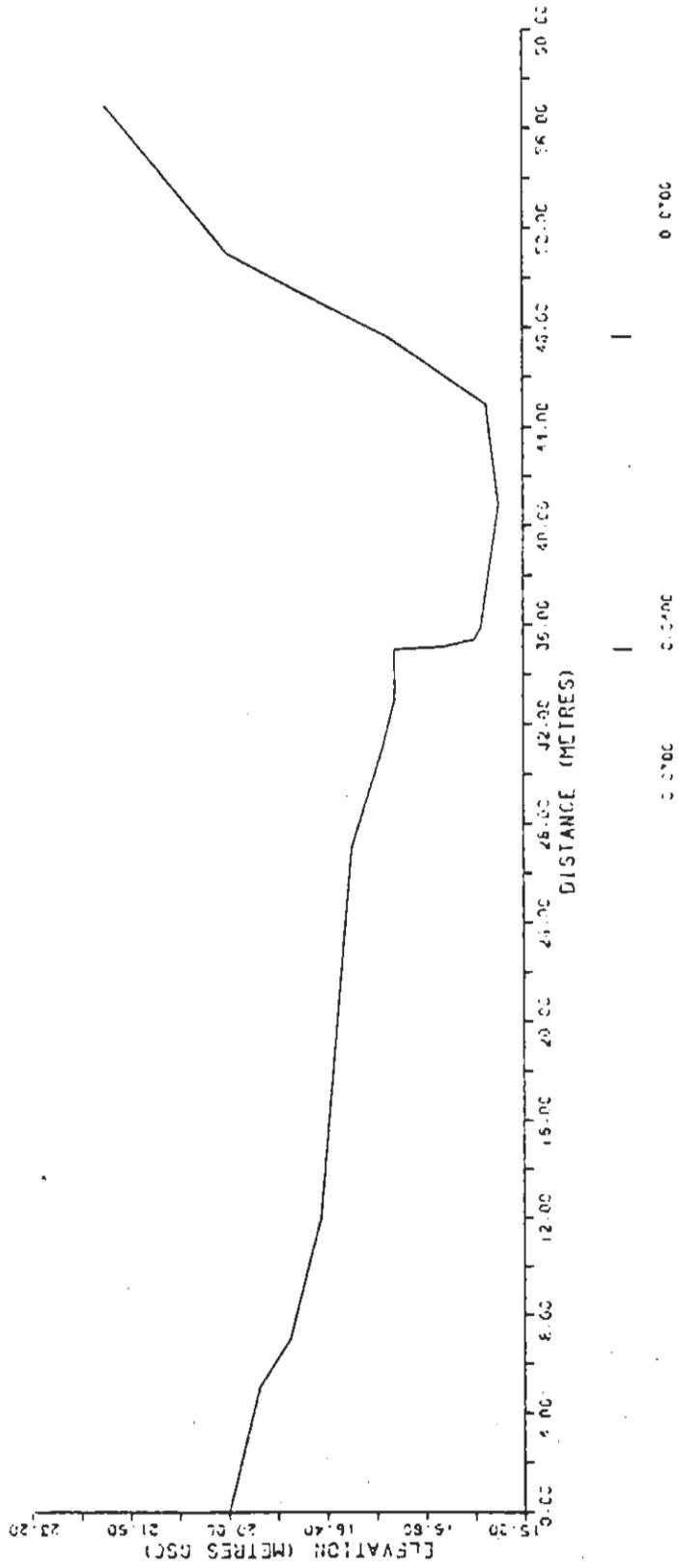


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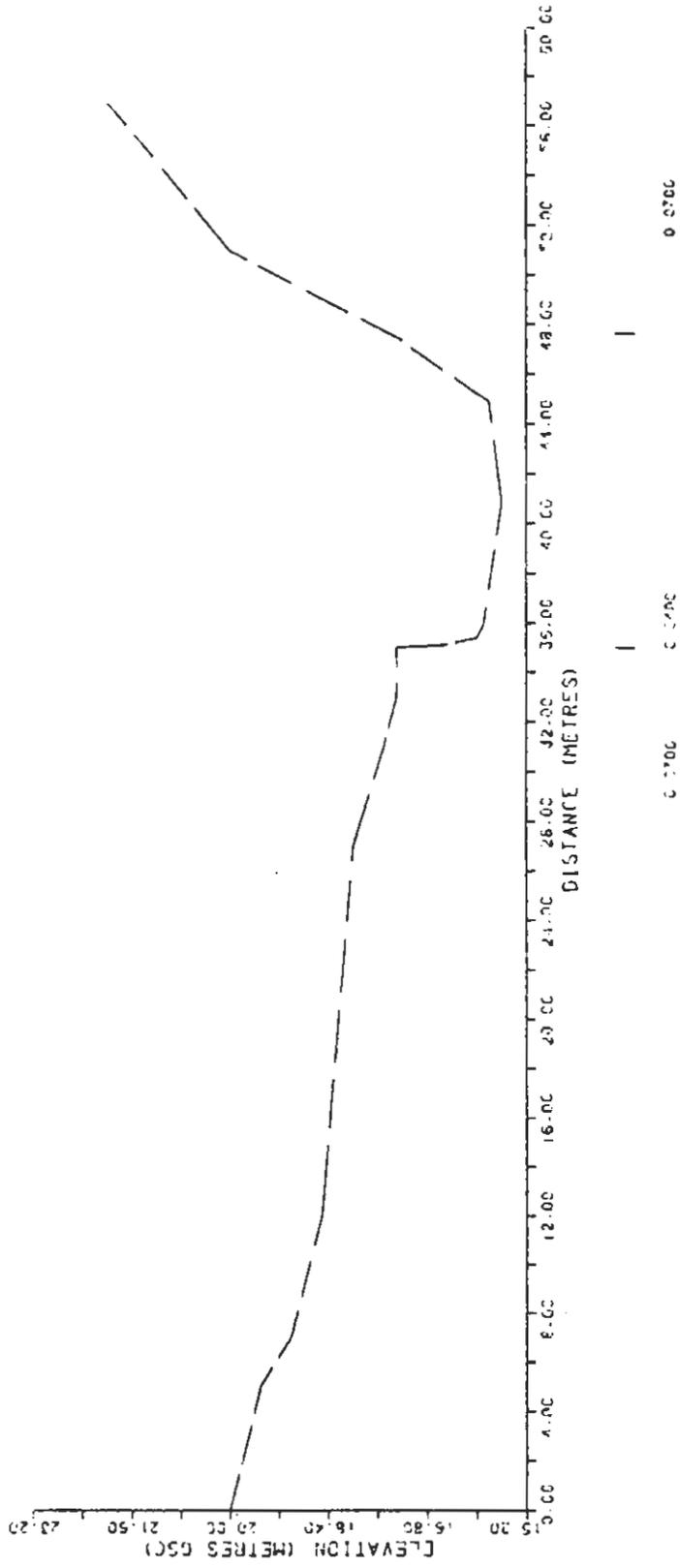
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CROSS SECTION NUMBER 2591.



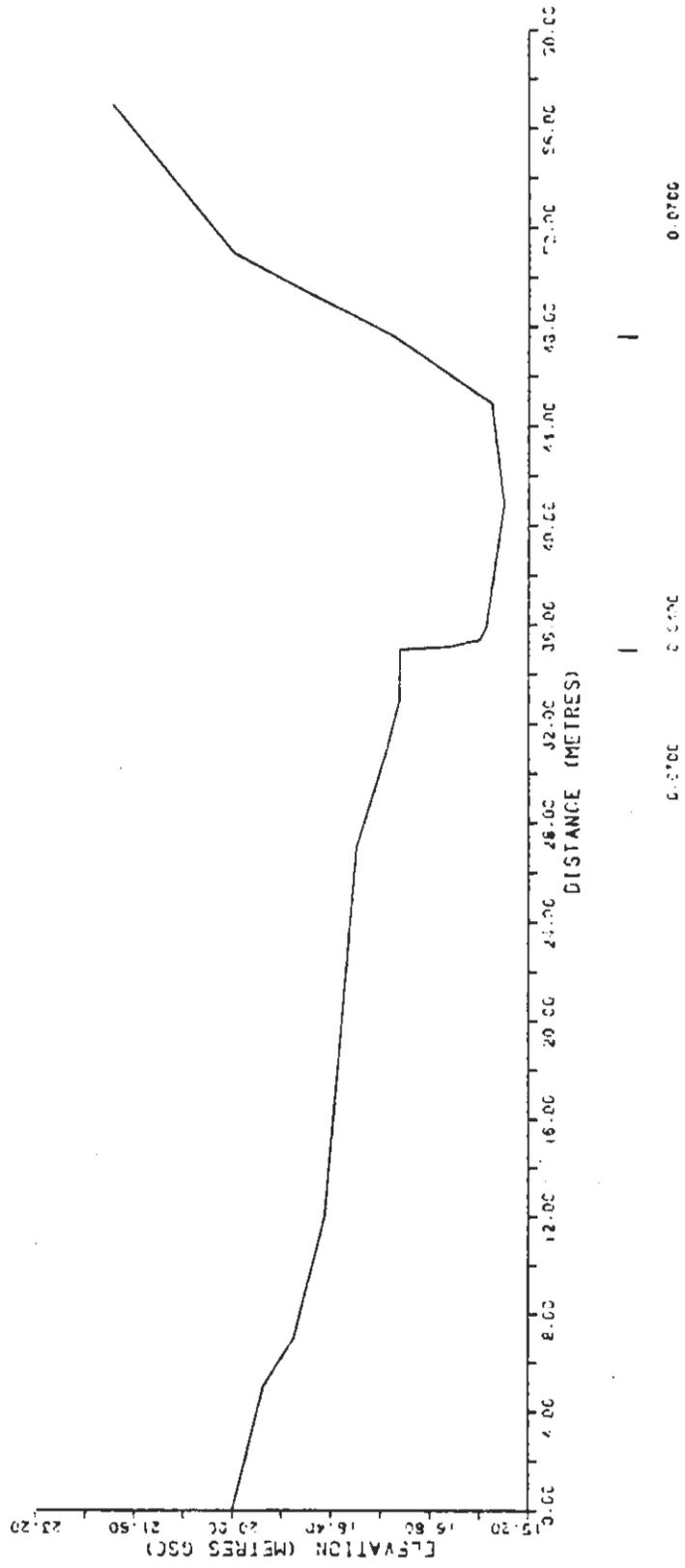
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CROSS SECTION NUMBER 2682.0



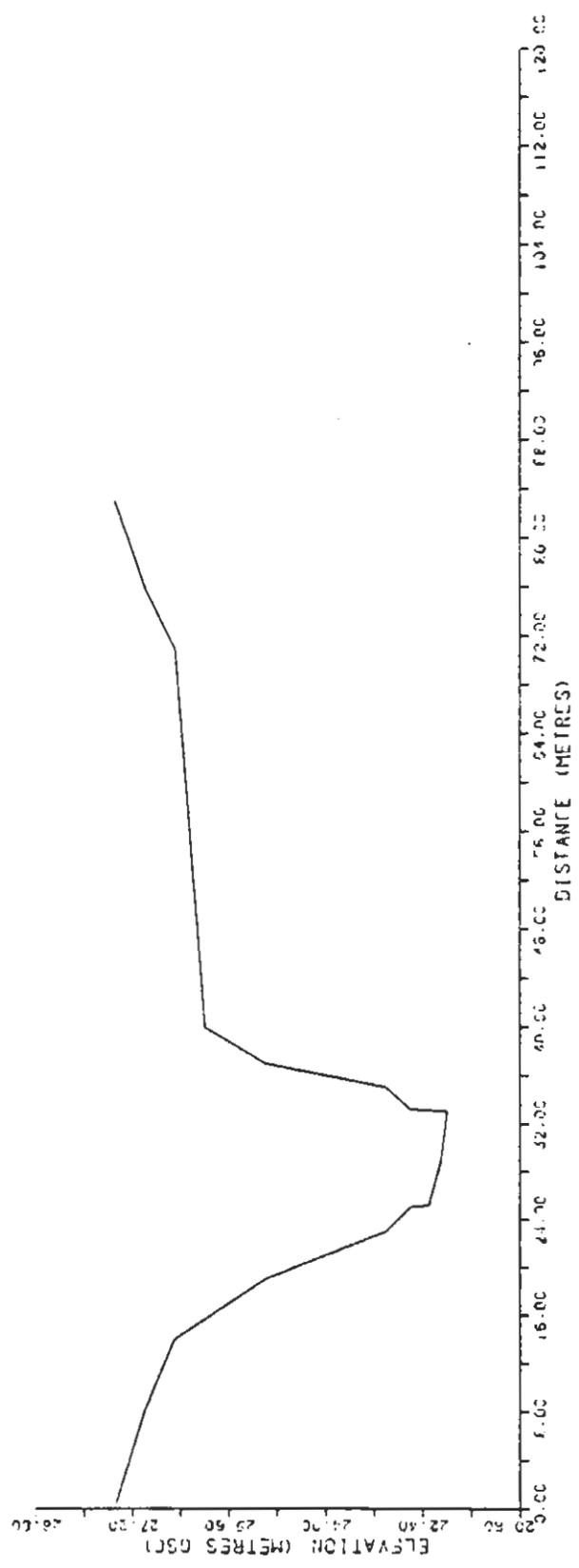
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 2802.



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 2902.

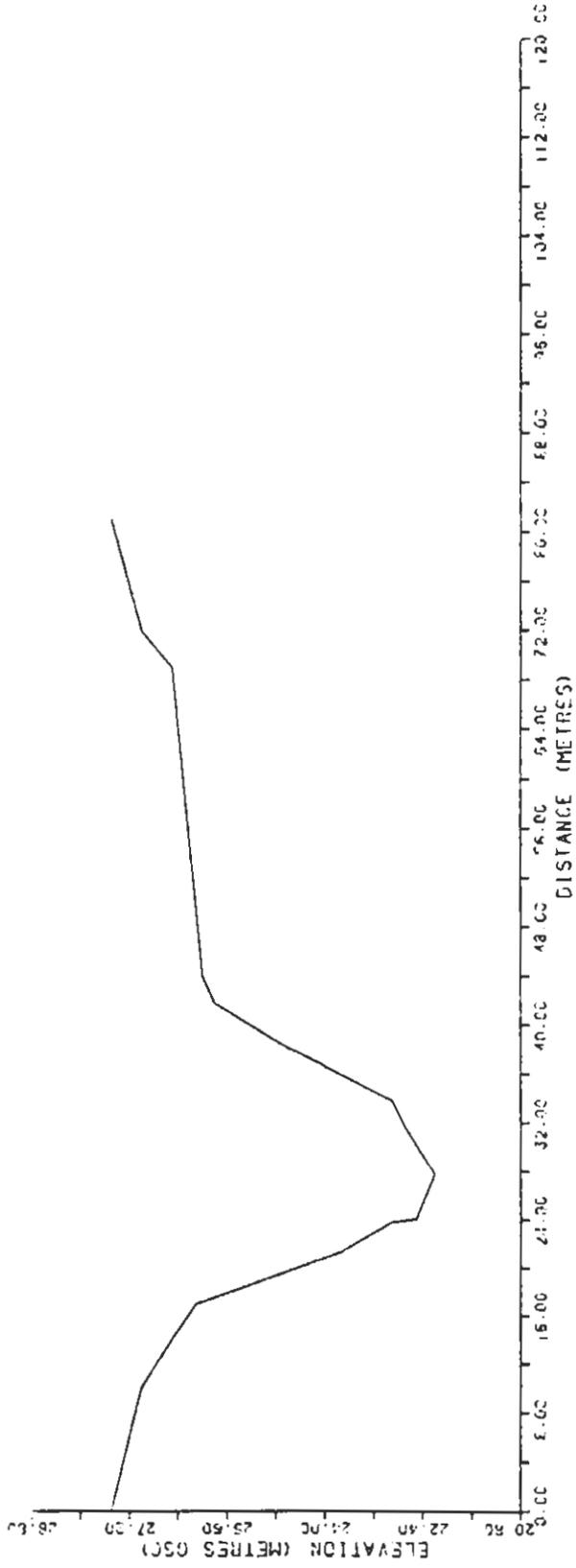


WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 2940.0



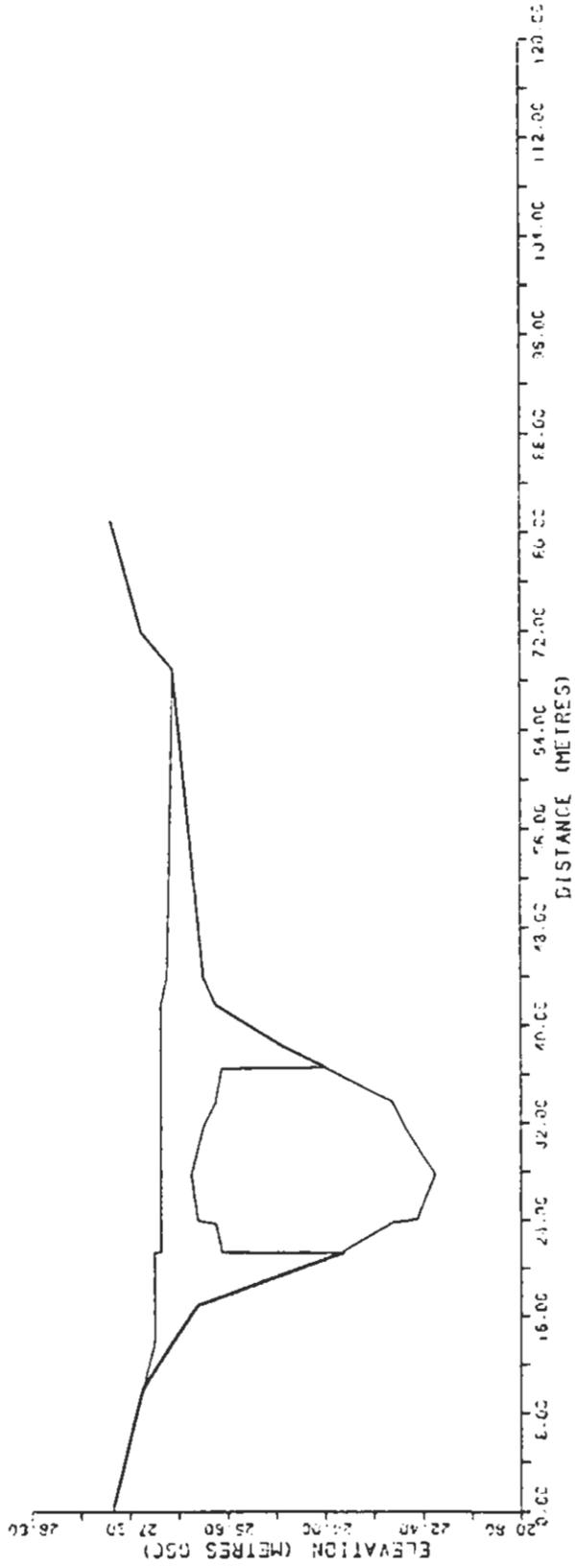
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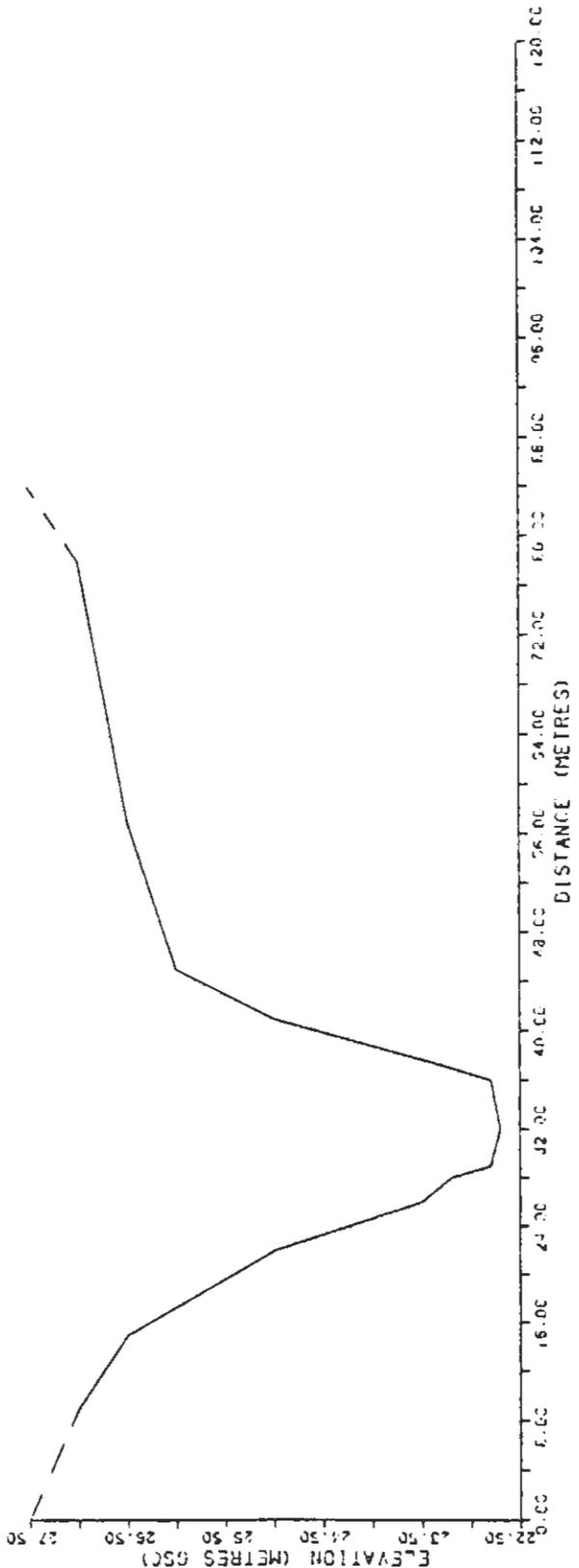


0.0500
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0.0500

WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 2965.0

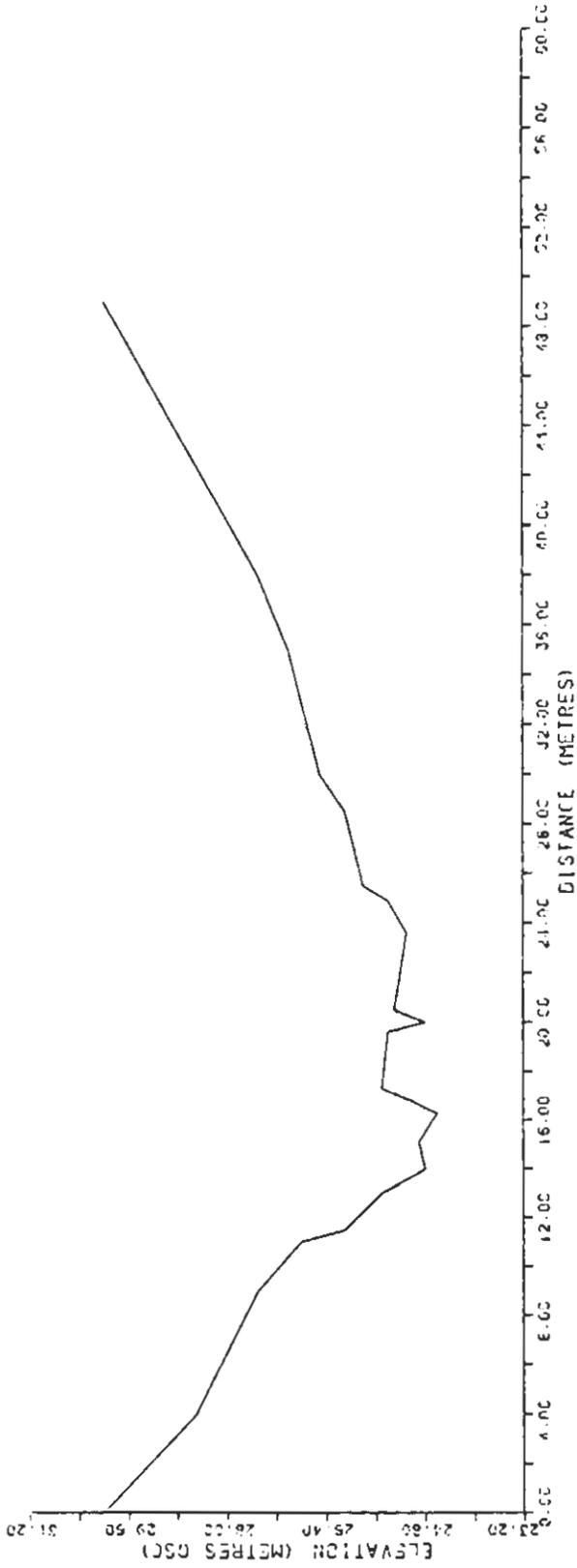


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 2980.0



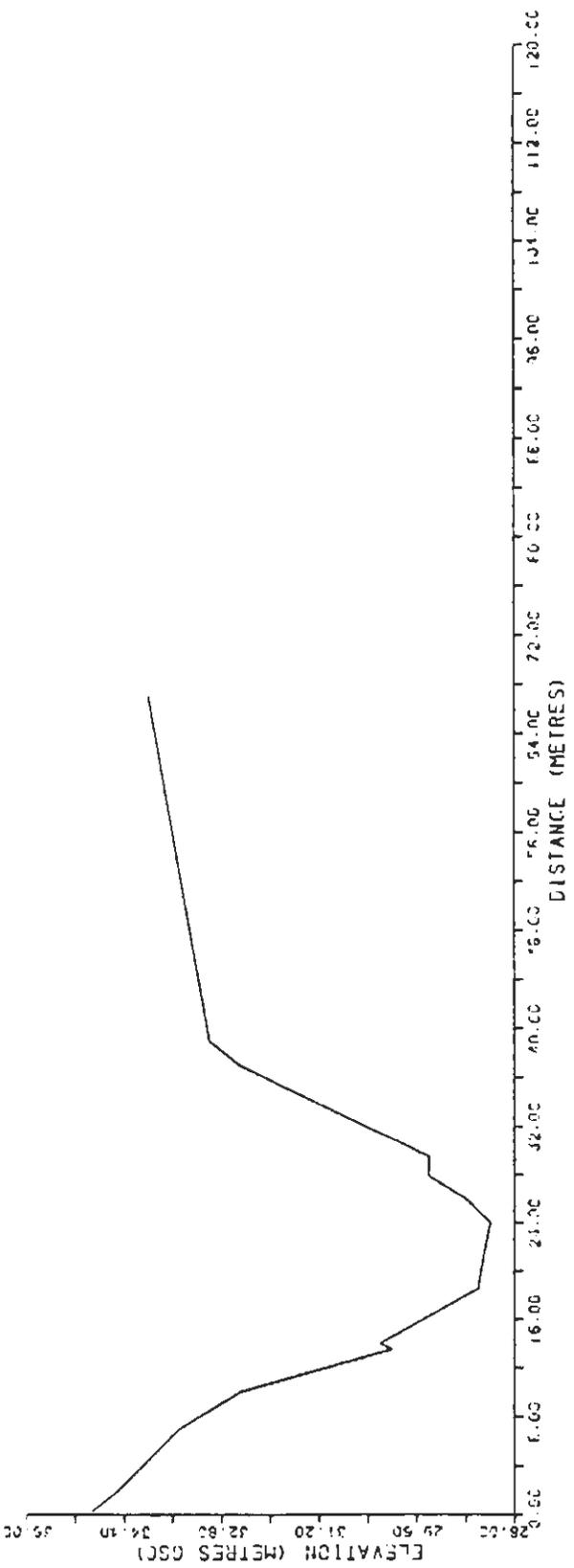
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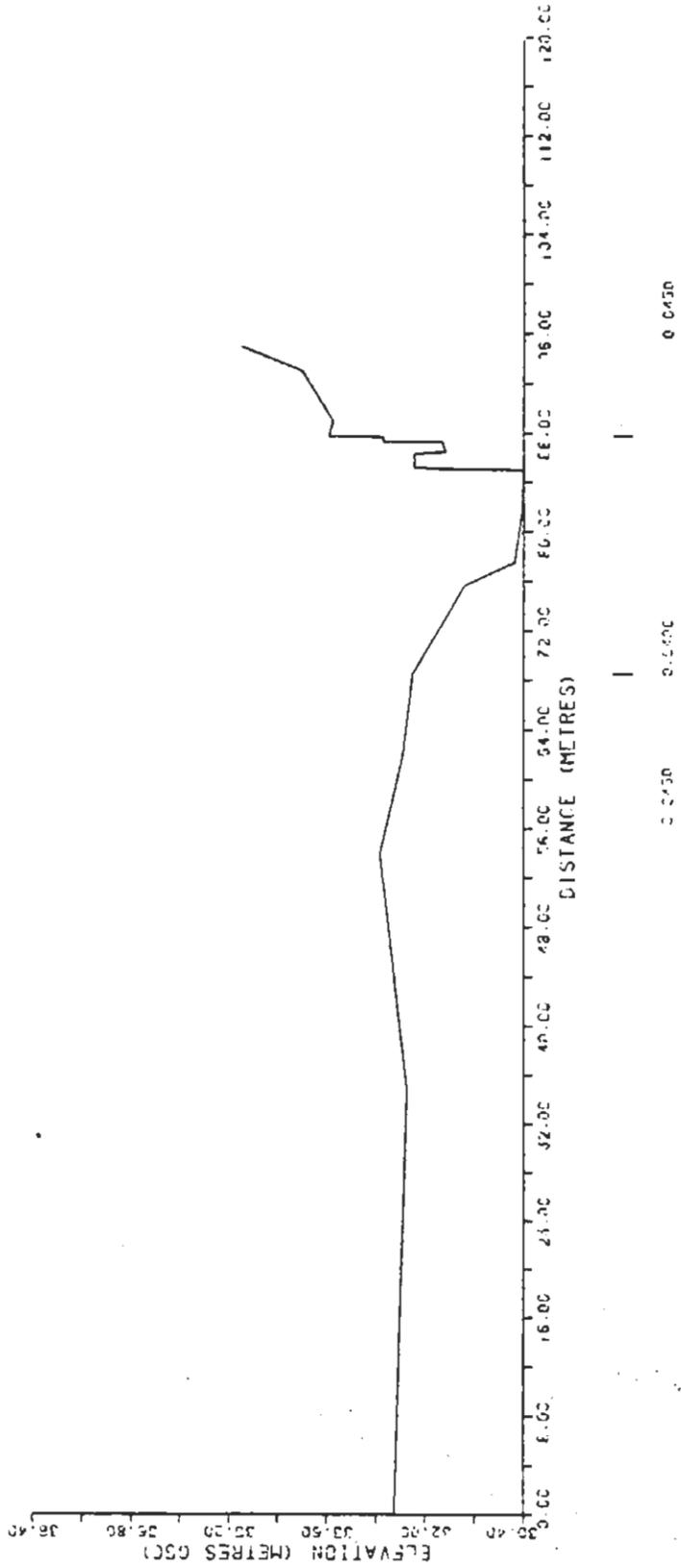
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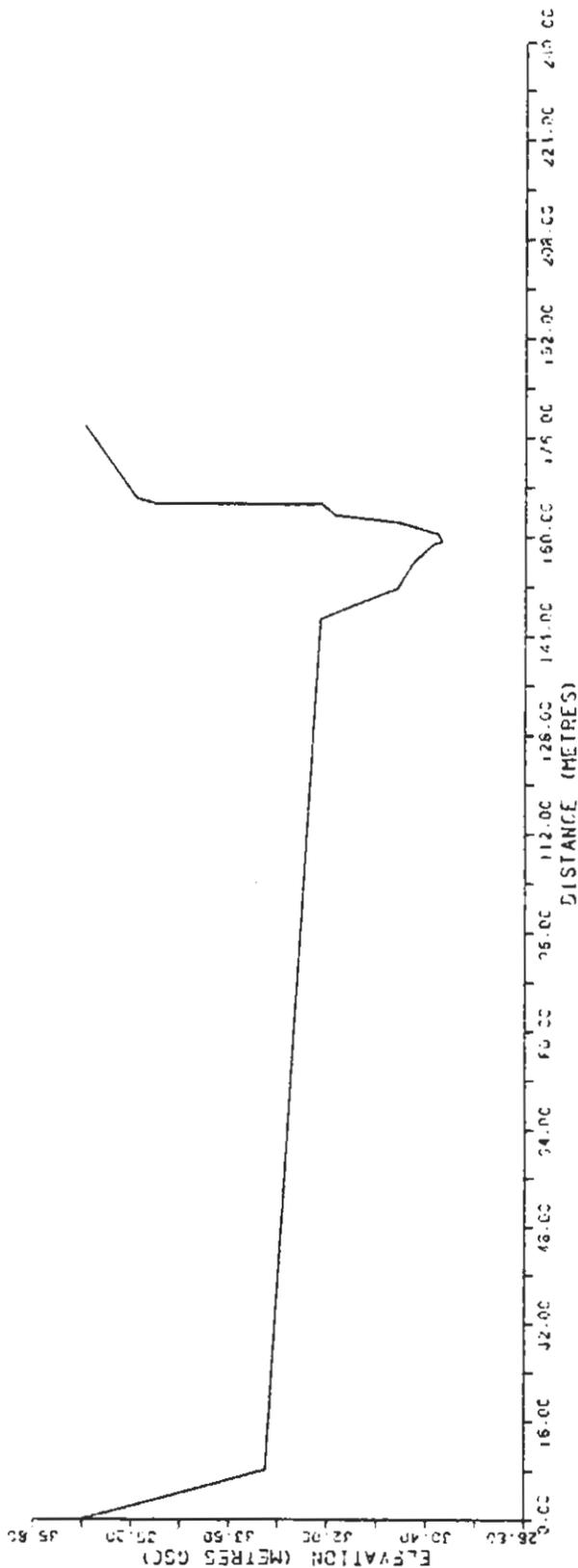


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WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 3690.

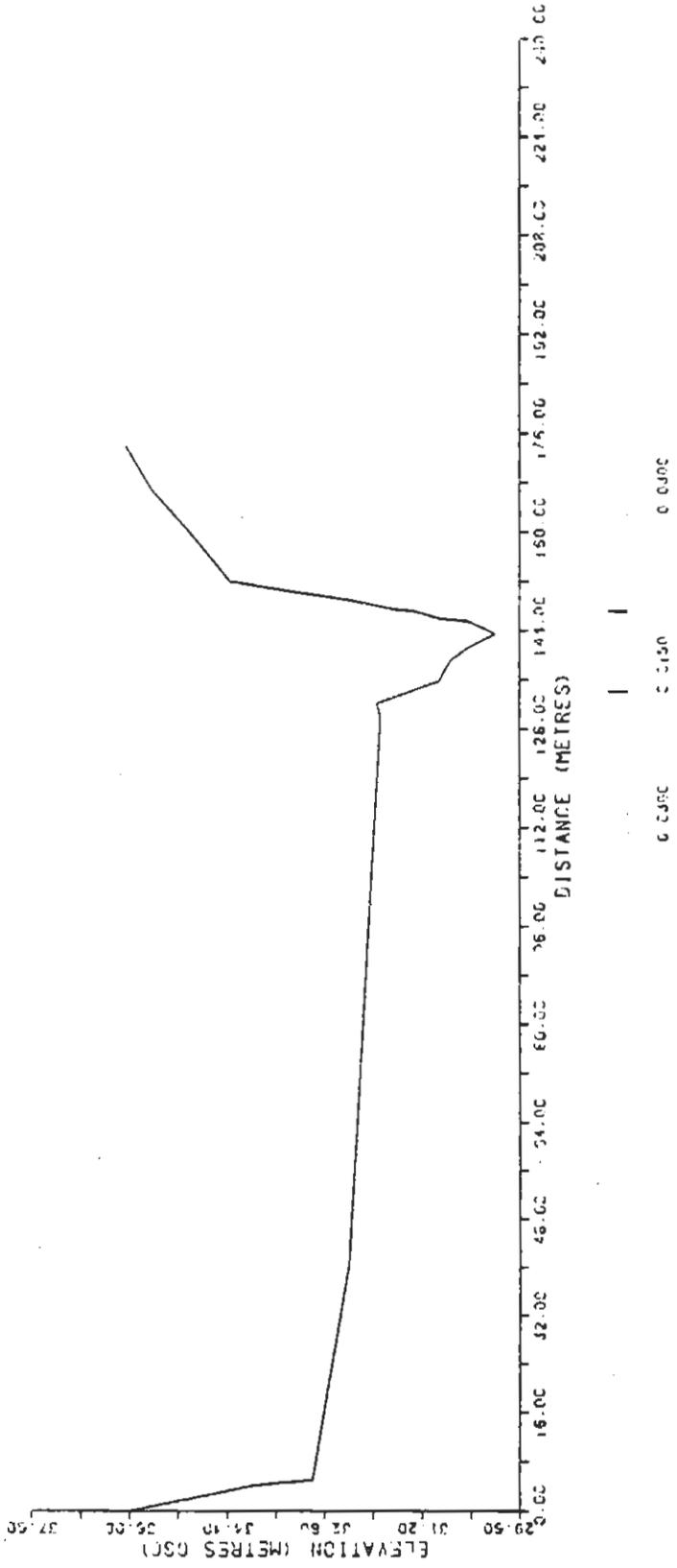


WATERFORD RIVER HEC-2 MODEL
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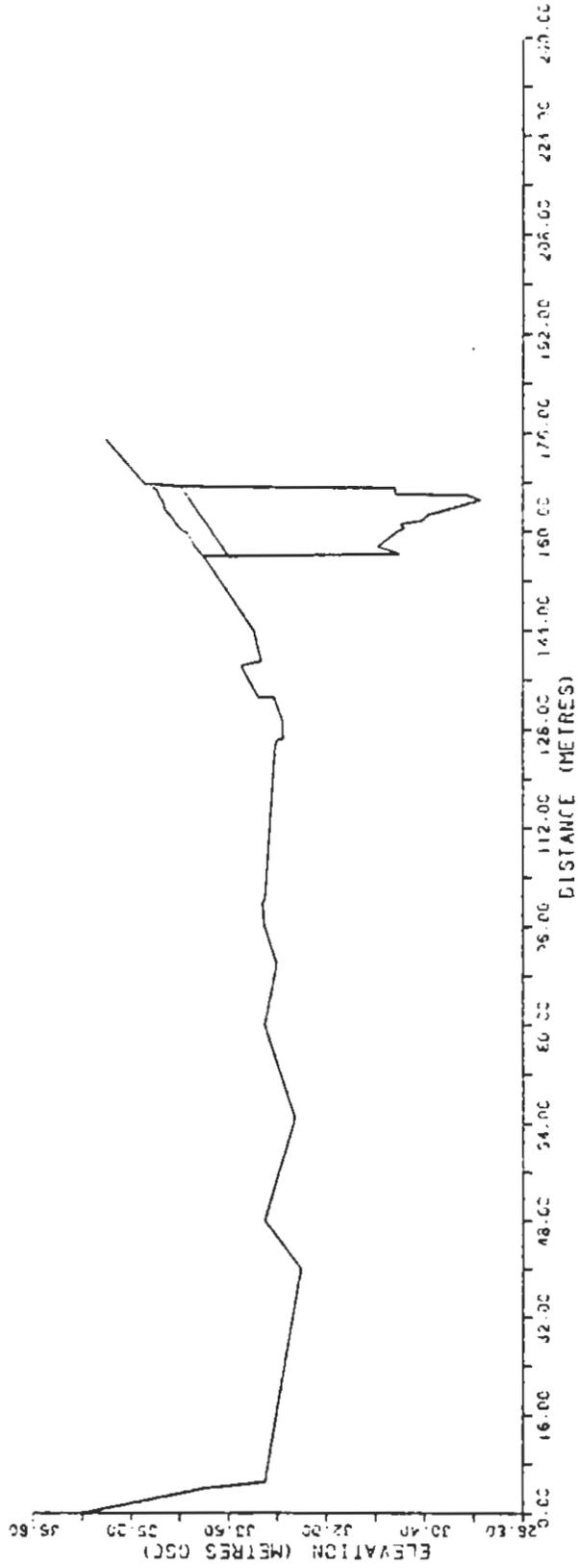


0.0000 0.0400
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WATRFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1001.5

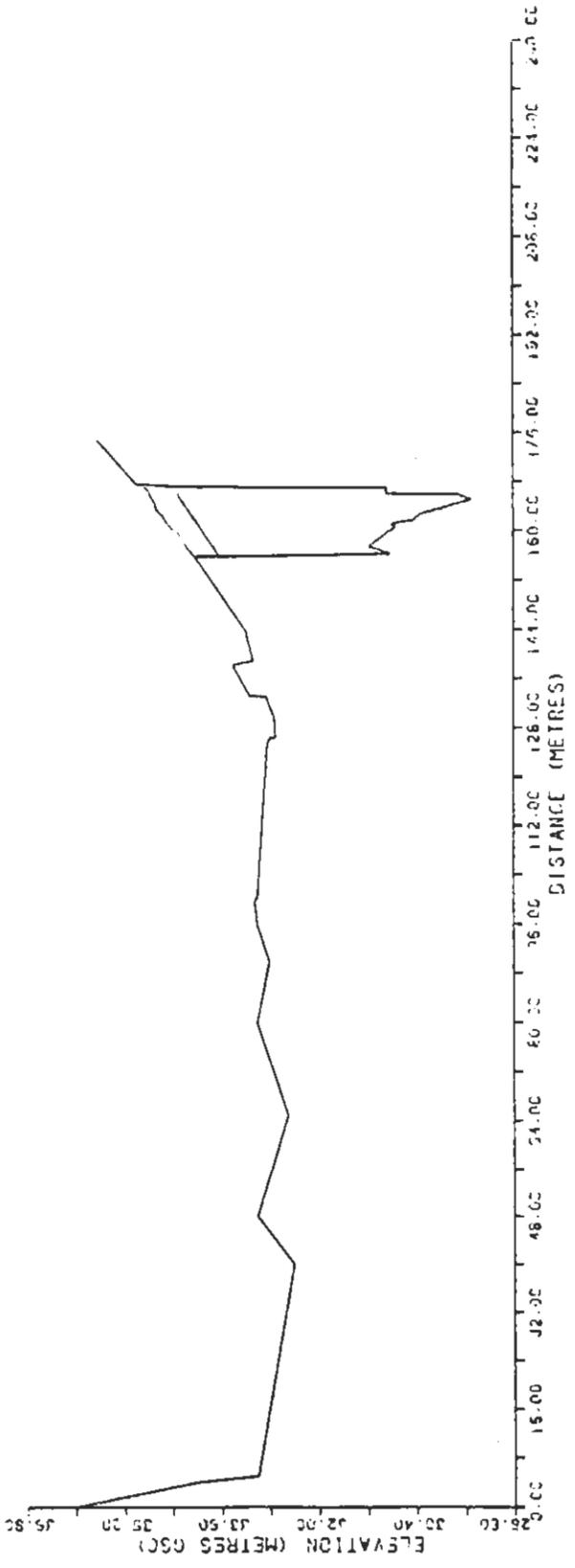


WATERFORD RIVER HEC-2 MODEL
 CROSS SECTION NUMBER 1002.1



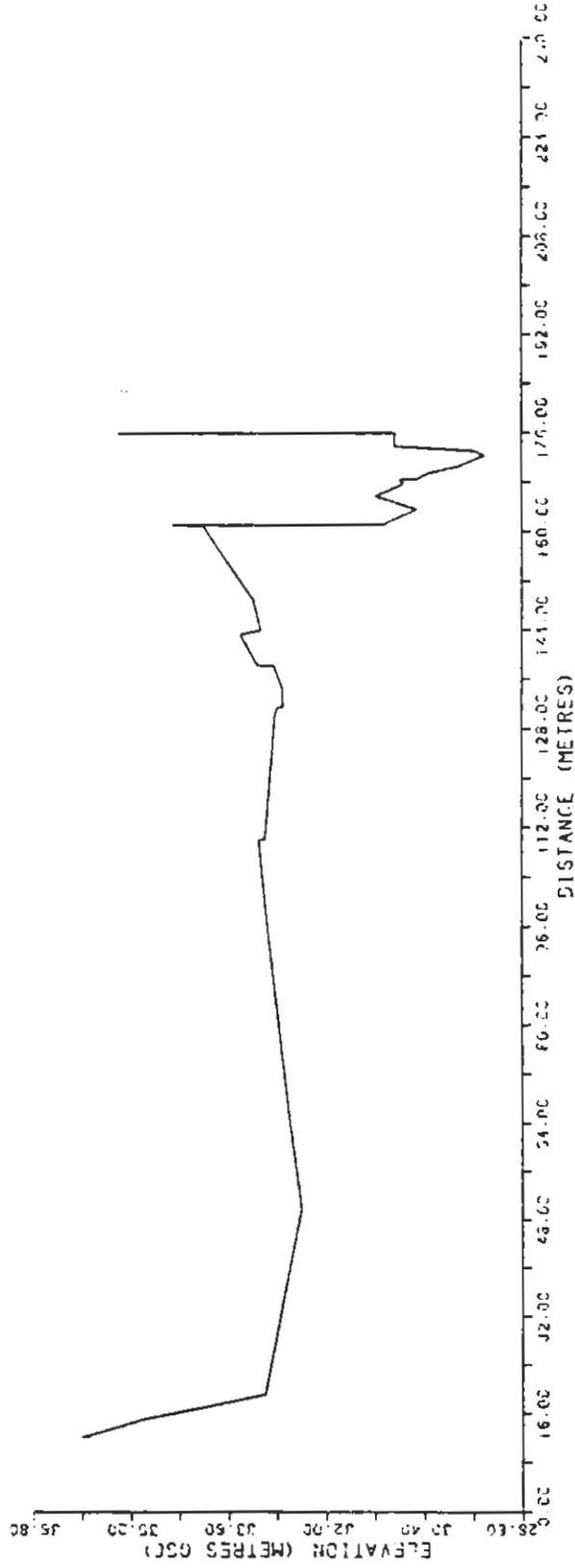
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 C CUSC 0.0000

WATERFORD RIVER HEC-2 MODEL
 CROSS SECTION NUMBER 1002.9



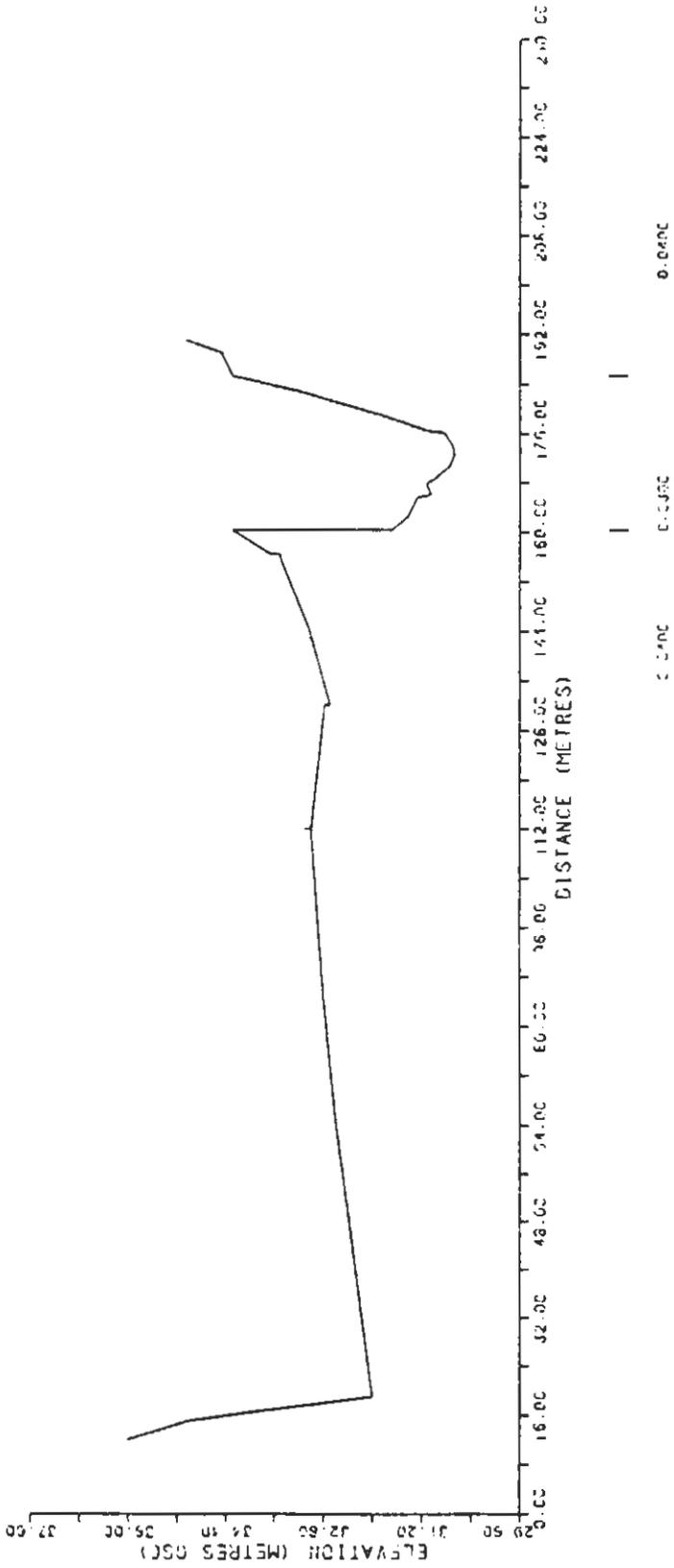
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1003

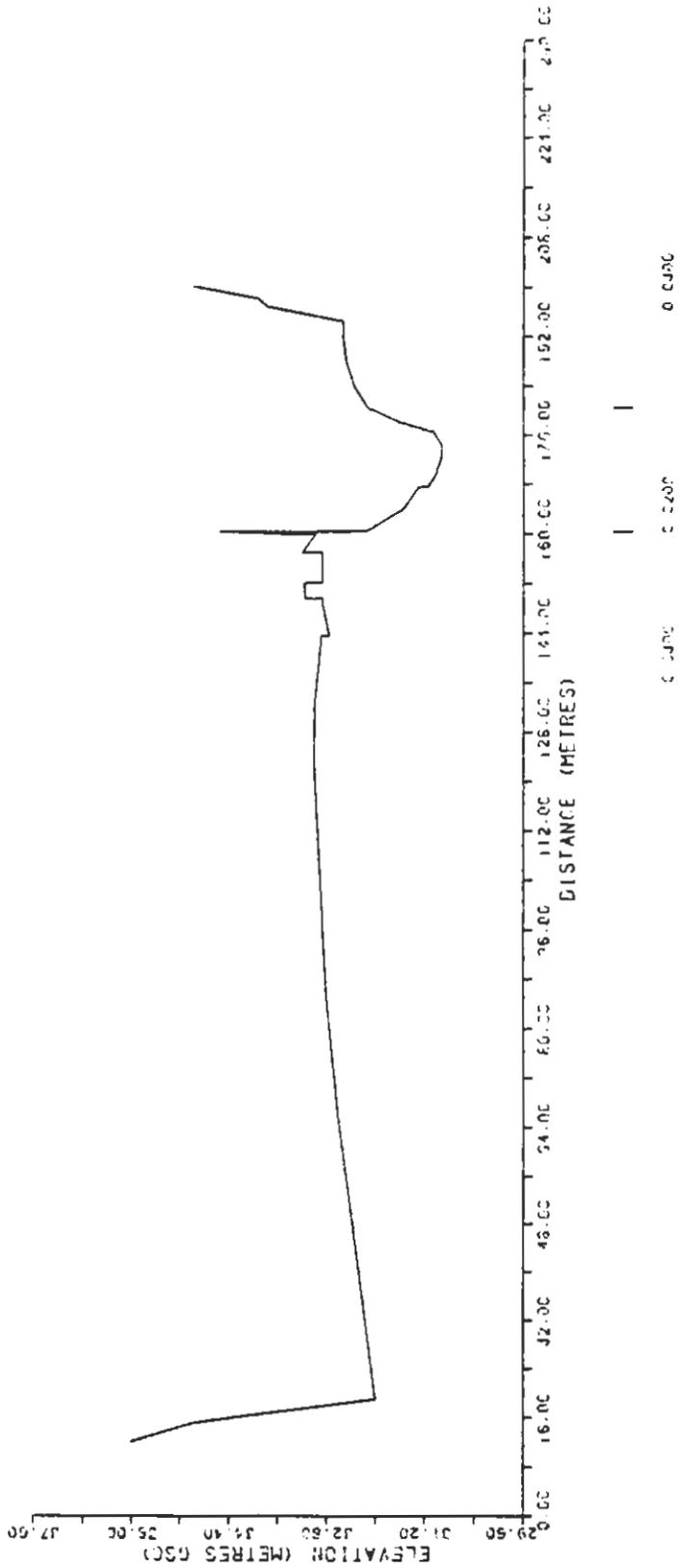


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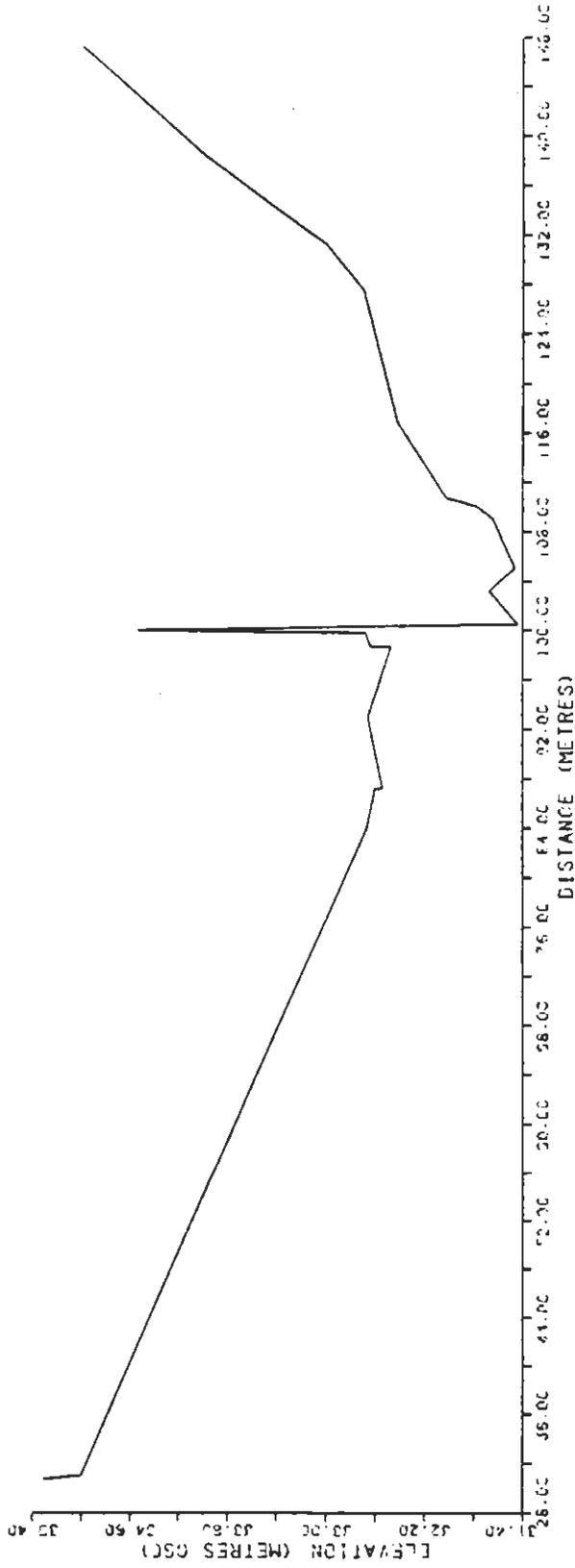
WATERFORD RIVER HEC-2 MODEL
 CROSS SECTION NUMBER 1004



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1005

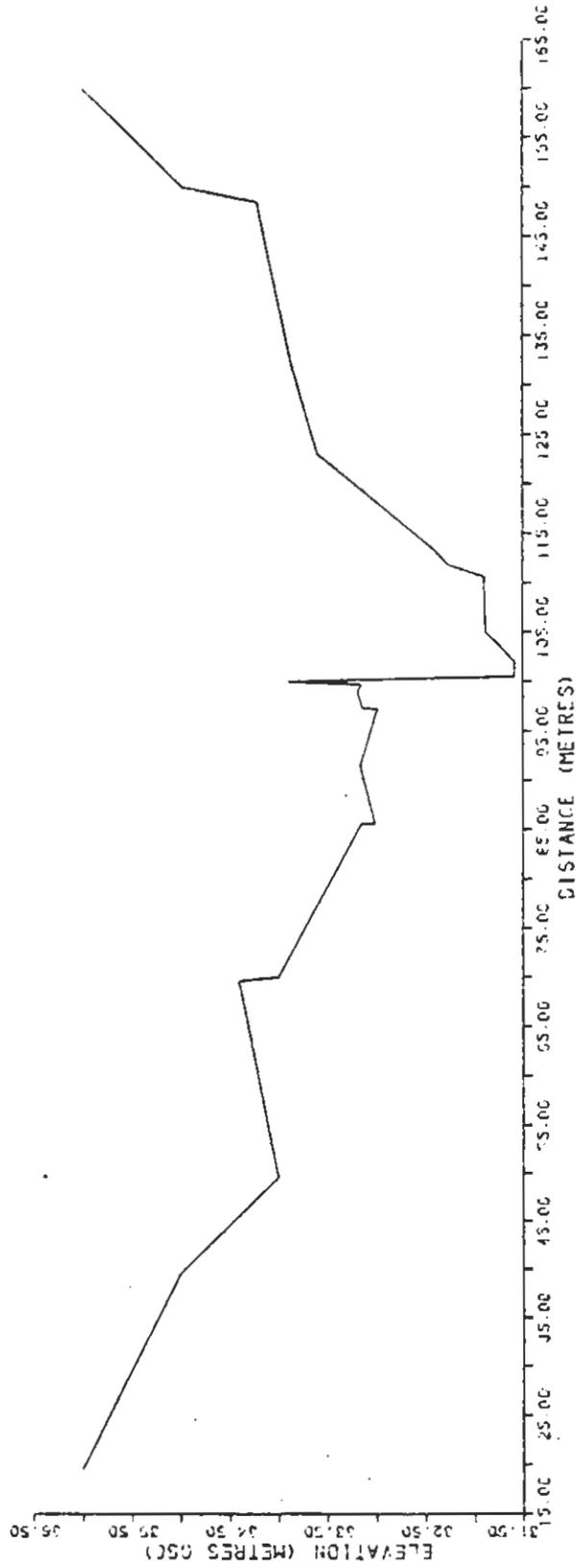


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1005.7



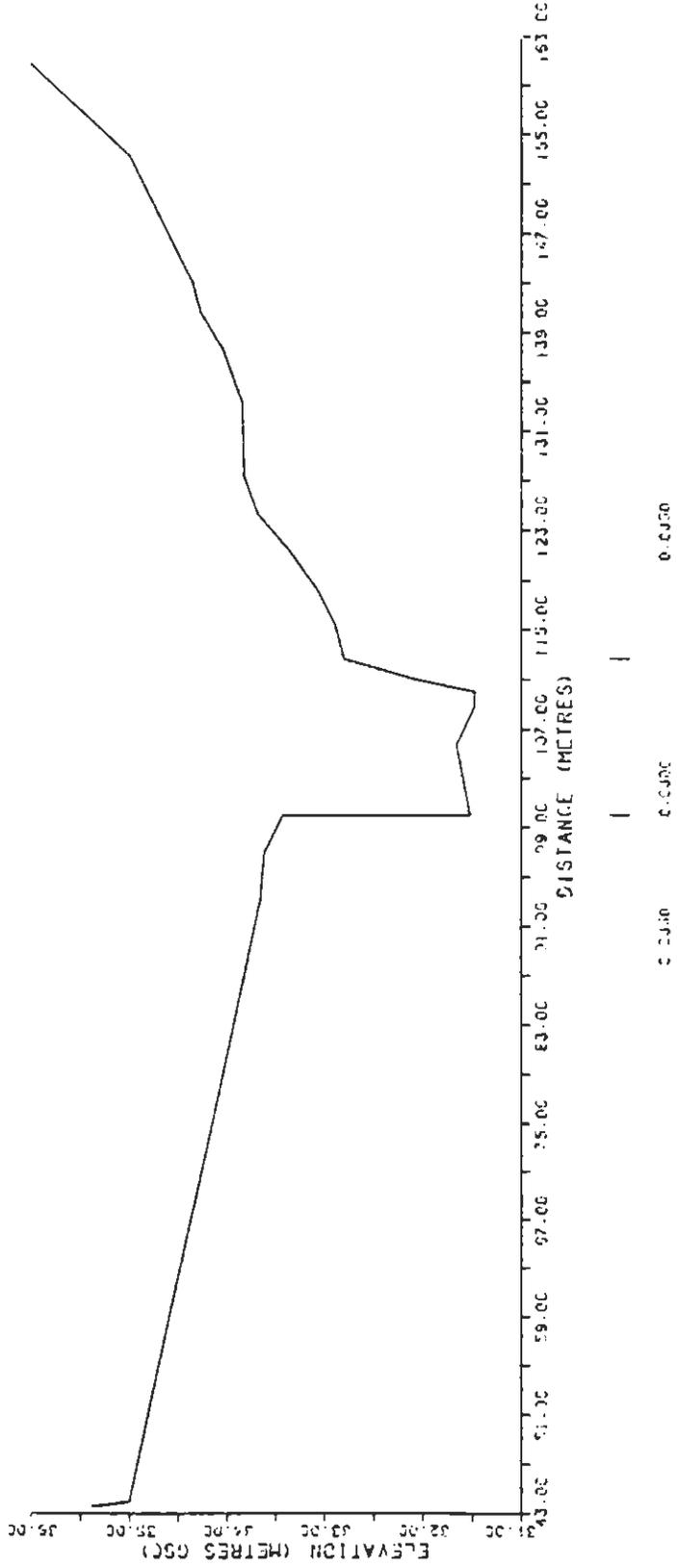
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1005.8

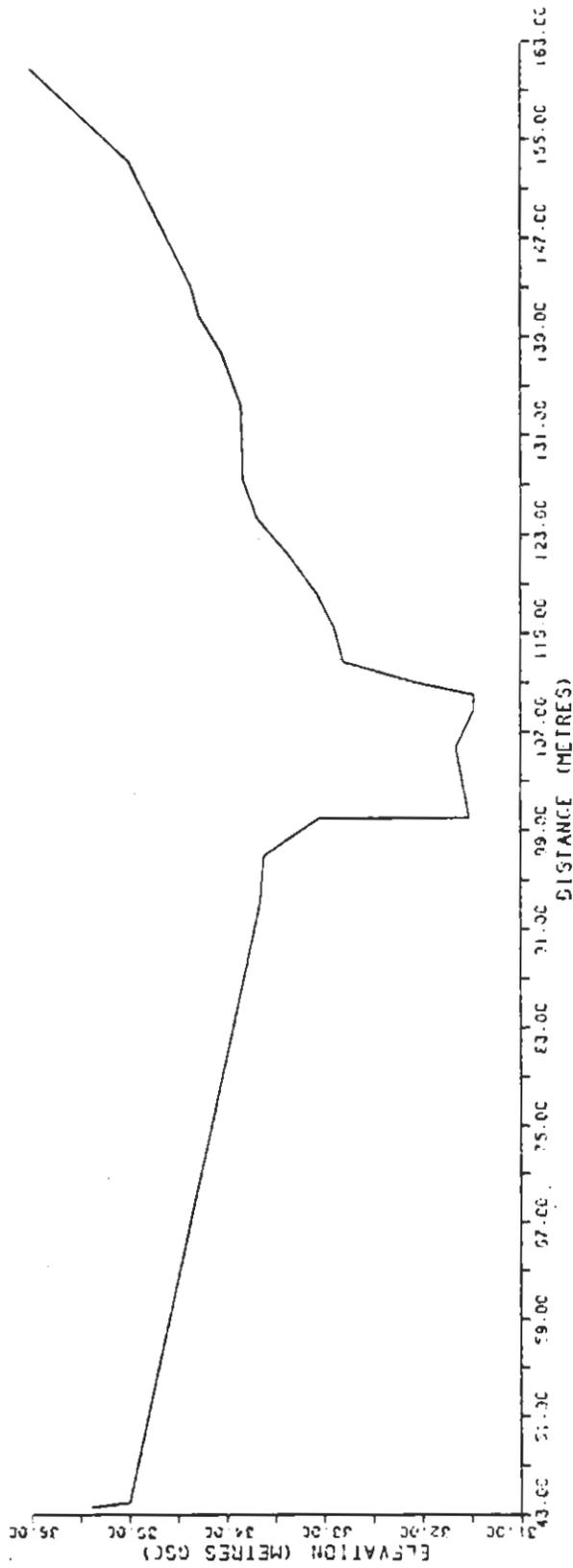


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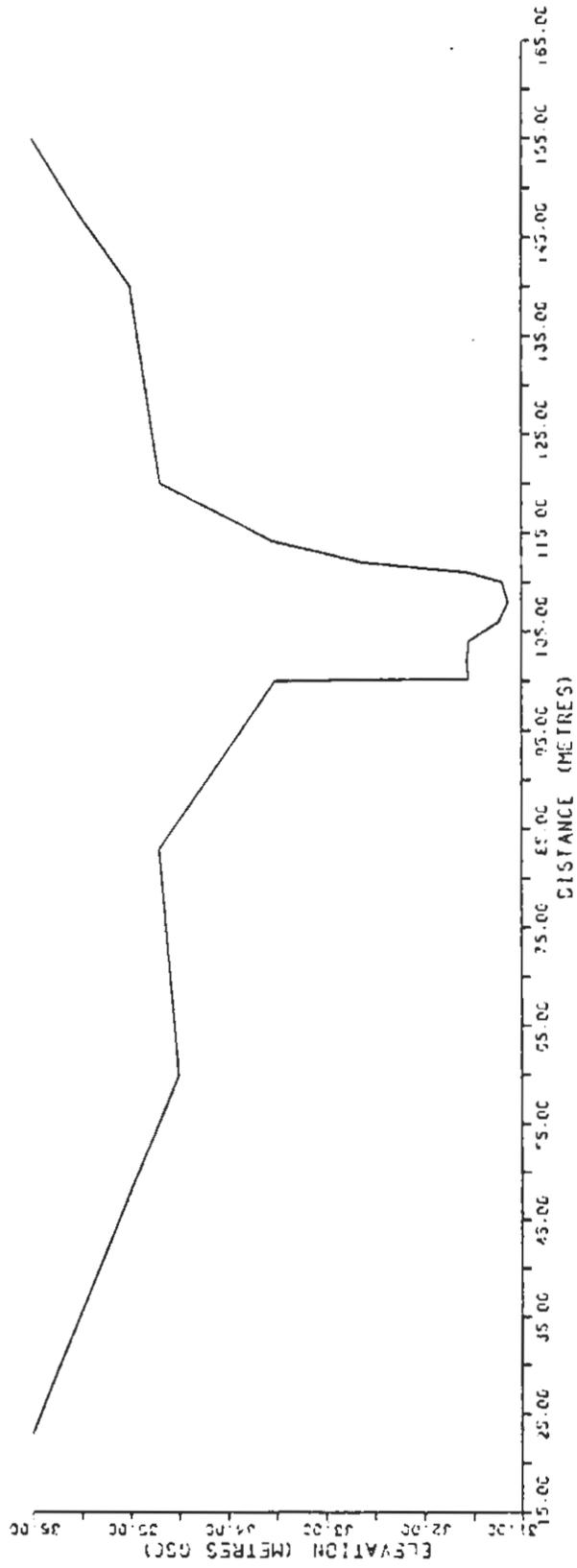
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1005.9



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1006

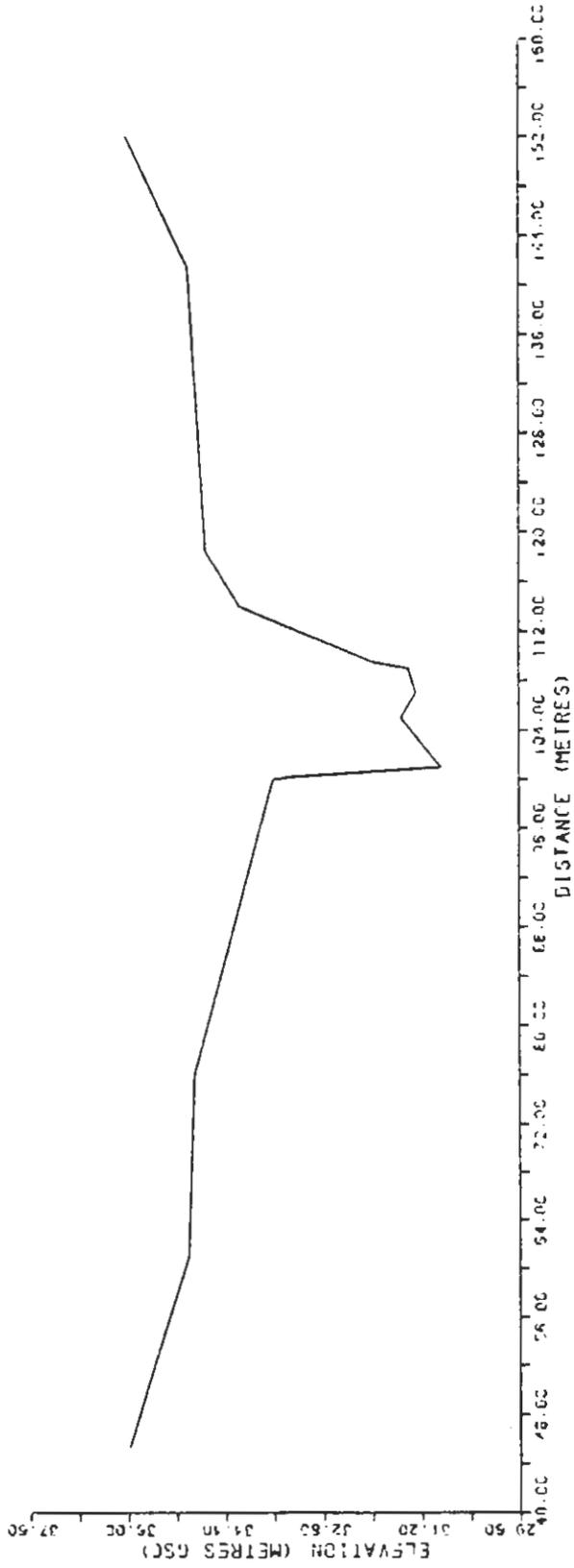


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1006.1



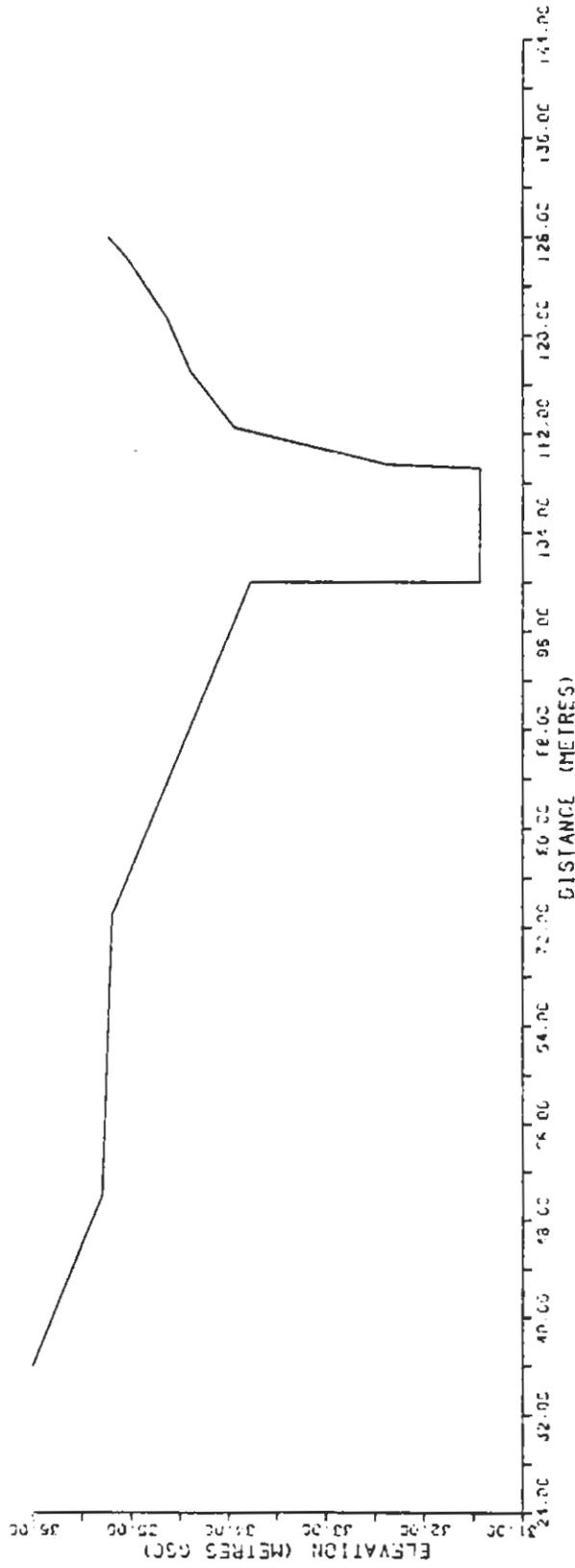
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WATERFORD RIVER HEC-2 MODEL
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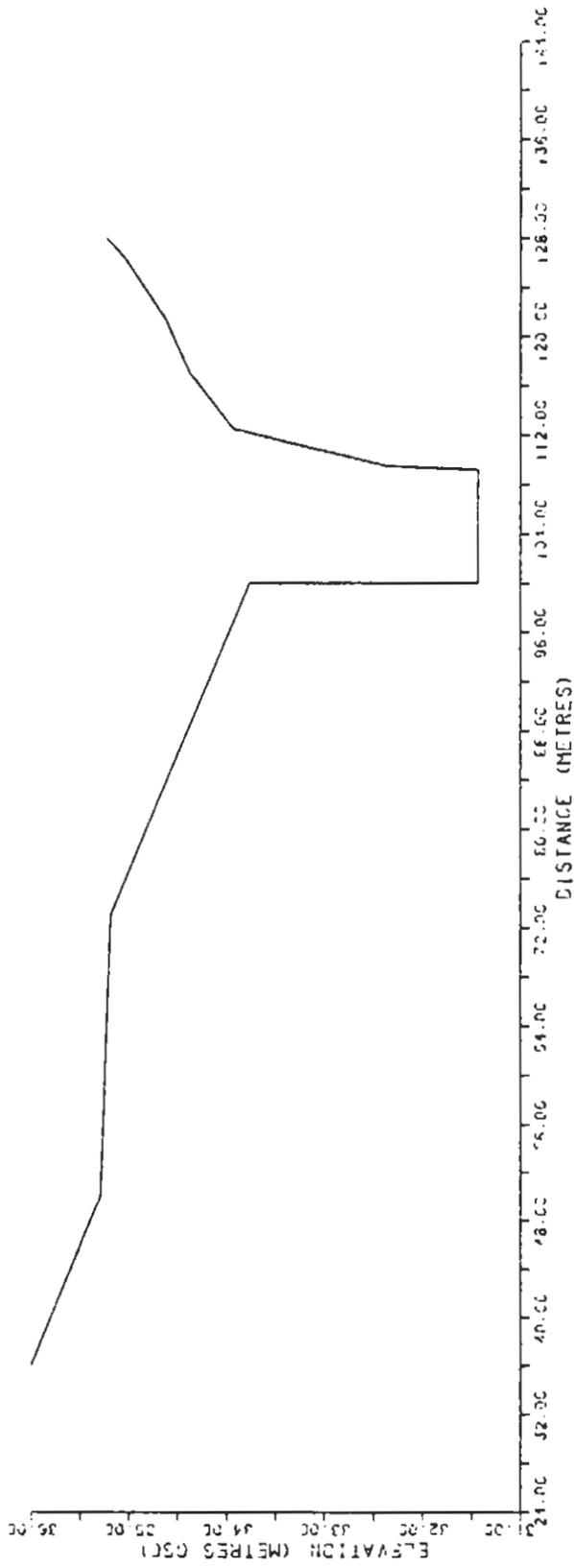
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1006.3



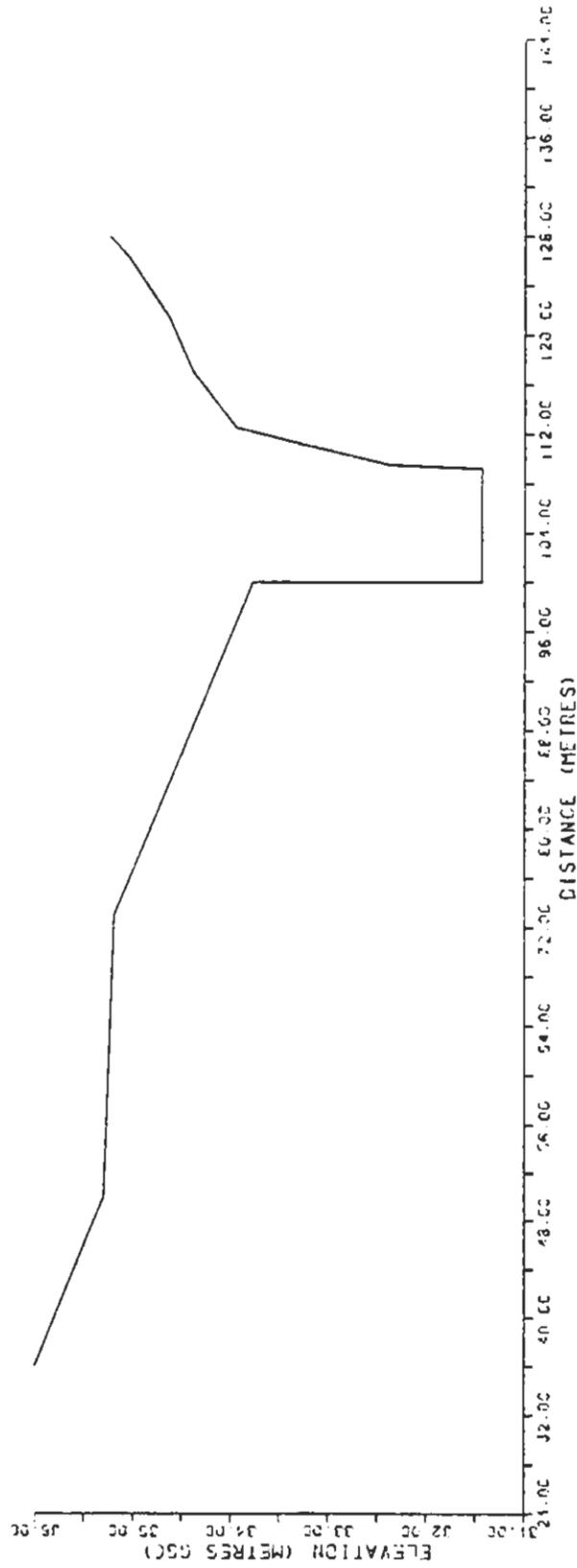
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1006.4



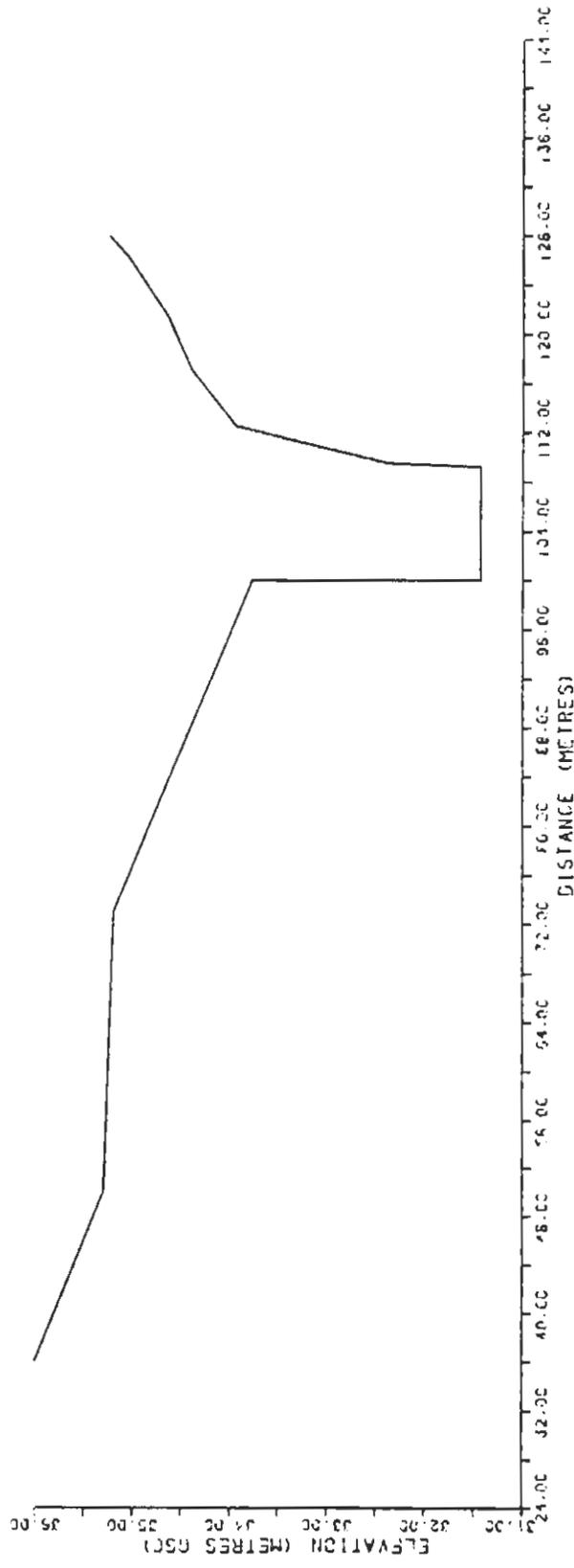
C 1000 C 1000 0 0000

WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1006.5



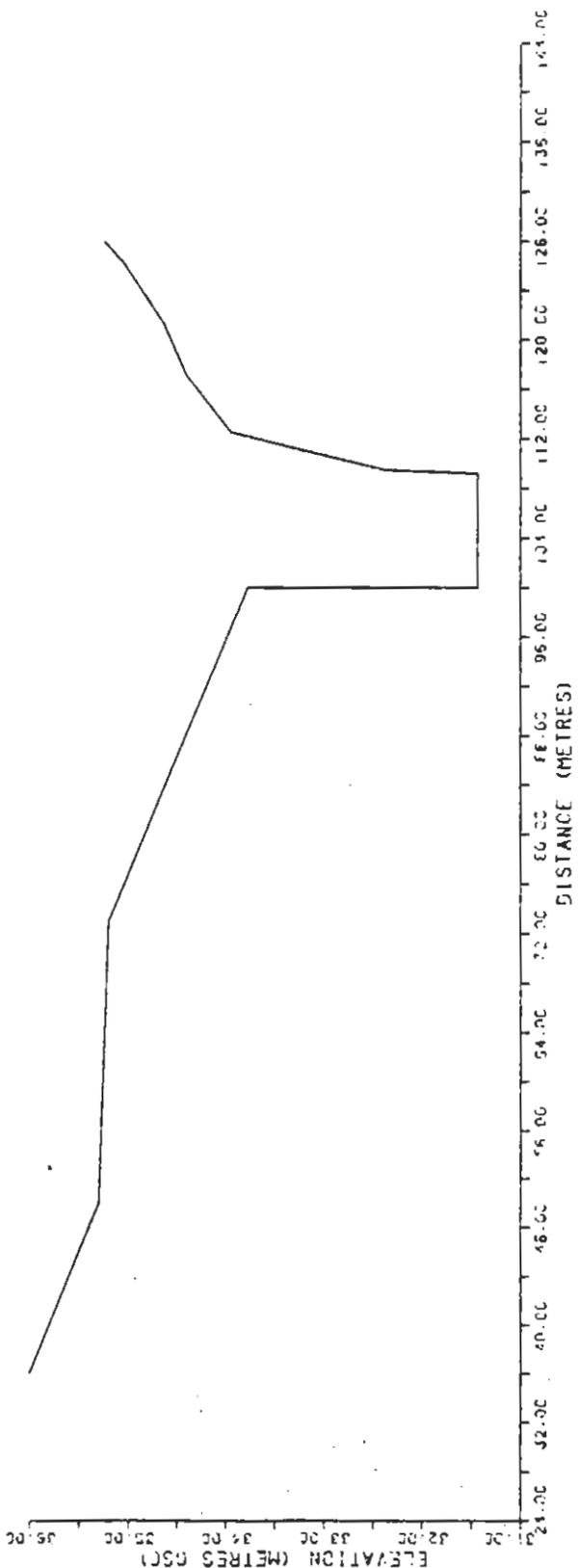
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WATERFORD RIVER HEC-2 MODEL
 CROSS SECTION NUMBER 1006.7



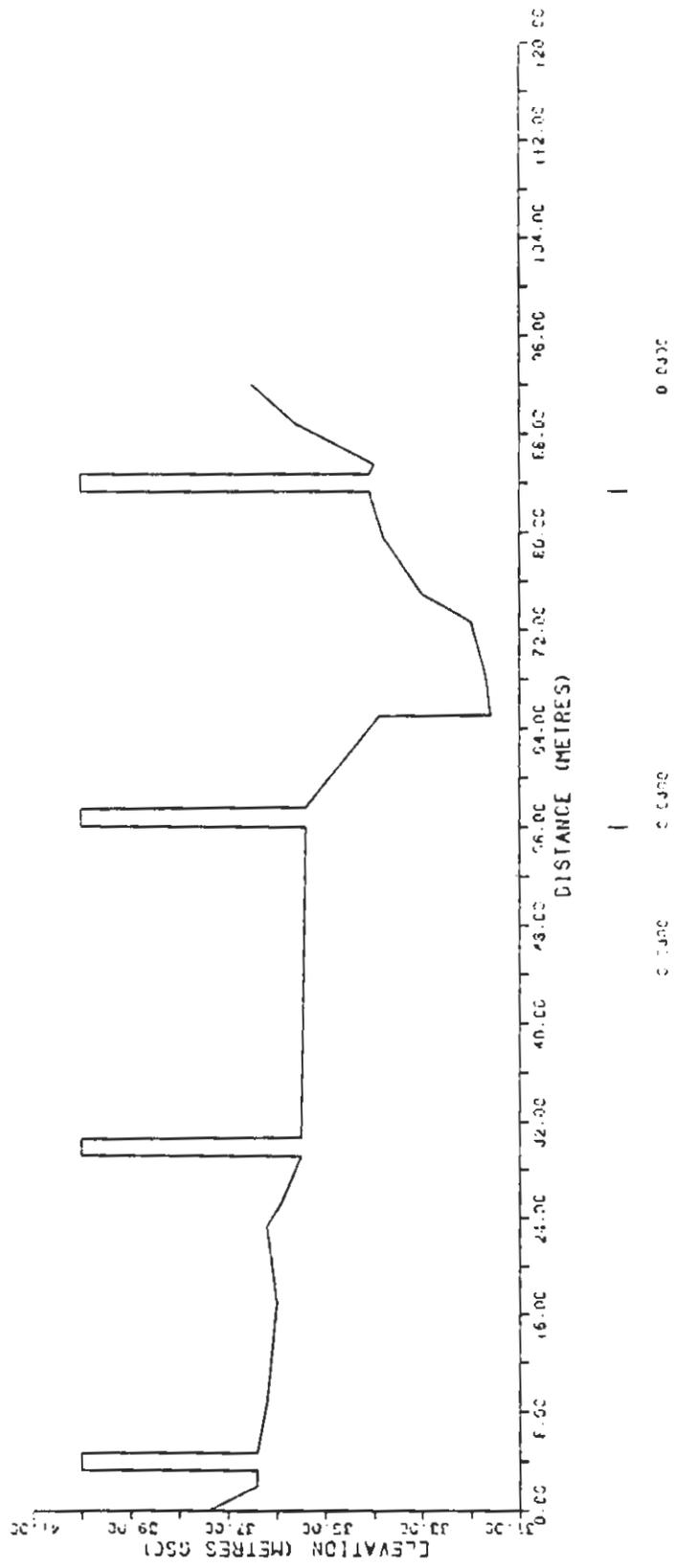
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1006.8

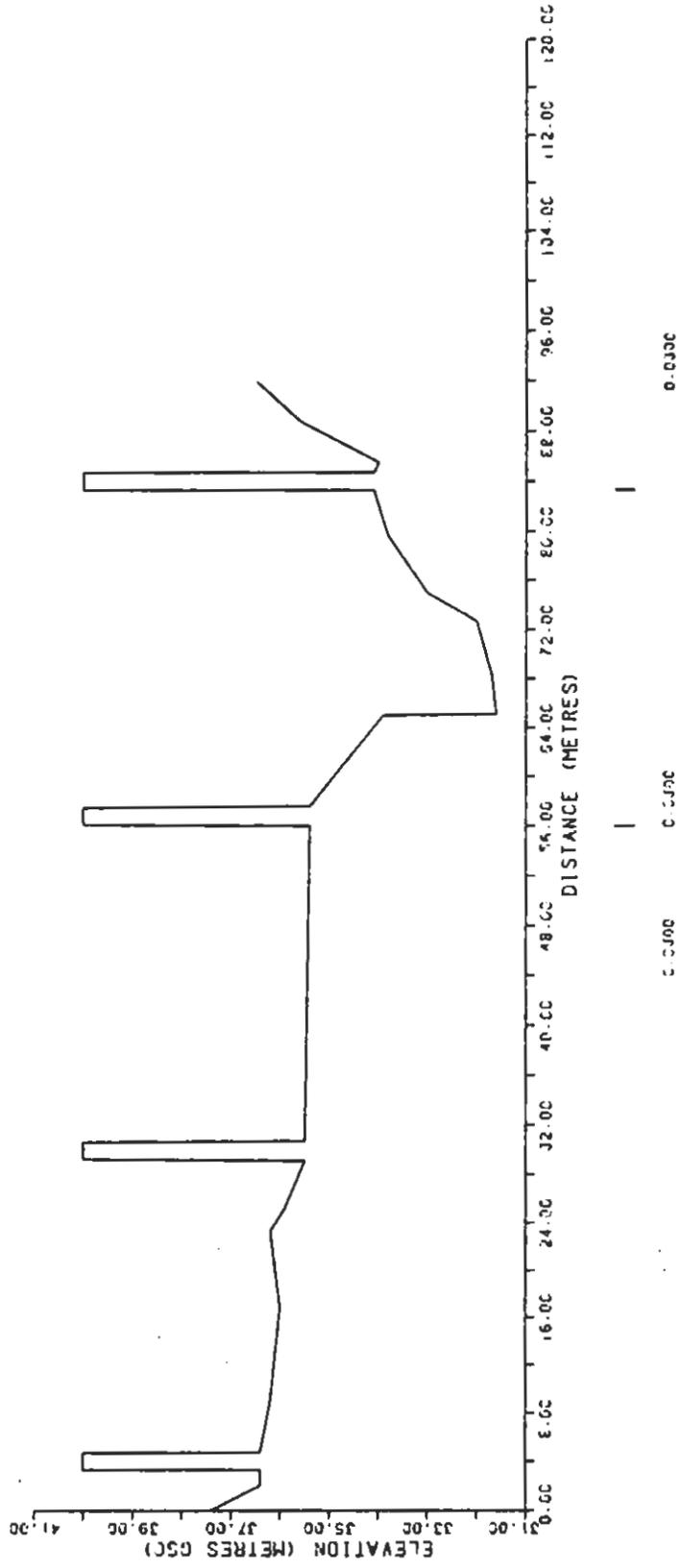


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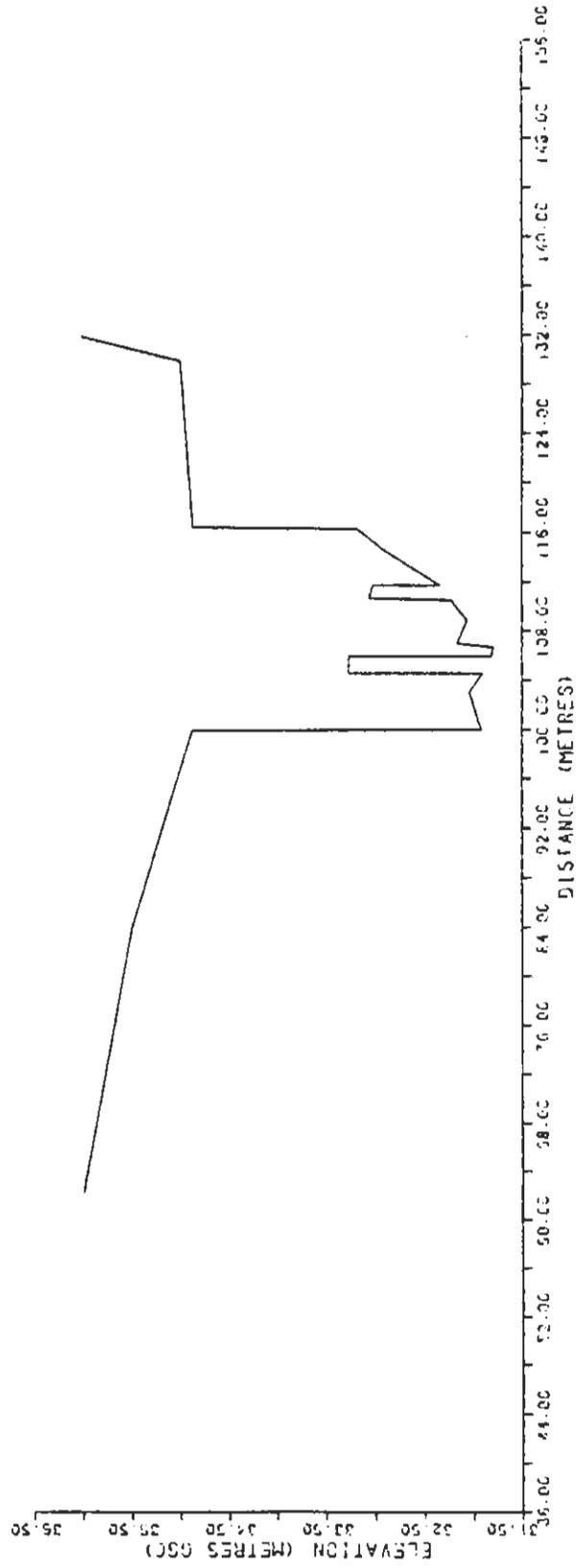
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3985.0



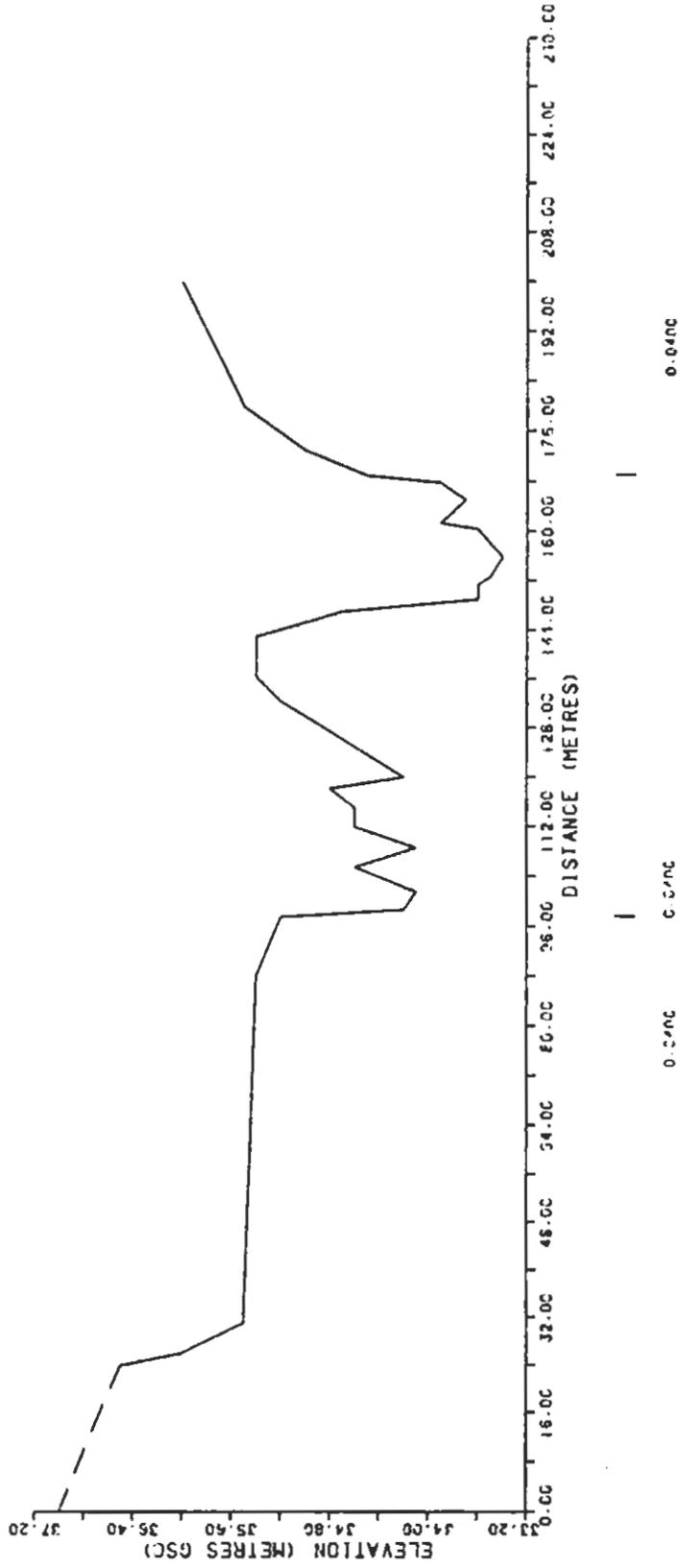
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CROSS SECTION NUMBER 4008.0



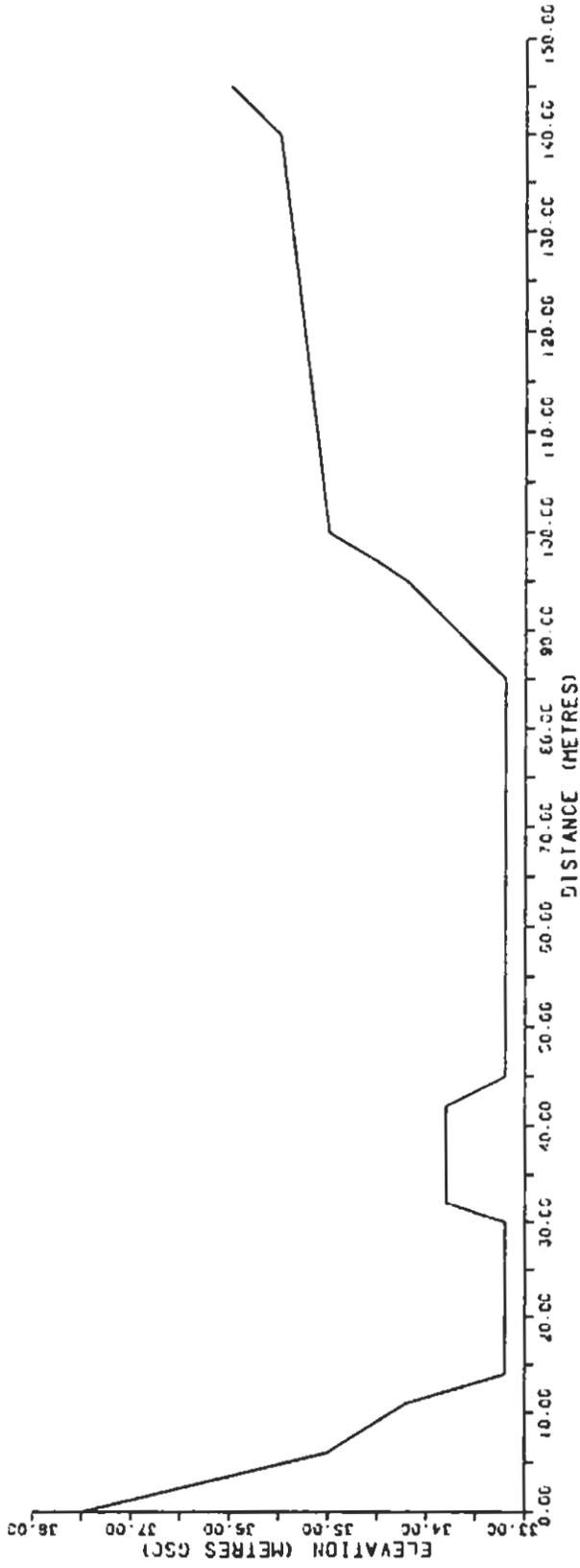
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 1008



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4070.0



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4100.0



0.0400

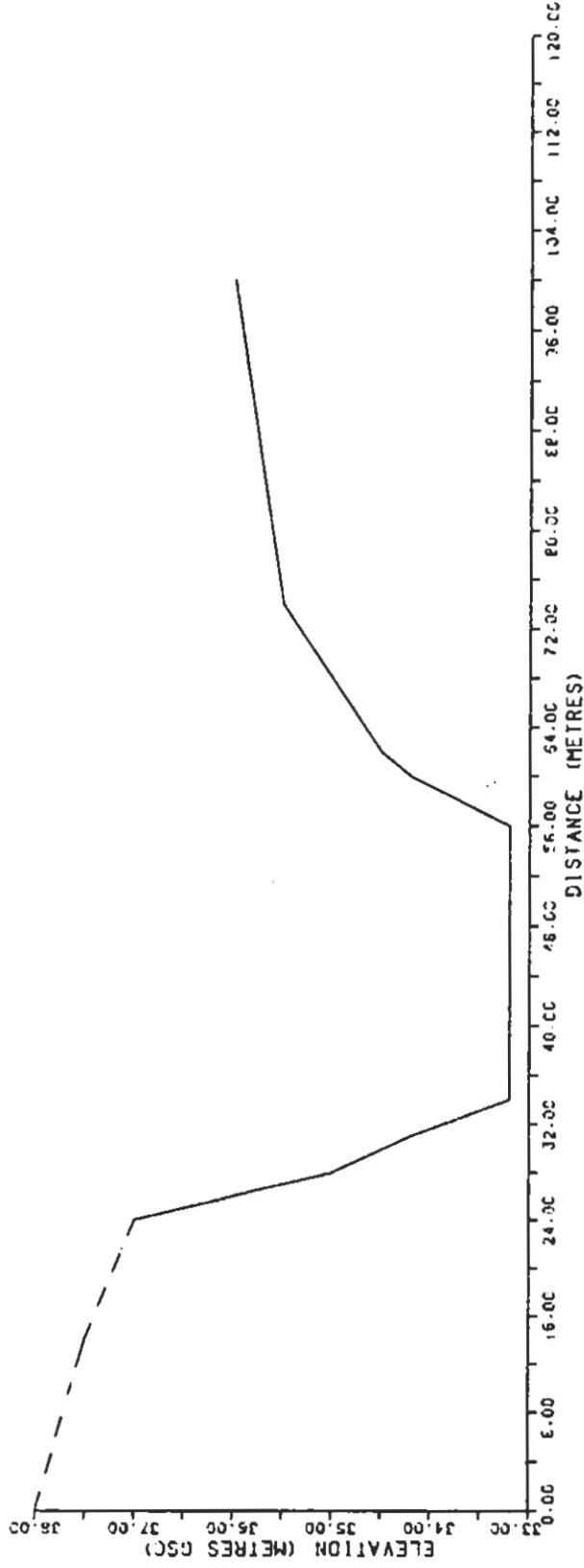
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0.0000

WATERFORD RIVER

HEC-2 MODEL

CROSS SECTION NUMBER 4138.0

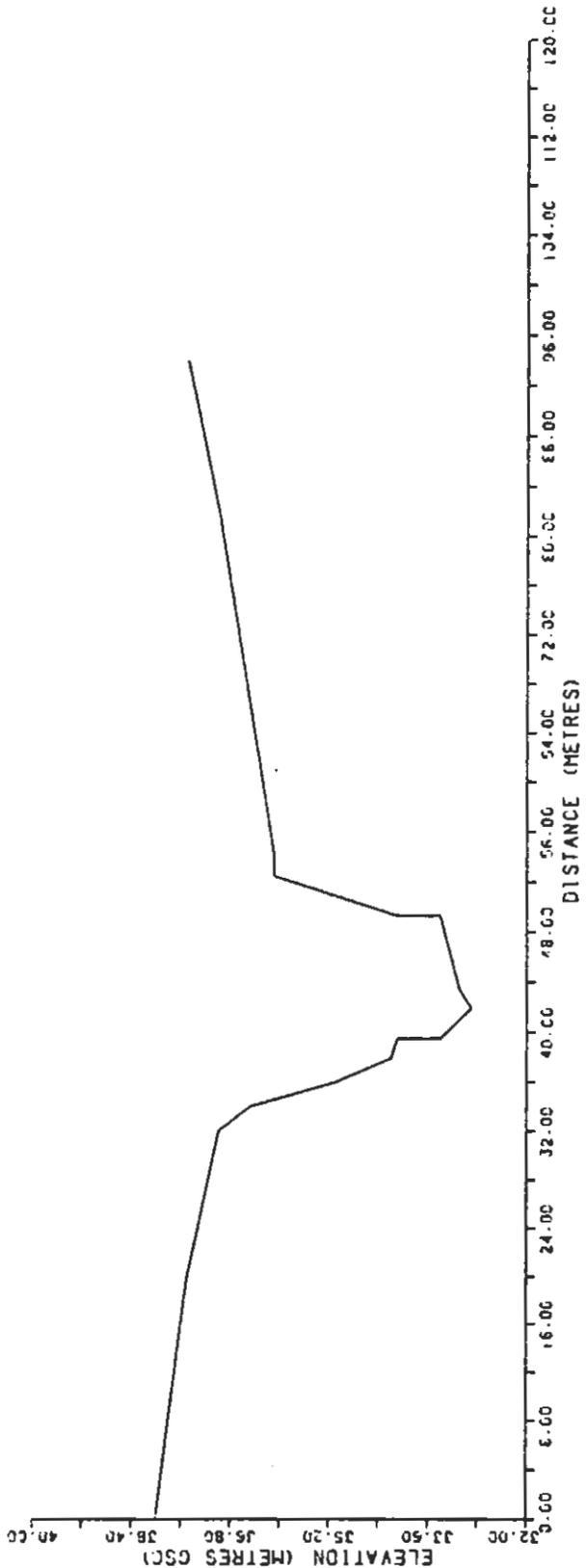


0.240C

0.550C

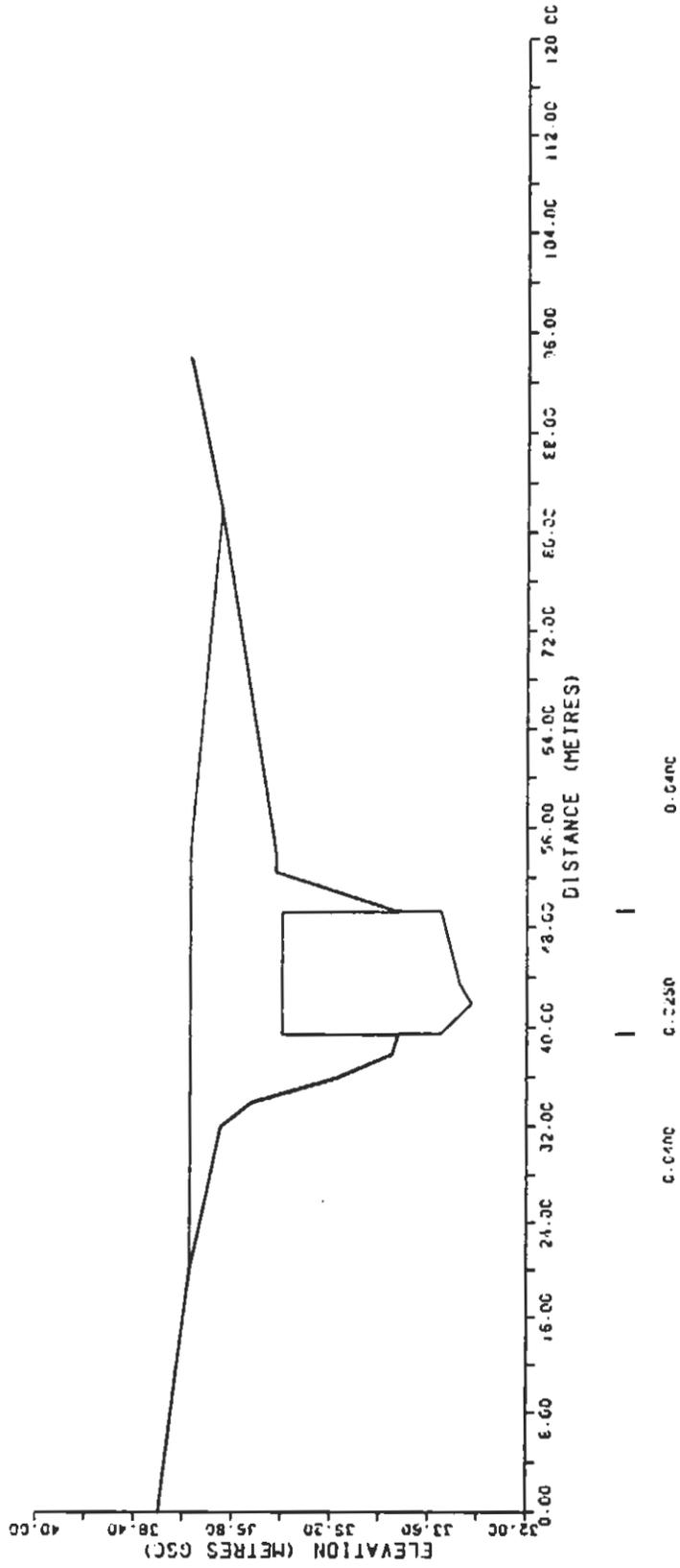
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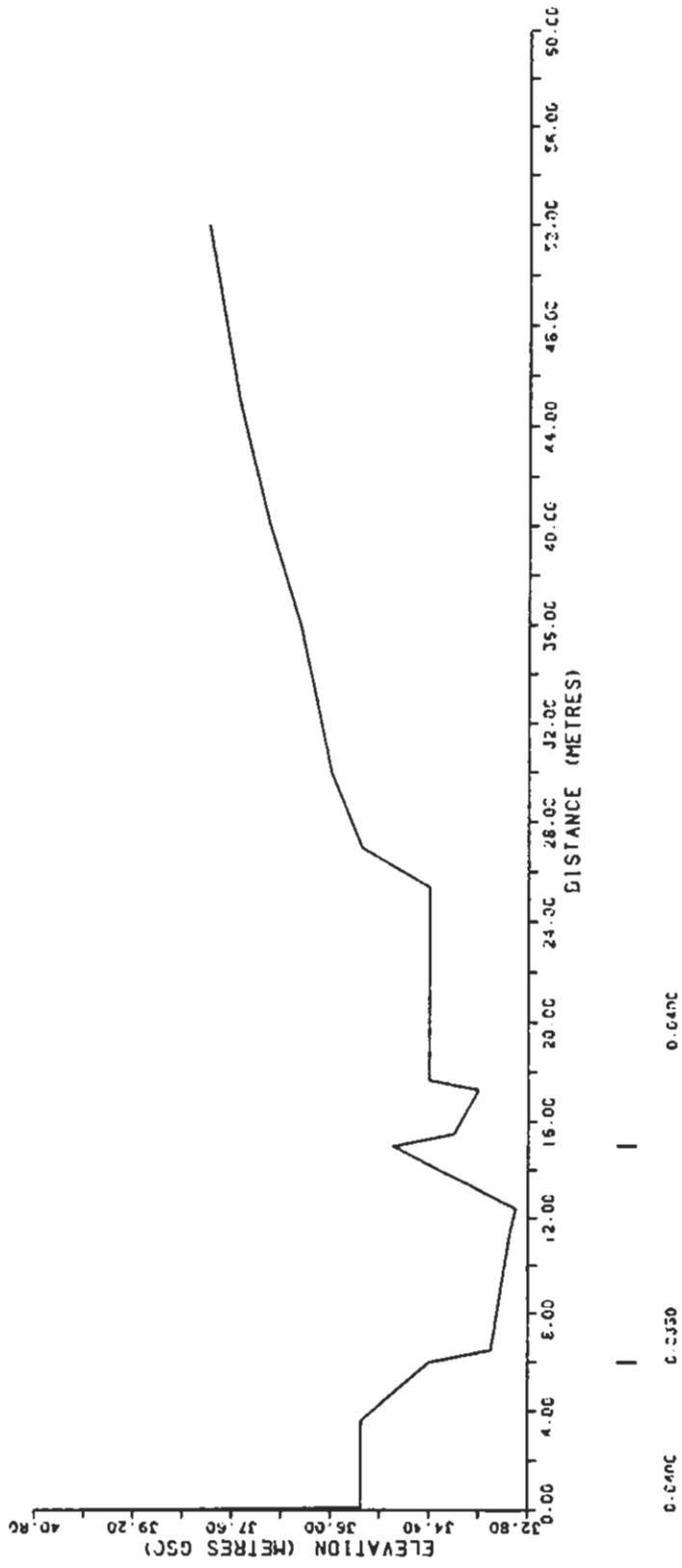


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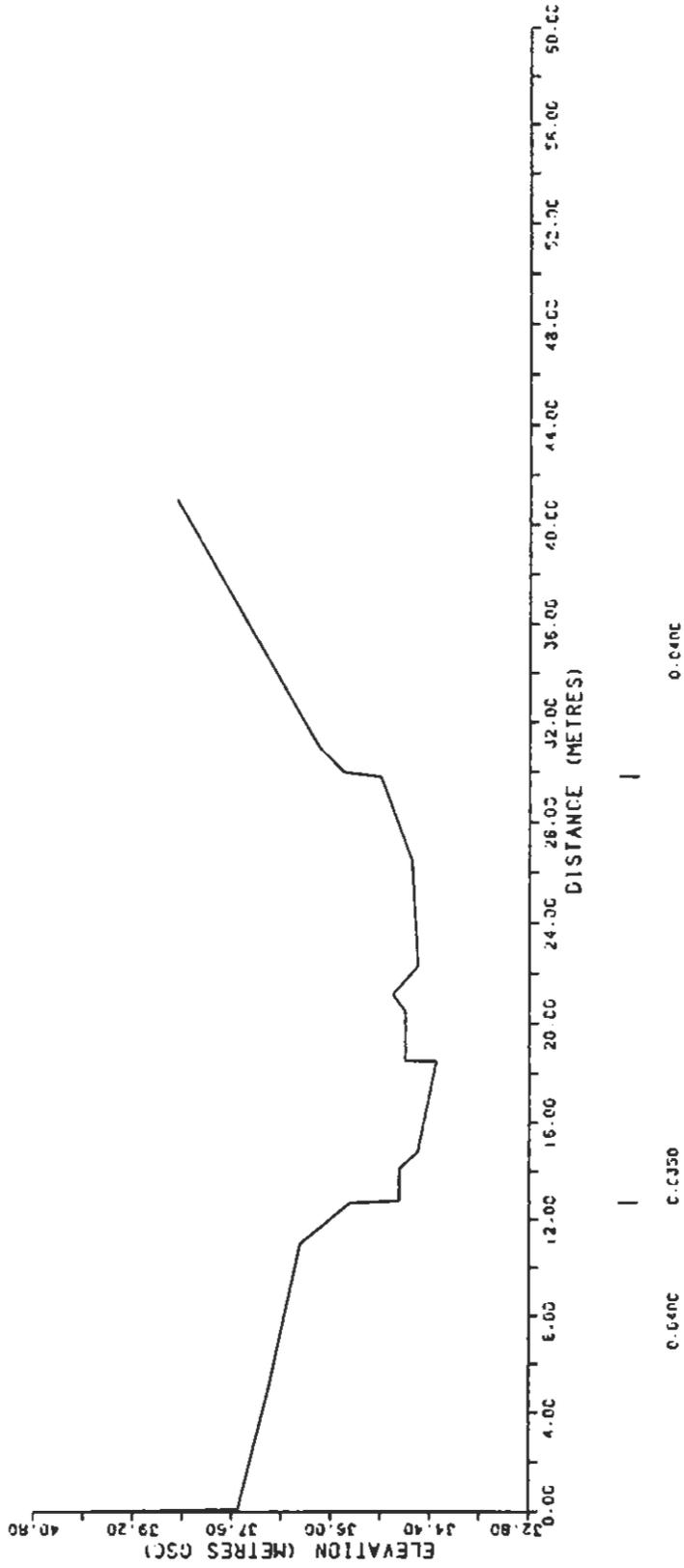
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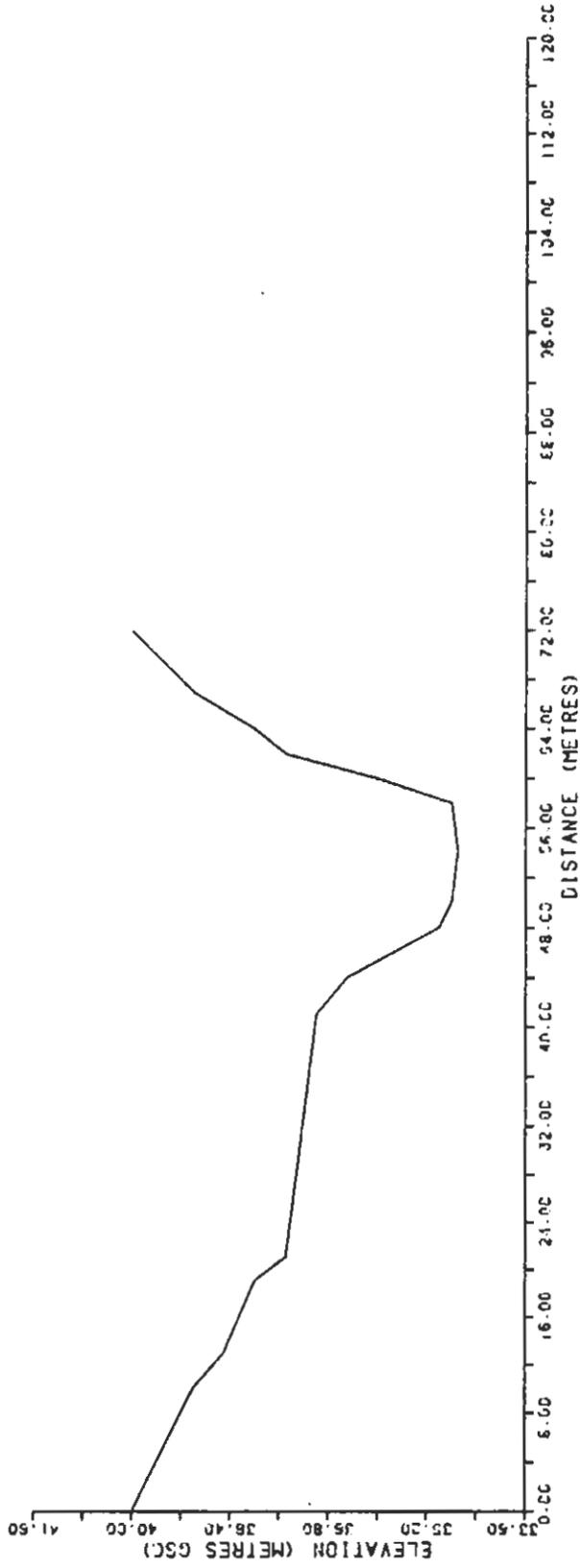
WATERFORD RIVER
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CROSS SECTION NUMBER 4176.0



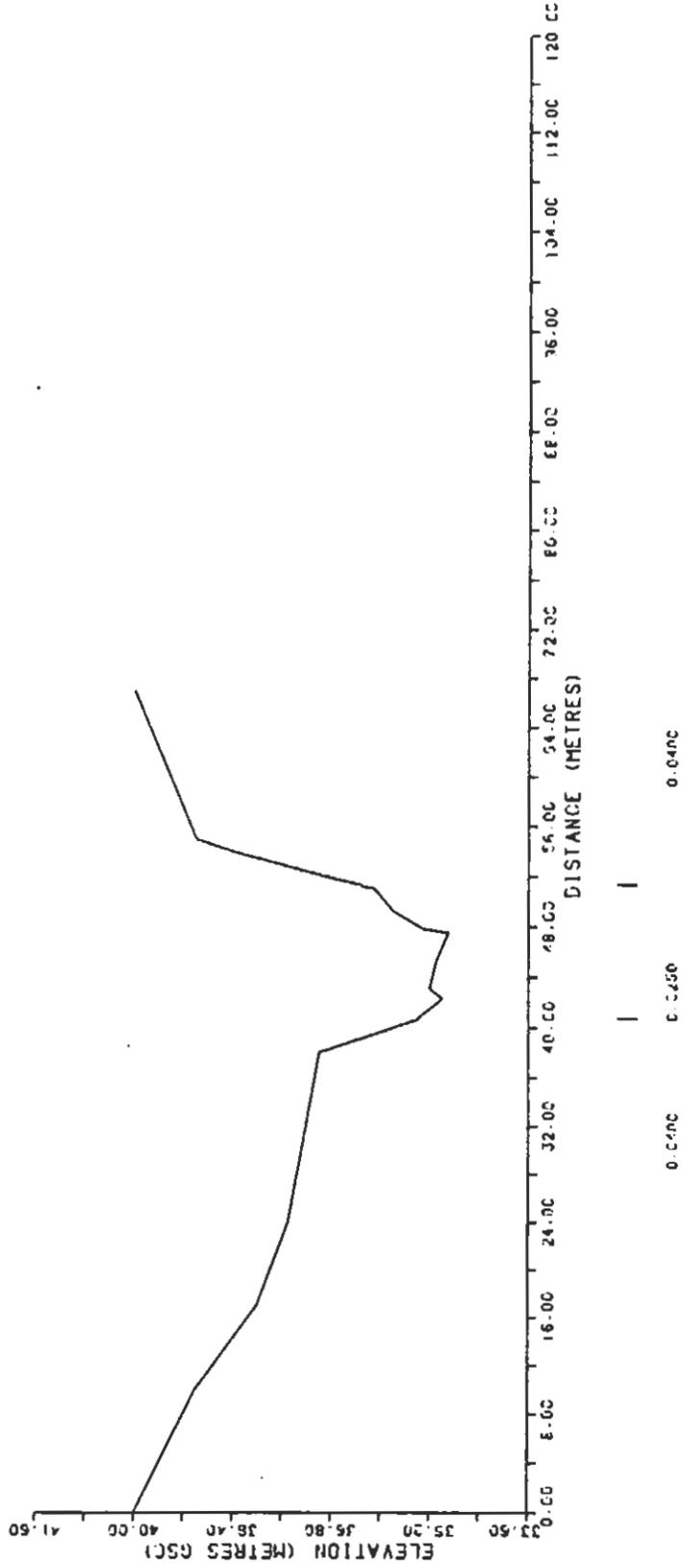
WATERFORD RIVER
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CROSS SECTION NUMBER 4218.0



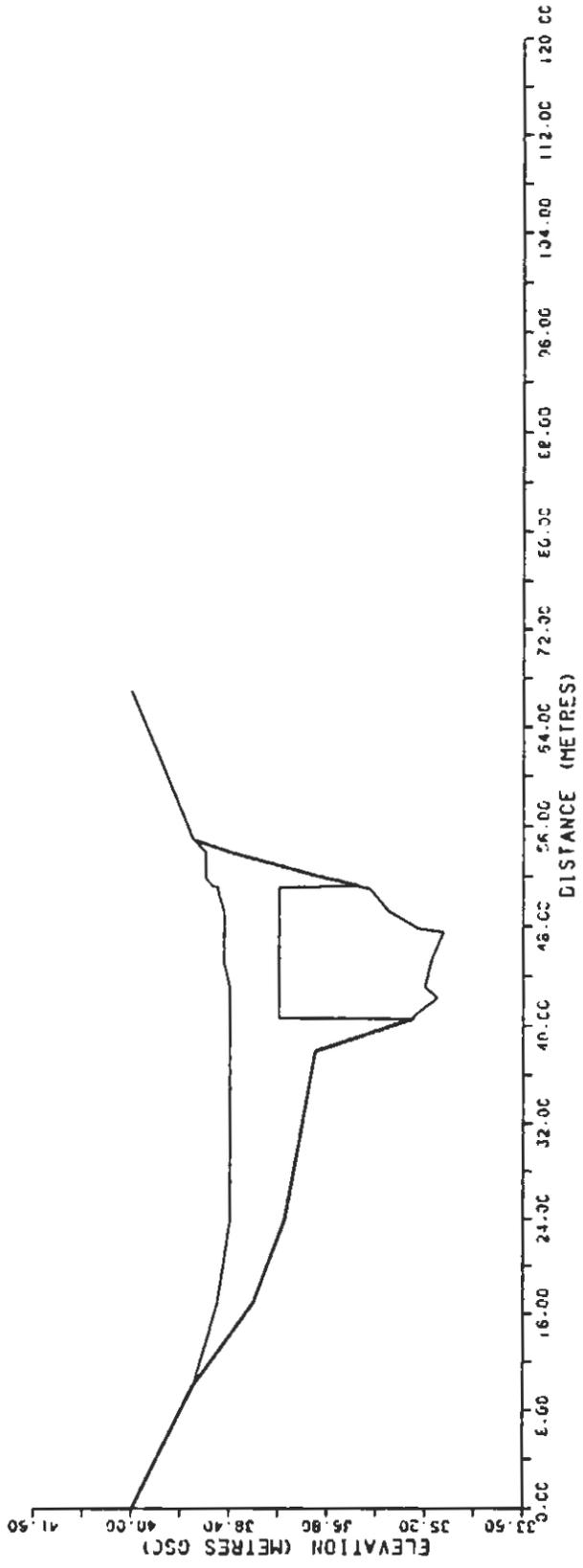
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4238.0



WATERFORD RIVER HEC-2 MODEL
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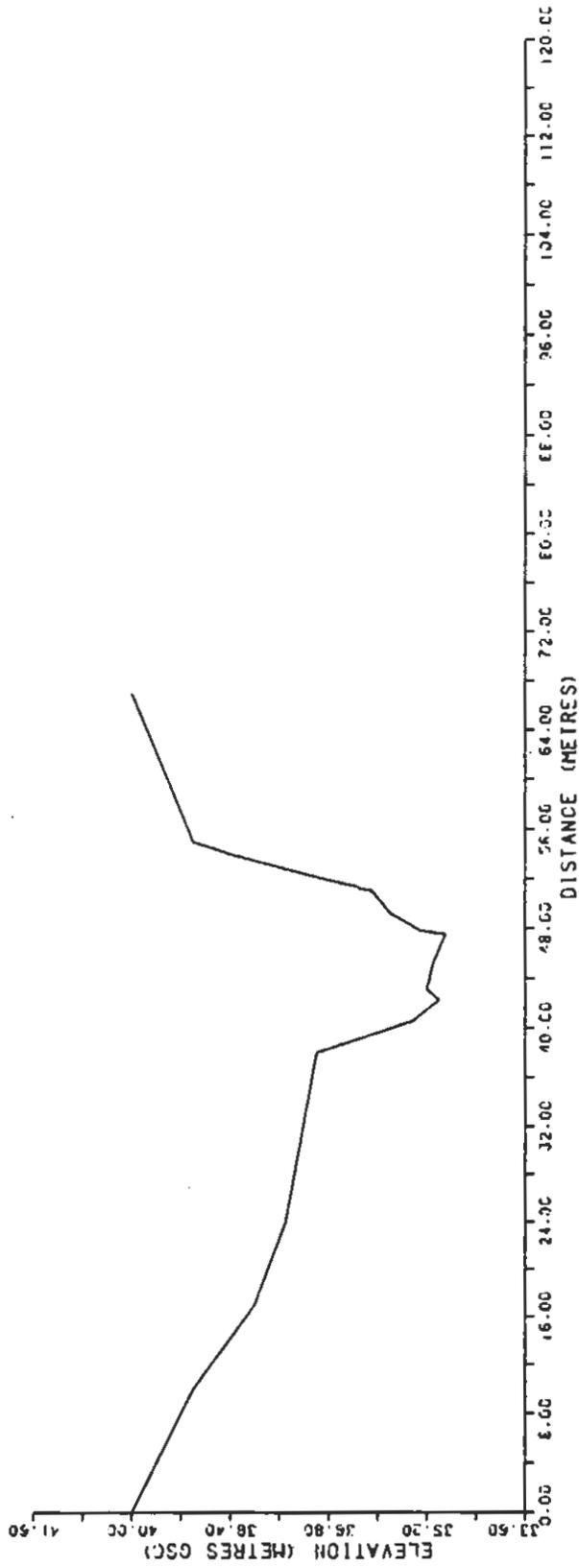


WATERFORD RIVER HEC-2 MODEL
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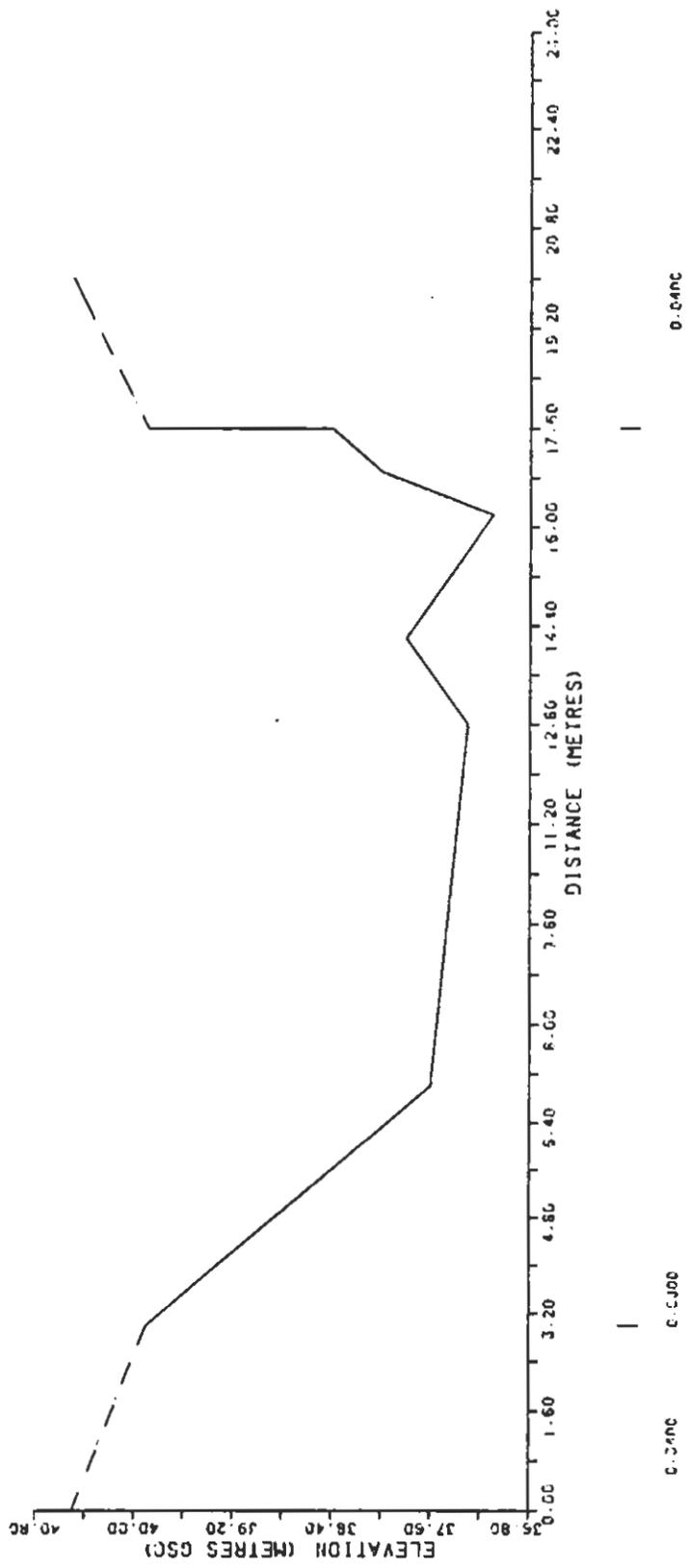
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WATERFORD RIVER
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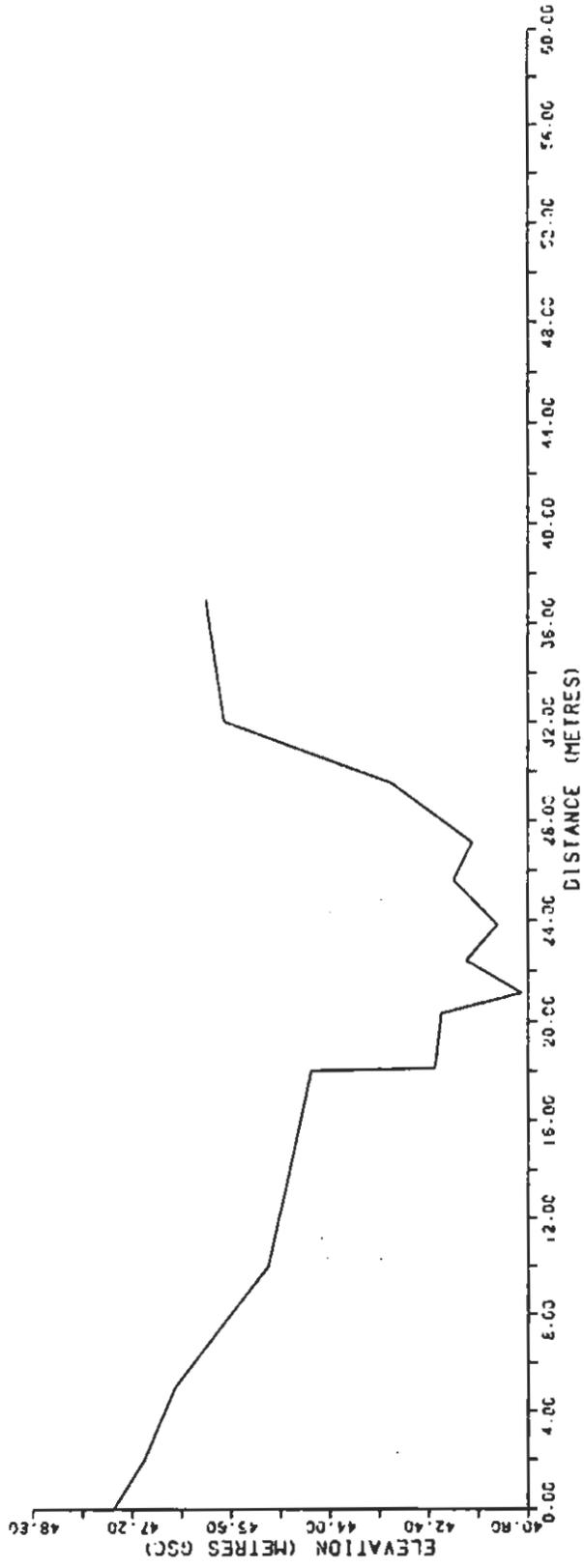


0.040C
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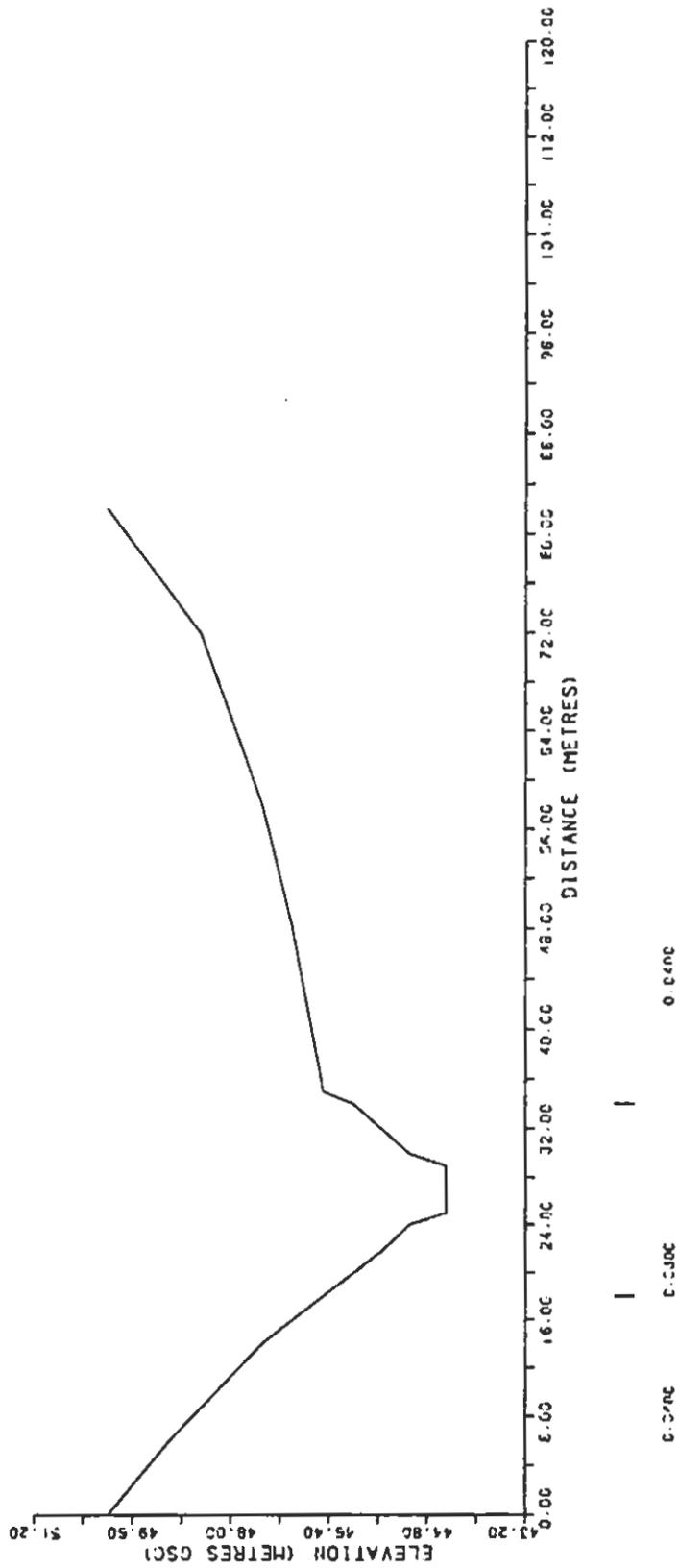
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CROSS SECTION NUMBER 4356.0



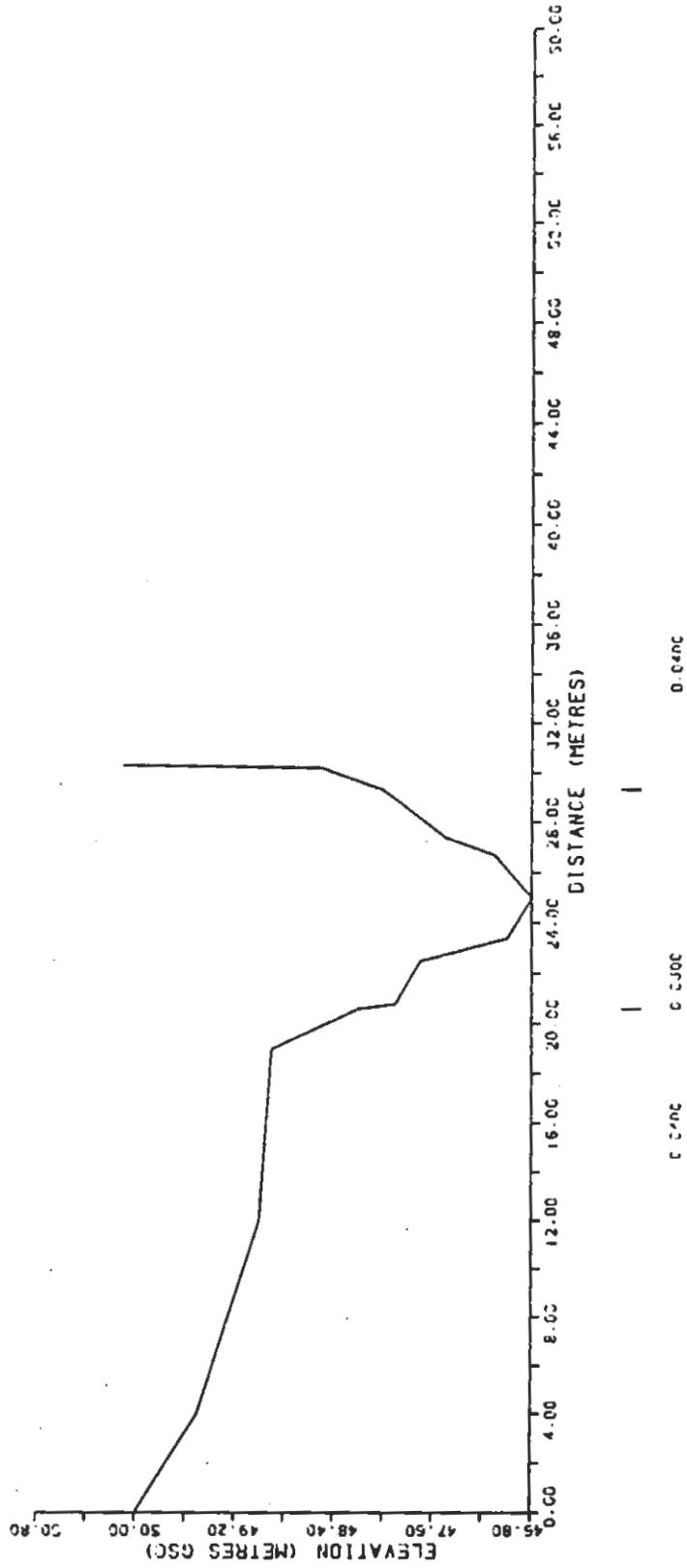
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CROSS SECTION NUMBER 4455.0



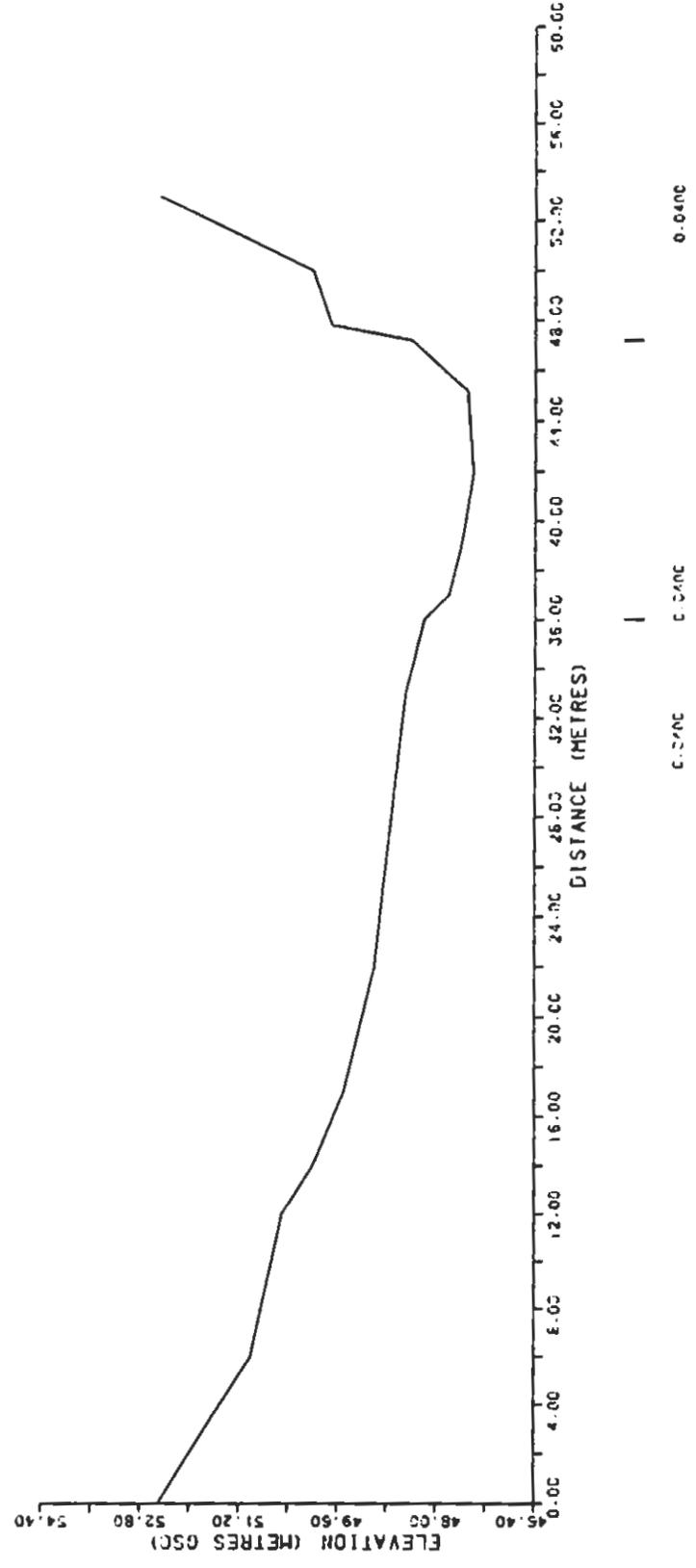
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 493.0



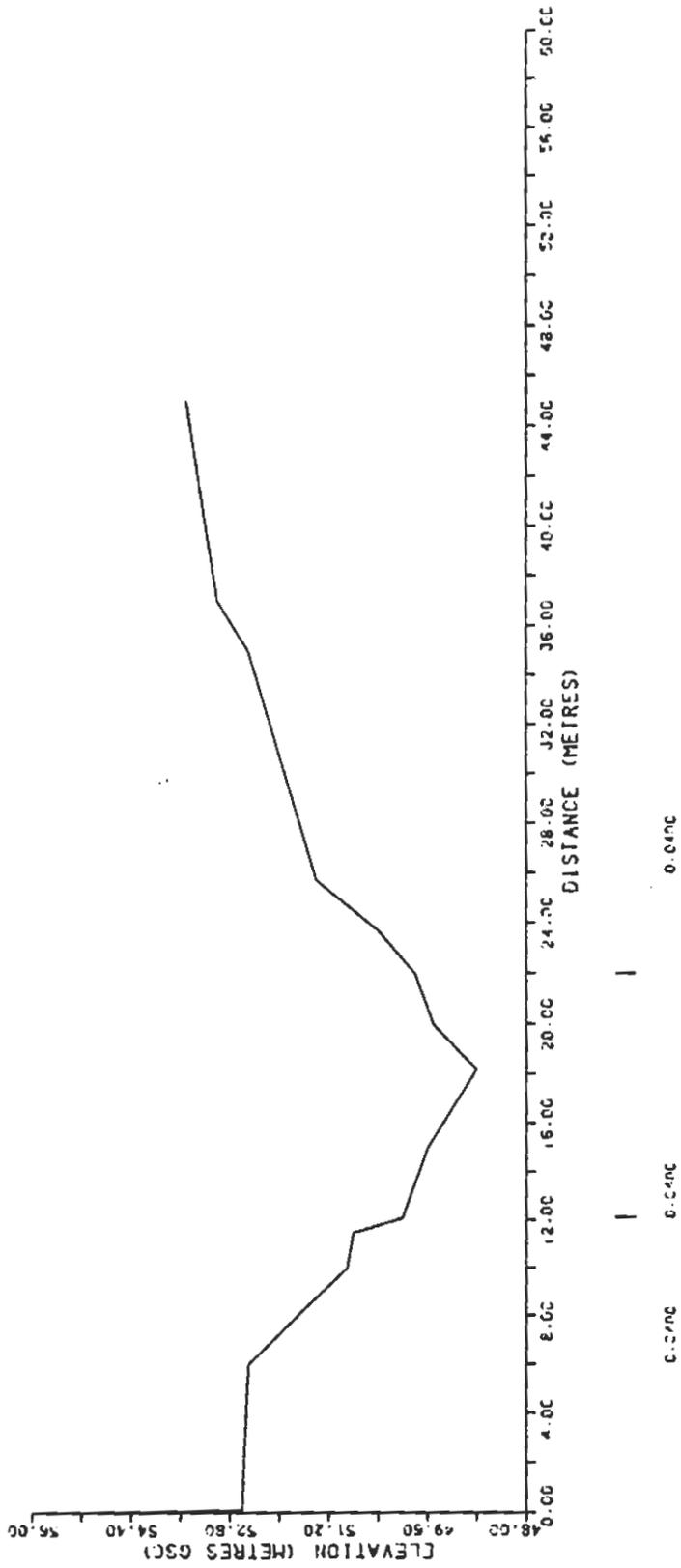
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4593.



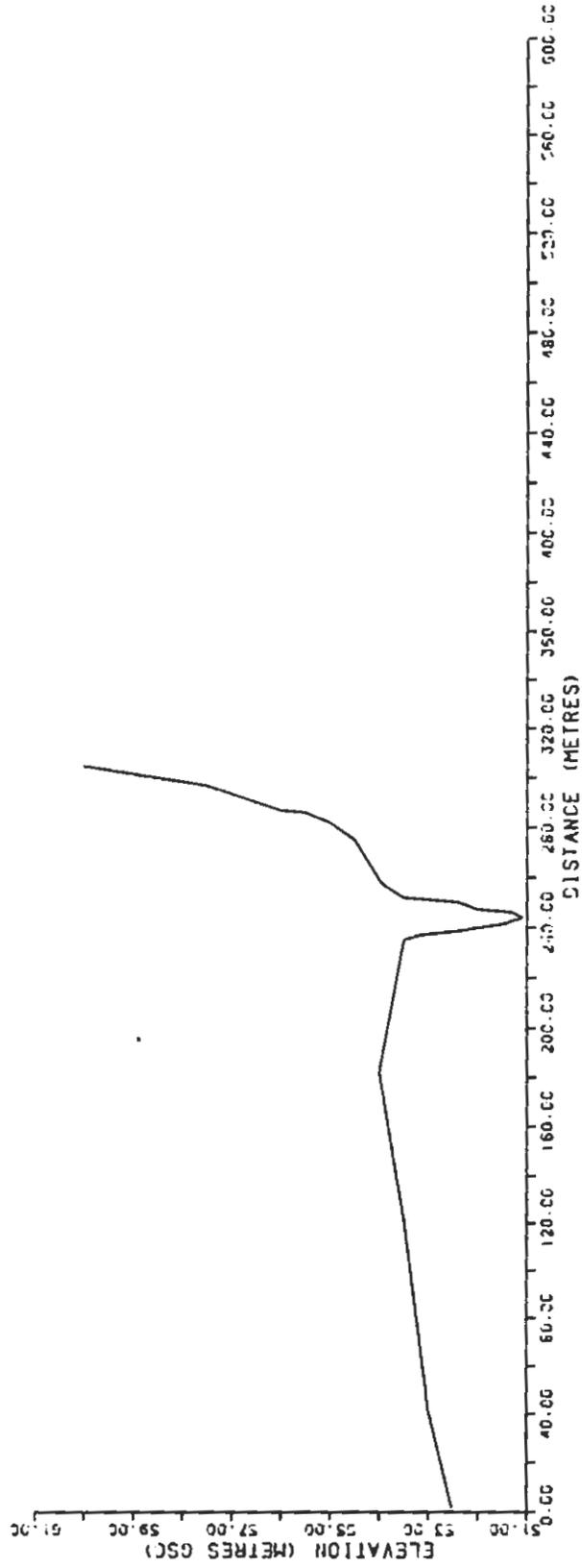
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4608.



WATERFORD RIVER
CROSS SECTION NUMBER 4688
HEC-2 MODEL
4688.

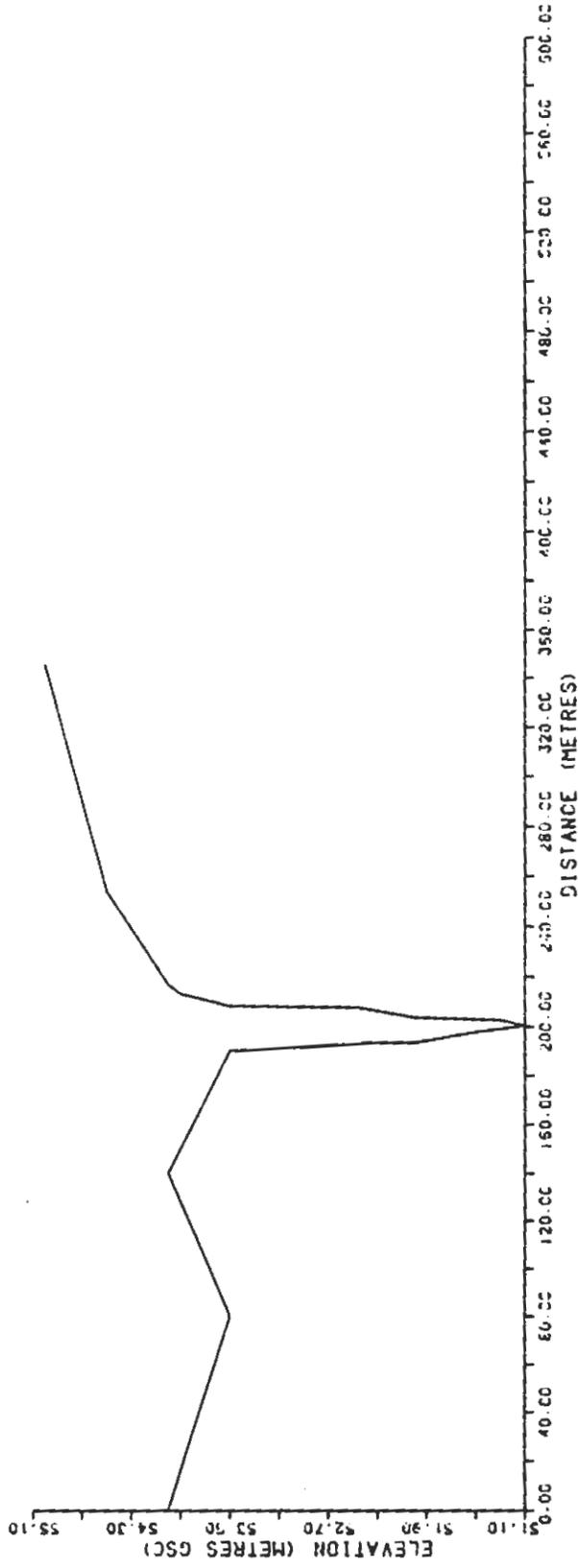


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4830.



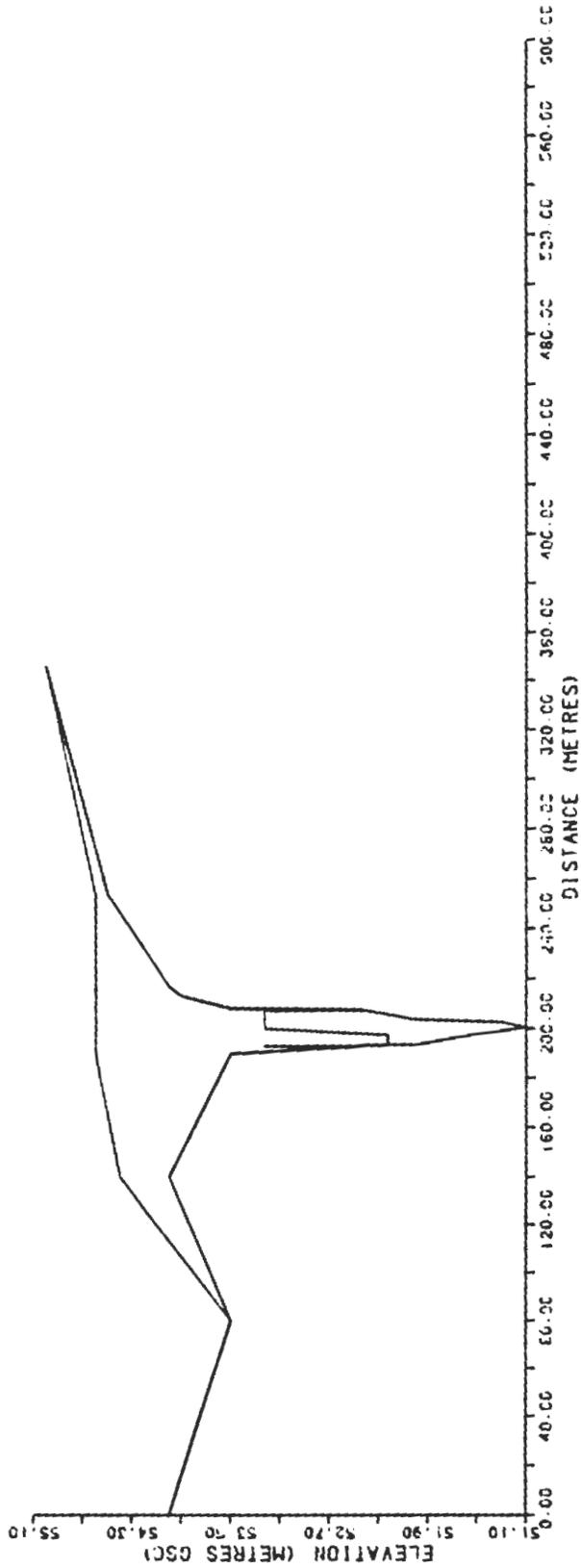
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4840.



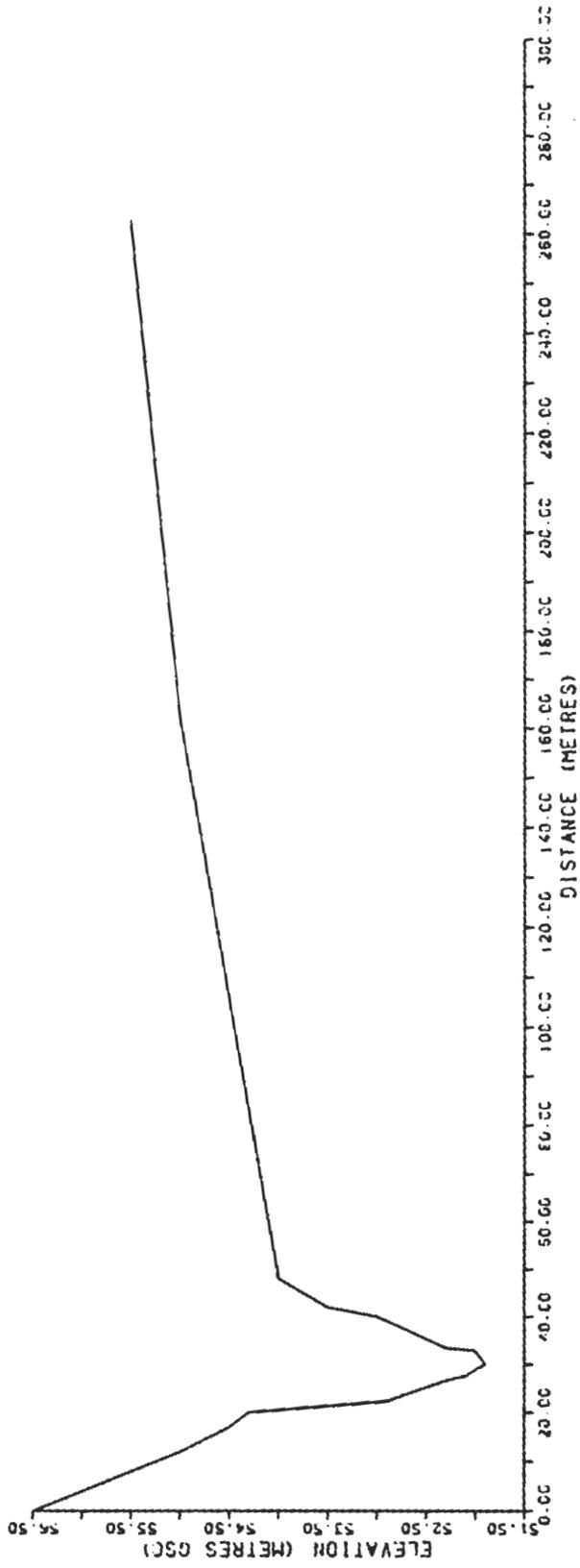
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WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 4865.



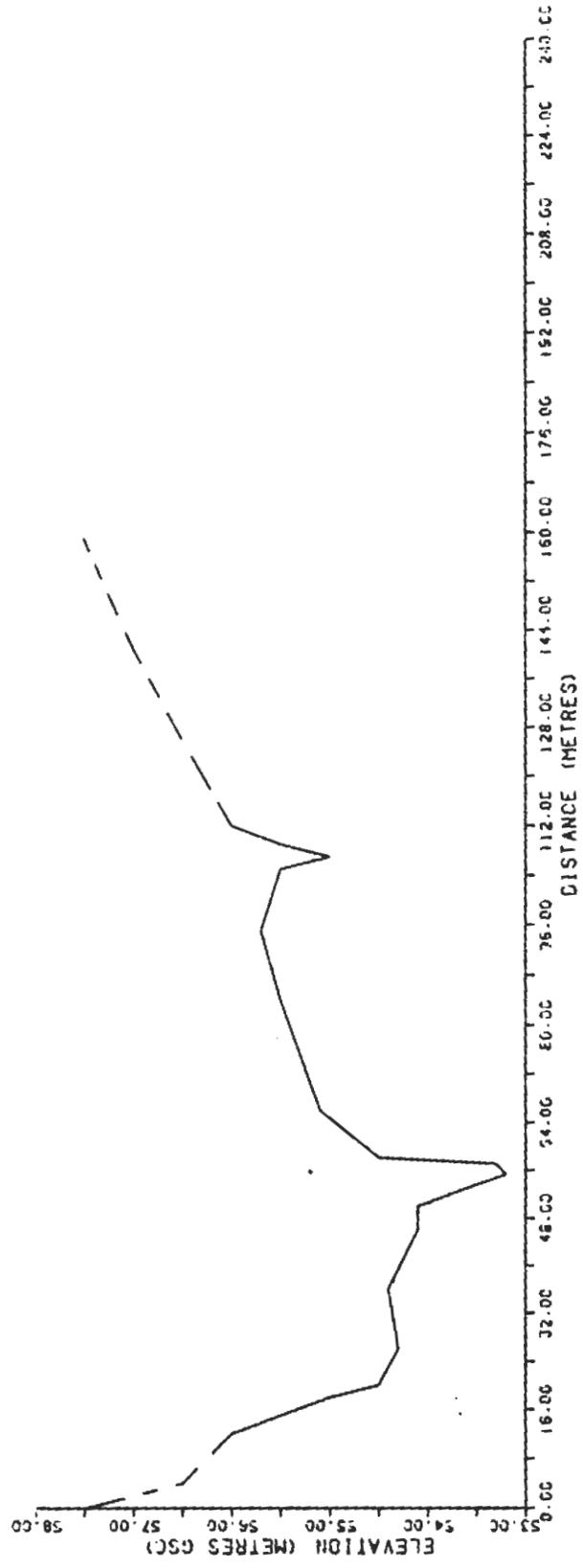
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 4880.



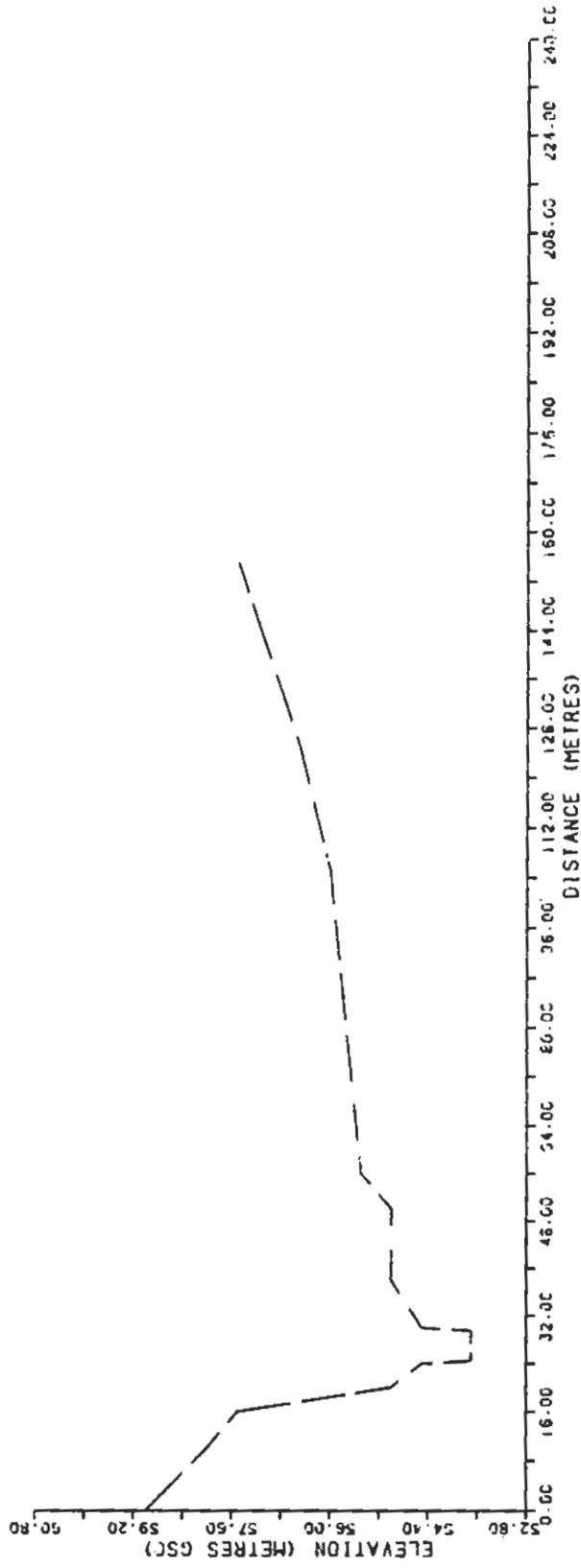
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 5135.



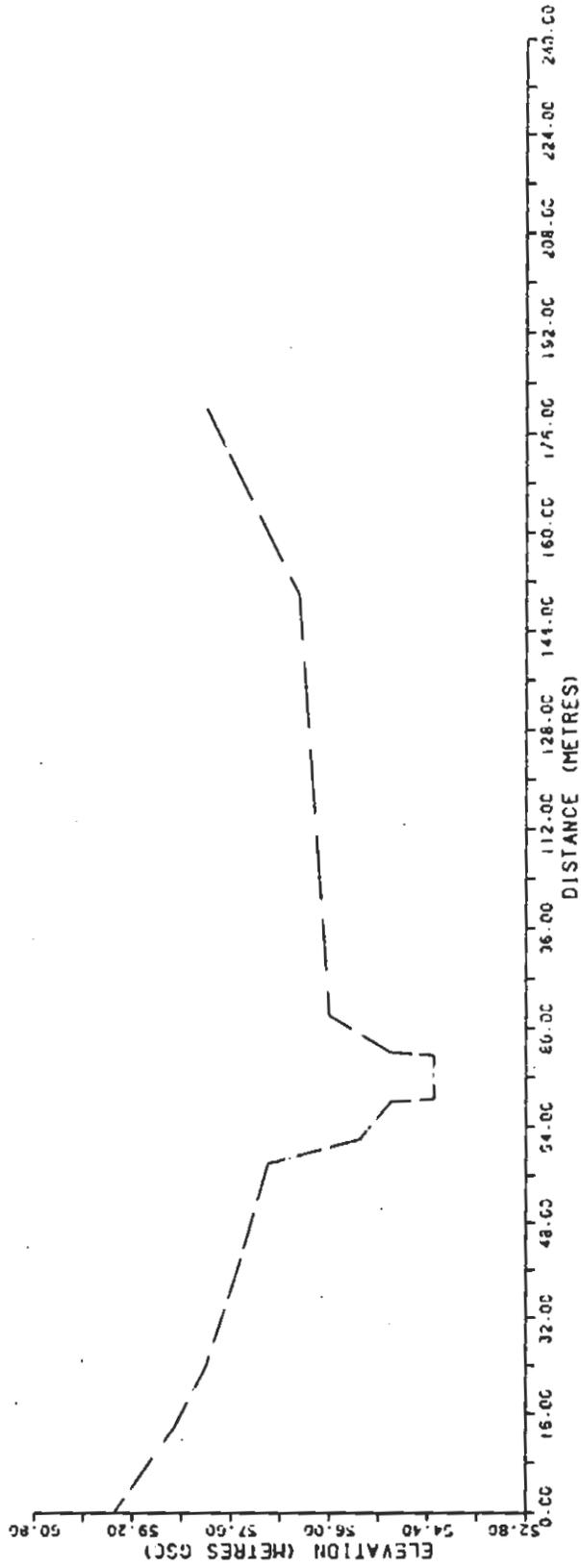
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0.0J0C C.0J5D 0.0J0C

WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 5235.



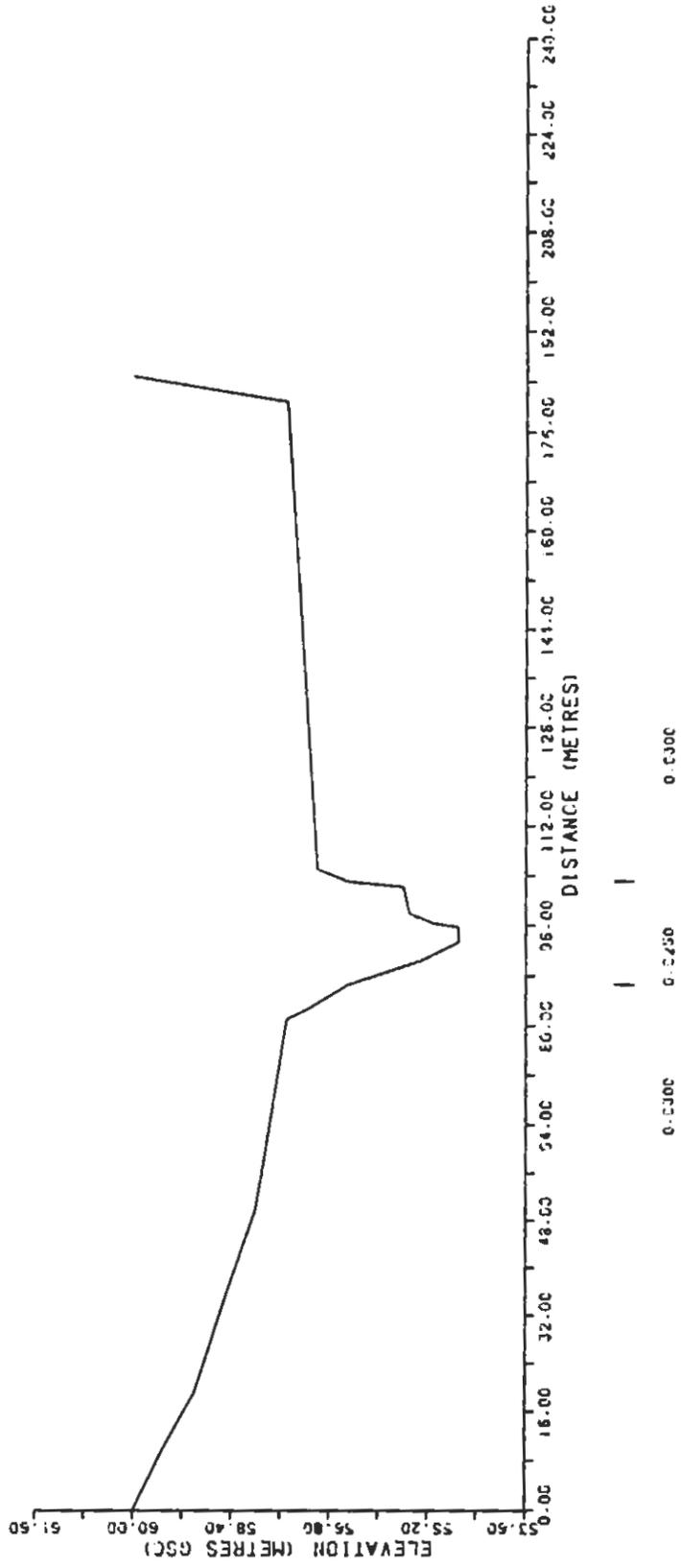
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 5340.

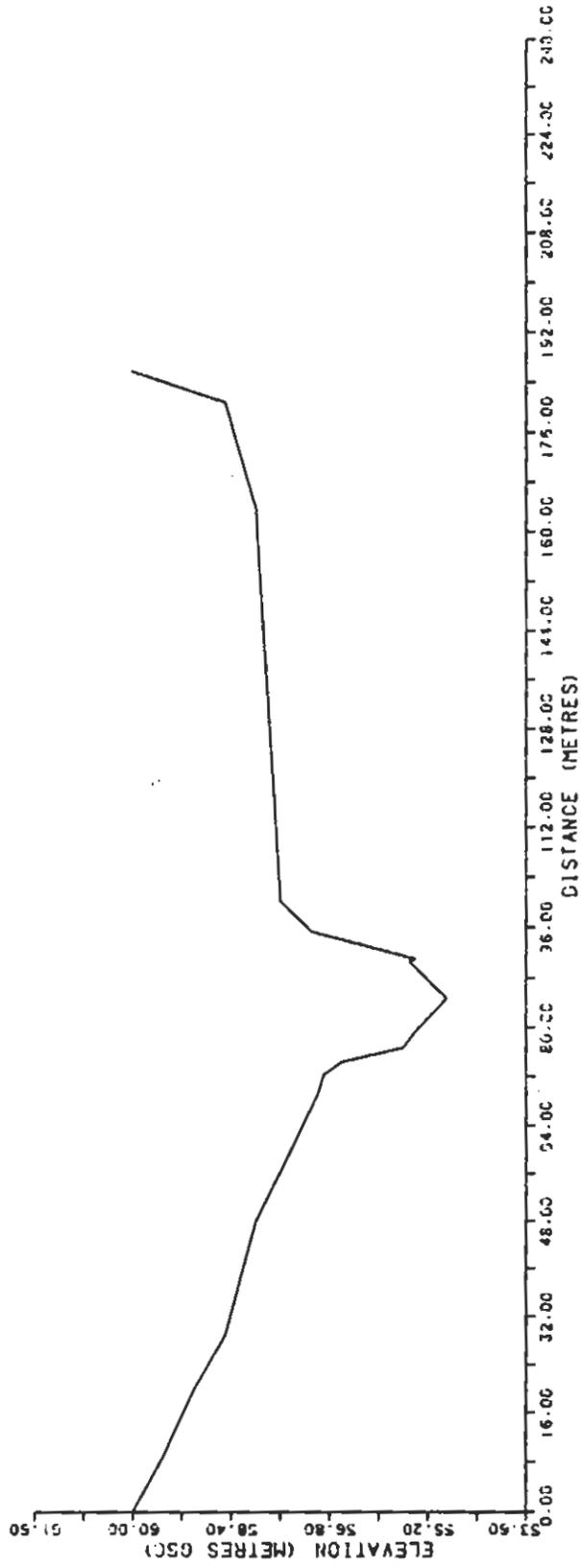


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WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 5390.

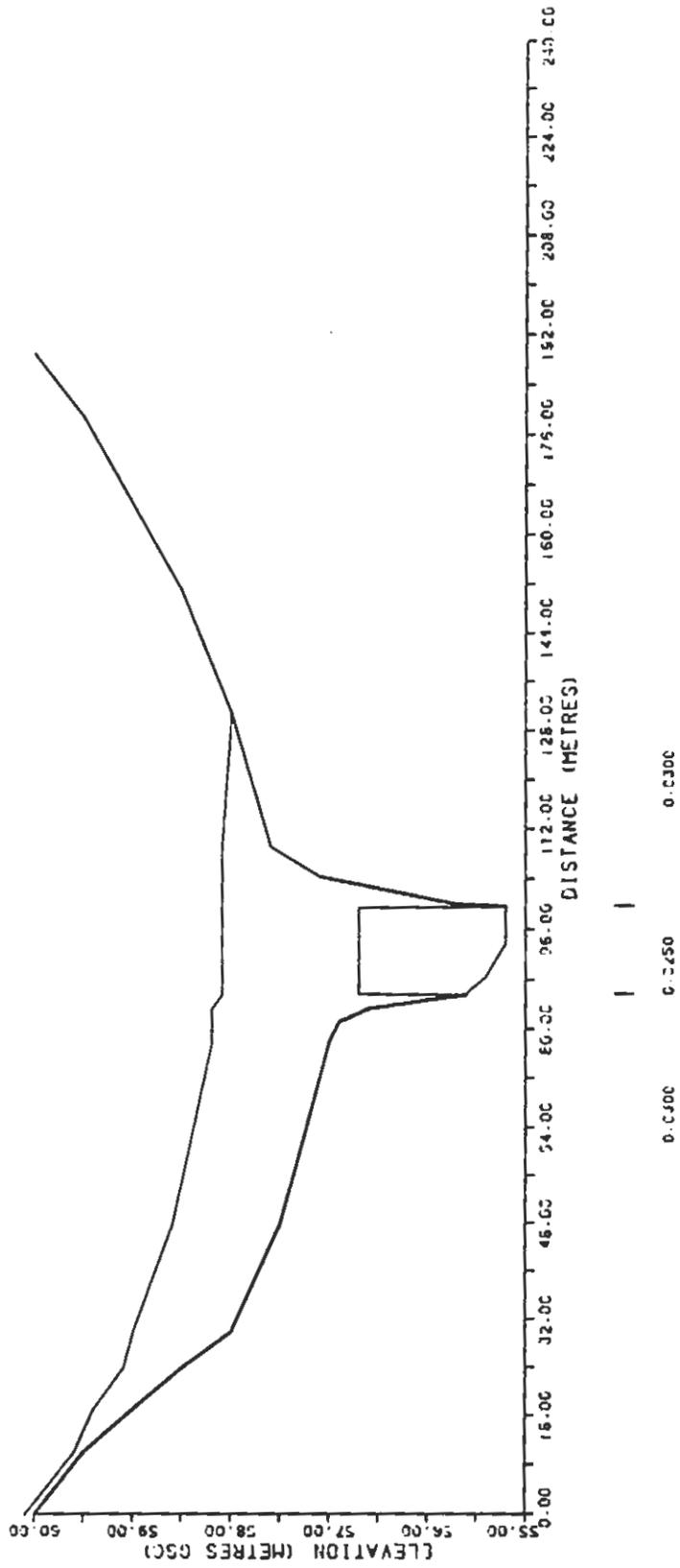


WATERFORD RIVER
CROSS SECTION NUMBER 5405.
HEC-2 MODEL

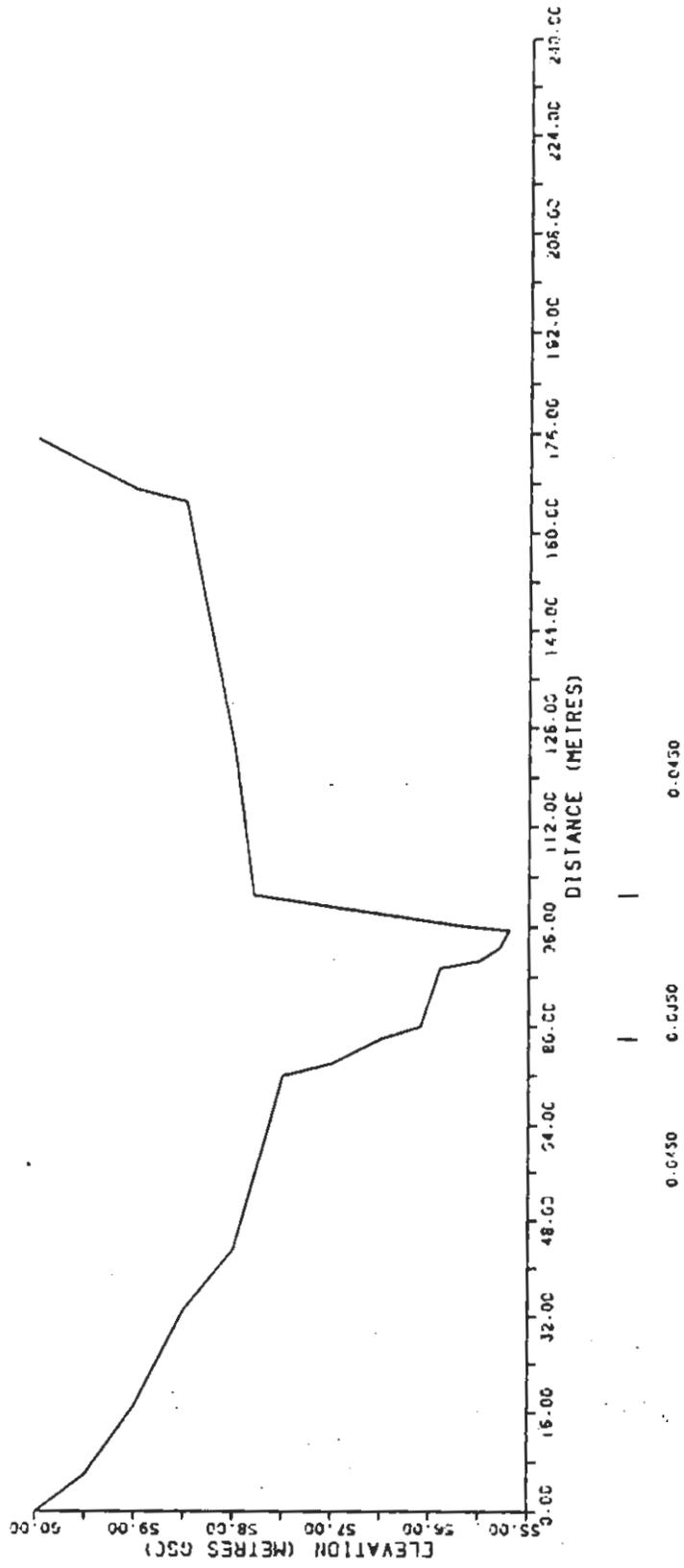


0.0000
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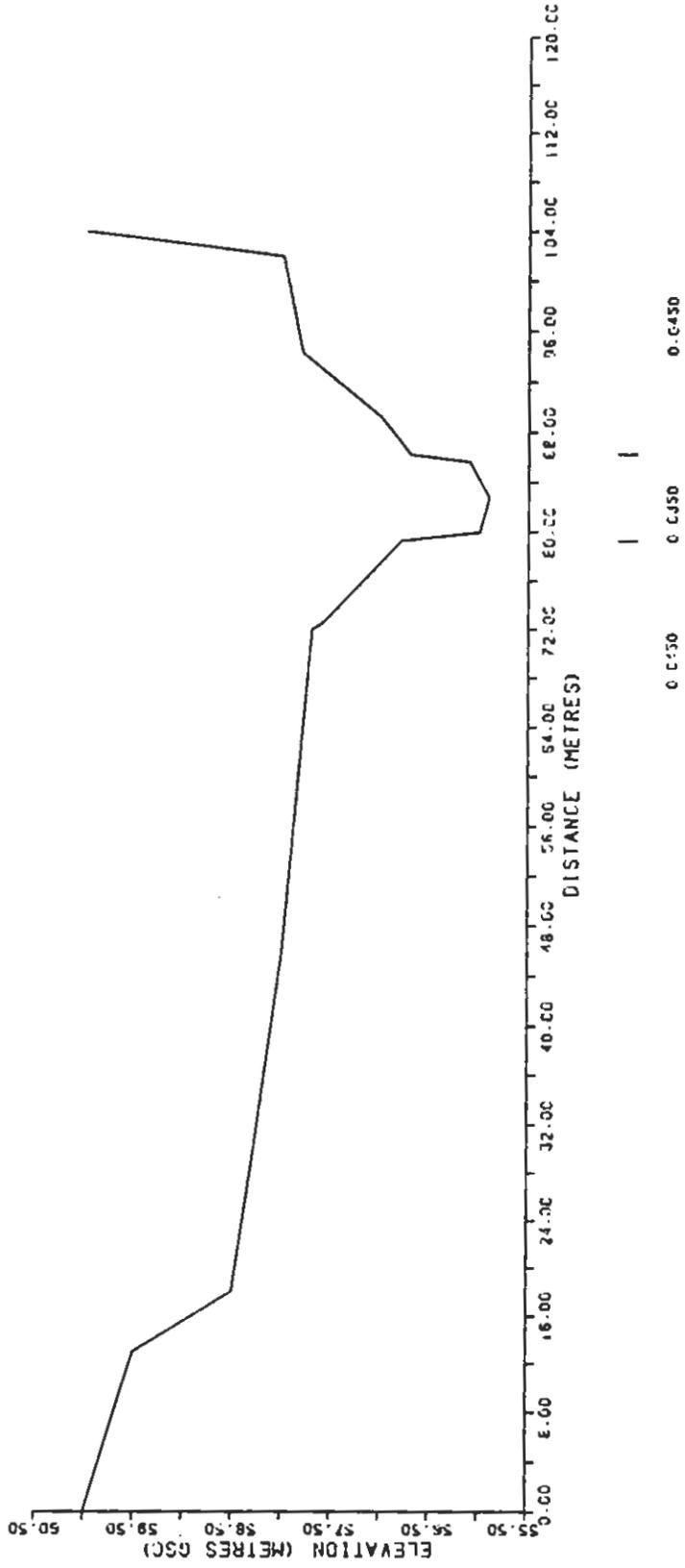
WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 5425.



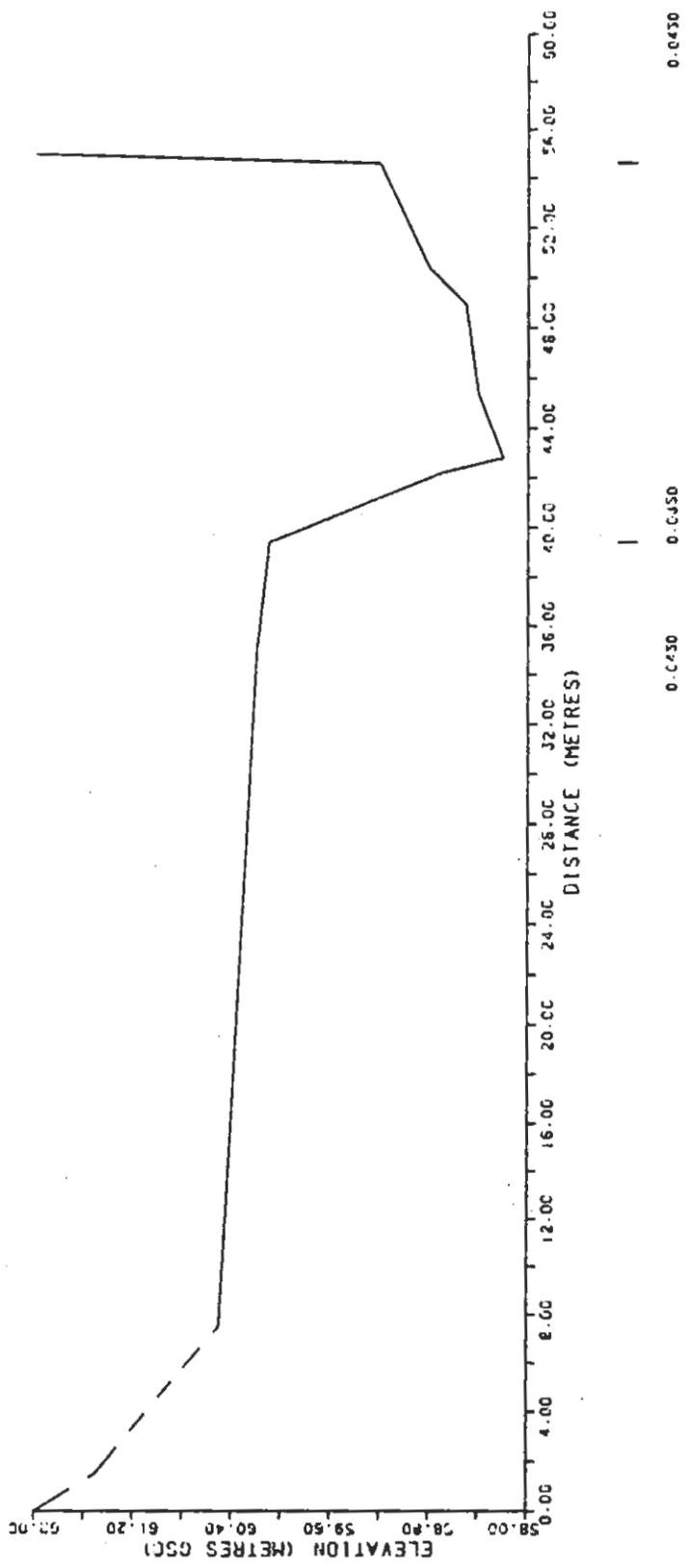
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CROSS SECTION NUMBER 5445.



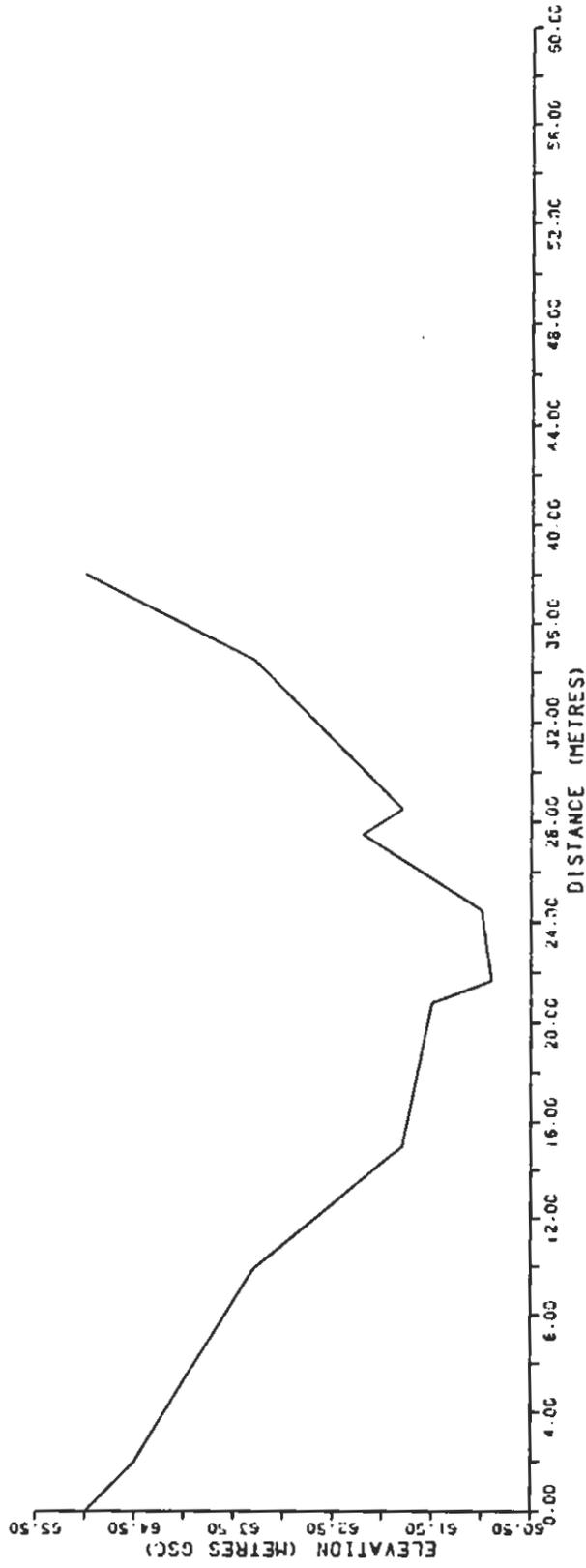
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 5615.



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 5895.

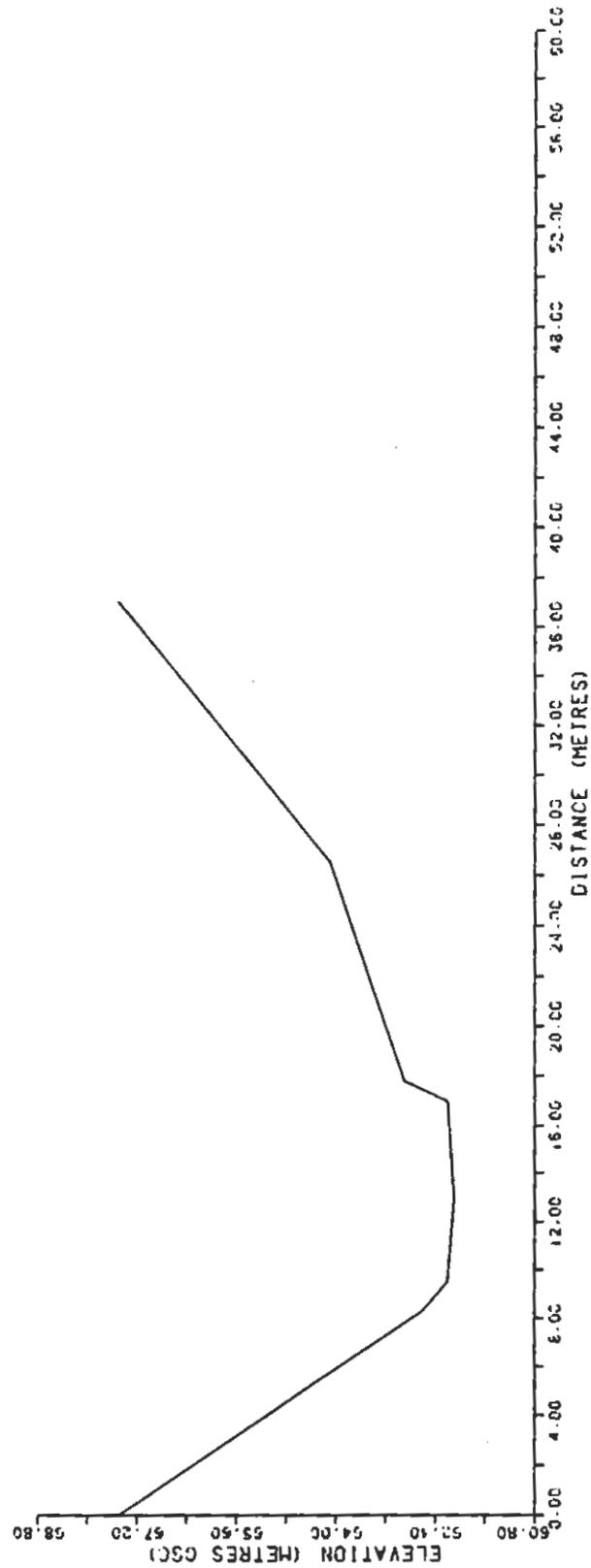


WATERFORD RIVER
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CROSS SECTION NUMBER 6200.



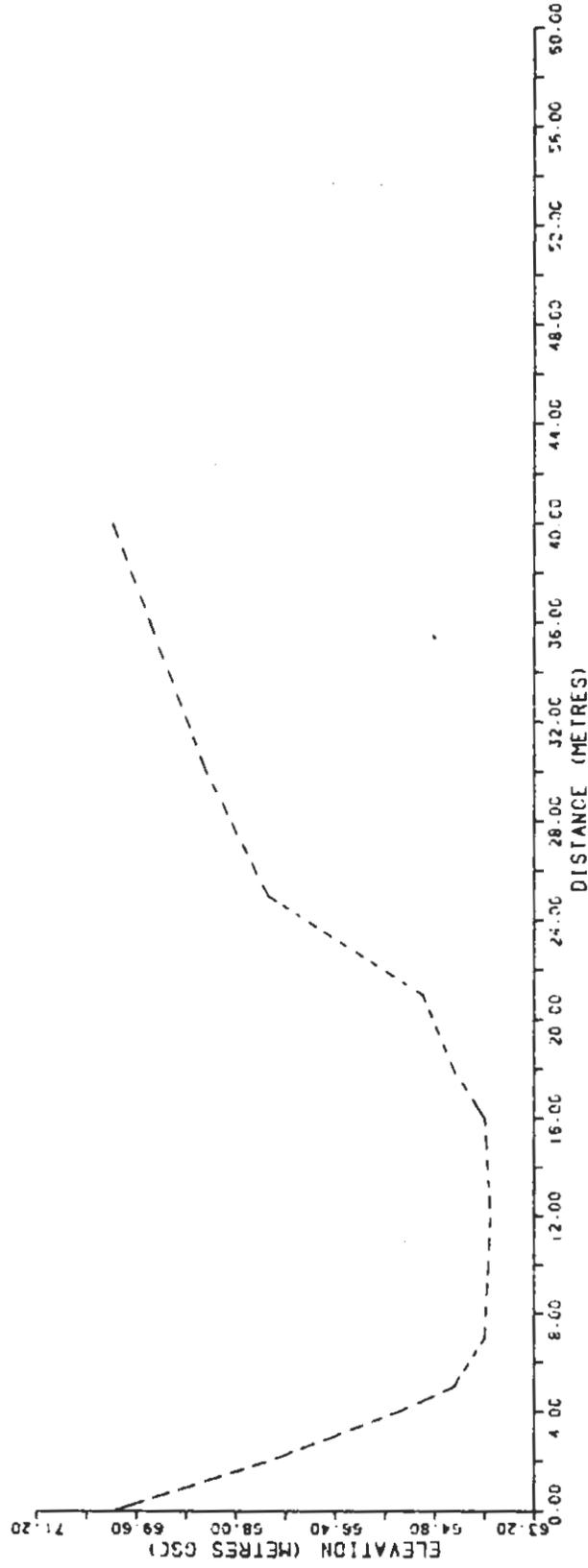
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 6450.



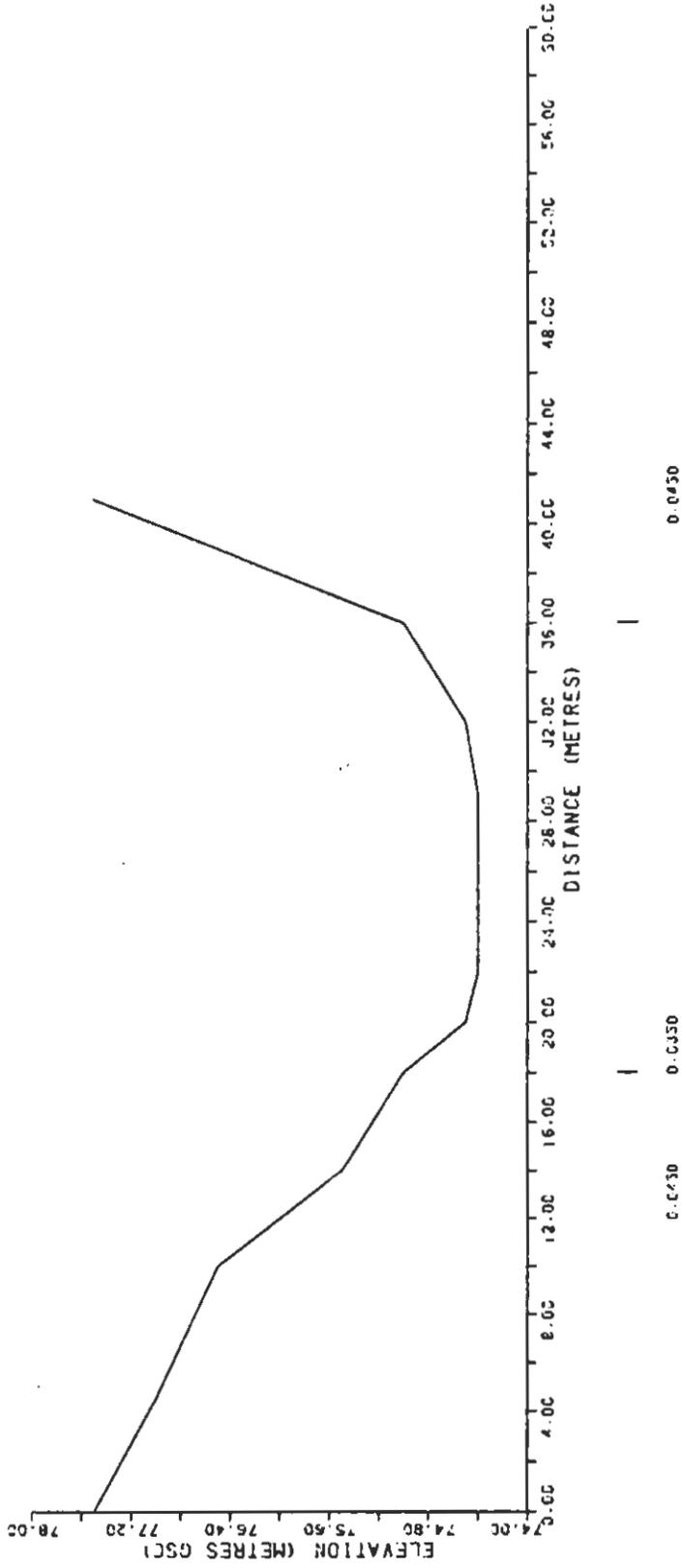
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 6736.

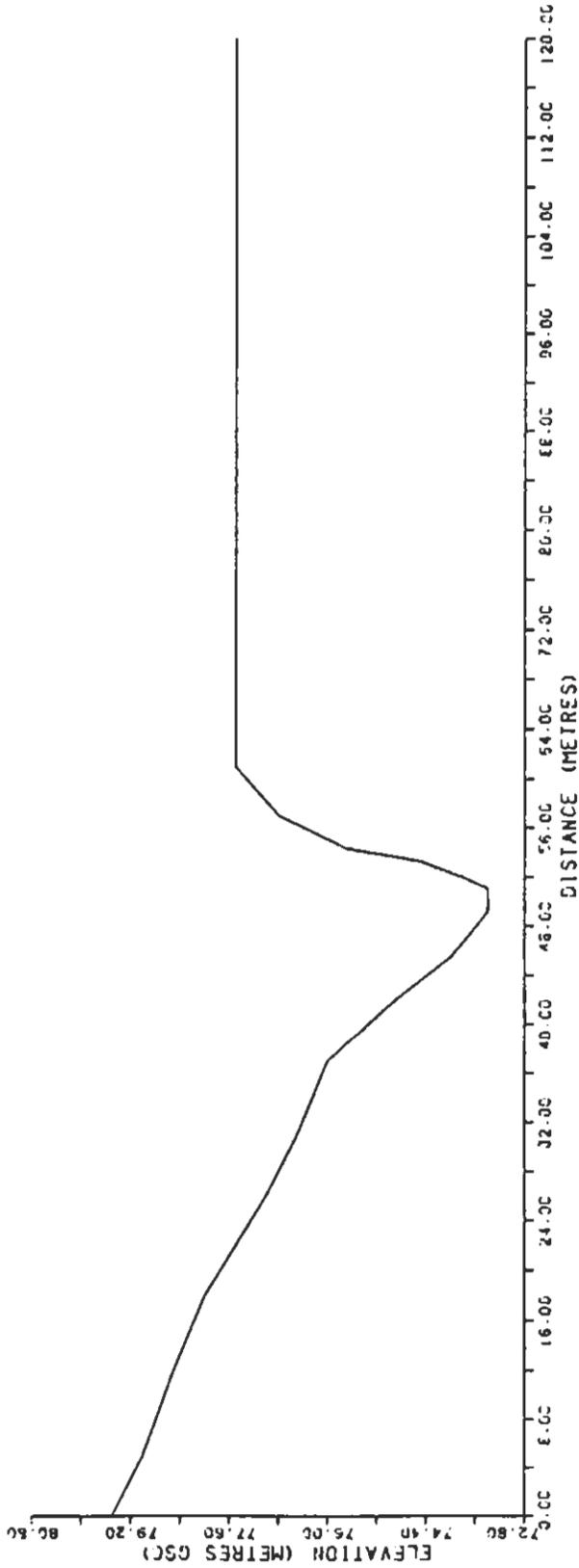


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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 6910.

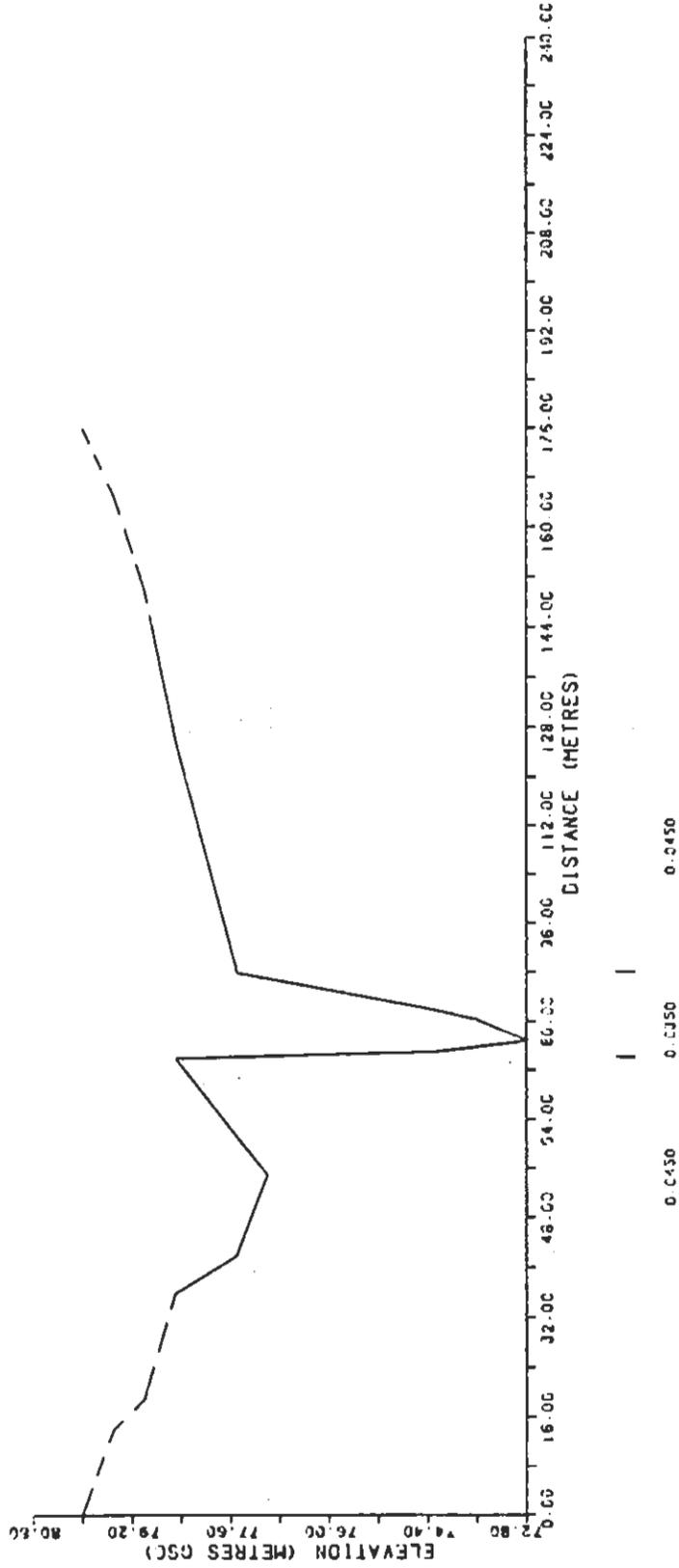


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 6940.

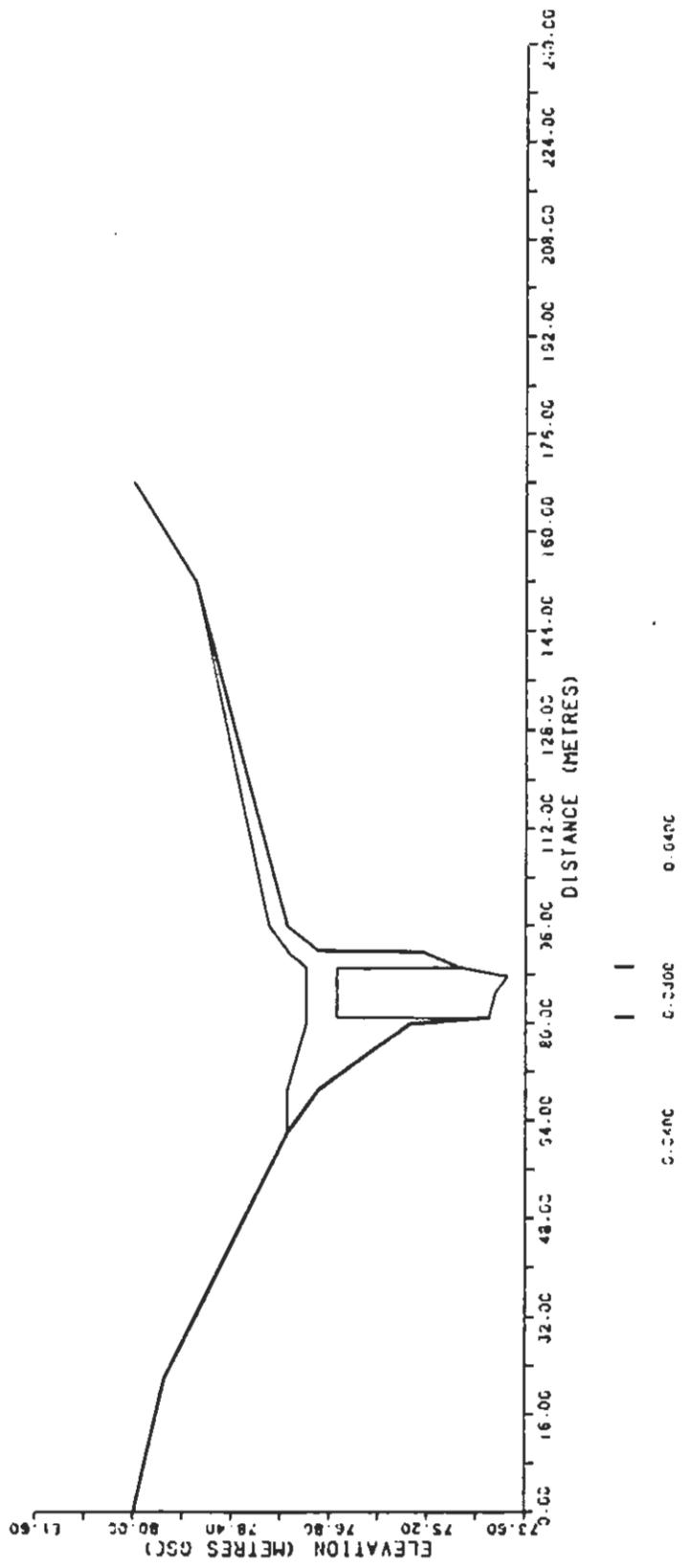


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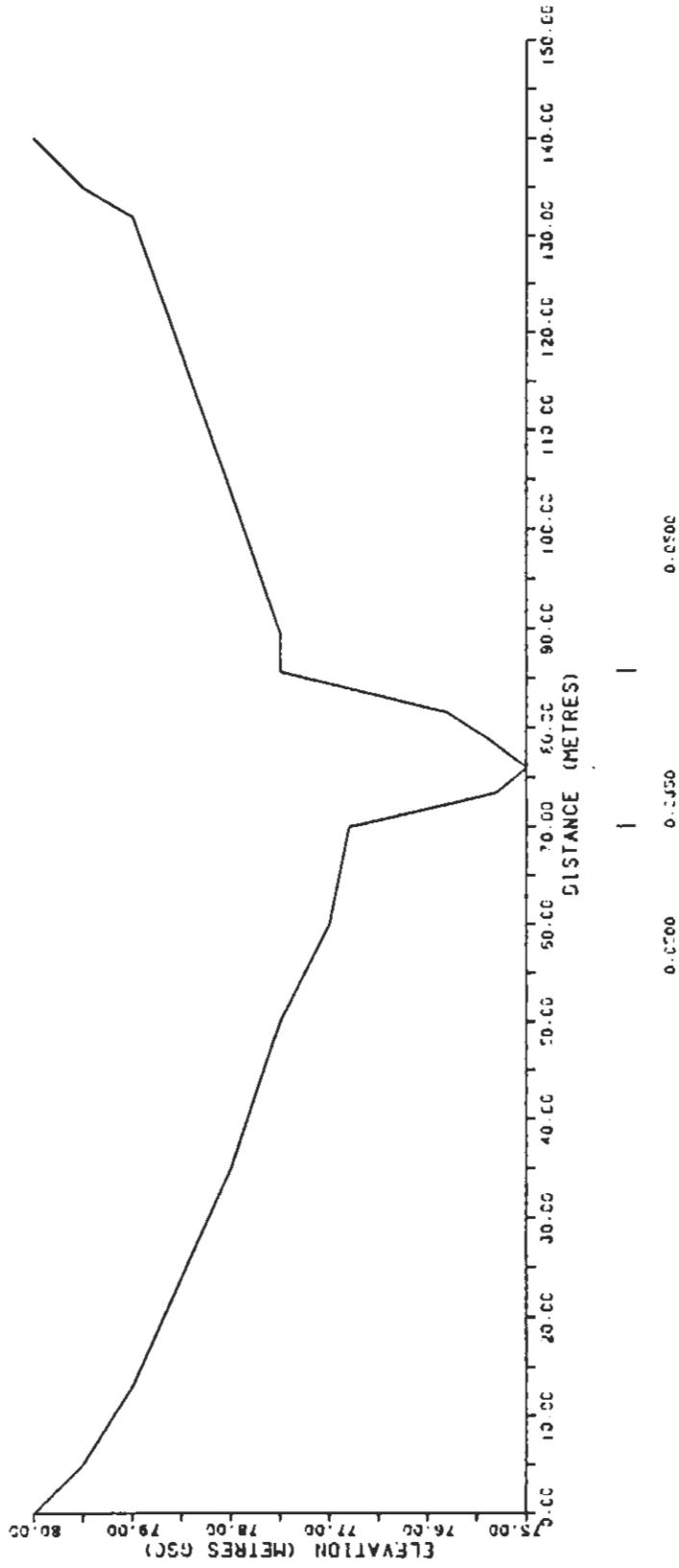
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CROSS SECTION NUMBER 6955.



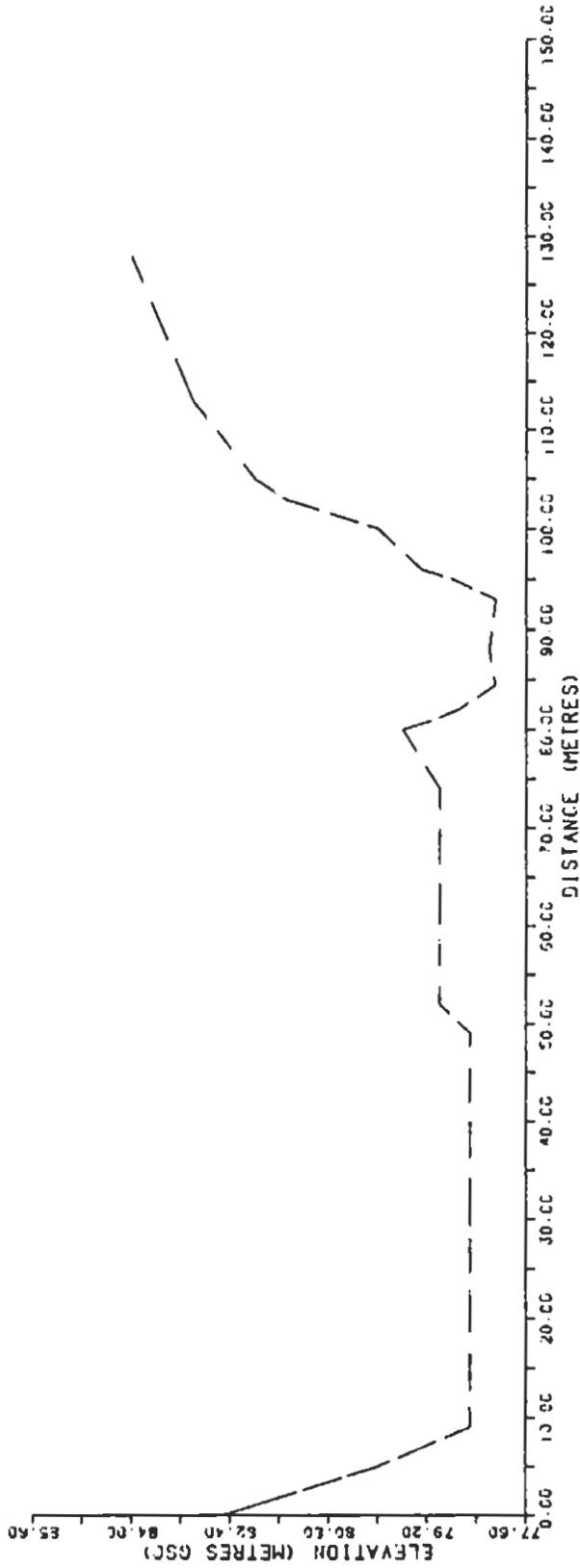
WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 6970.



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 6984.

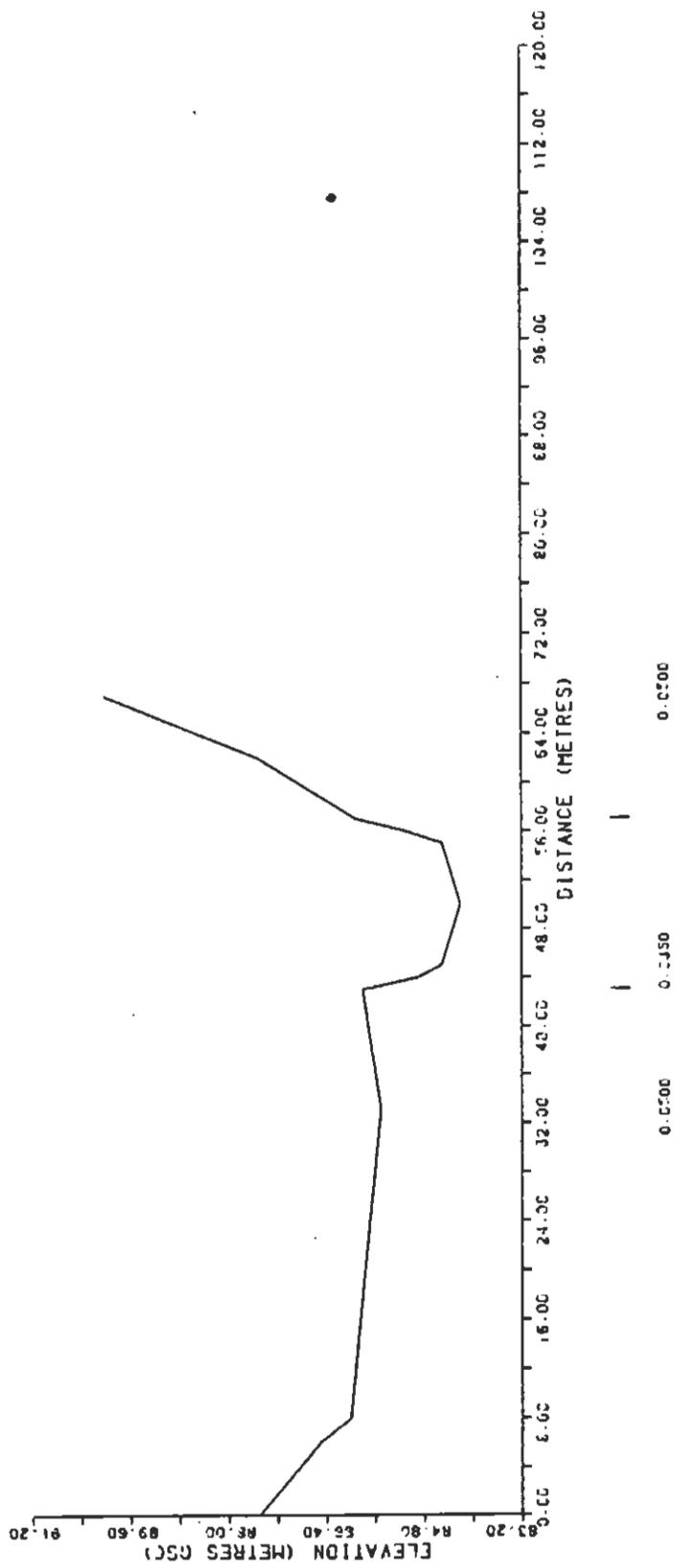


WATERFORD RIVER HEC-2 MODEL
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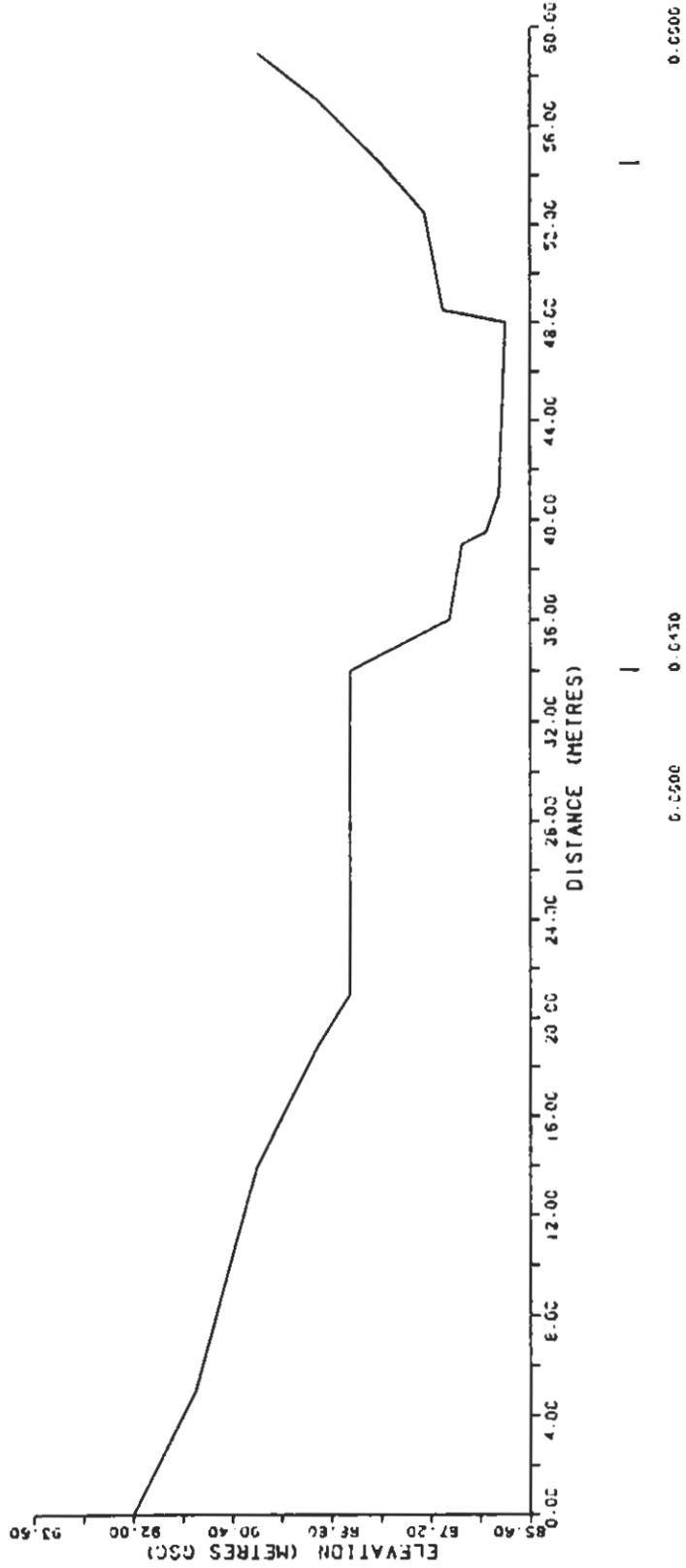


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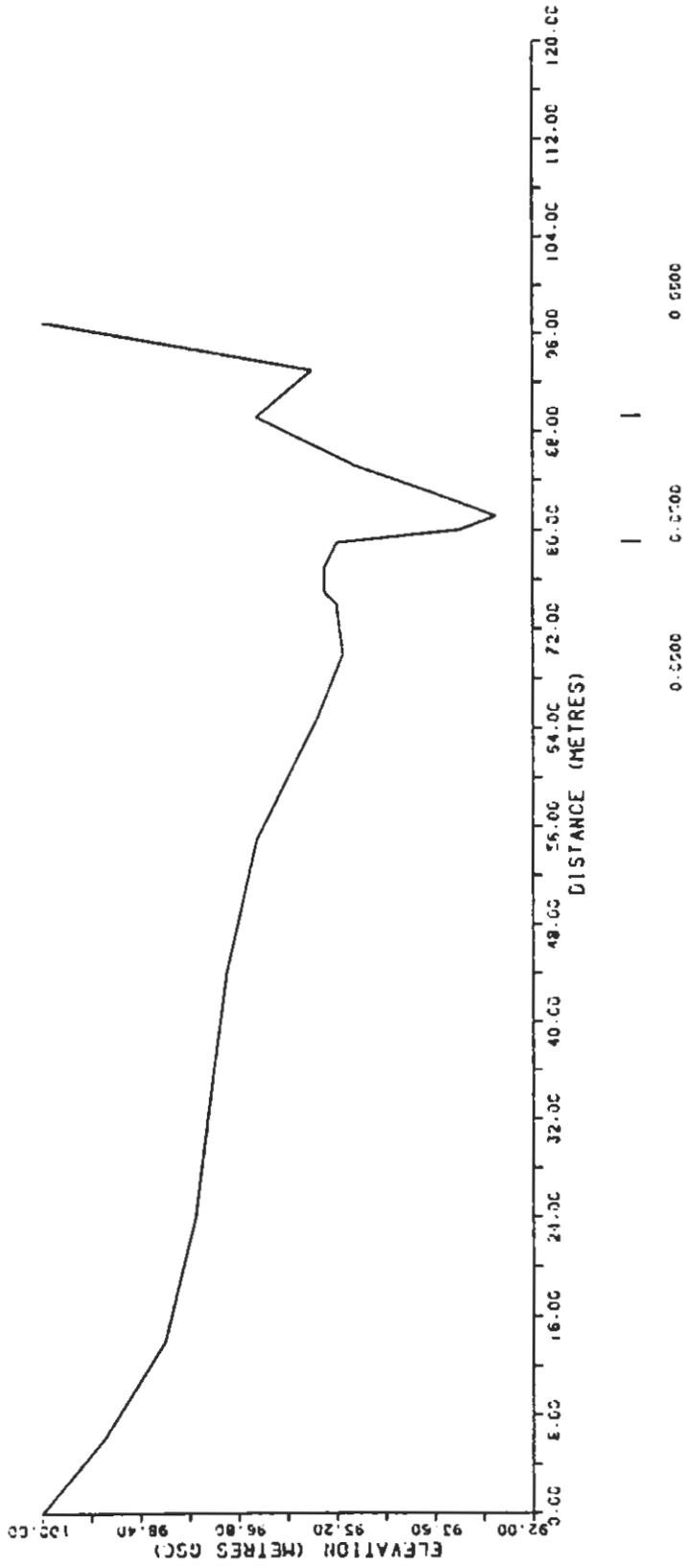
WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 7193.



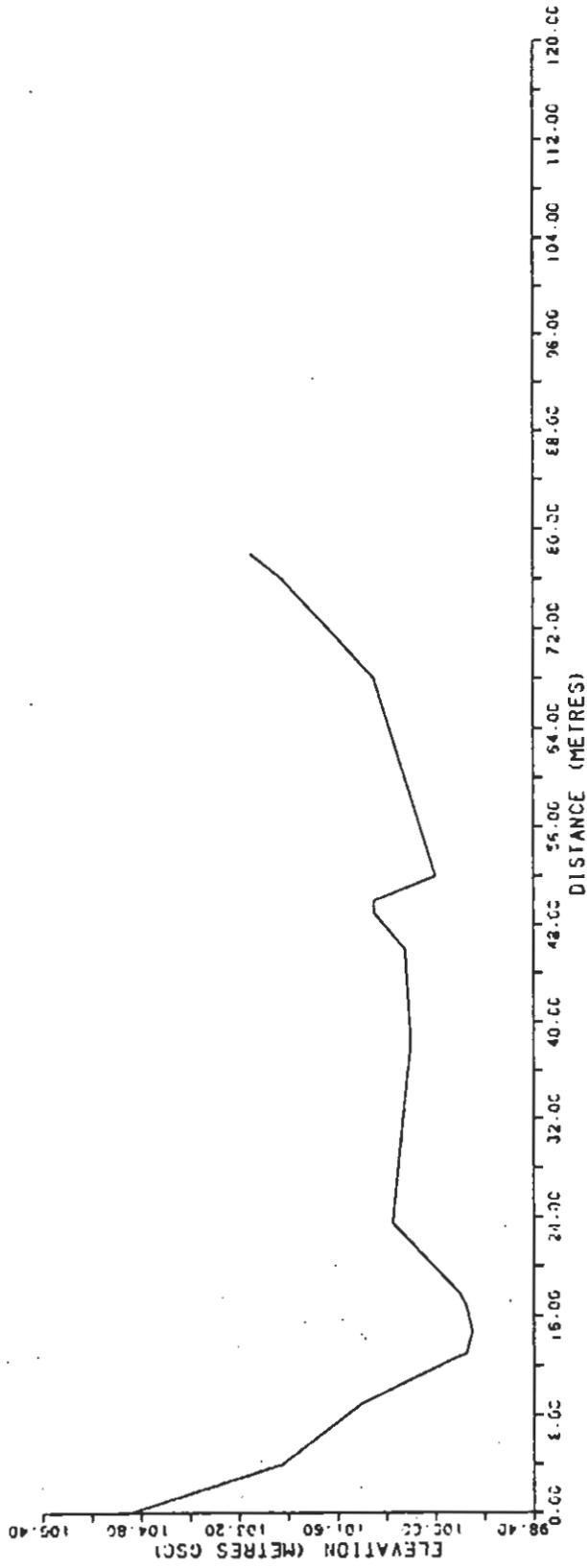
WATERFORD RIVER HEC-2 MODEL
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WATERFORD RIVER HEC-2 MODEL
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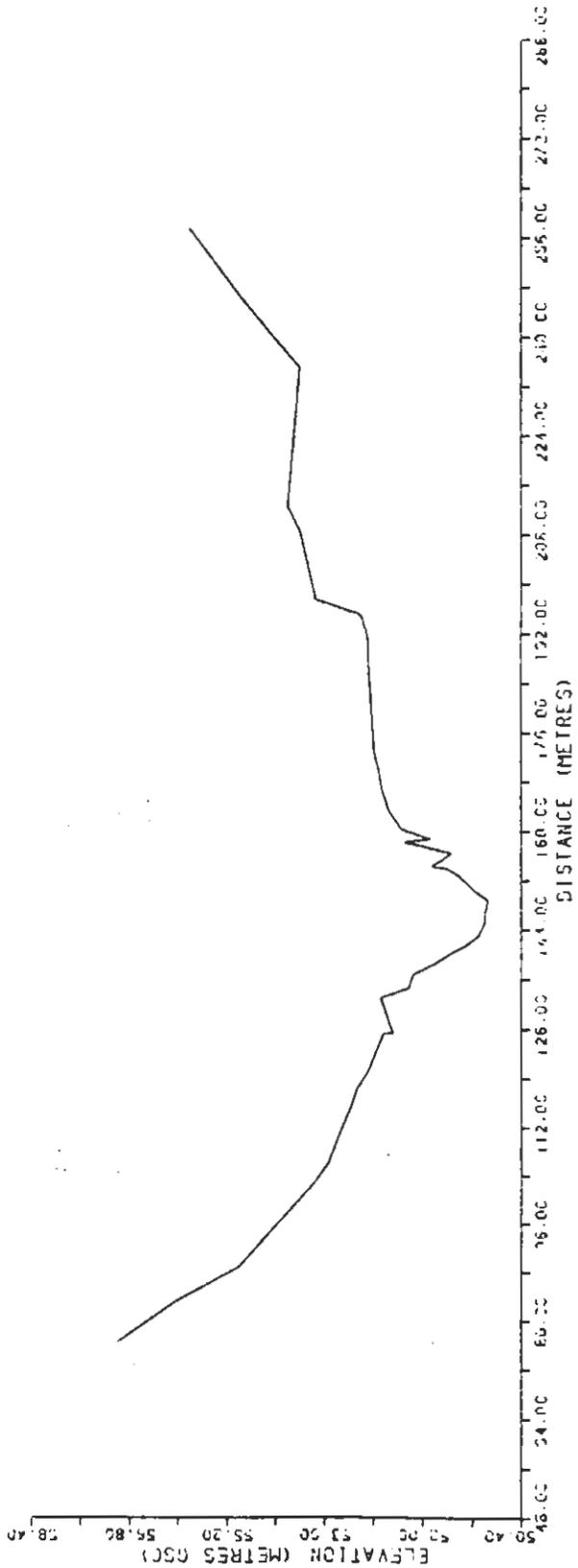


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 7697.

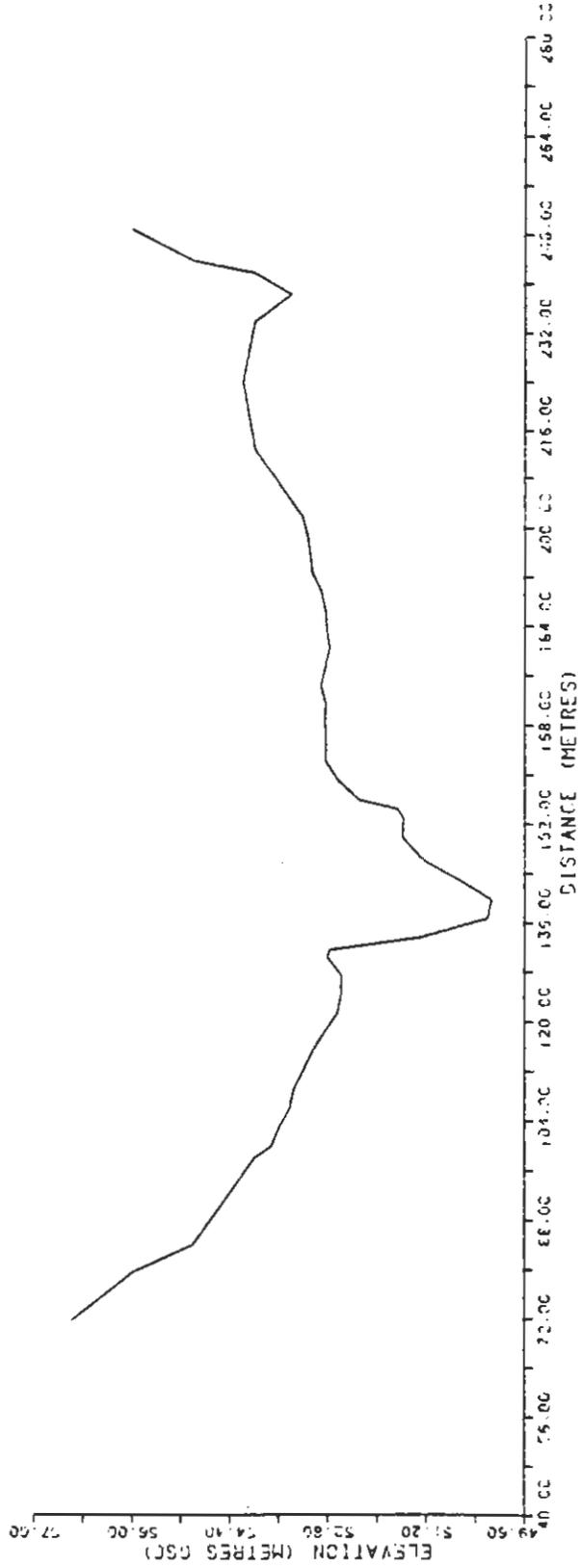


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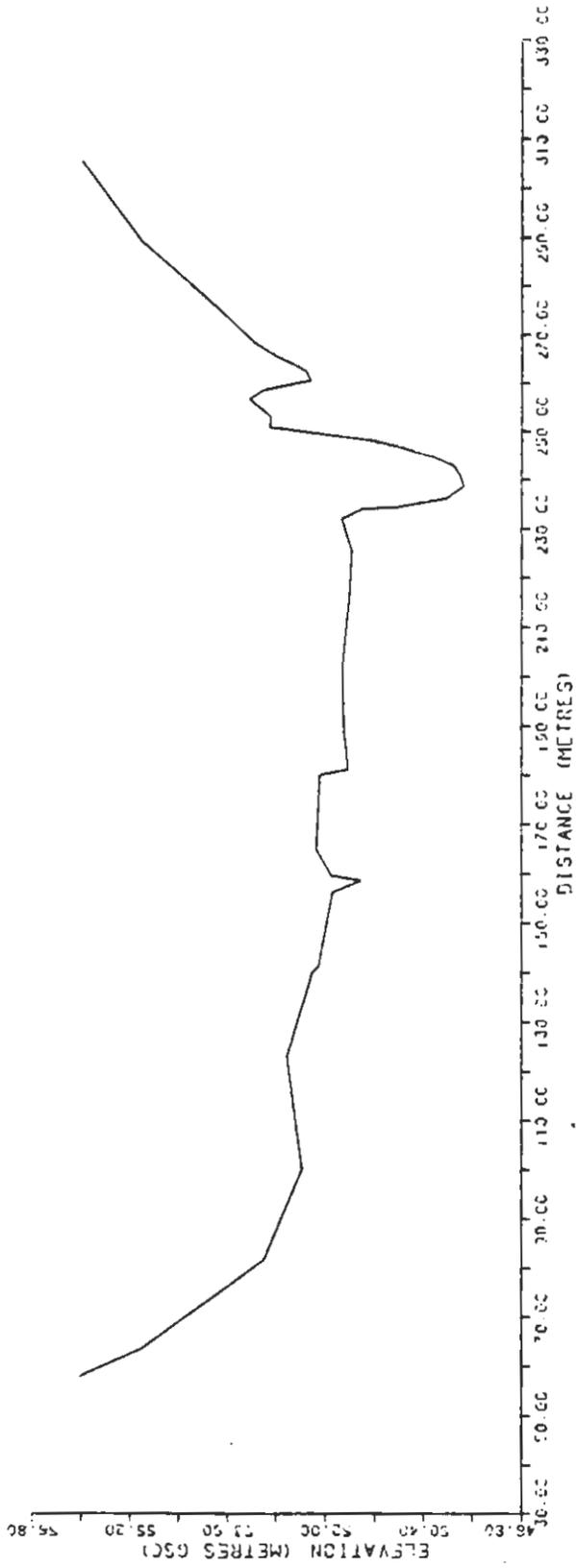
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WATERFORD RIVER HEC-2 MODEL
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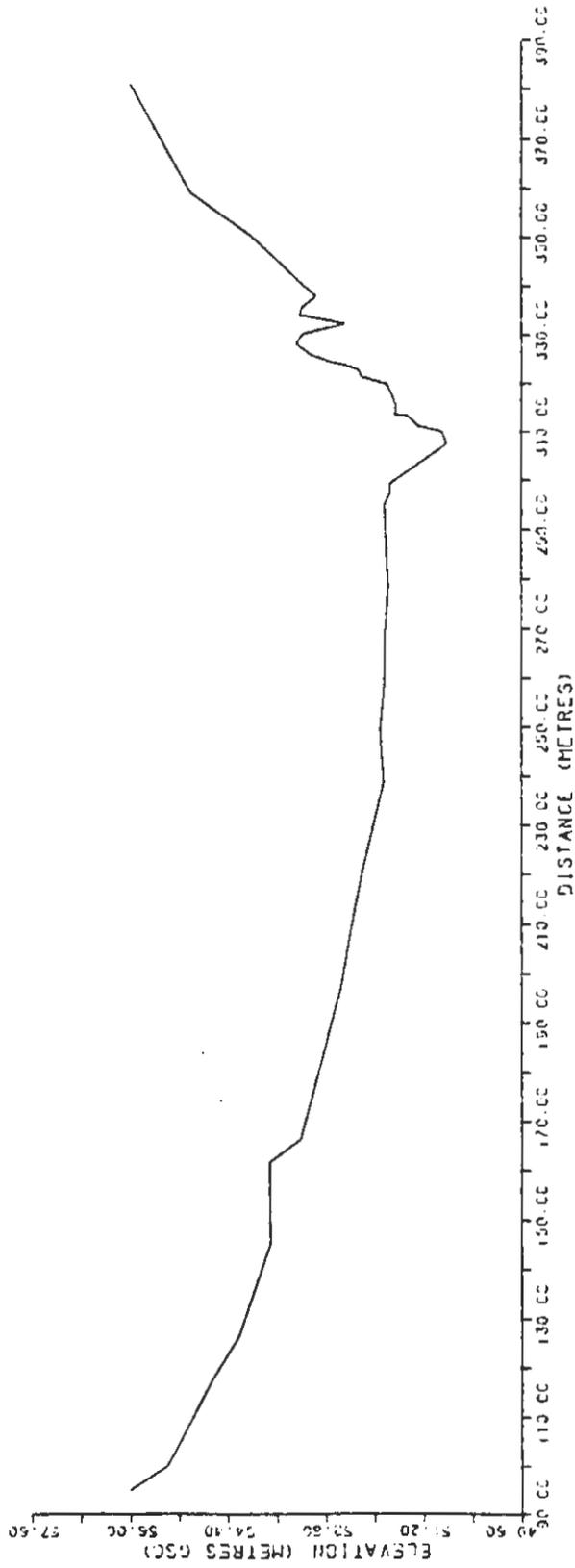


WATERFORD RIVER HEC-2 MODEL
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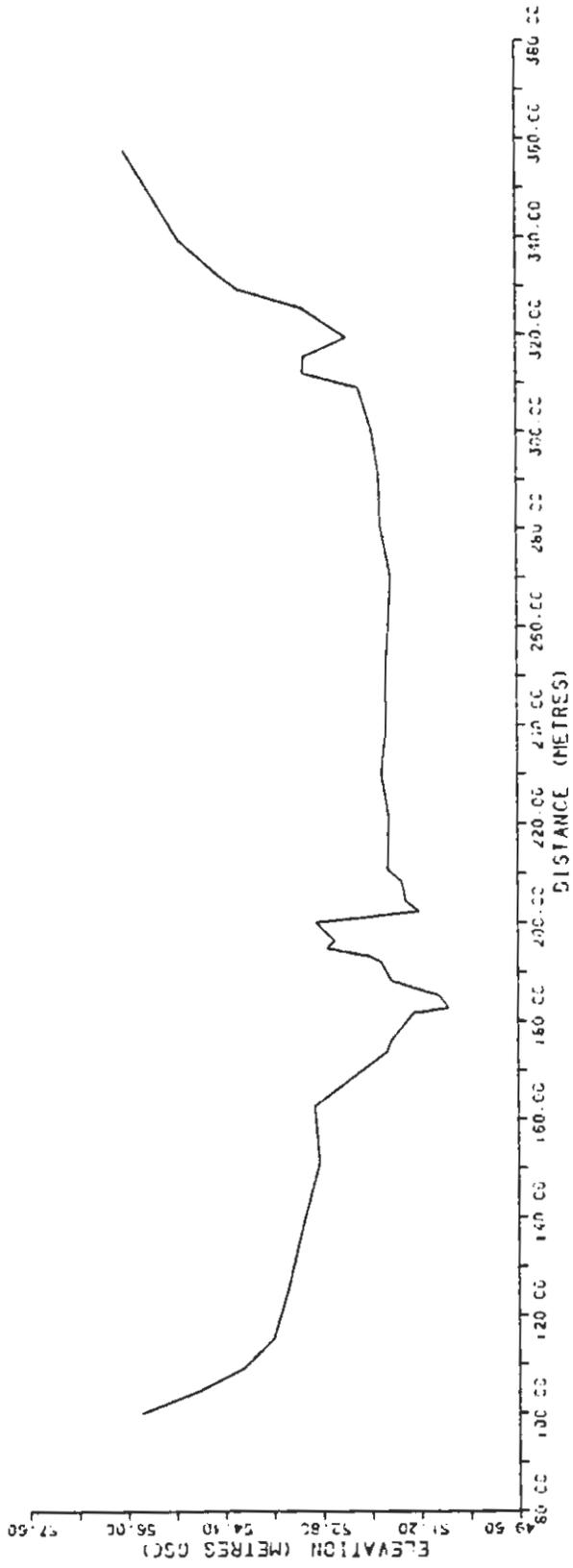
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WATERFORD RIVER HEC-2 MODEL
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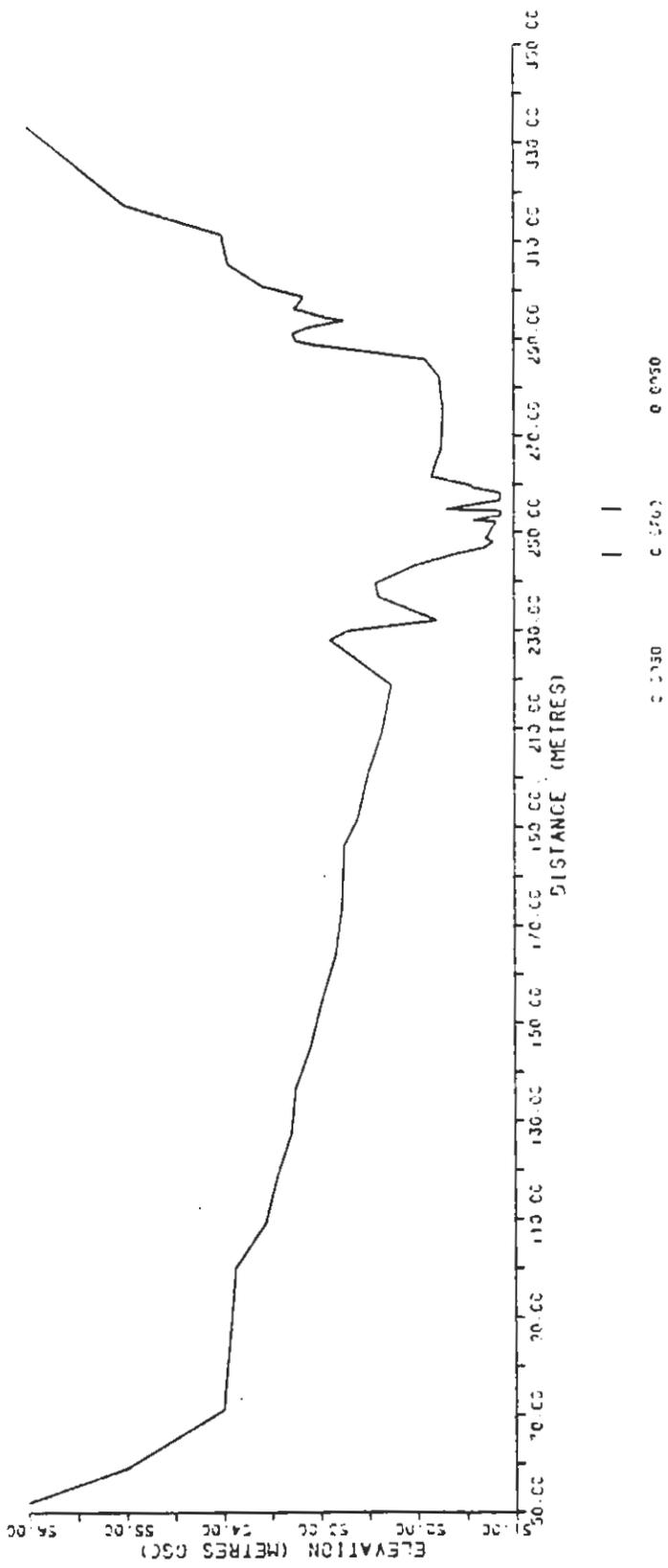
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WATERFORD RIVER
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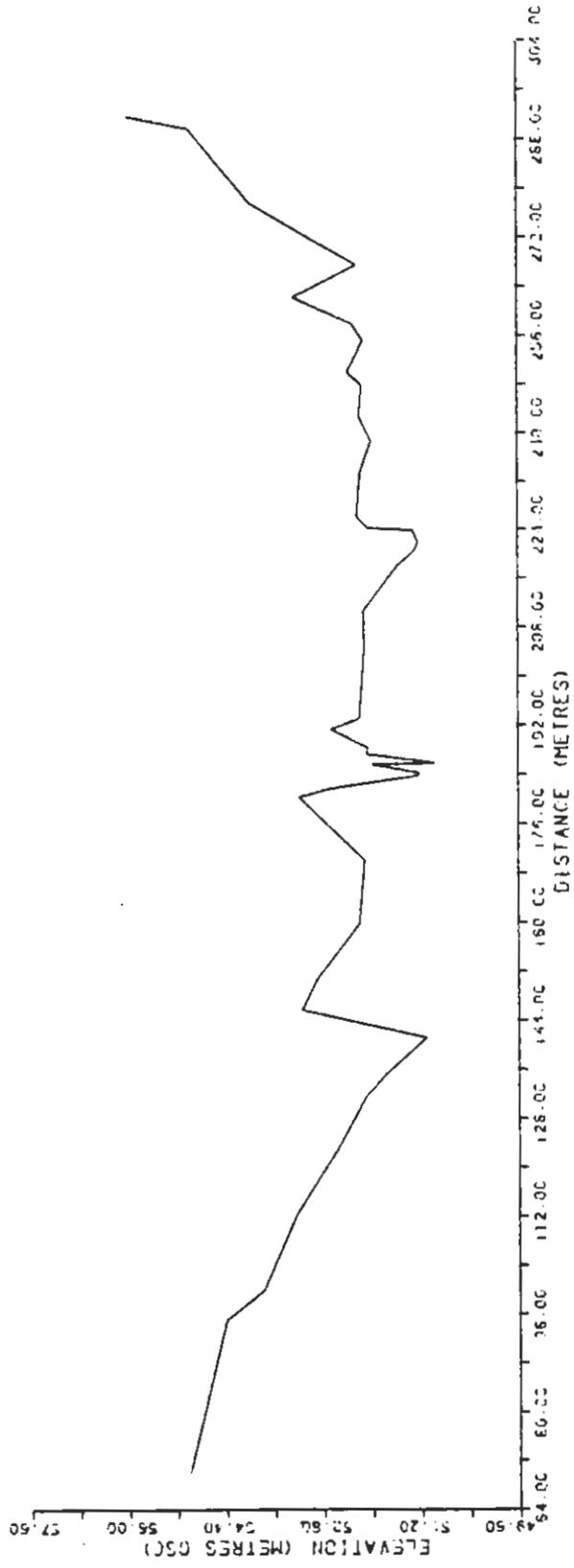


C.C.M.C. C.C.T.S.O. O.C.M.C.

WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 2006.0

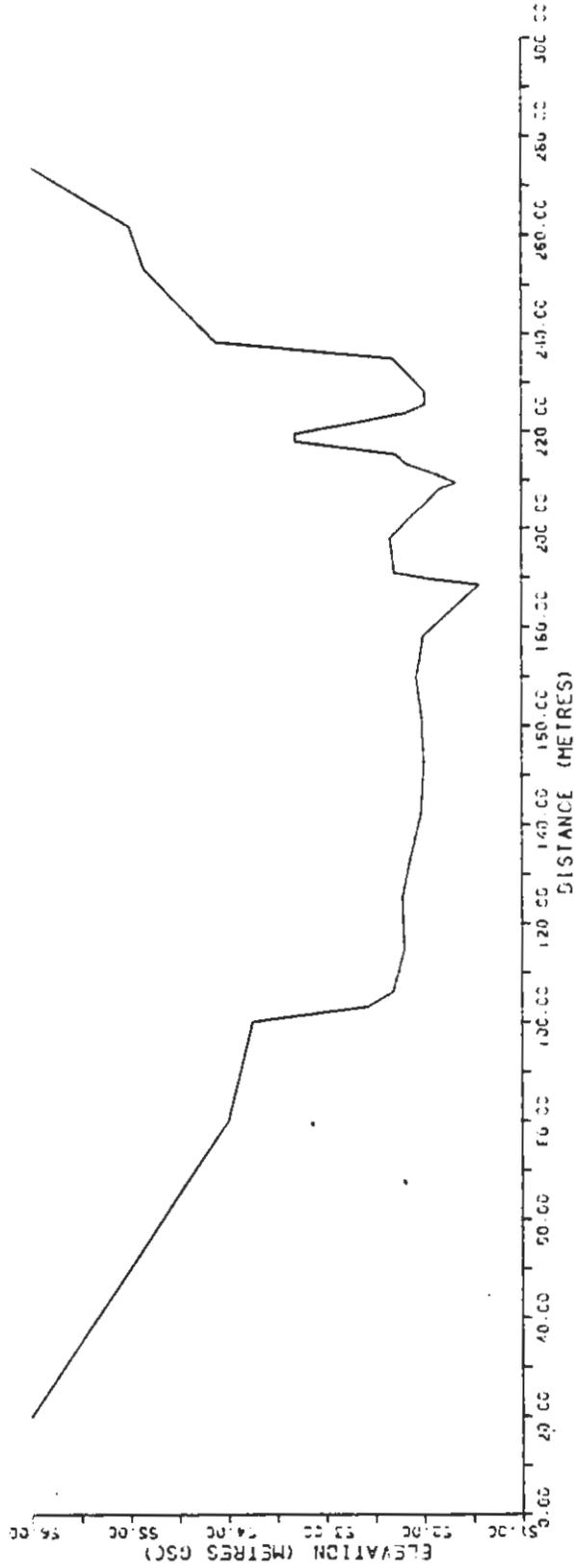


WATERFORD RIVER HEC-2 MODEL
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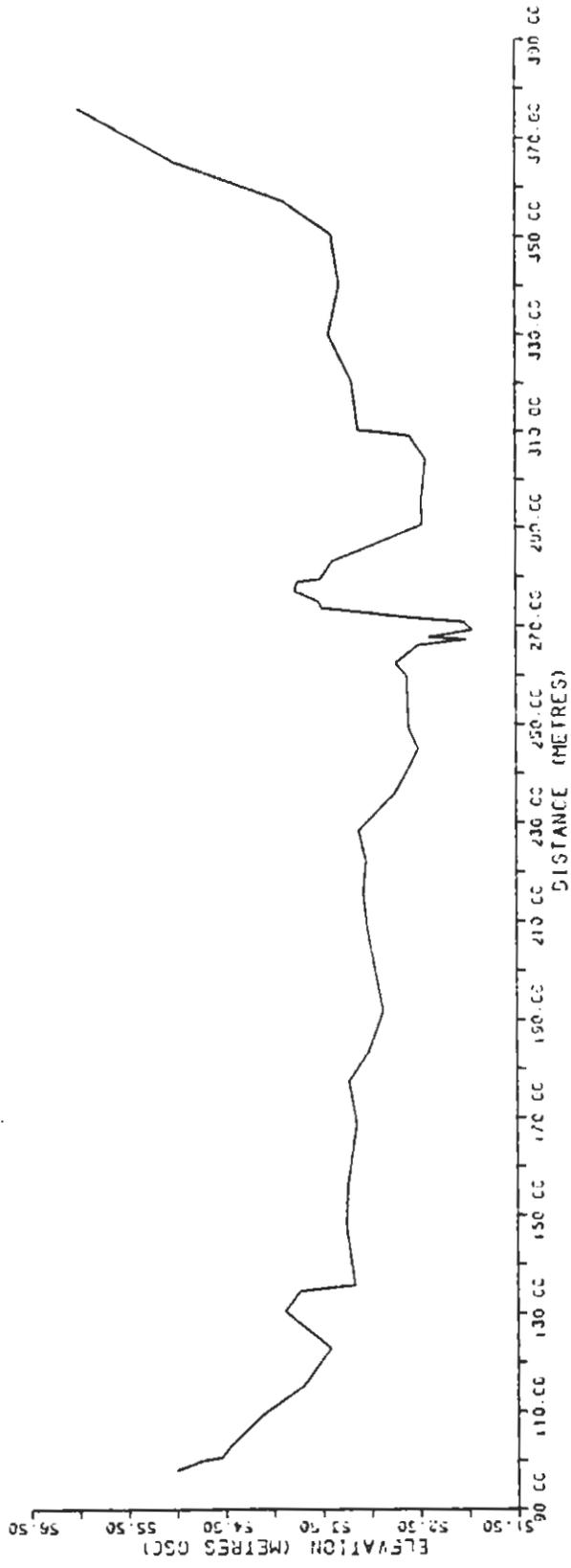
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WATERFORD RIVER HEC-2 MODEL
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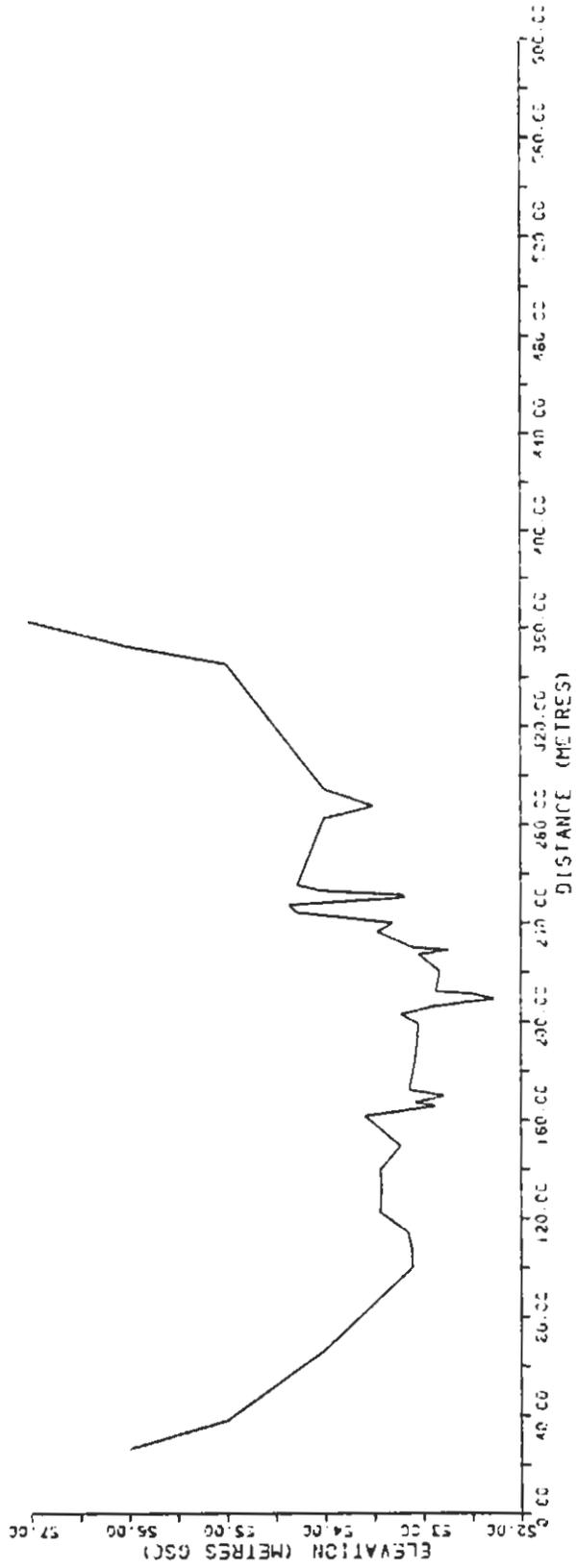
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WATERFORD RIVER HEC-2 MODEL
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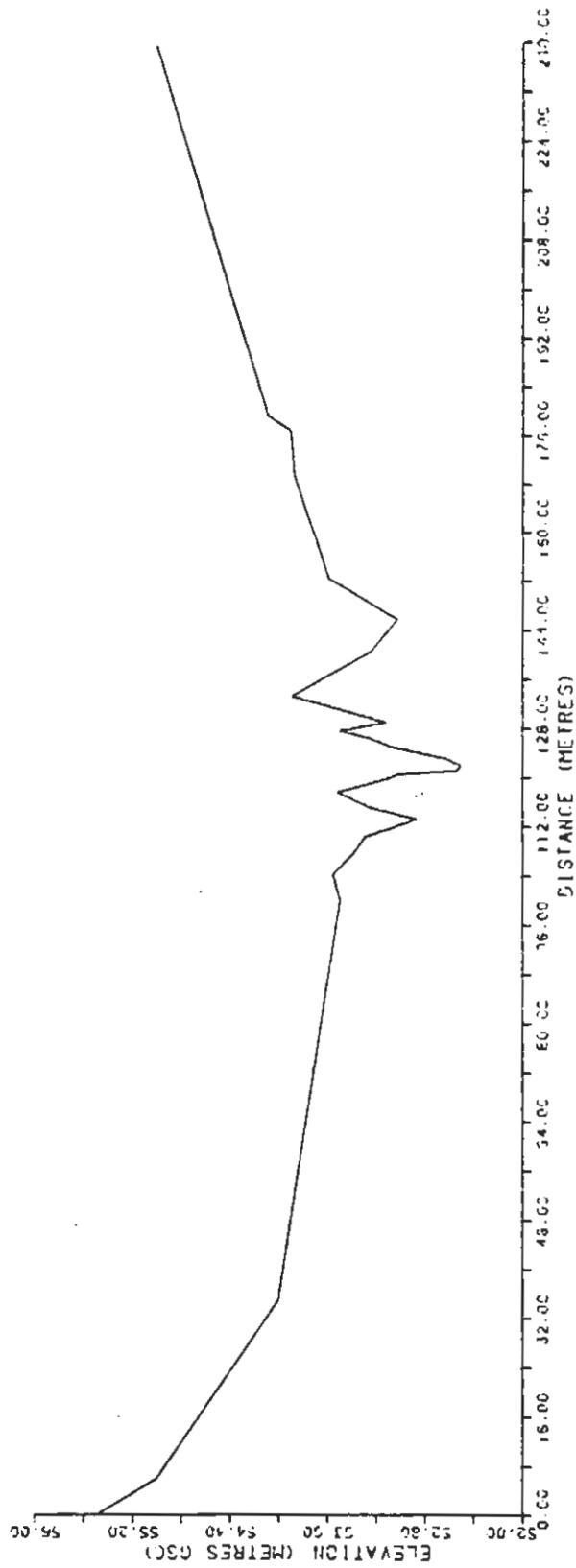
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WATERFORD RIVER HEC-2 MODEL
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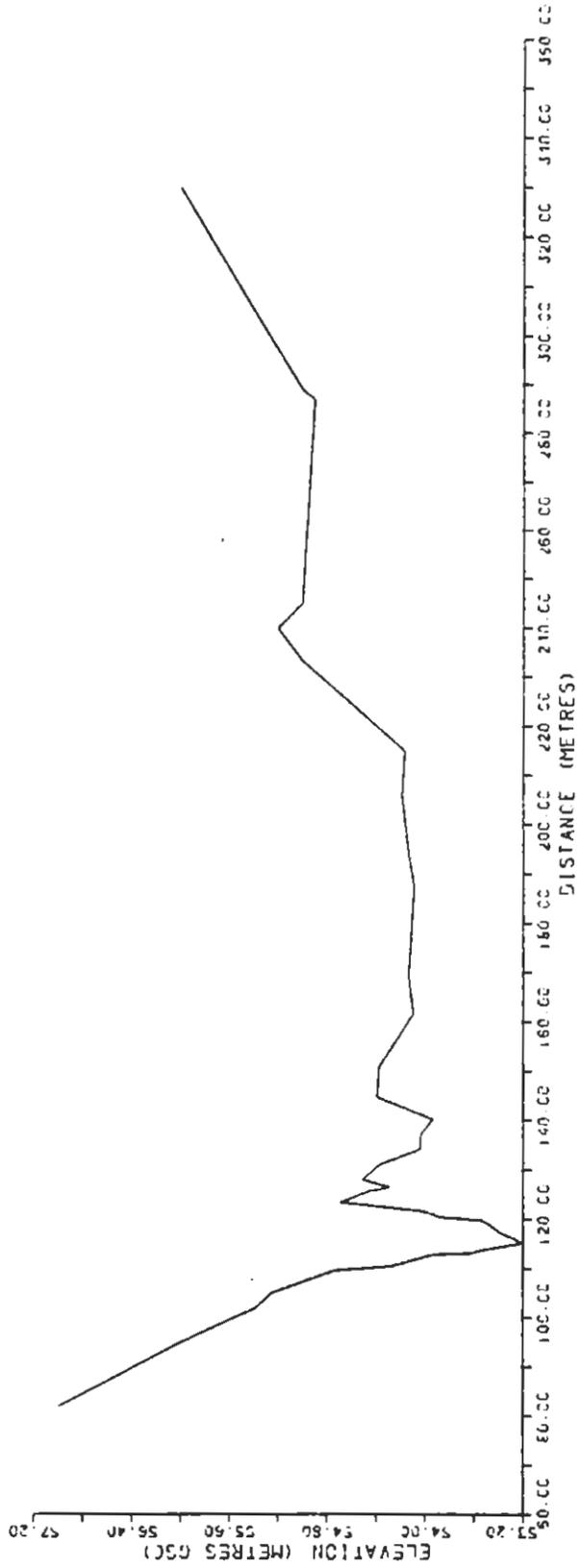
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WATERFORD RIVER HEC-2 MODEL
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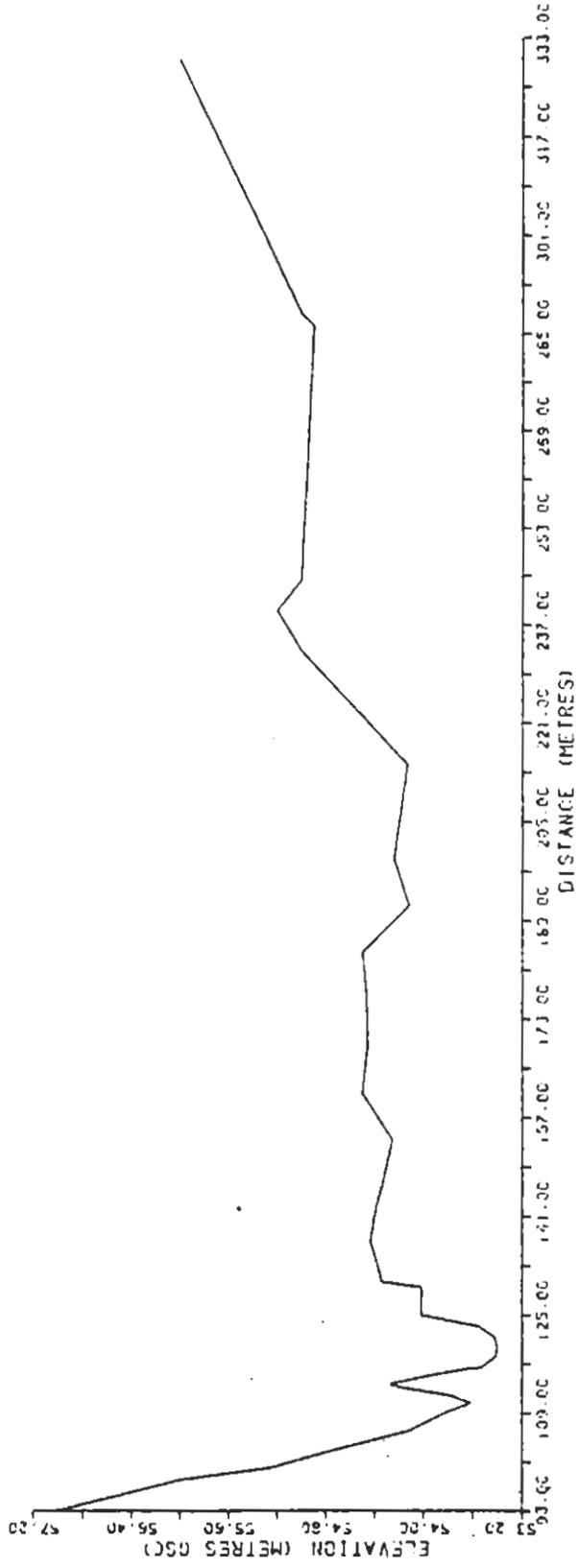
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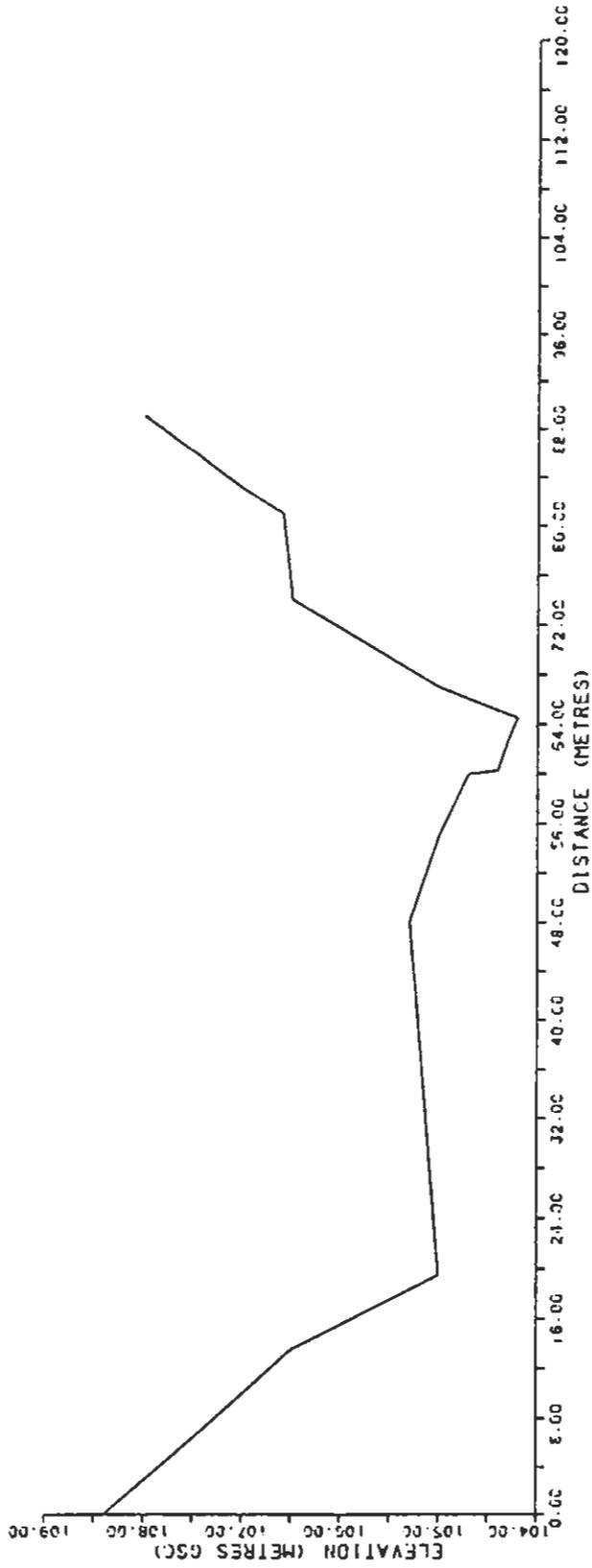
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WATERFORD RIVER HEC-2 MODEL
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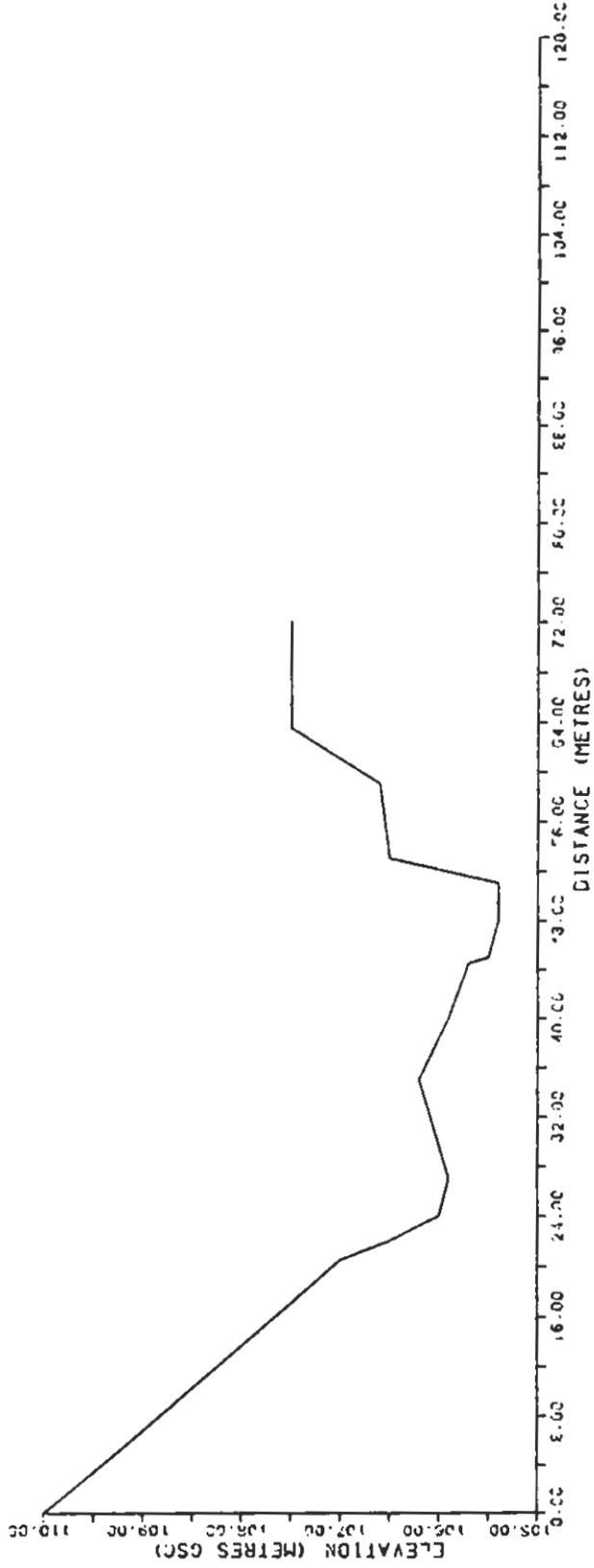


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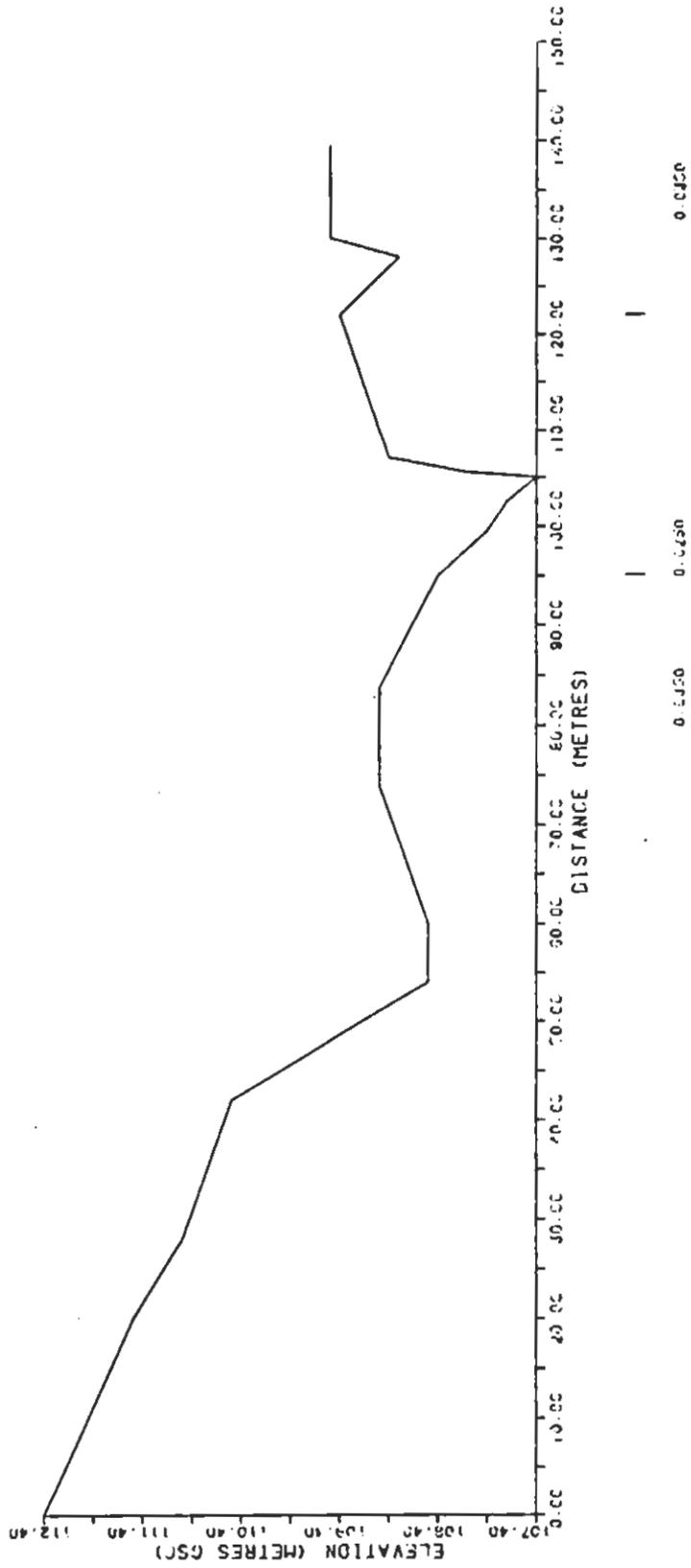


WATERFORD RIVER HEC-2 MODEL
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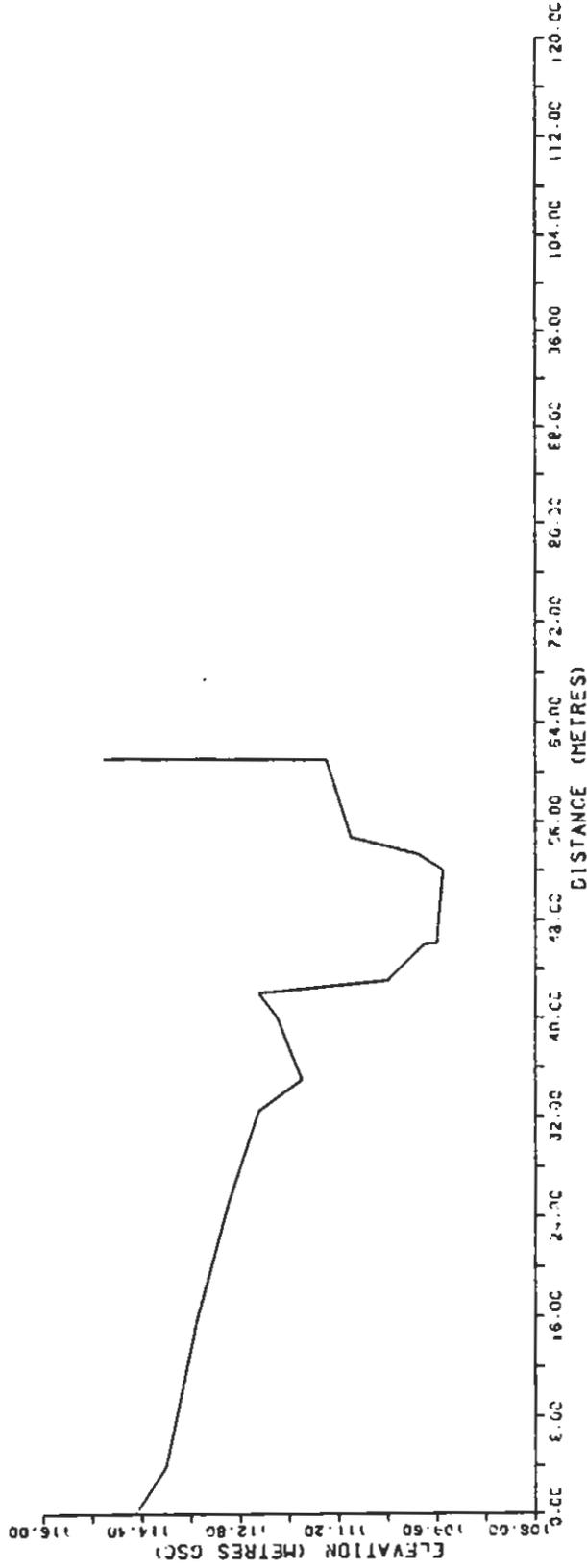


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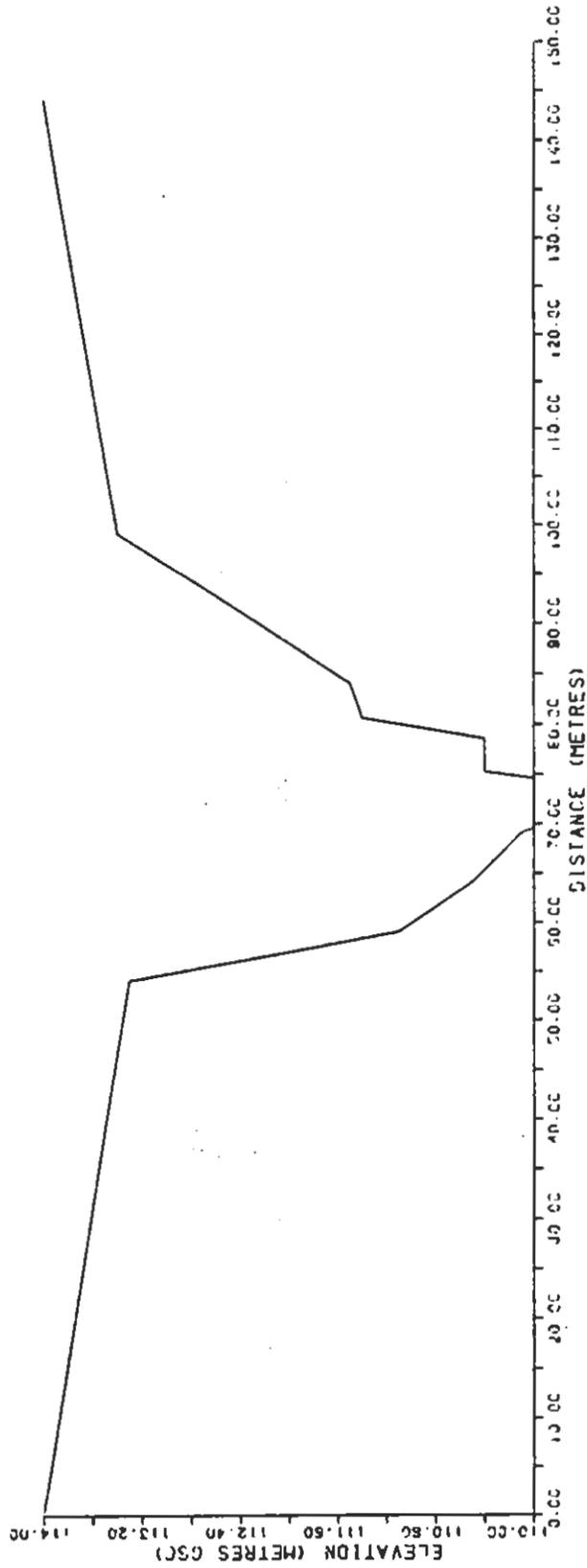


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 9836.



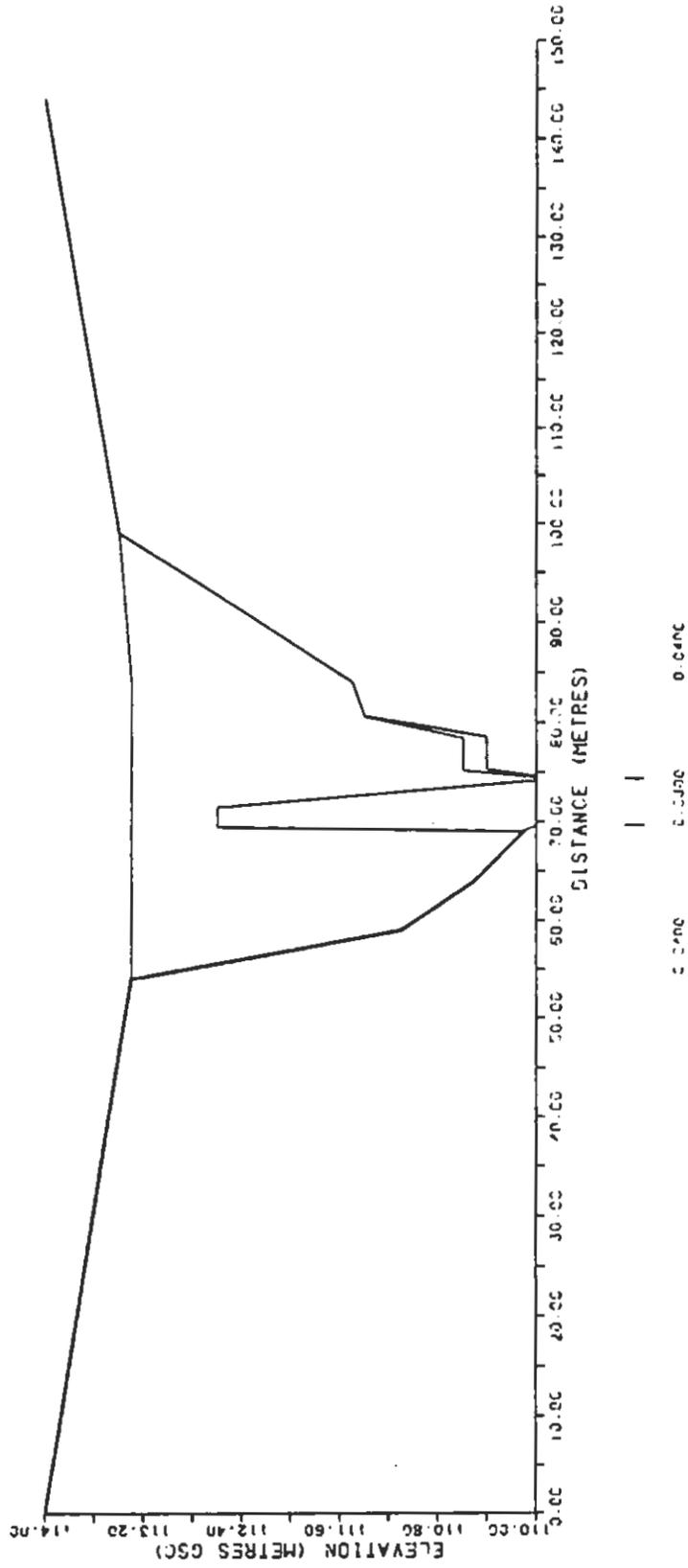
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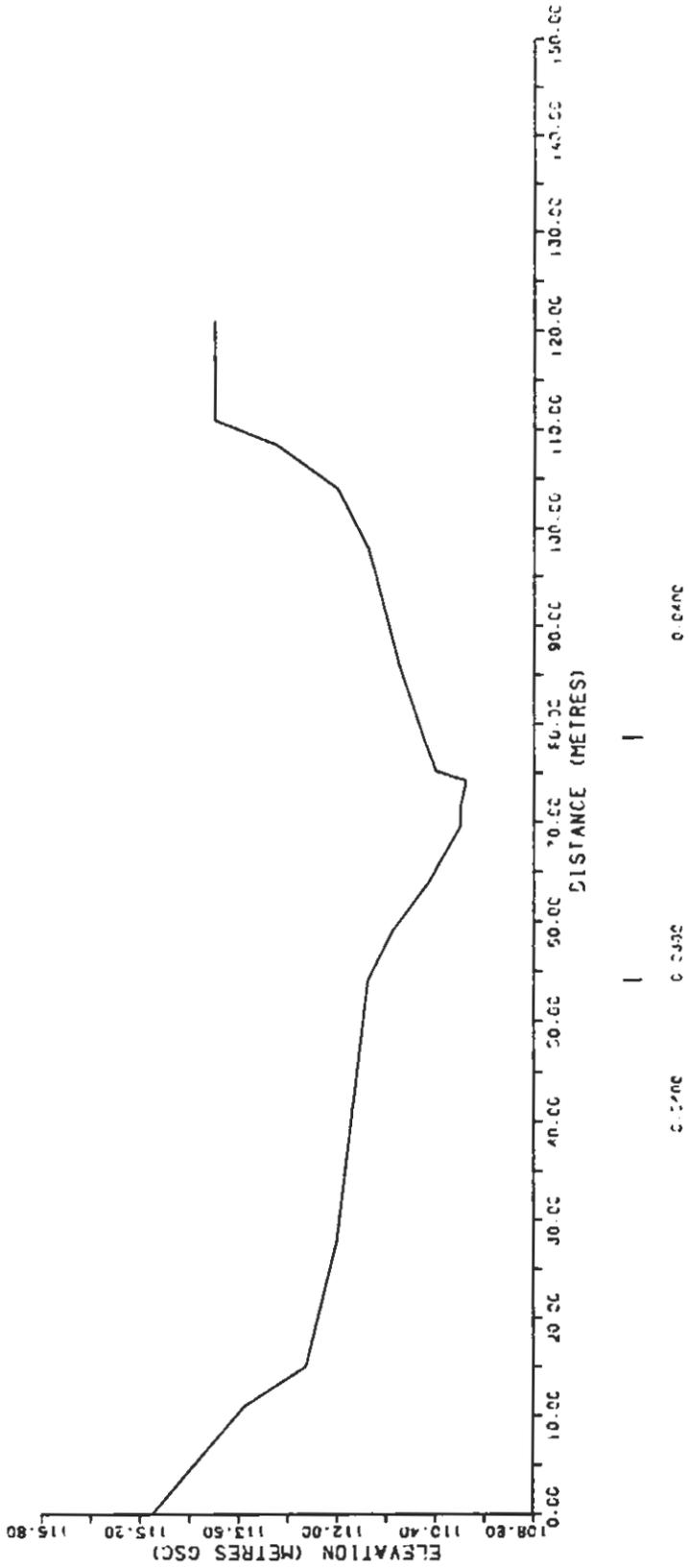


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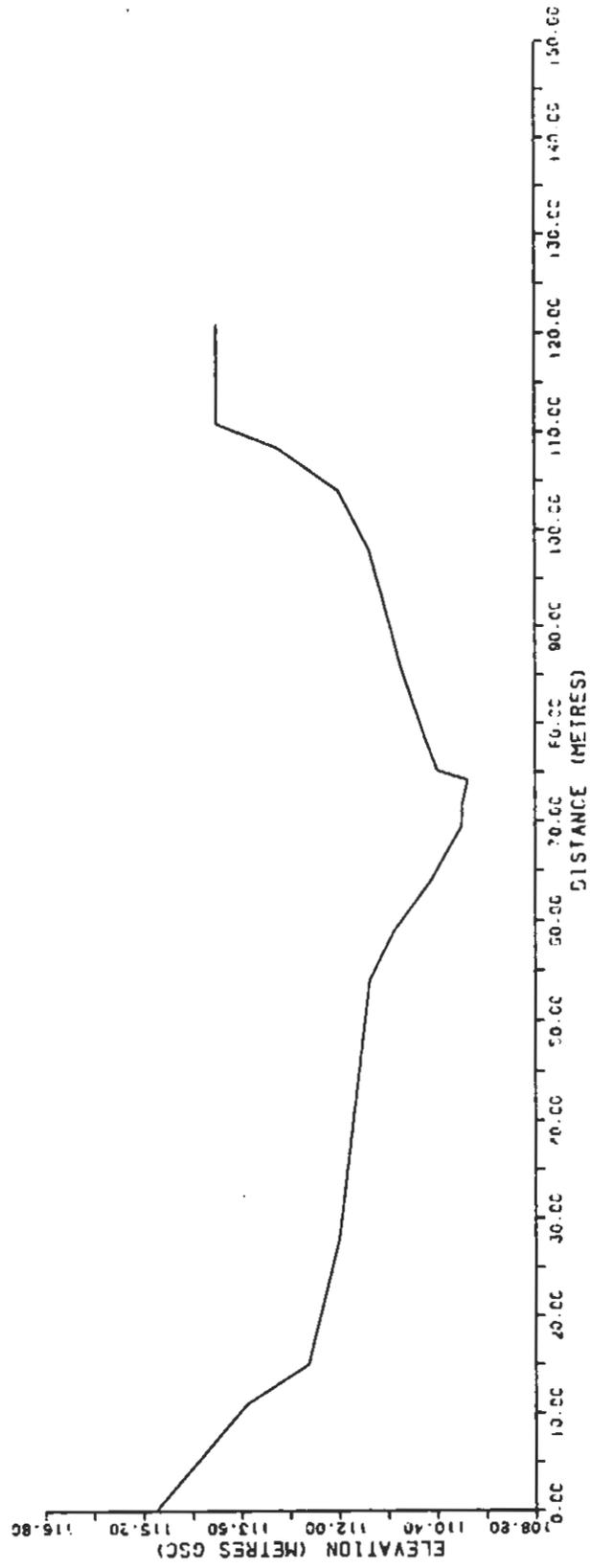
WATERFORD RIVER
CROSS SECTION NUMBER 9870.
HEC-2 MODEL



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 9876.

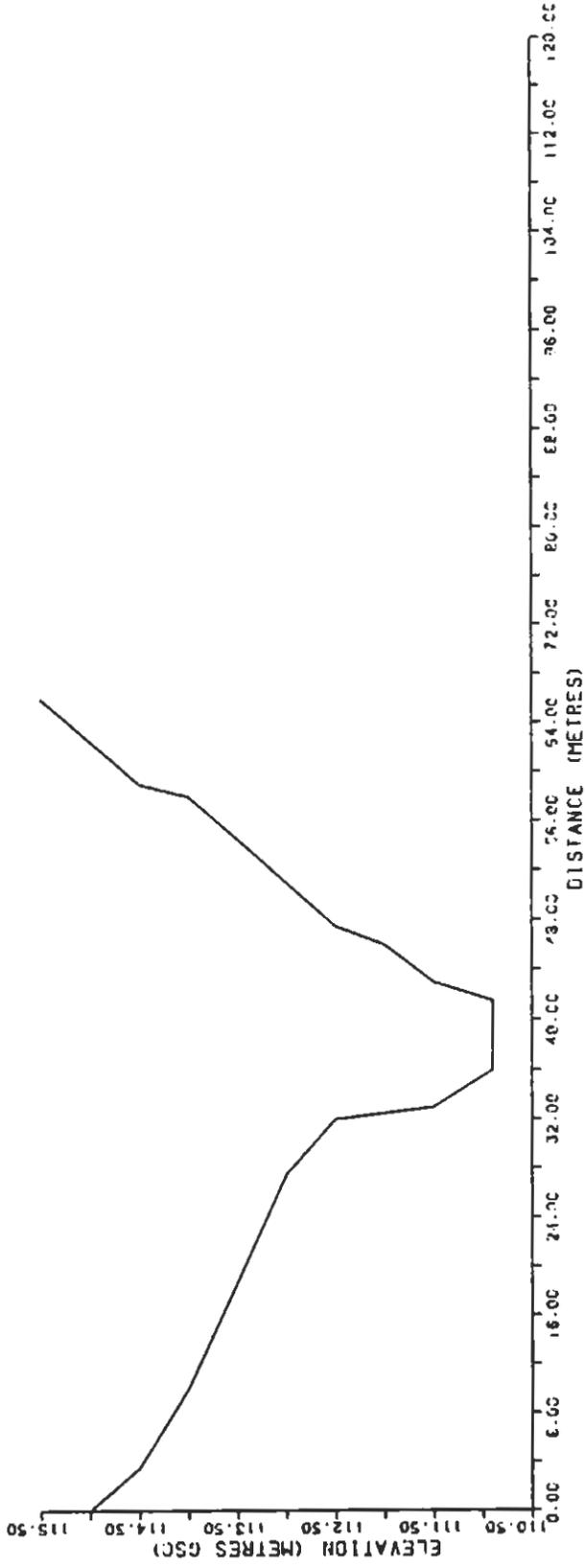


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CROSS SECTION NUMBER 9885.

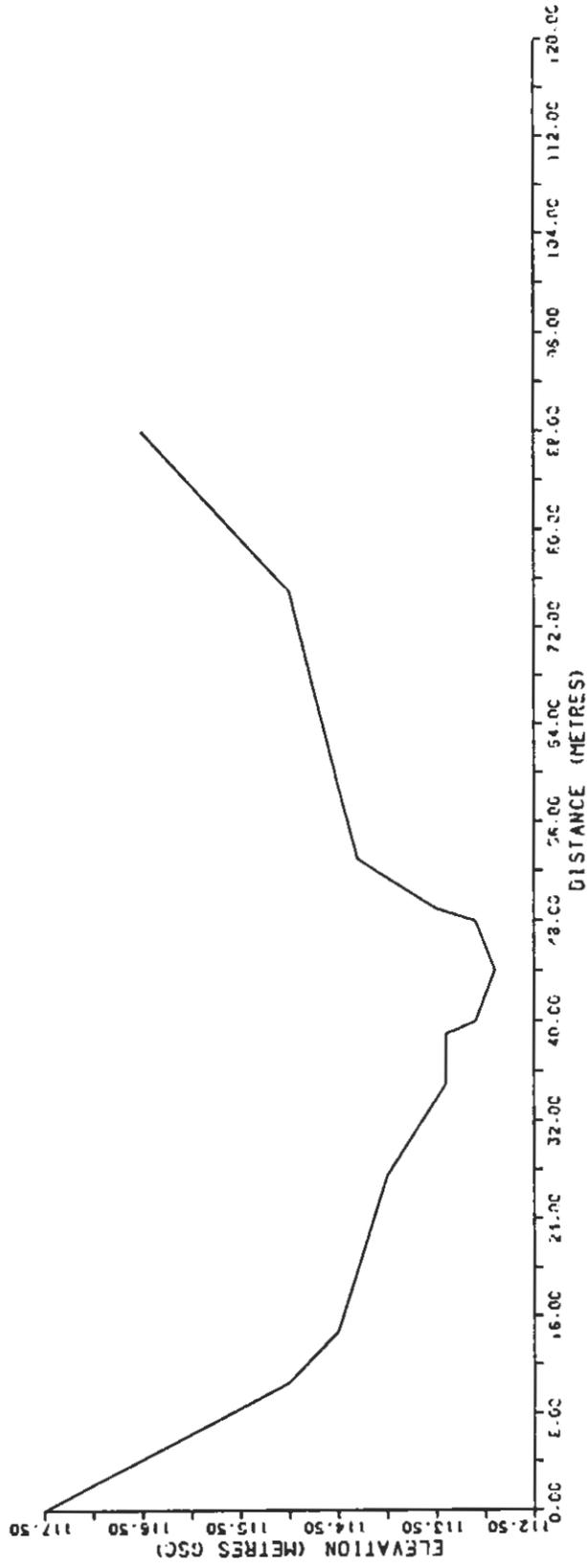


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CROSS SECTION NUMBER 10030.

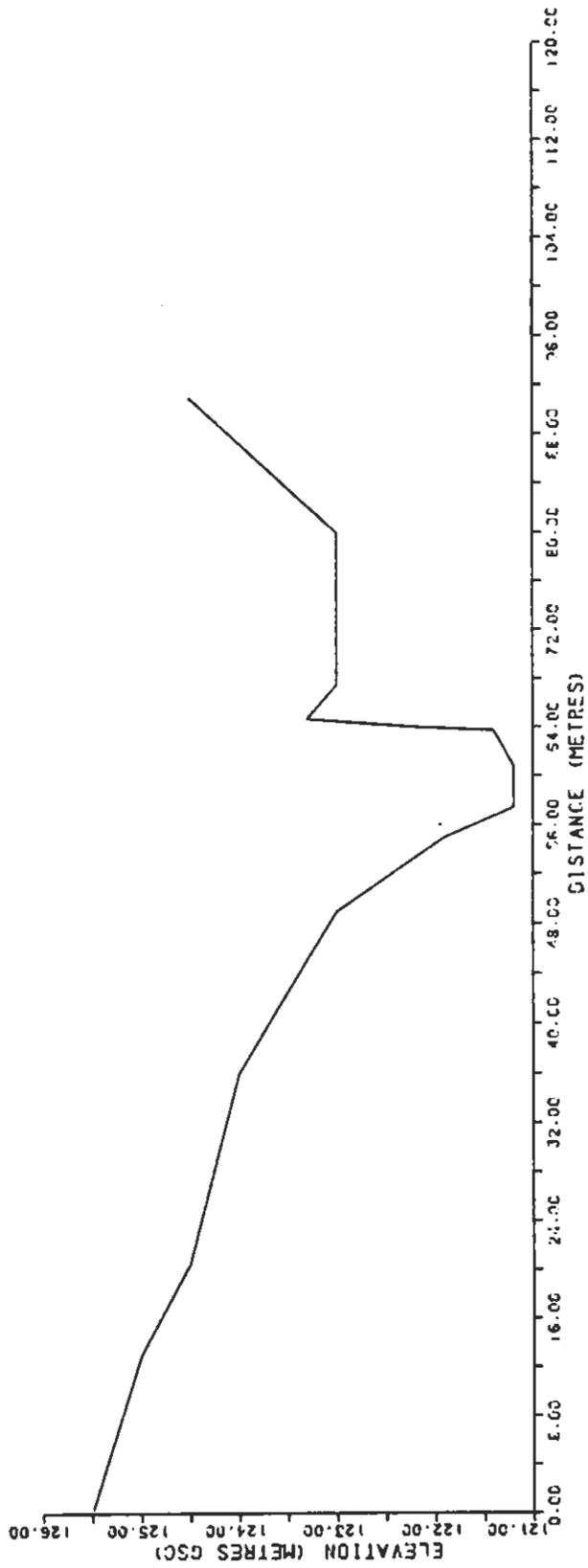


WATERFORD RIVER
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CROSS SECTION NUMBER 10247.



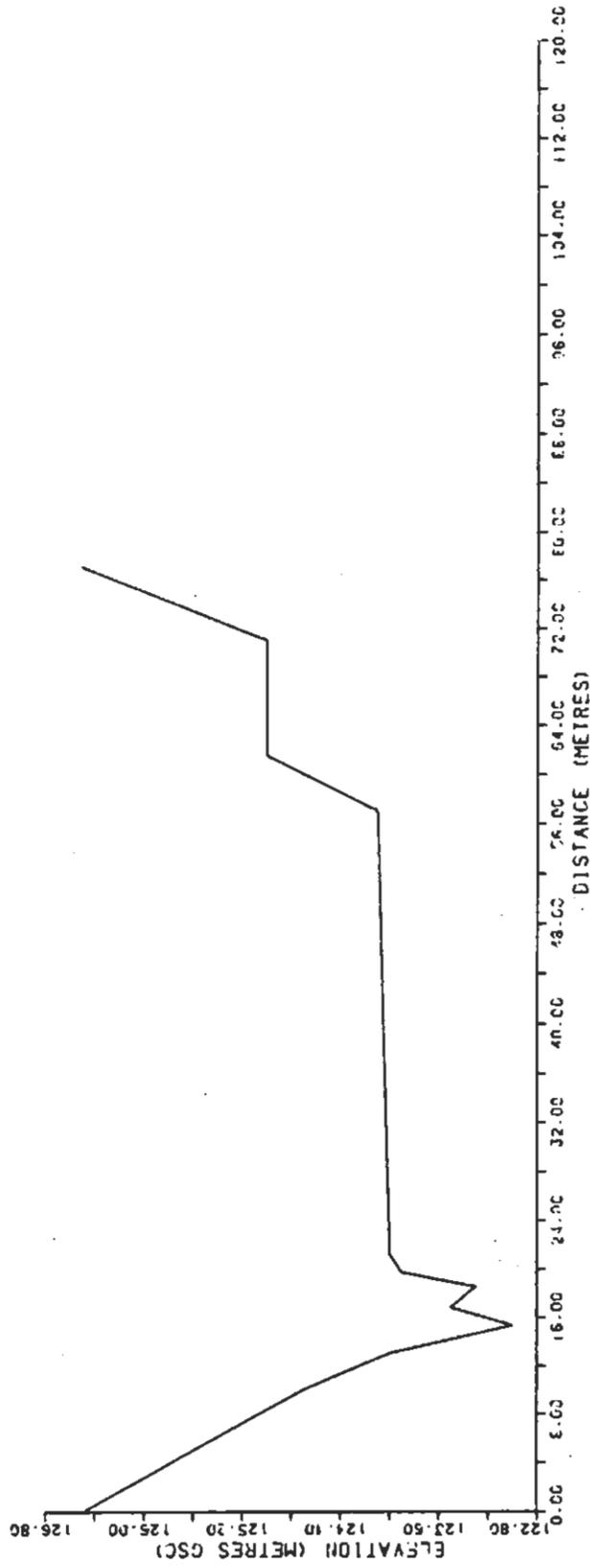
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0.0450 | 0.0450

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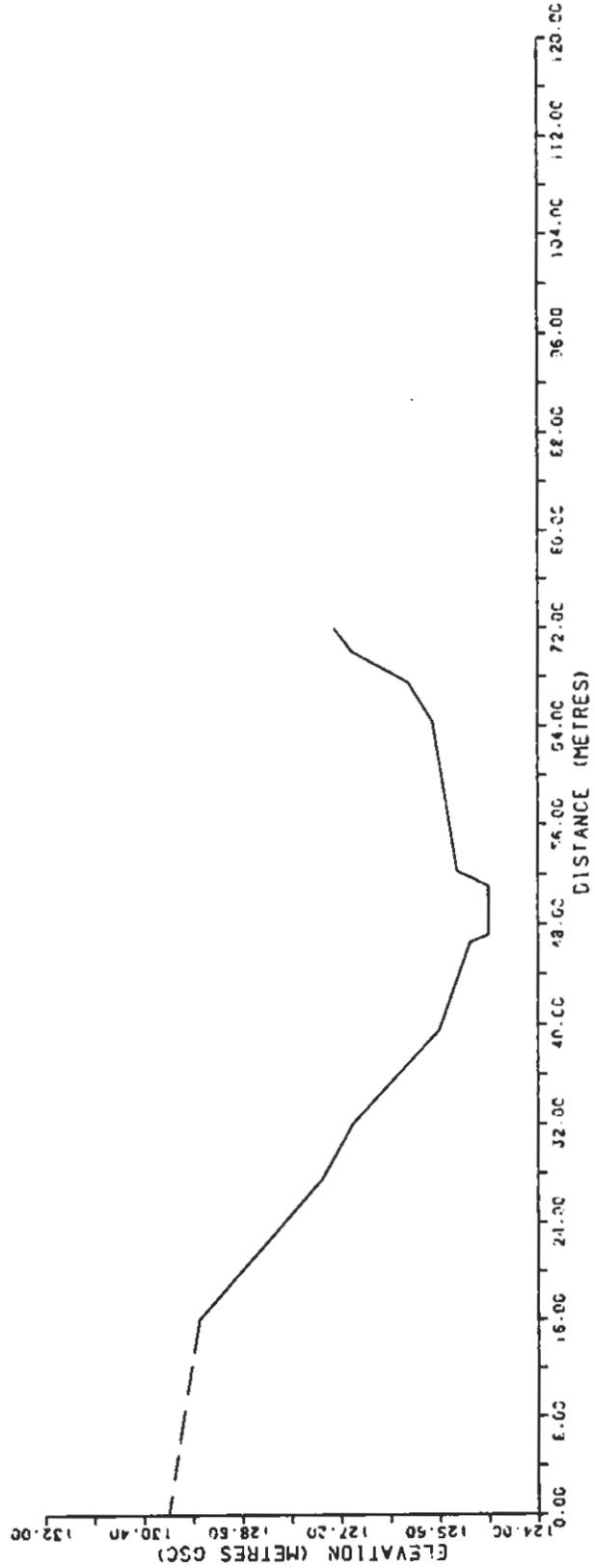
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WATERFORD RIVER
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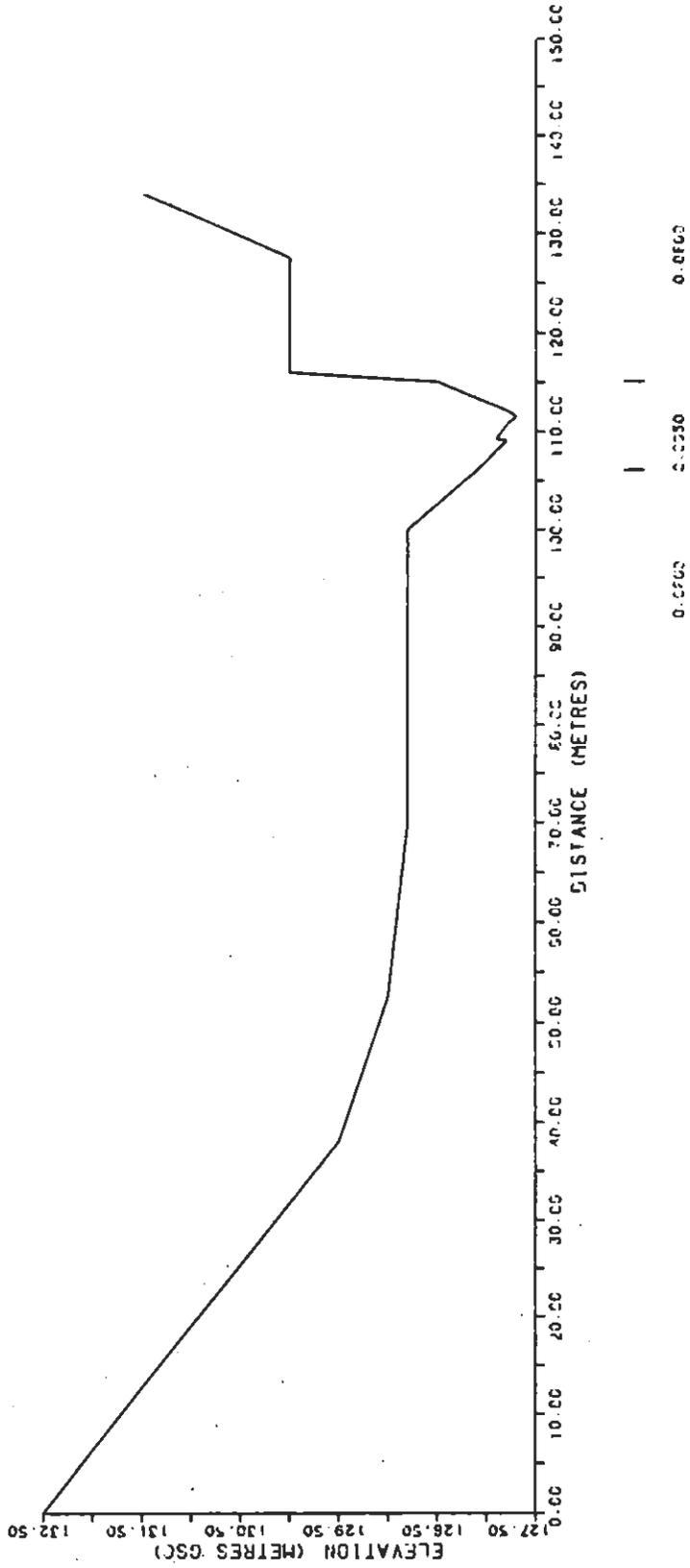
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WATERFORD RIVER HEC-2 MODEL
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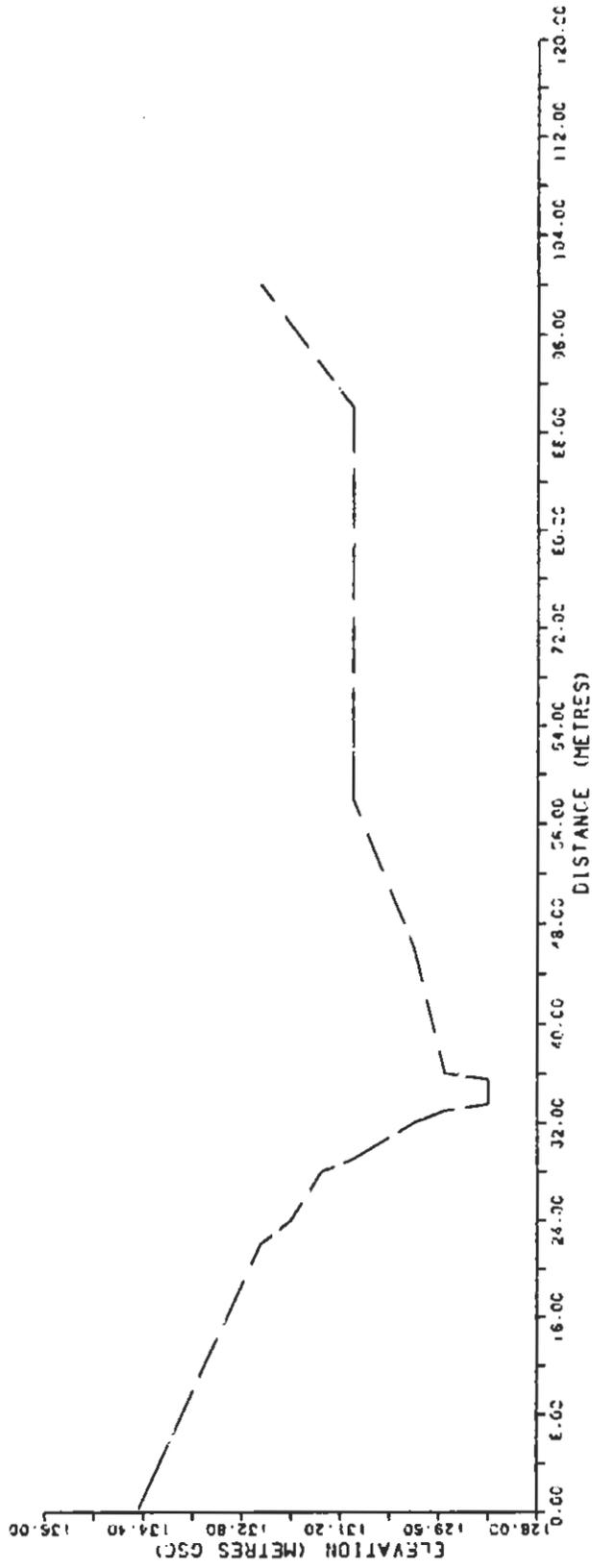


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WATERFORD RIVER
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CROSS SECTION NUMBER 11340.

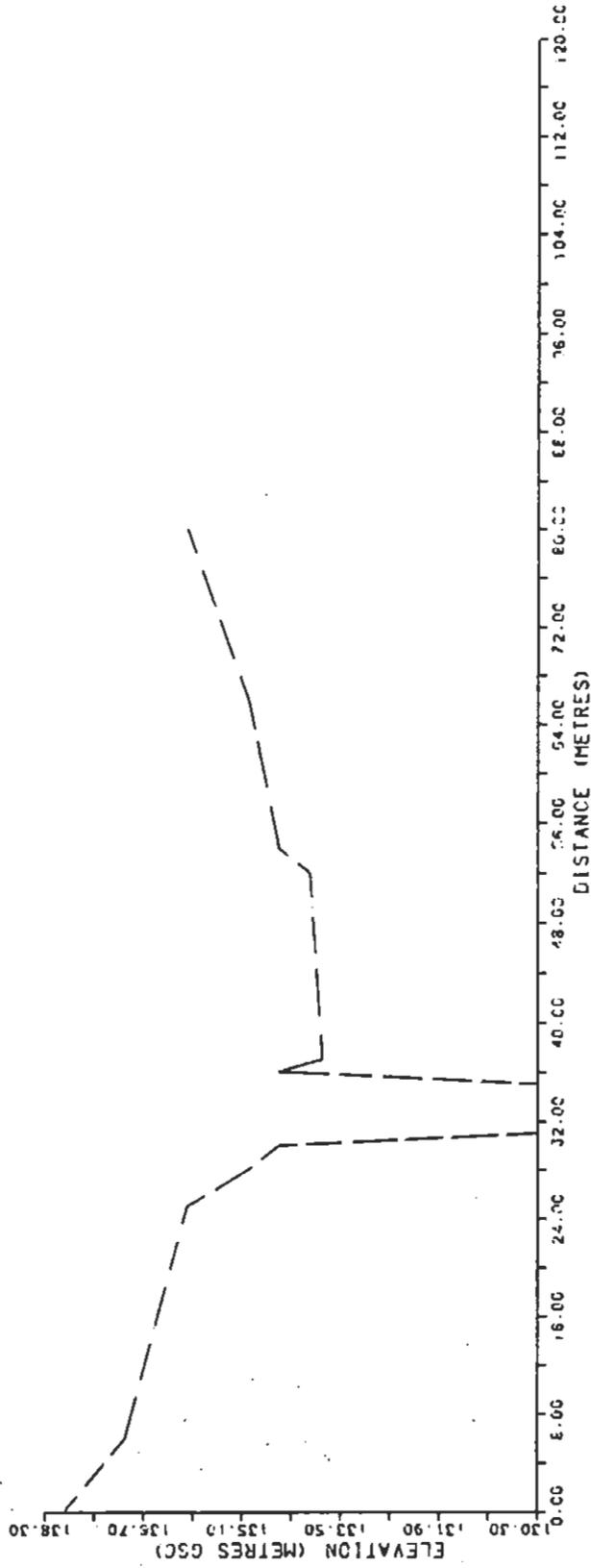


WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 11480



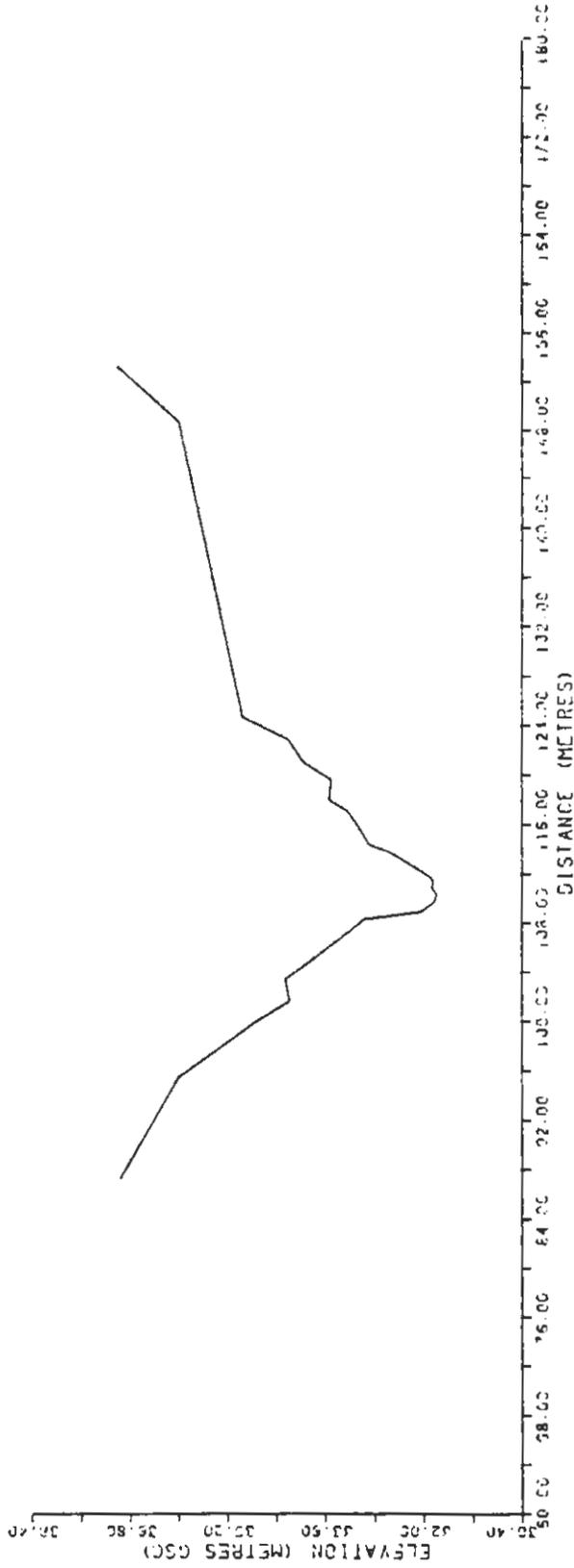
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WATERFORD RIVER HEC-2 MODEL
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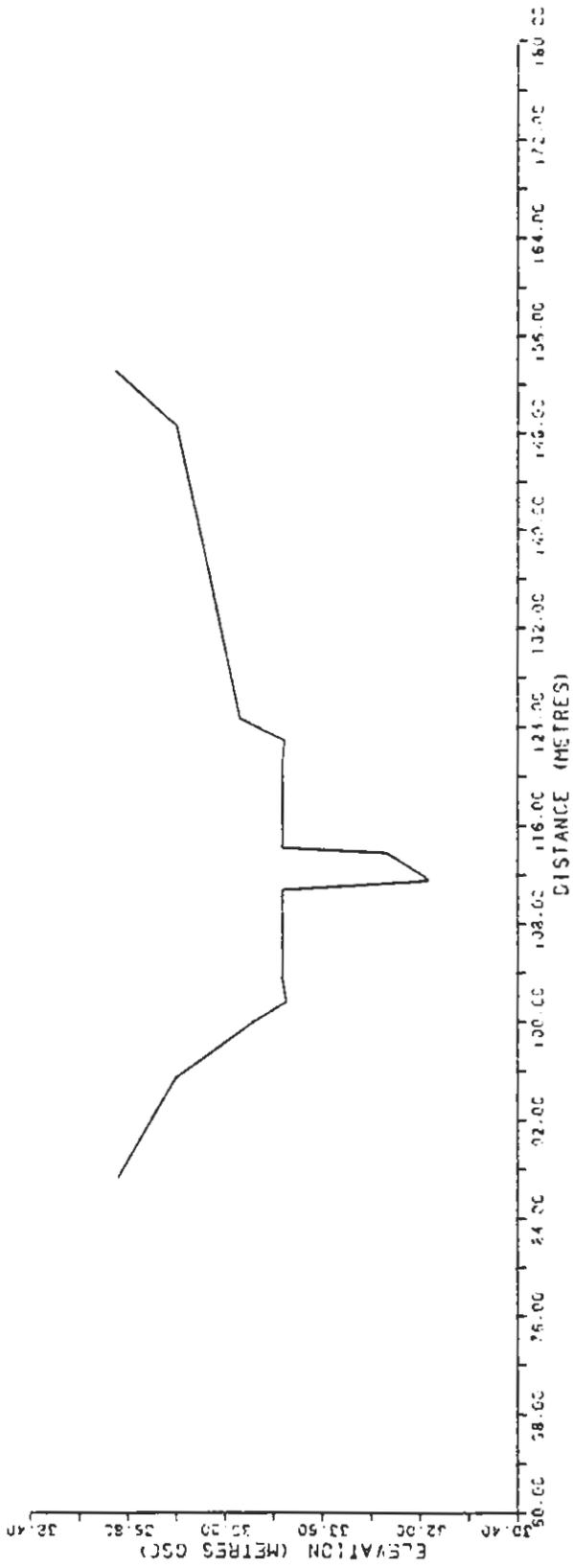


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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3001

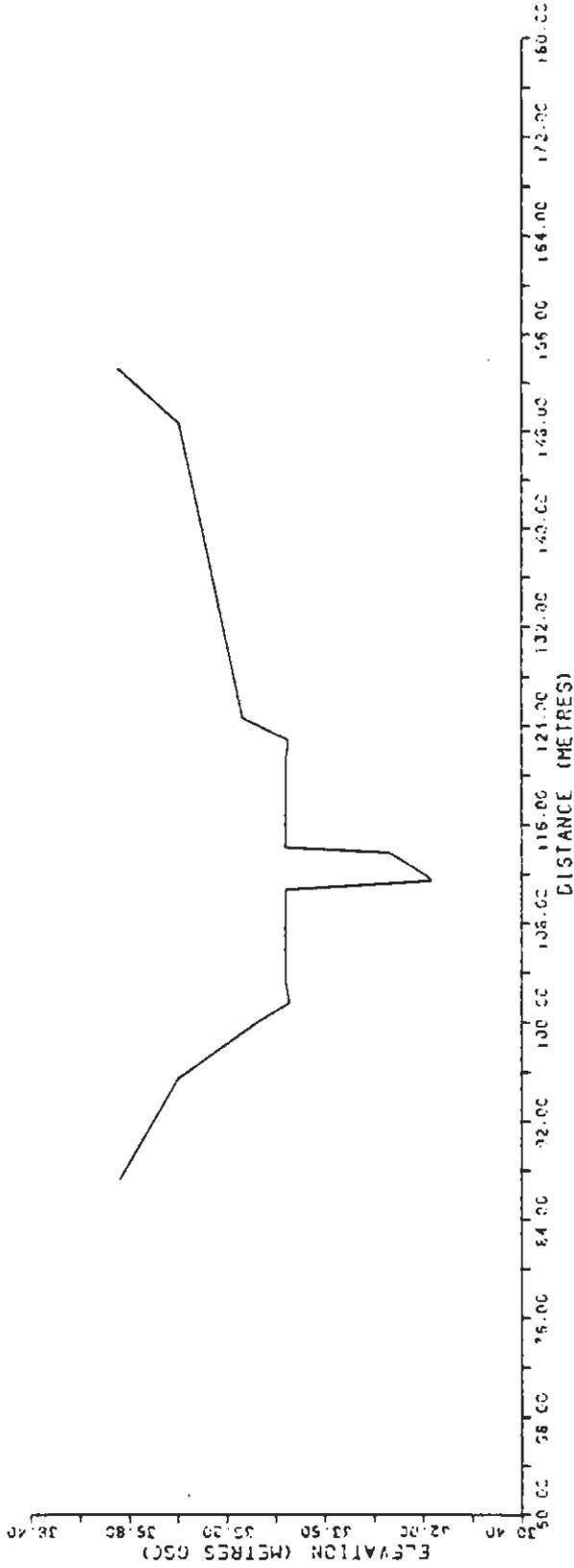


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3001.1



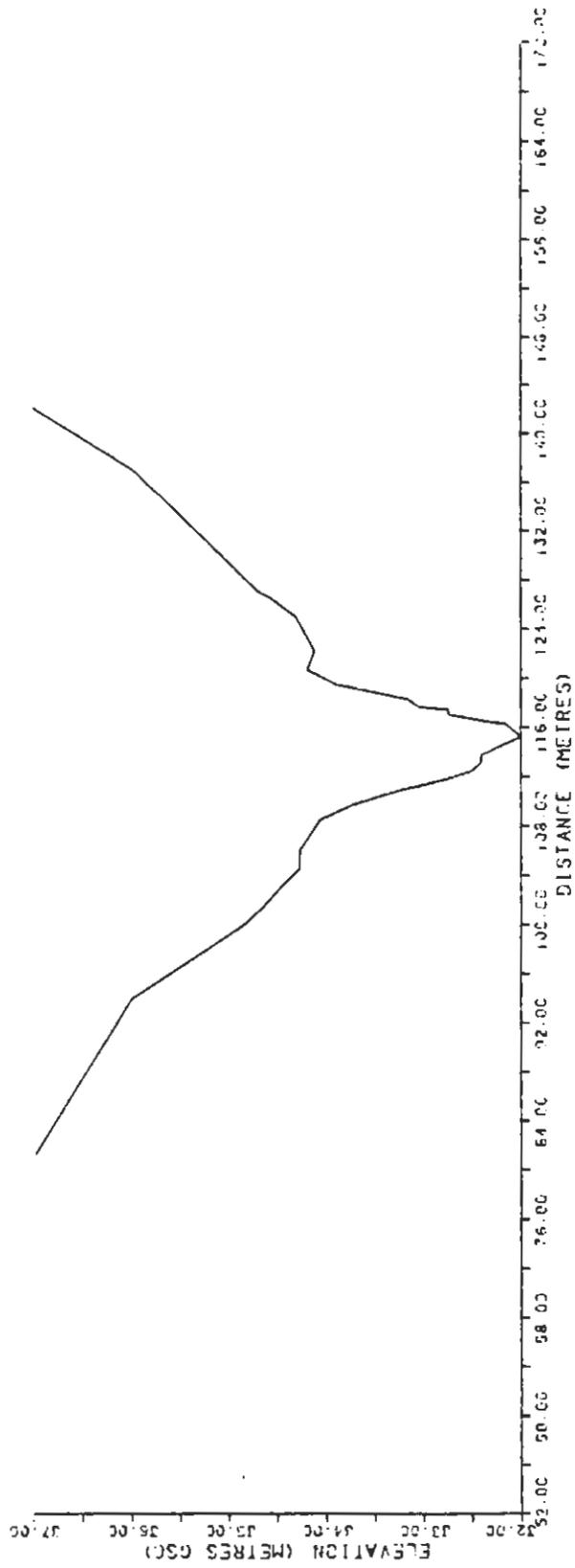
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WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 3001.9

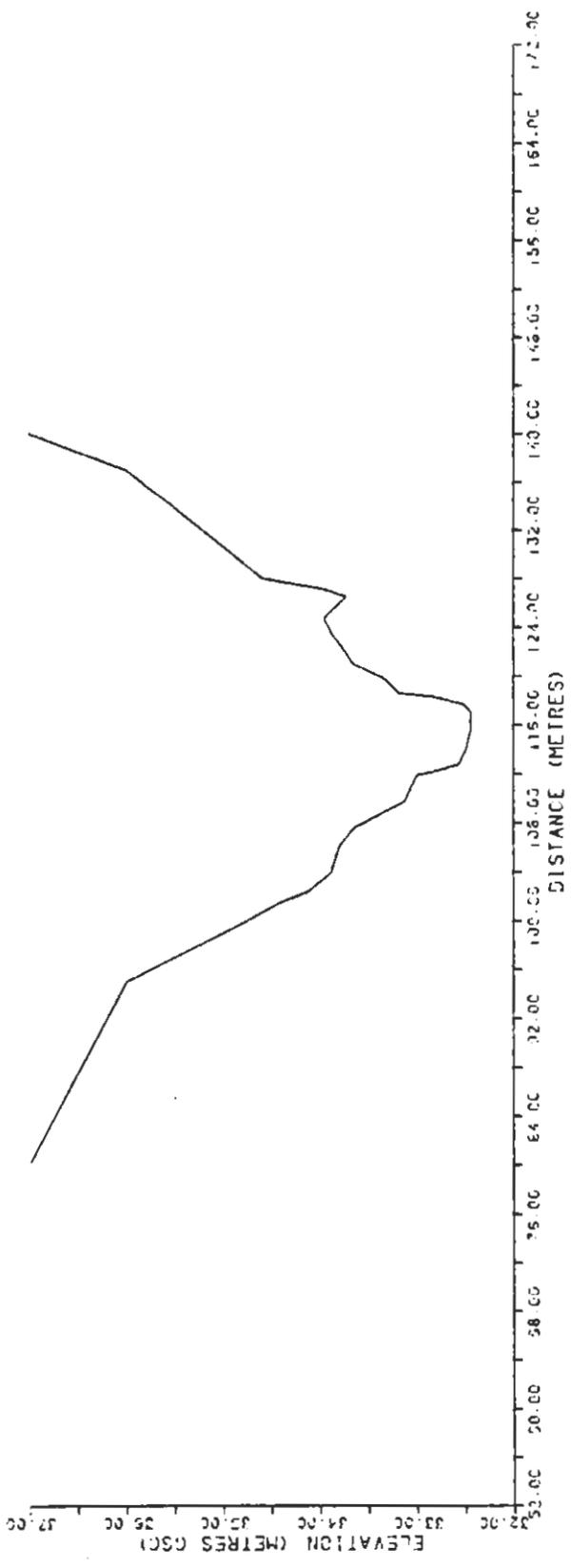


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WATERFORD RIVER
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 HEC-2 MODEL

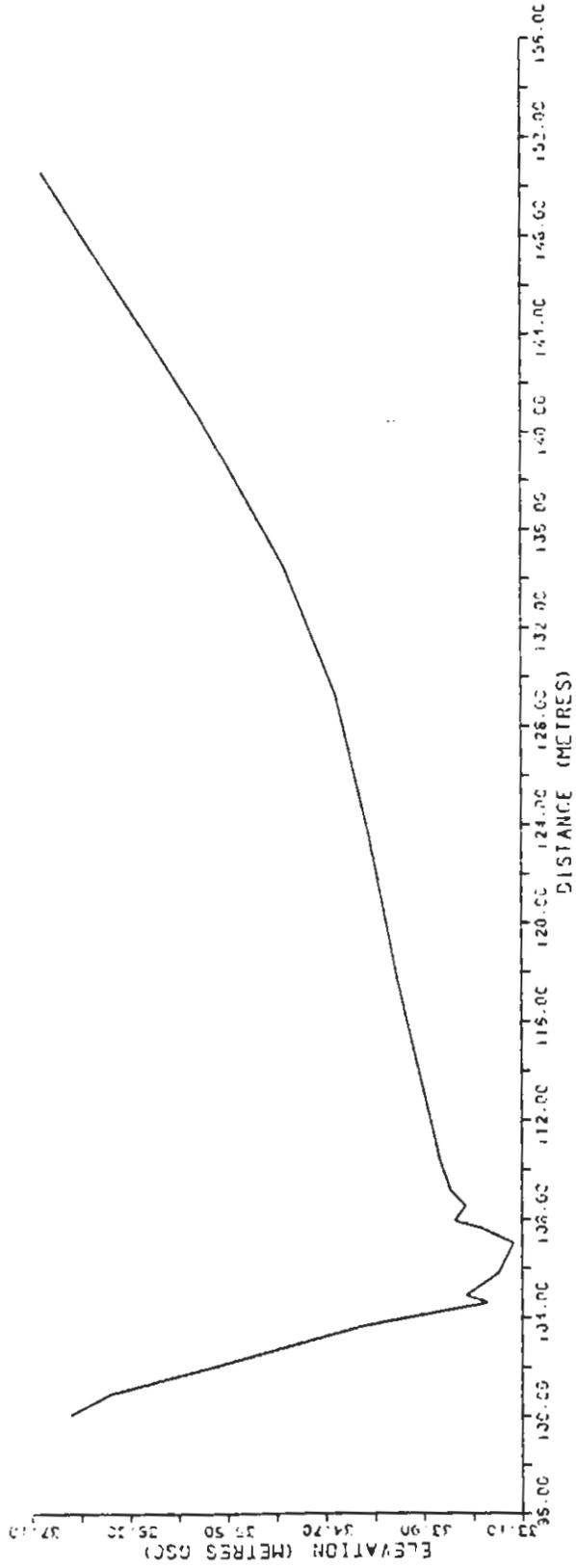


WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 3003.0



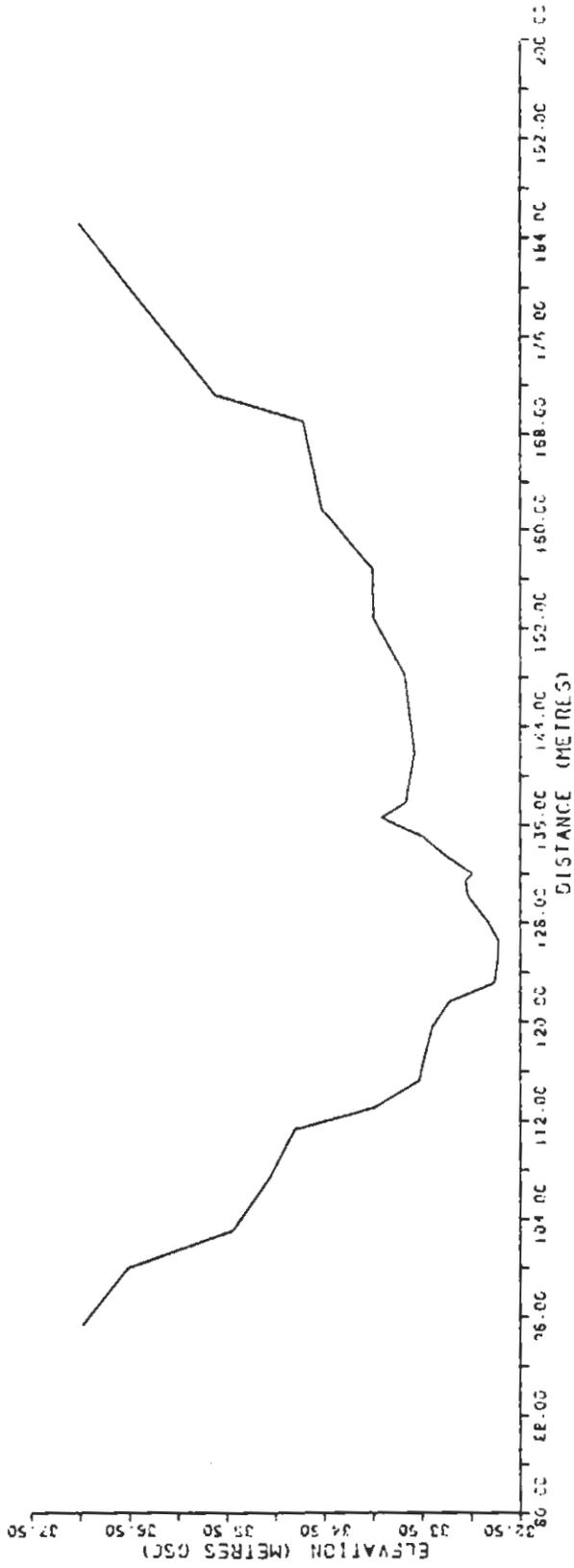
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3004.0



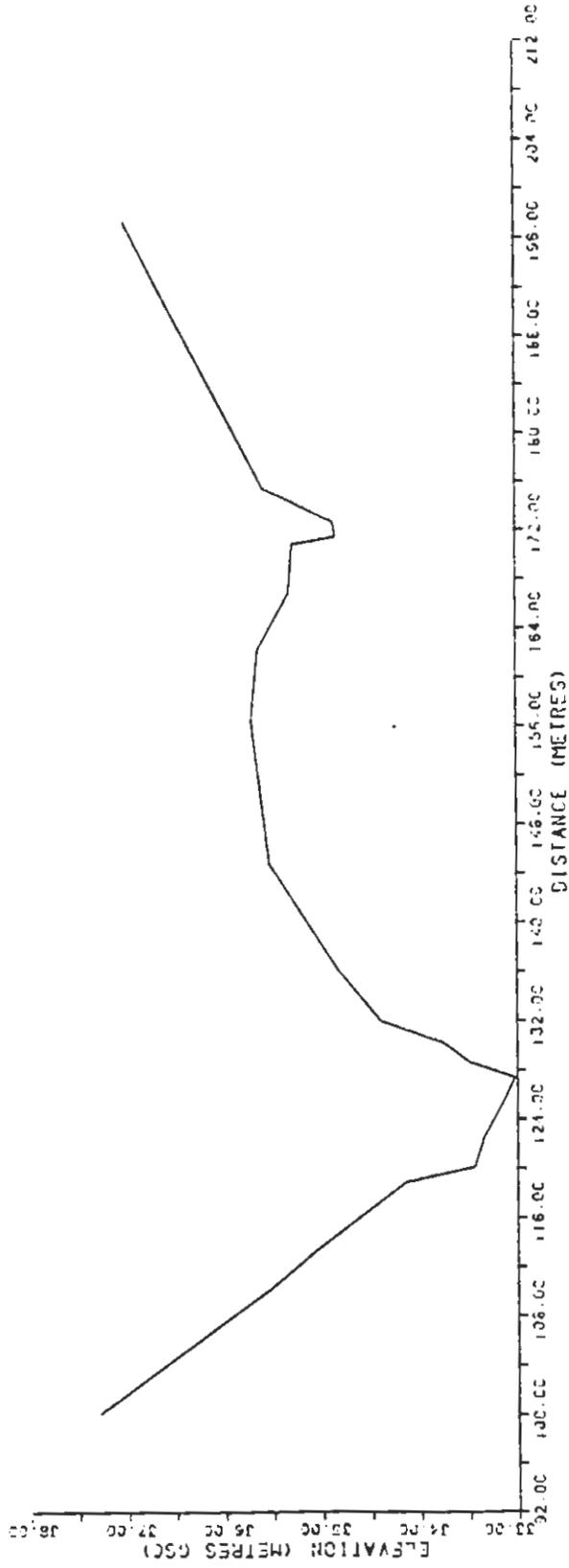
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3005.0



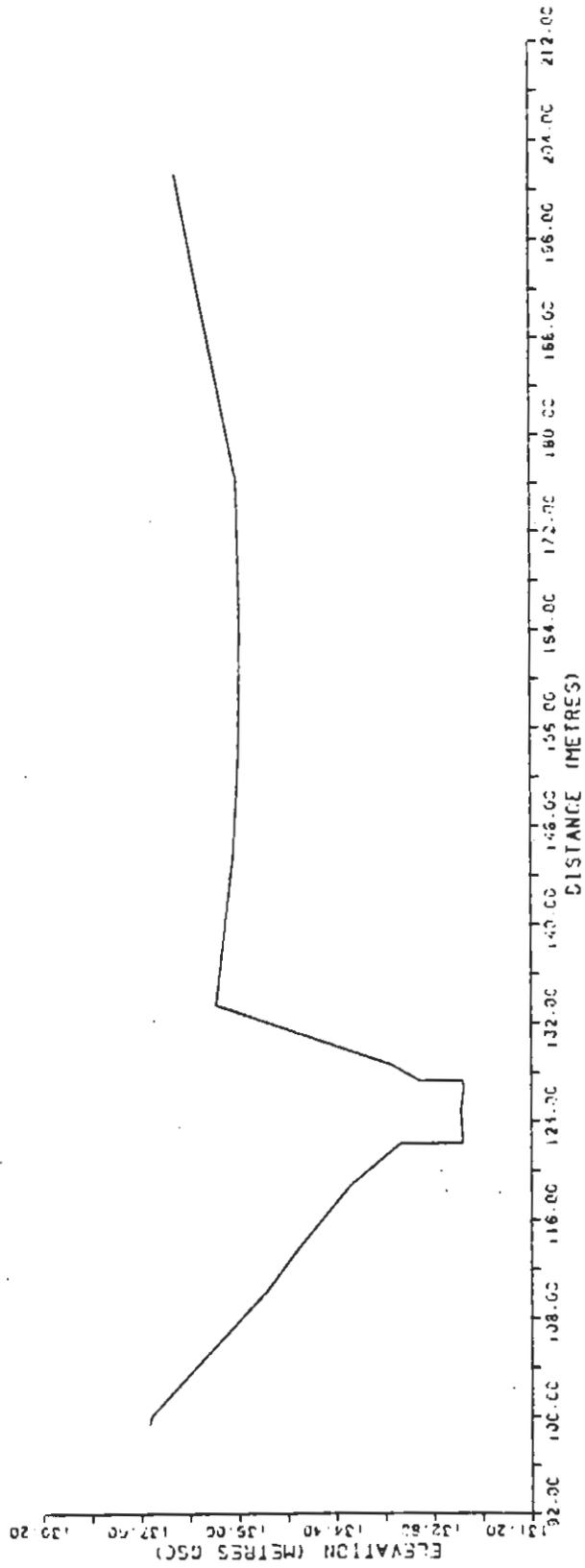
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3006.0



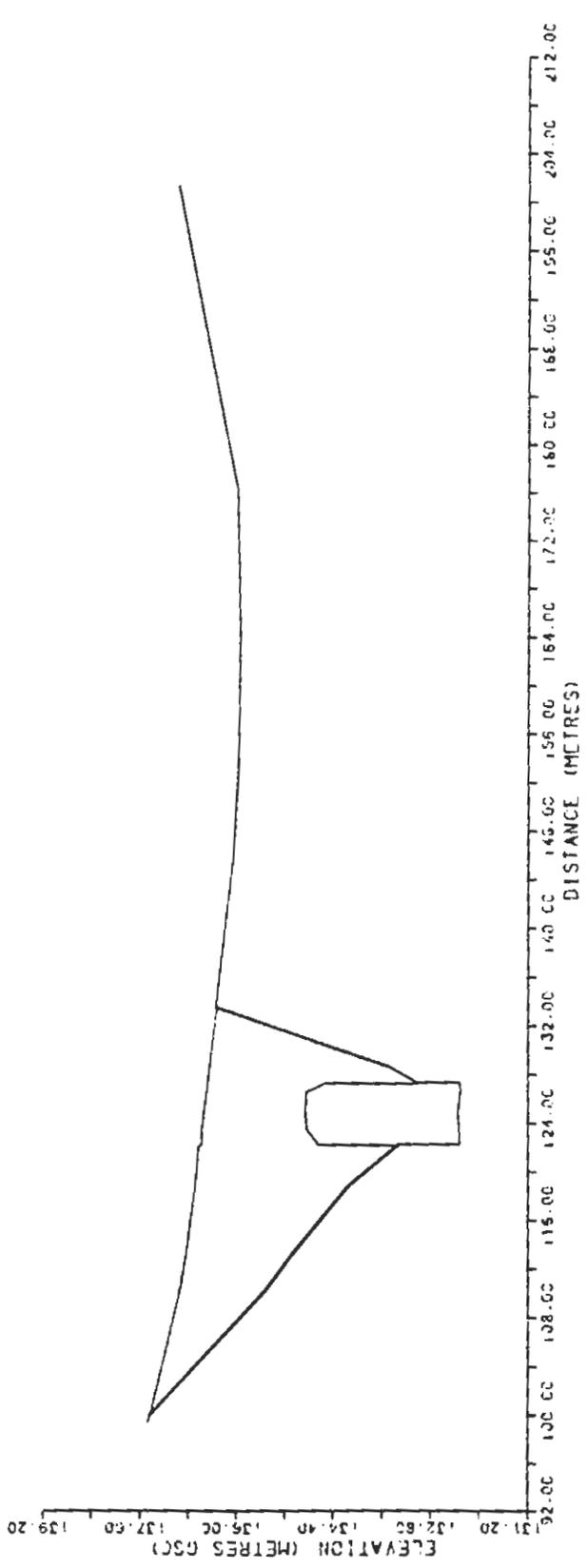
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WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 3007.1

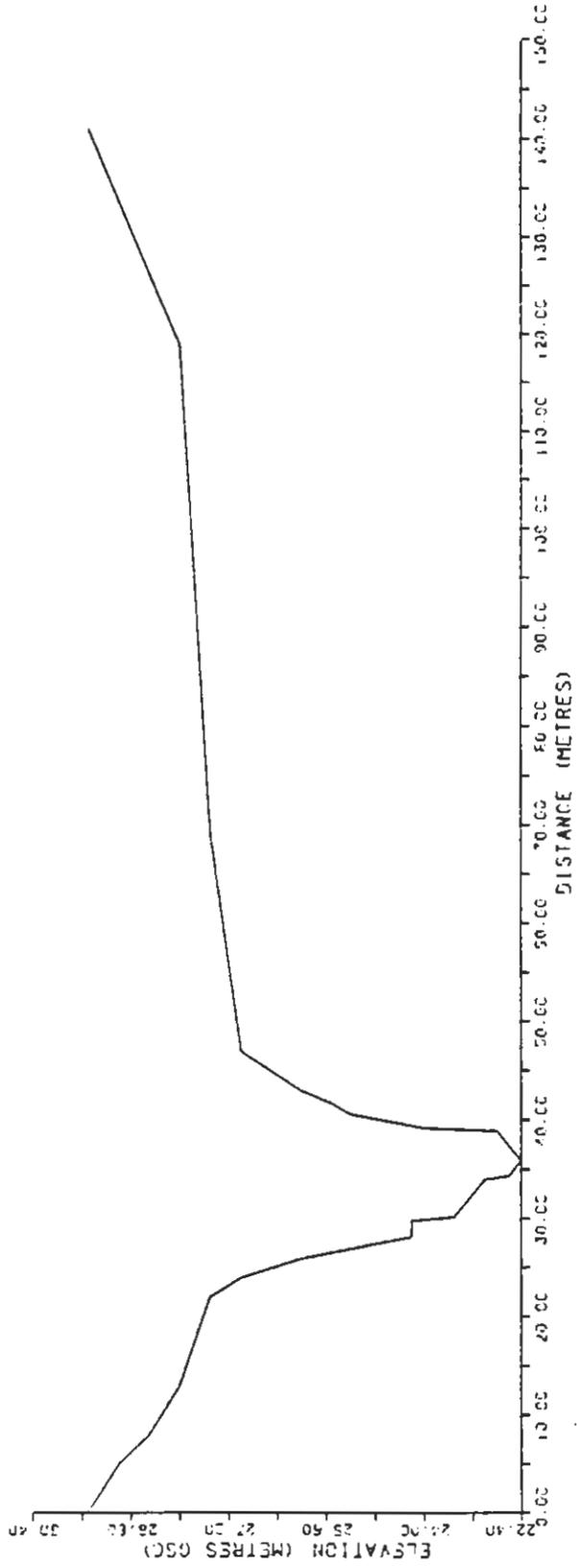


0.0000
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WATERFORD RIVER HEC-2 MODEL
 CROSS SECTION NUMBER 3007.9

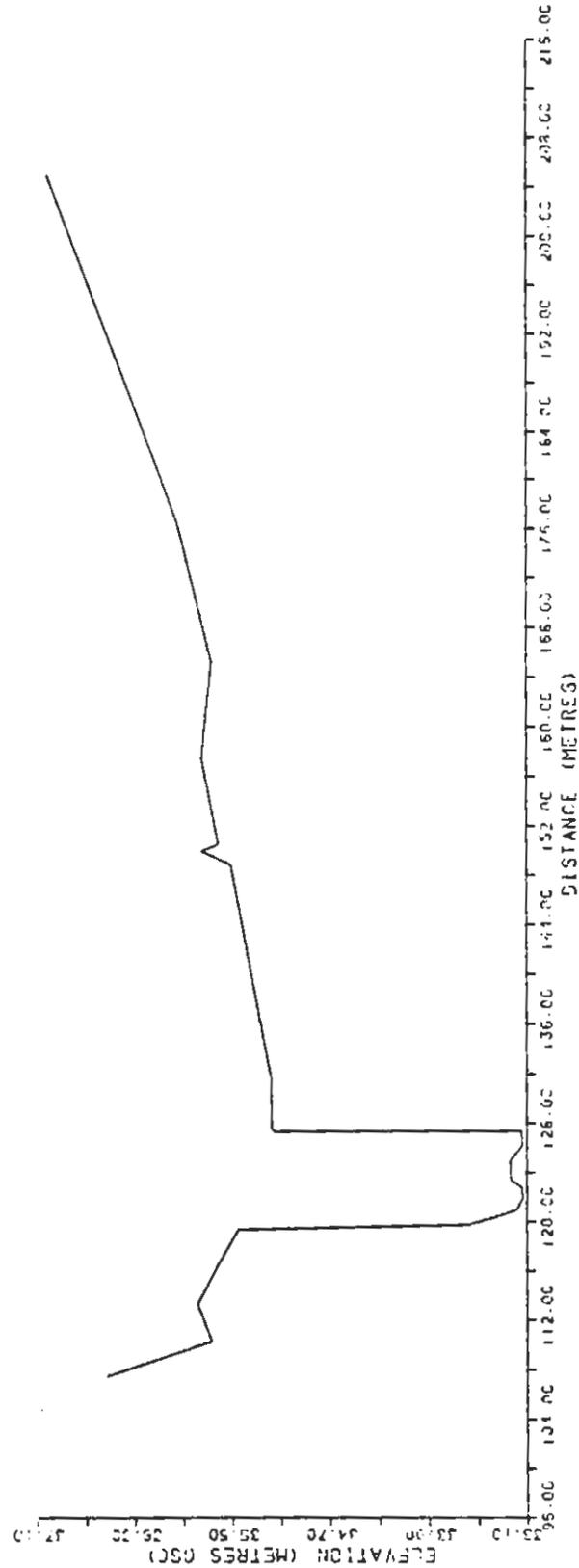


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3008.0



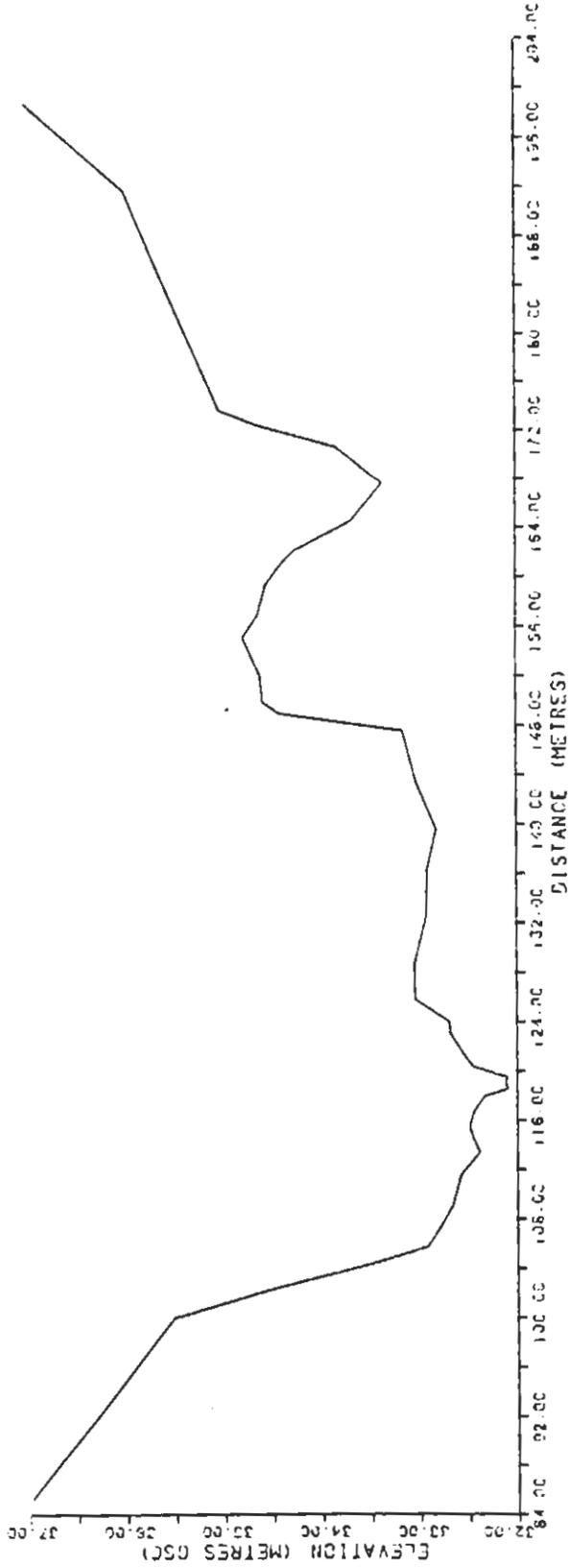
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3008.0



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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3009.0

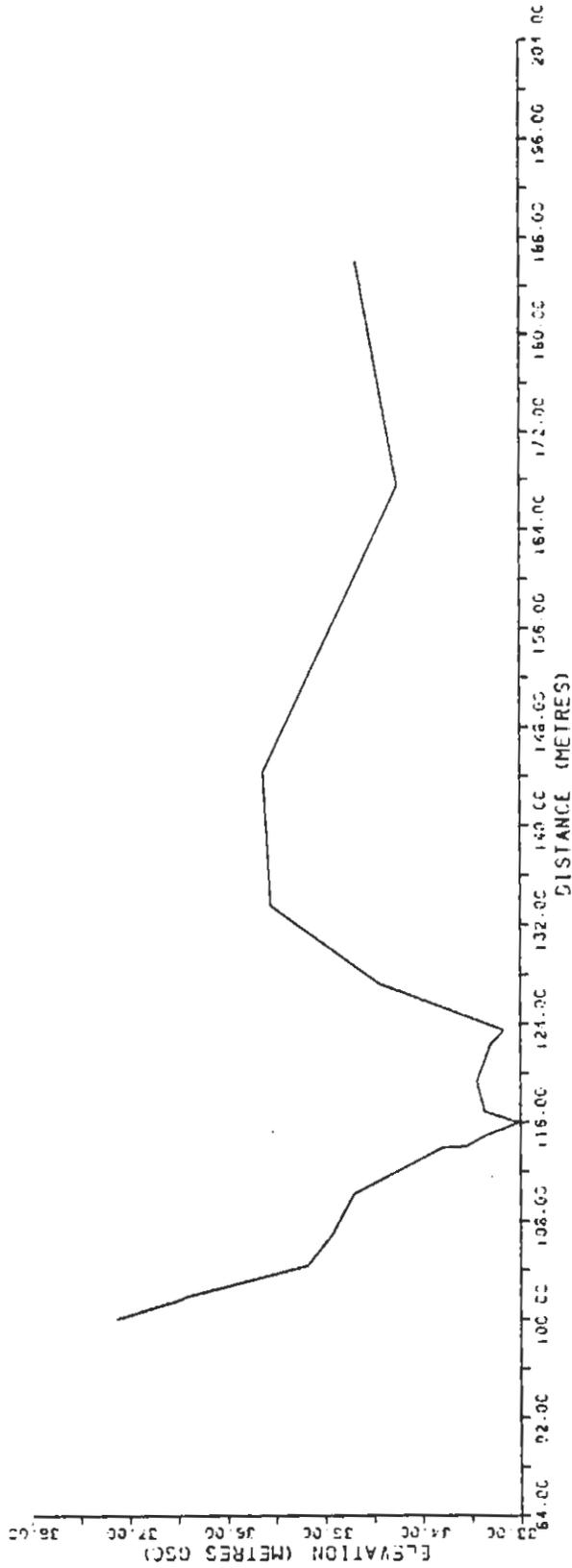


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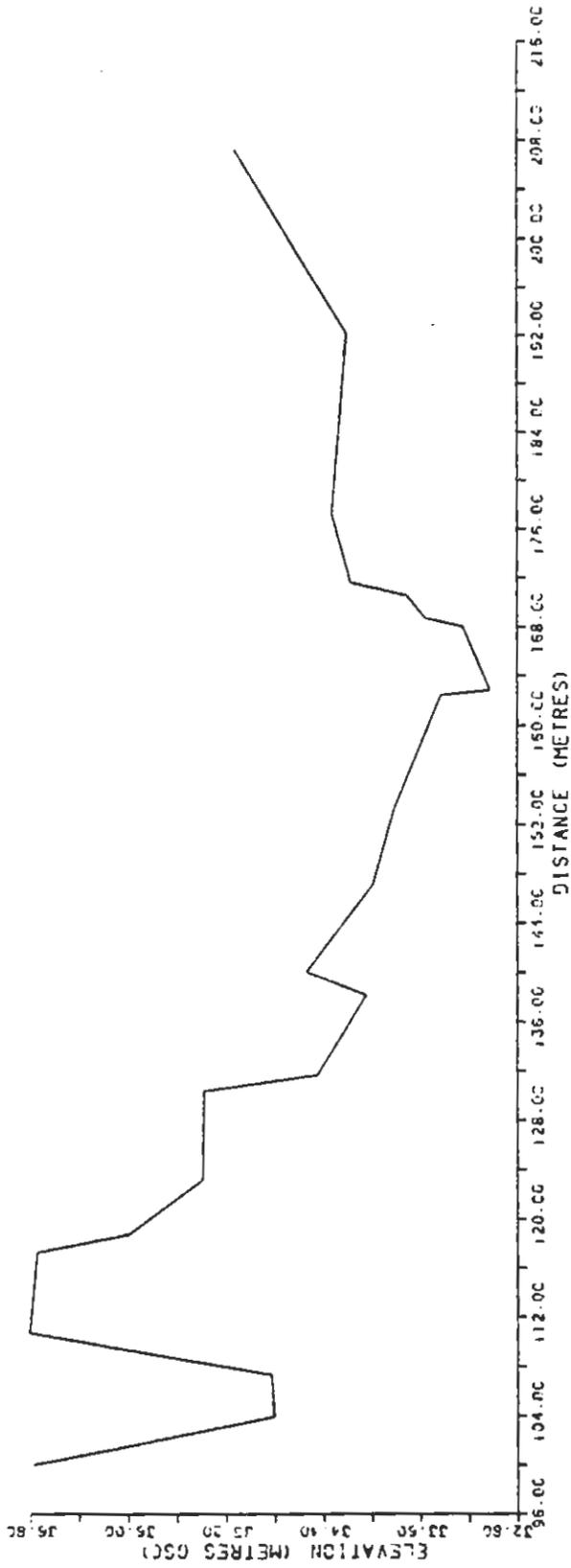
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 3010.0



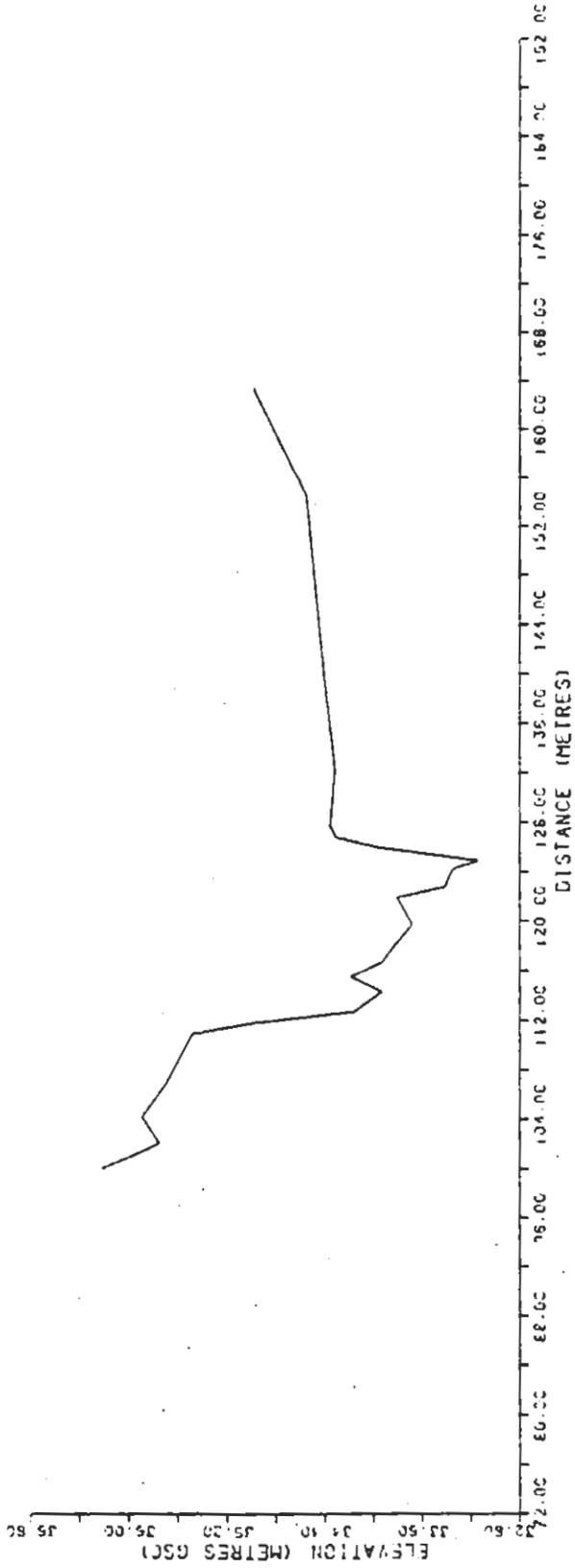
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WATERFORD RIVER HEC-2 MODEL
 CROSS SECTION NUMBER 3011.0



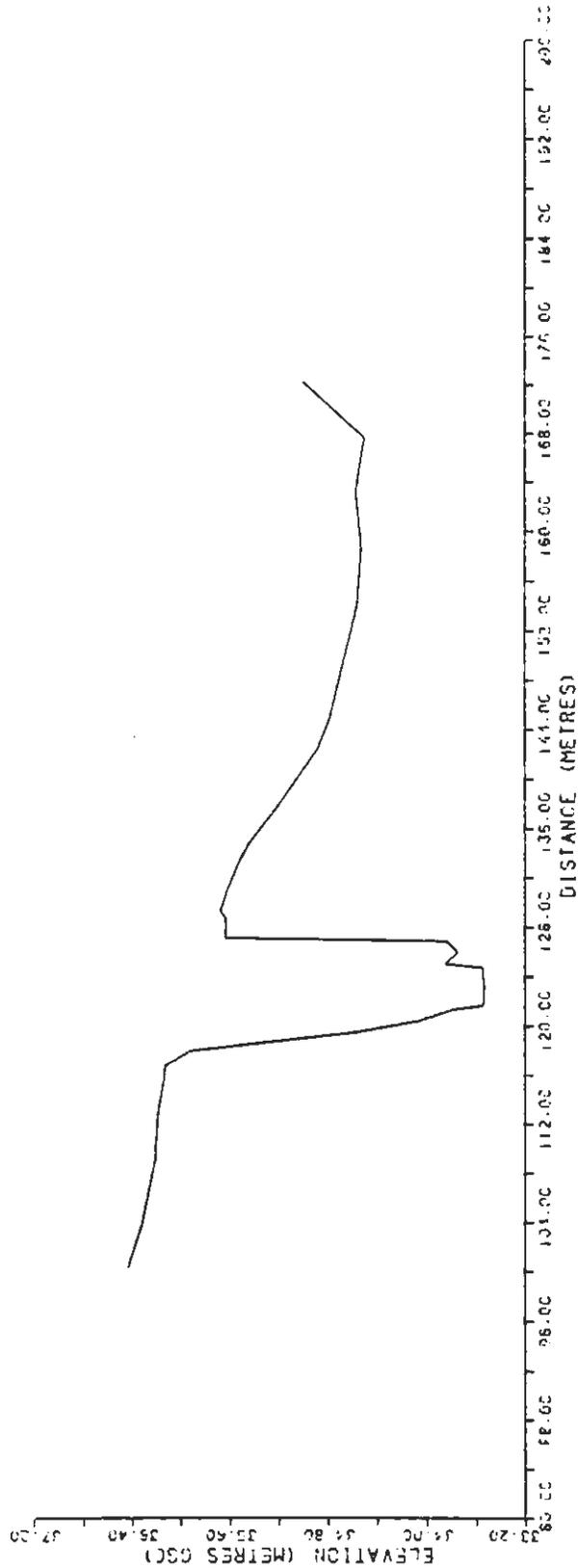
C 0750 C 0750

WATERFORD RIVER HEC-2 MODEL
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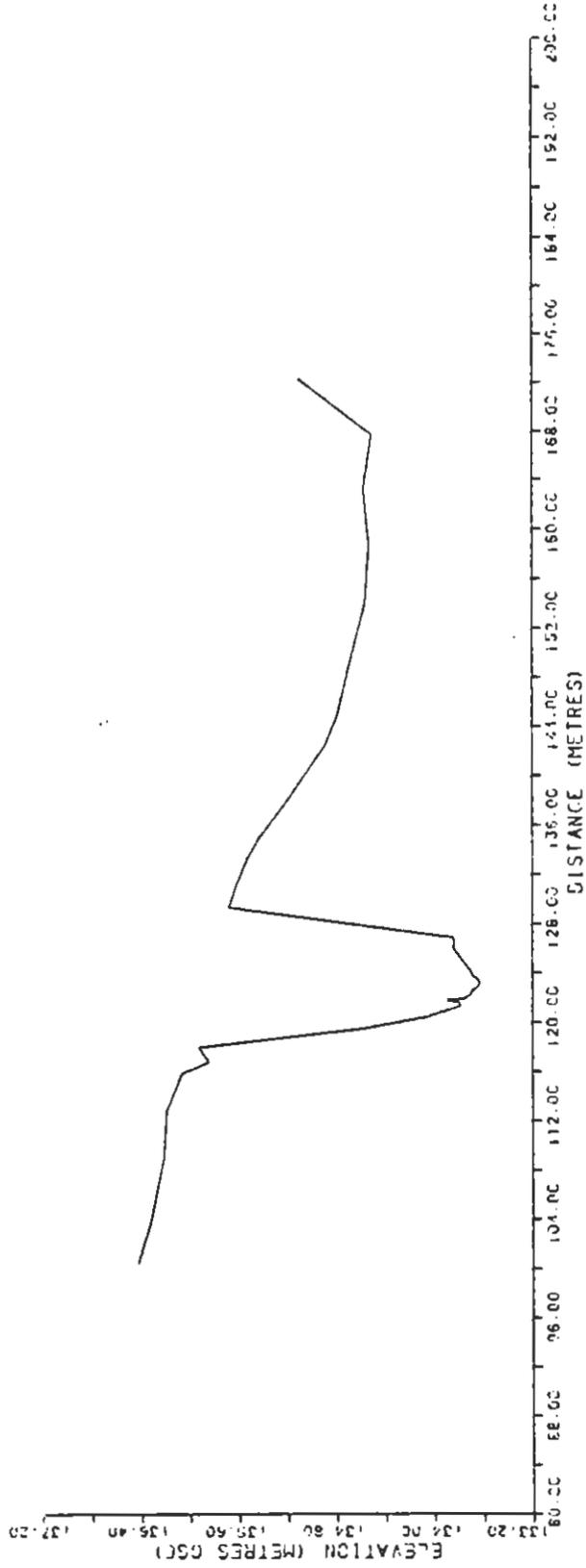
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WATERFORD RIVER HEC-2 MODEL
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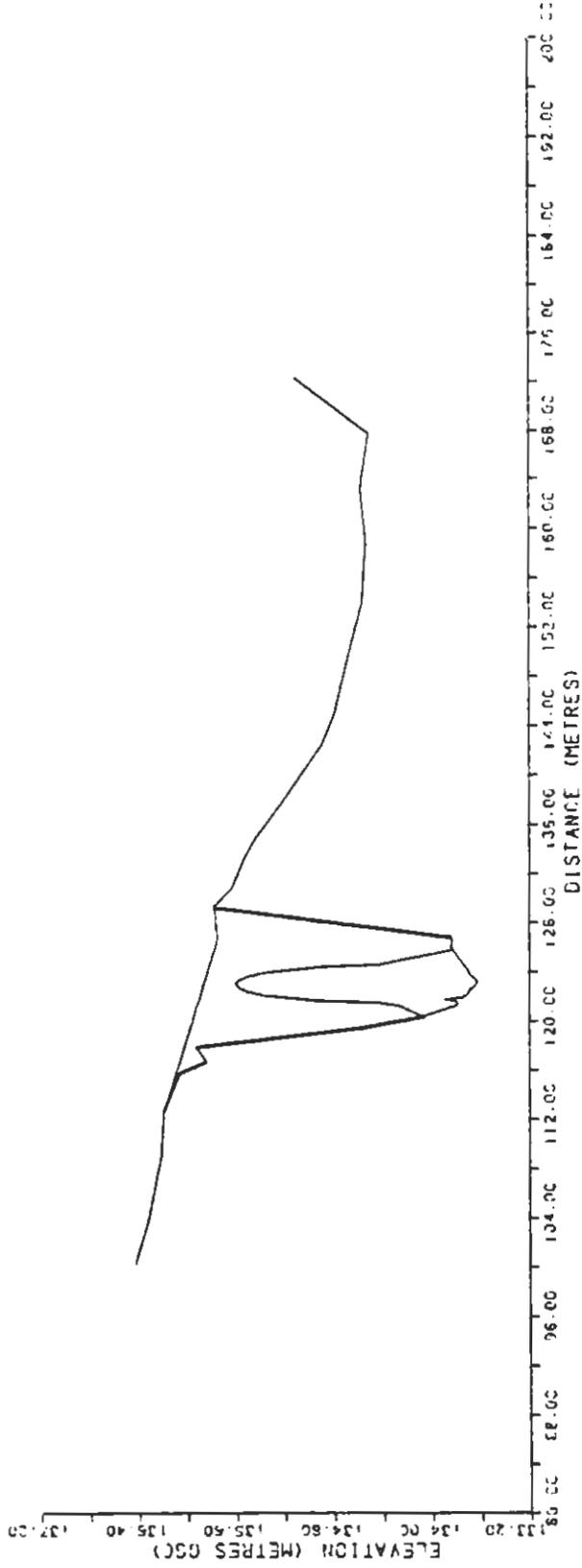
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WATERFORD RIVER HEC-2 MODEL
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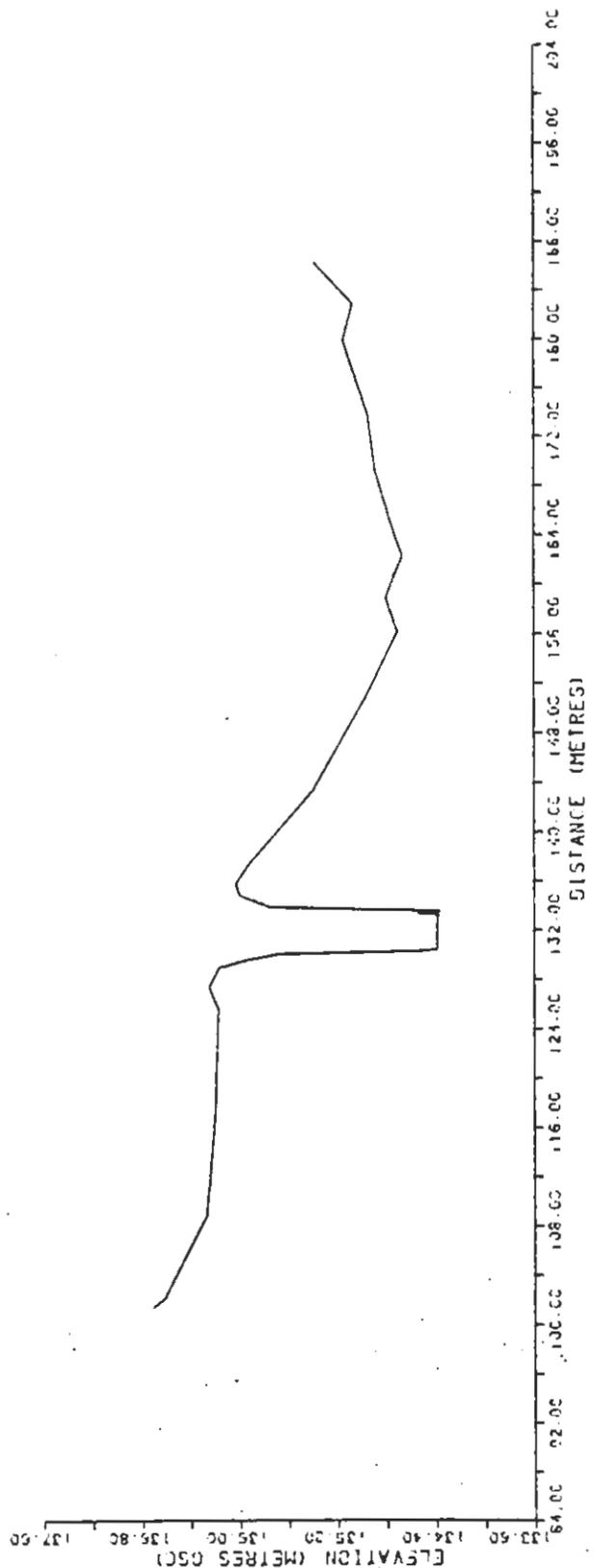
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CROSS SECTION NUMBER 3014.7



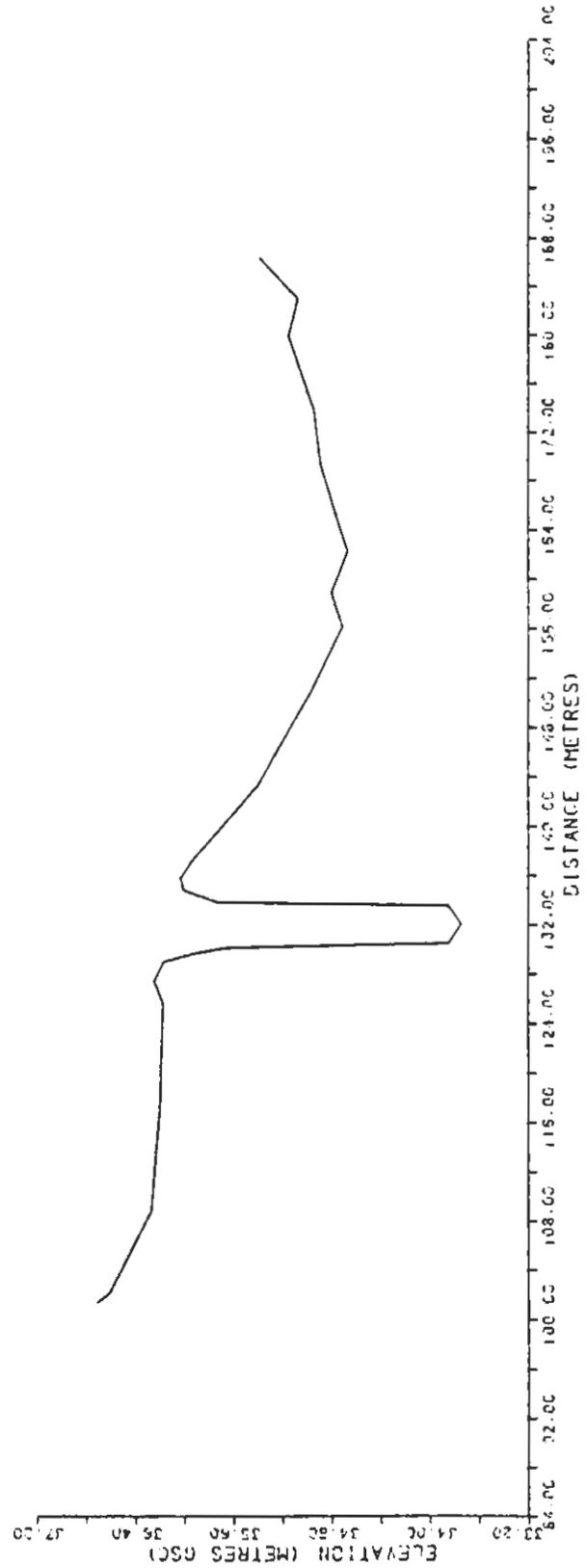
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 CROSS SECTION NUMBER 3014.8



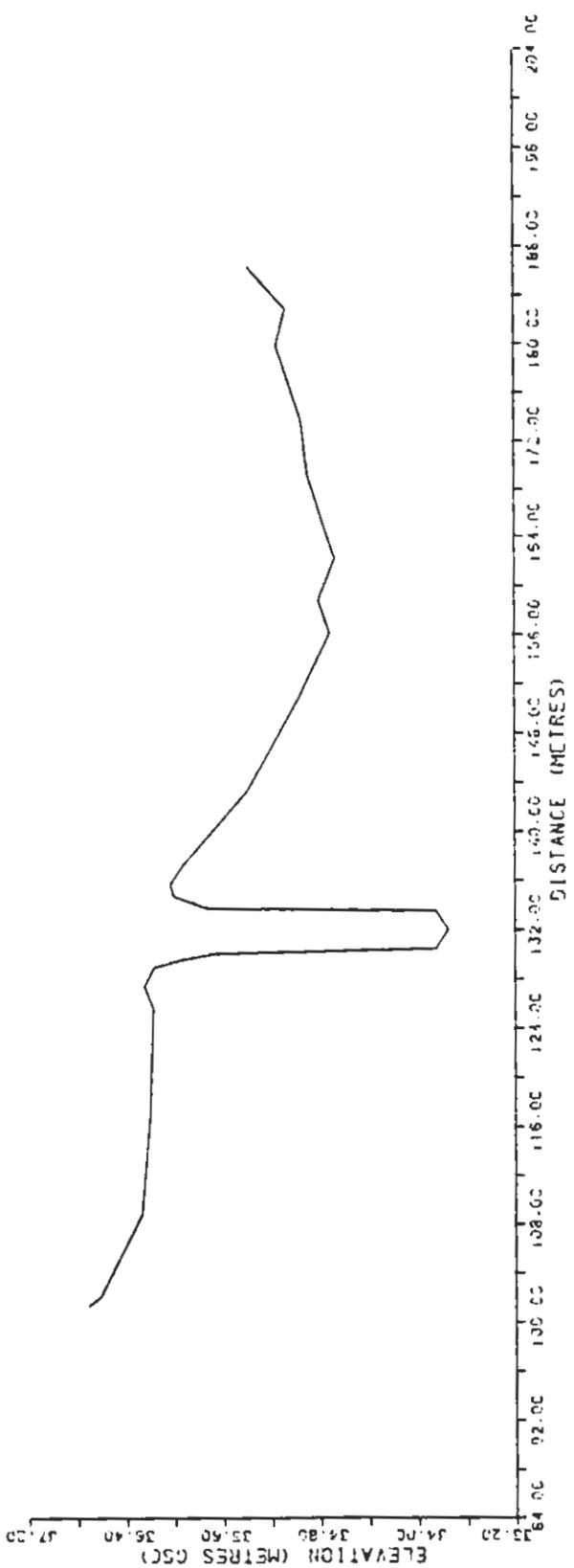
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CROSS SECTION NUMBER 3014.9



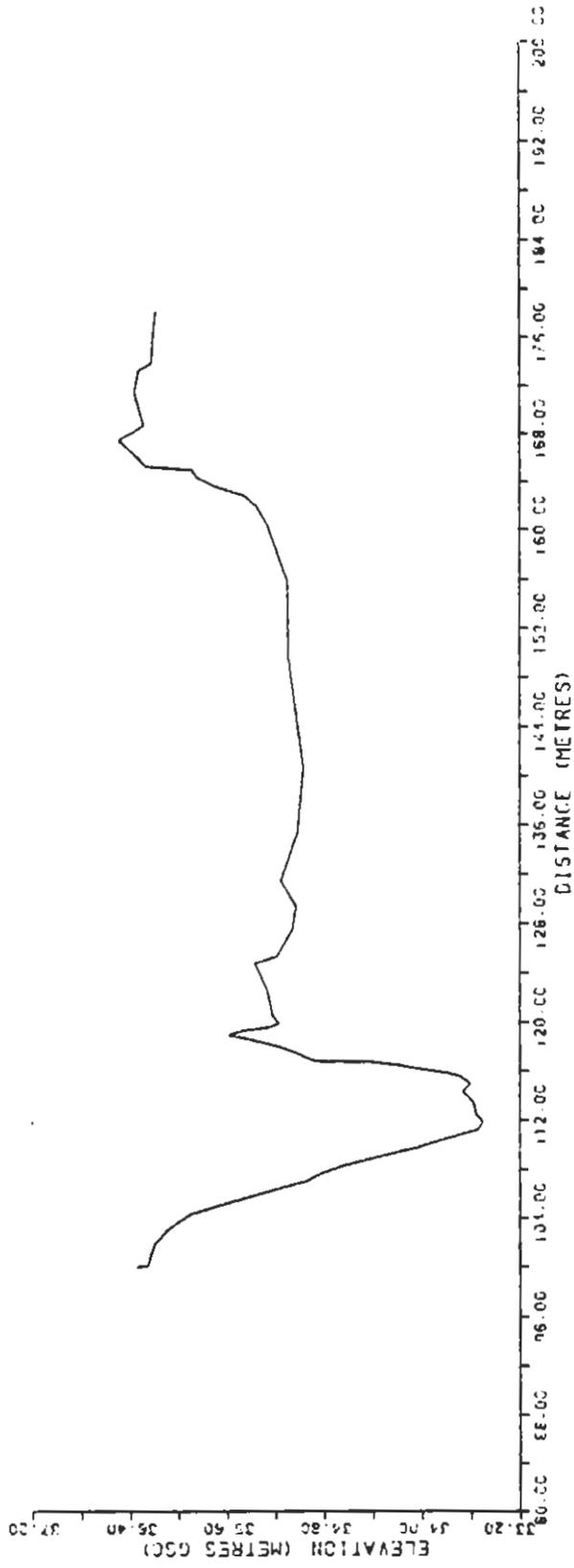
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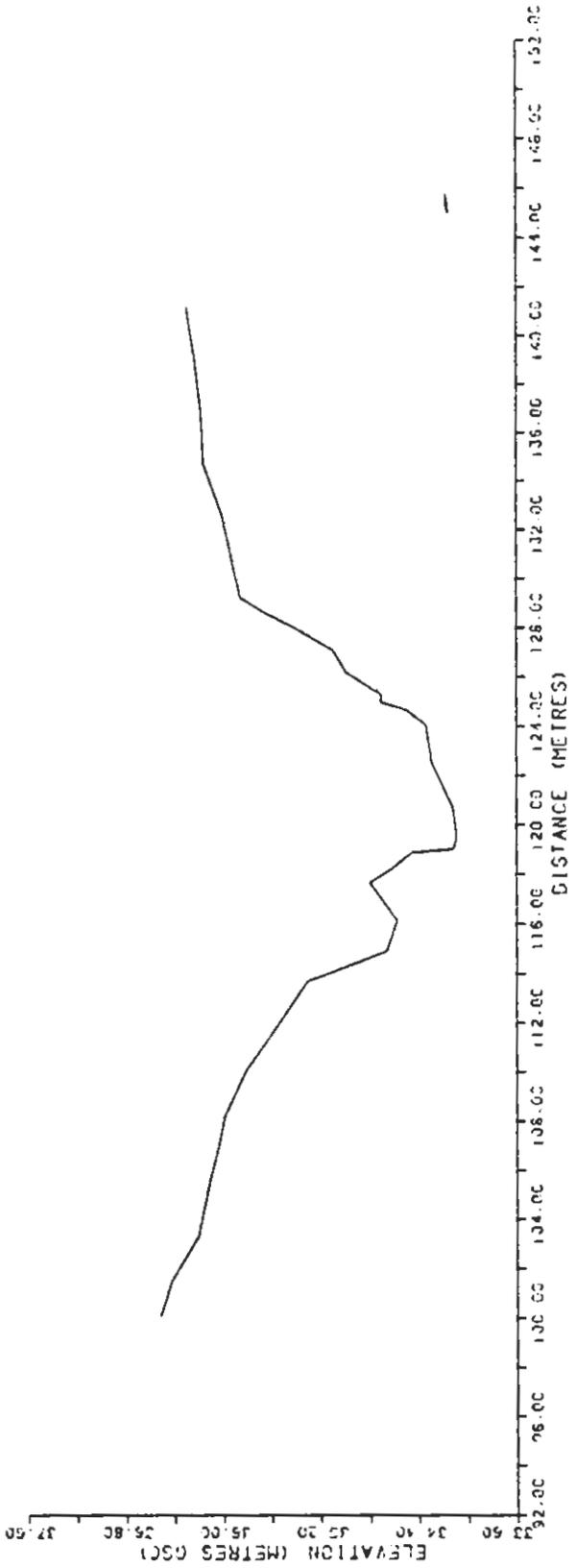


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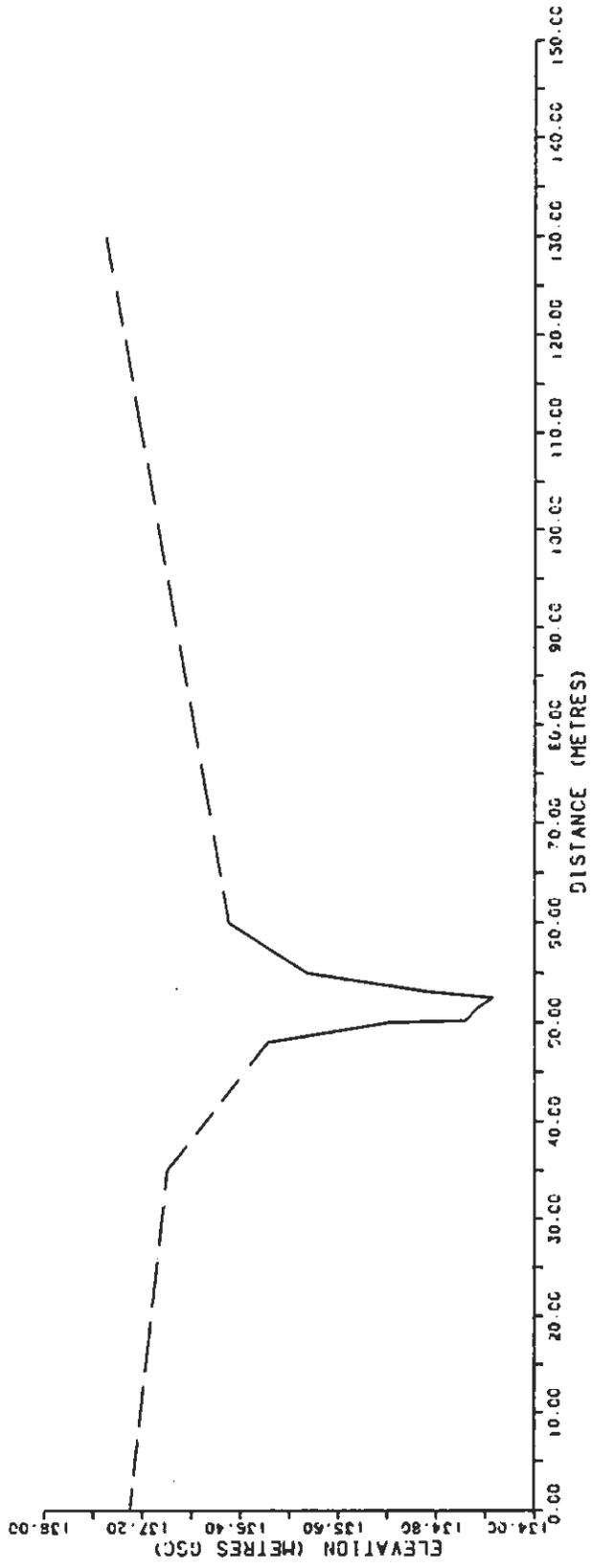
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CROSS SECTION NUMBER 3017.0

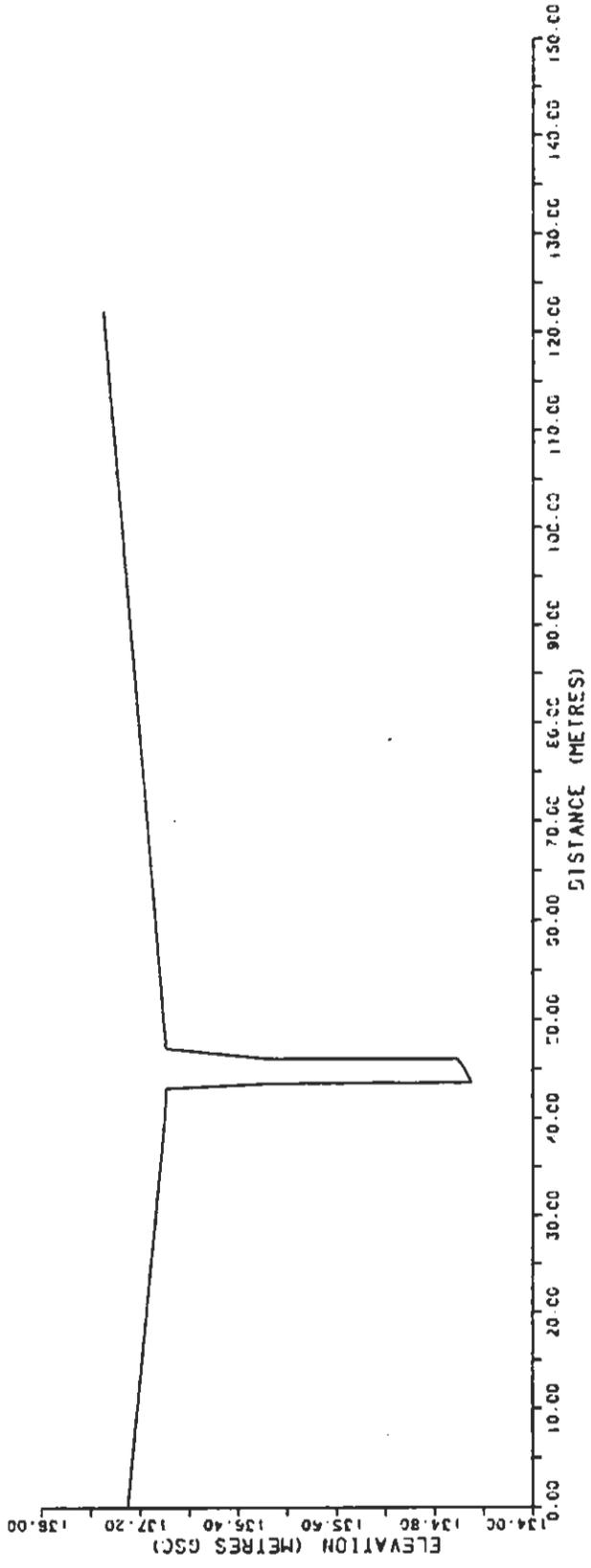


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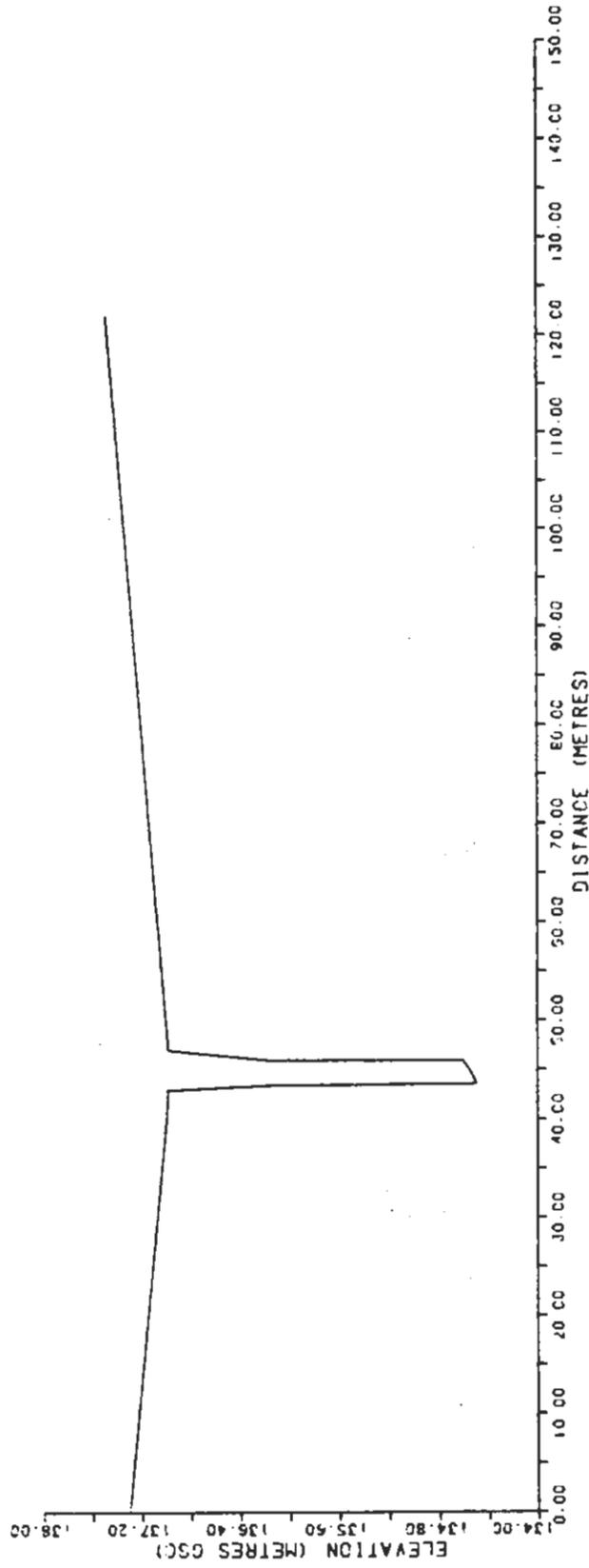
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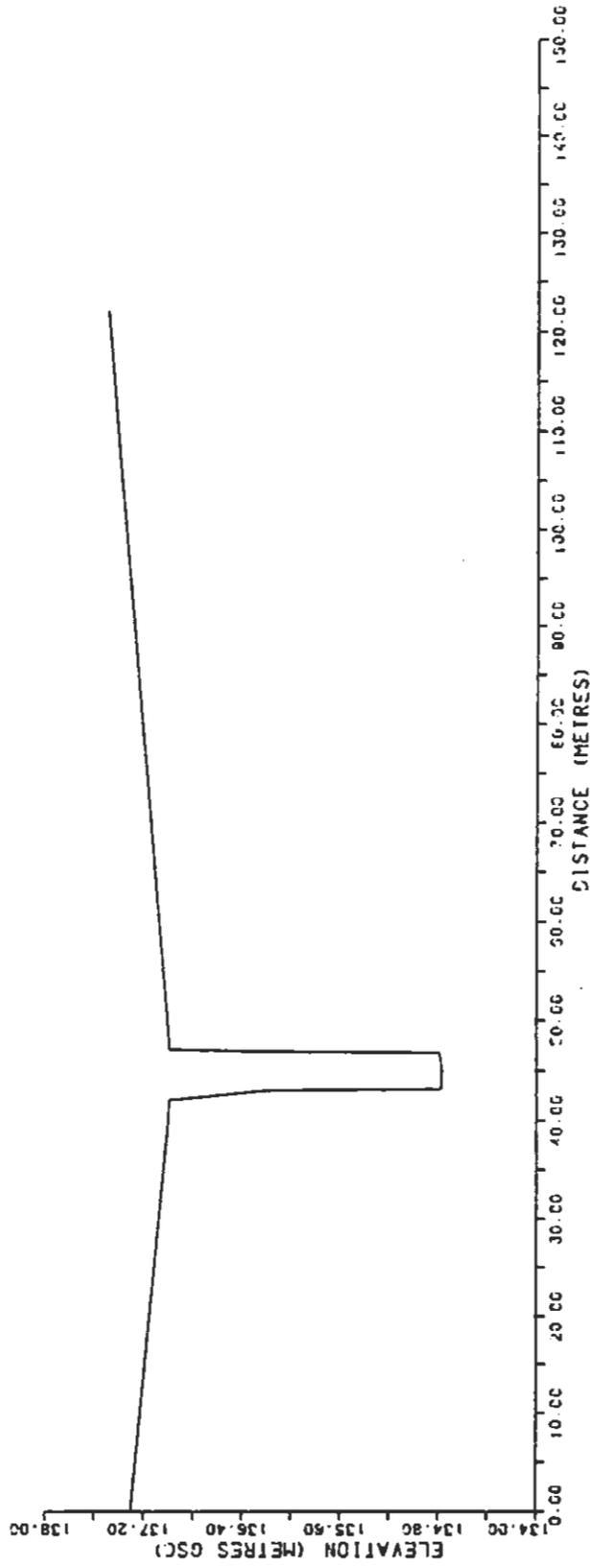
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WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 12327.

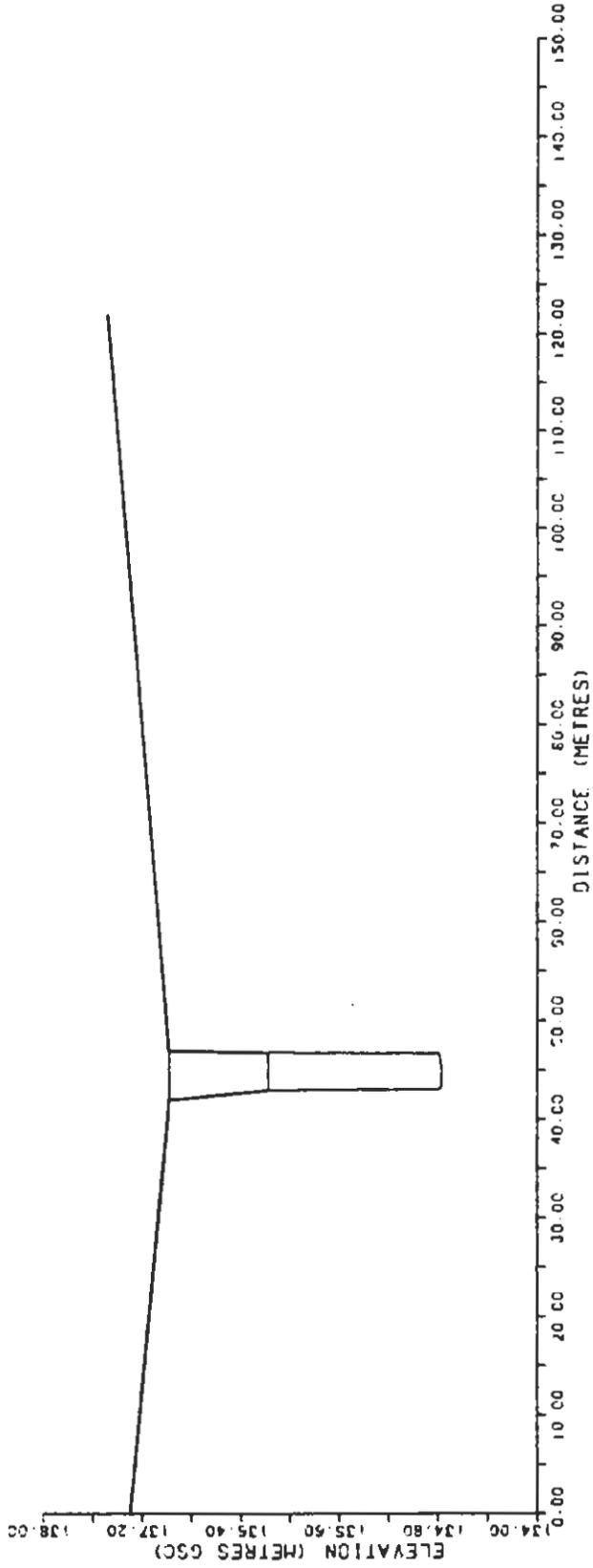


||
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WATERFORD RIVER HEC-2 MODEL
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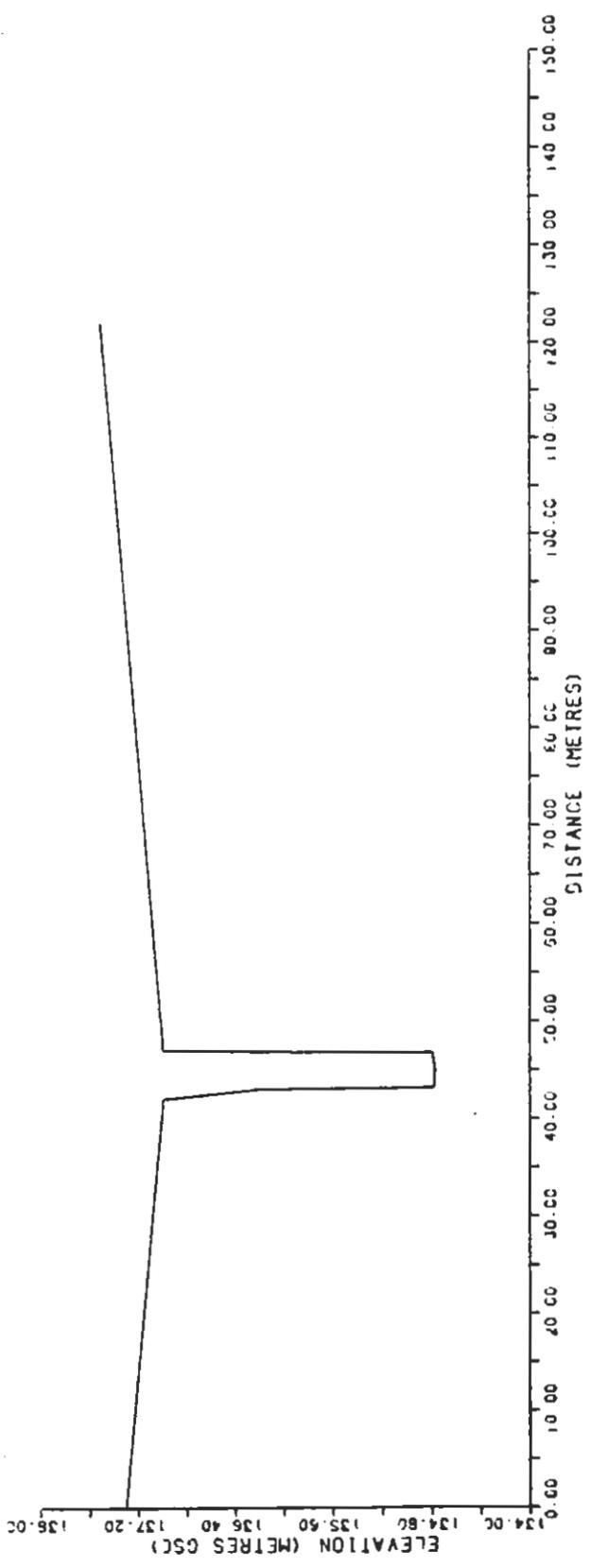


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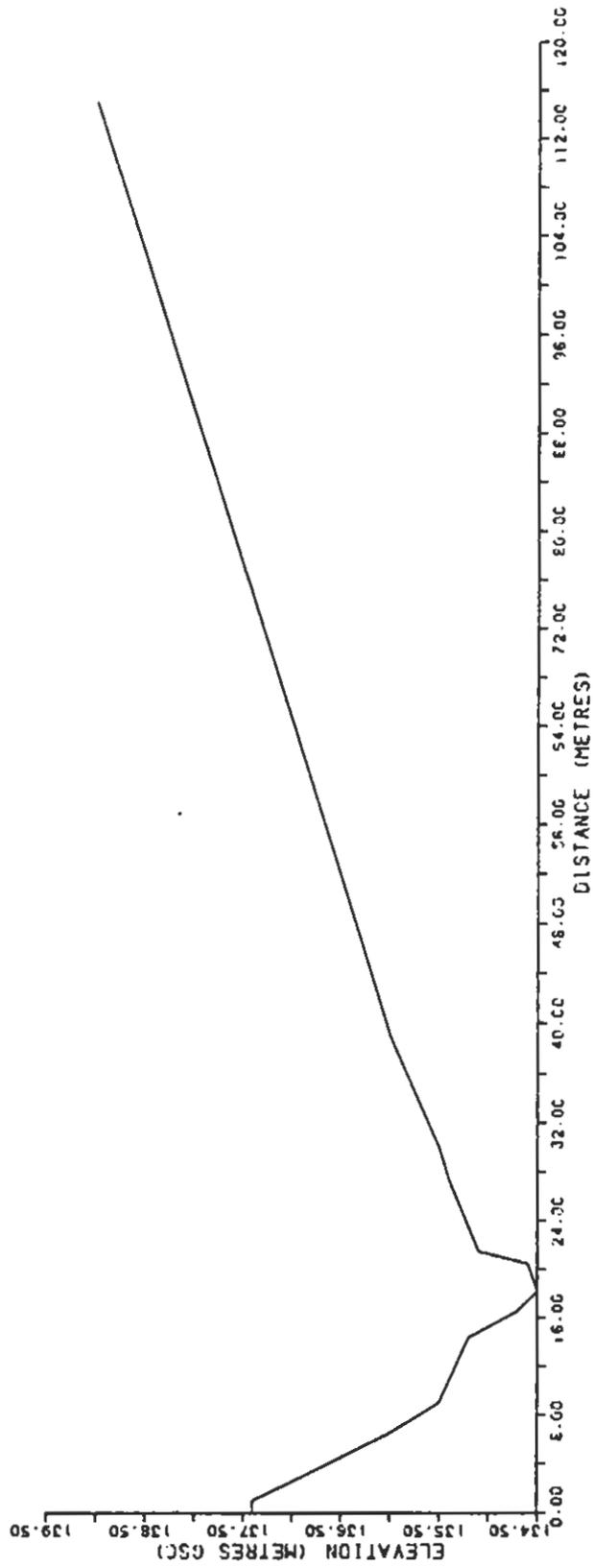
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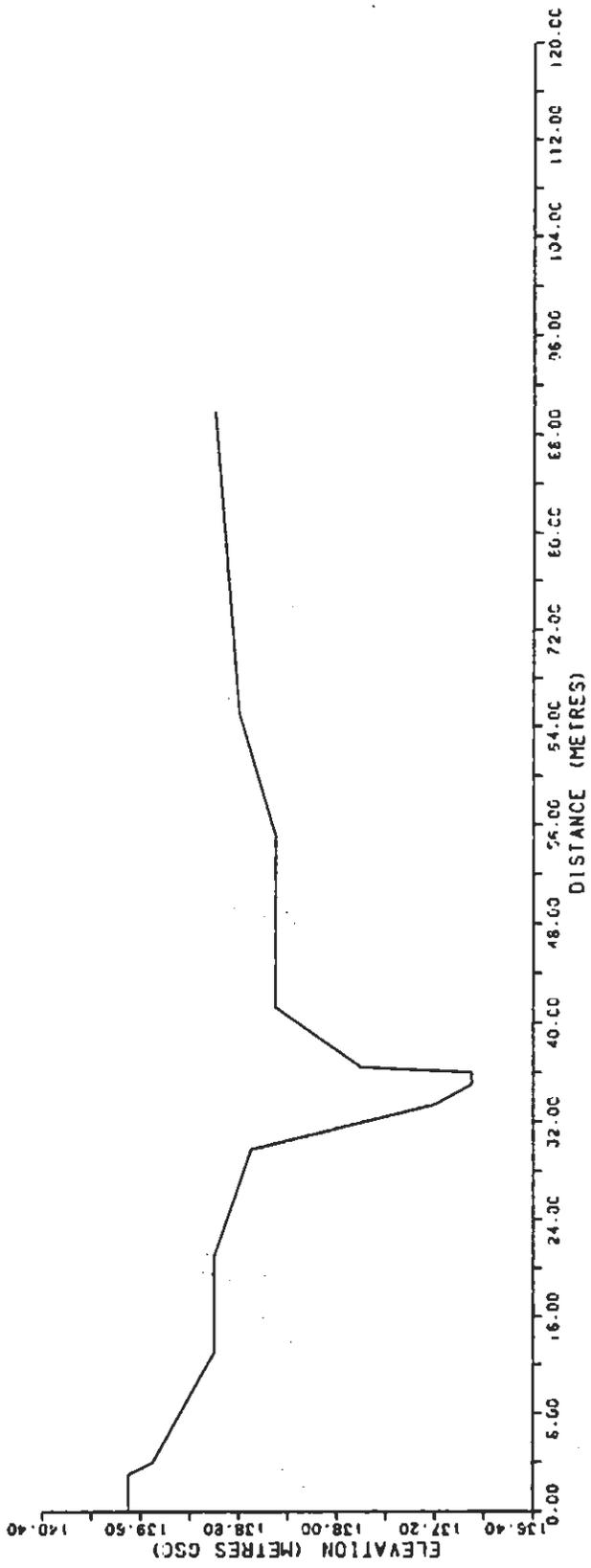


0.0500 0.0450 0.0500

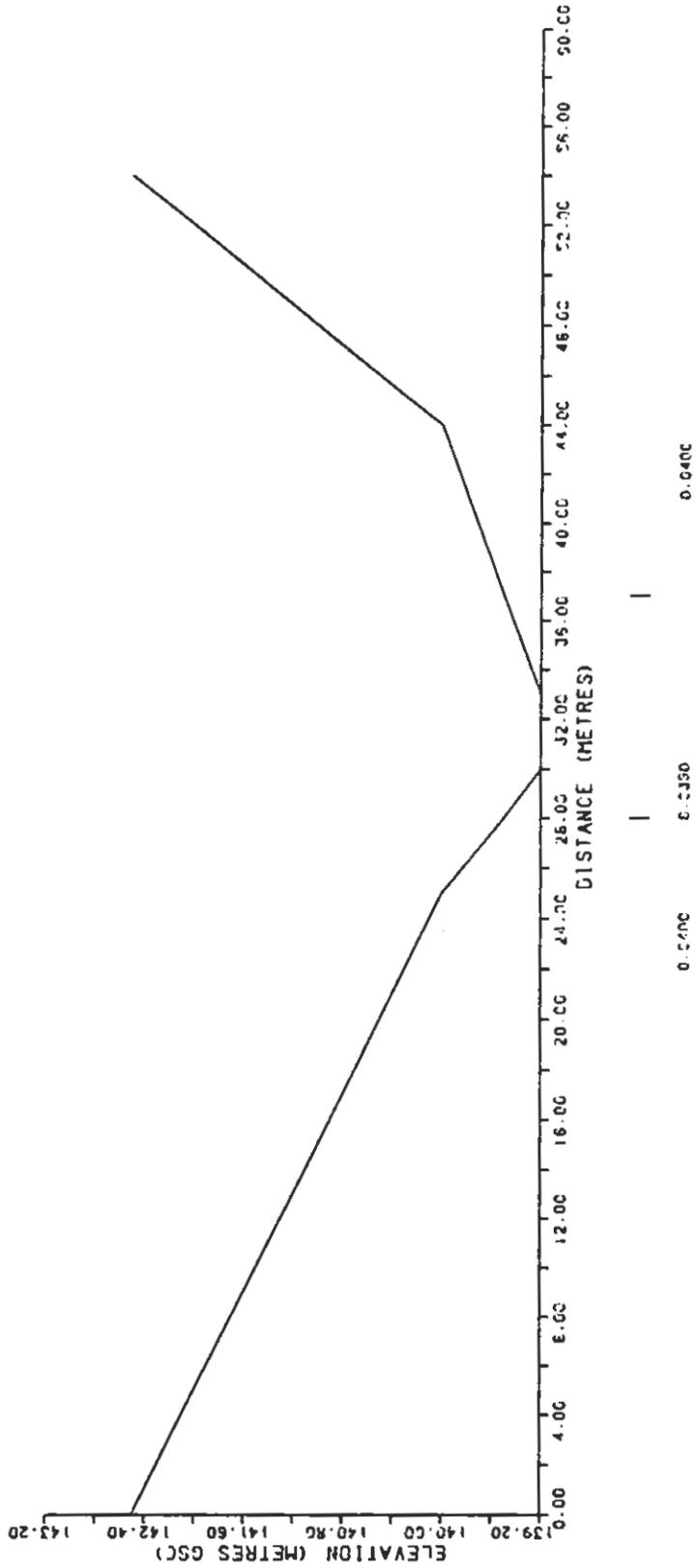
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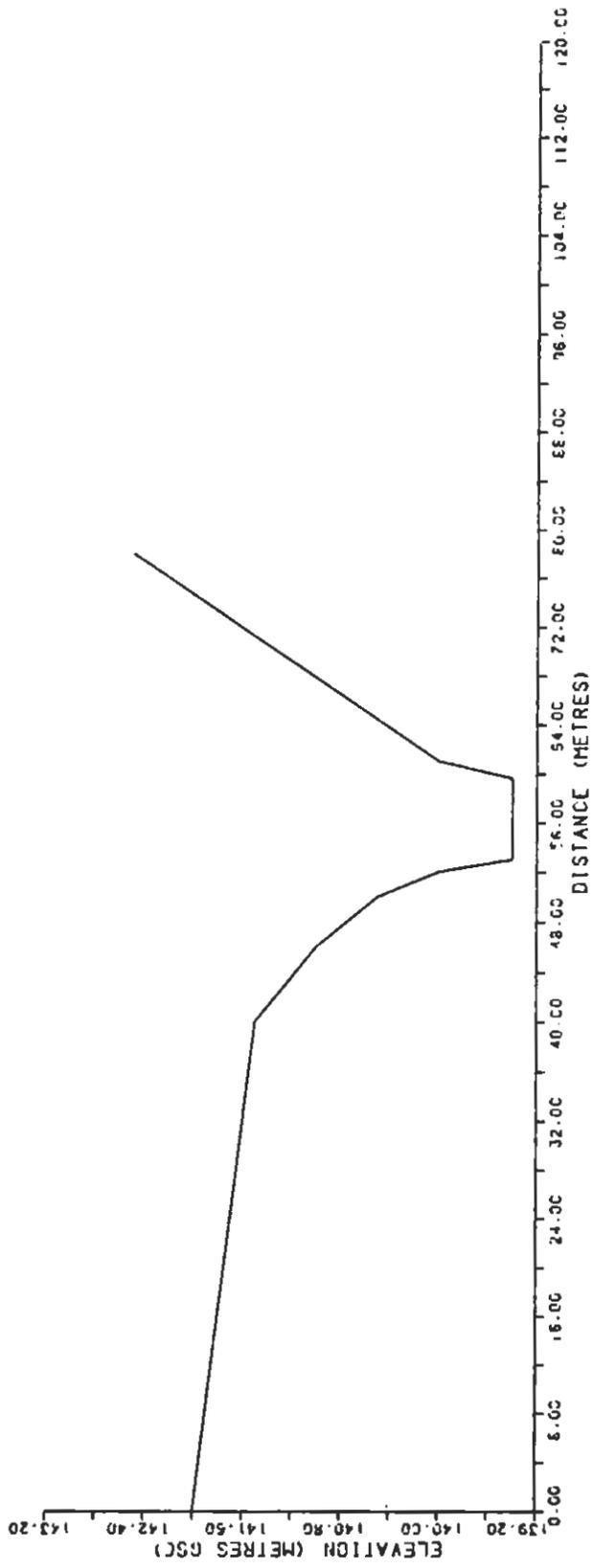
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CROSS SECTION NUMBER 12458.



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 12572.

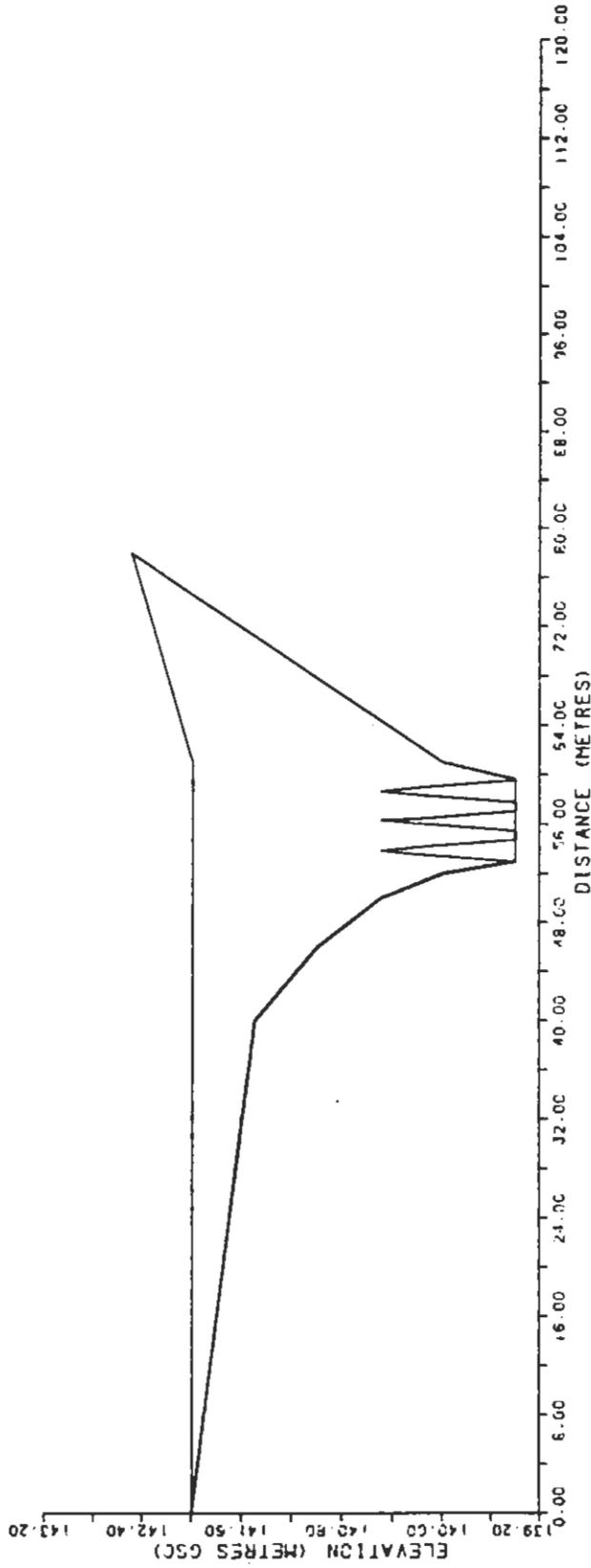


WATERFORD RIVER
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CROSS SECTION NUMBER 12593.

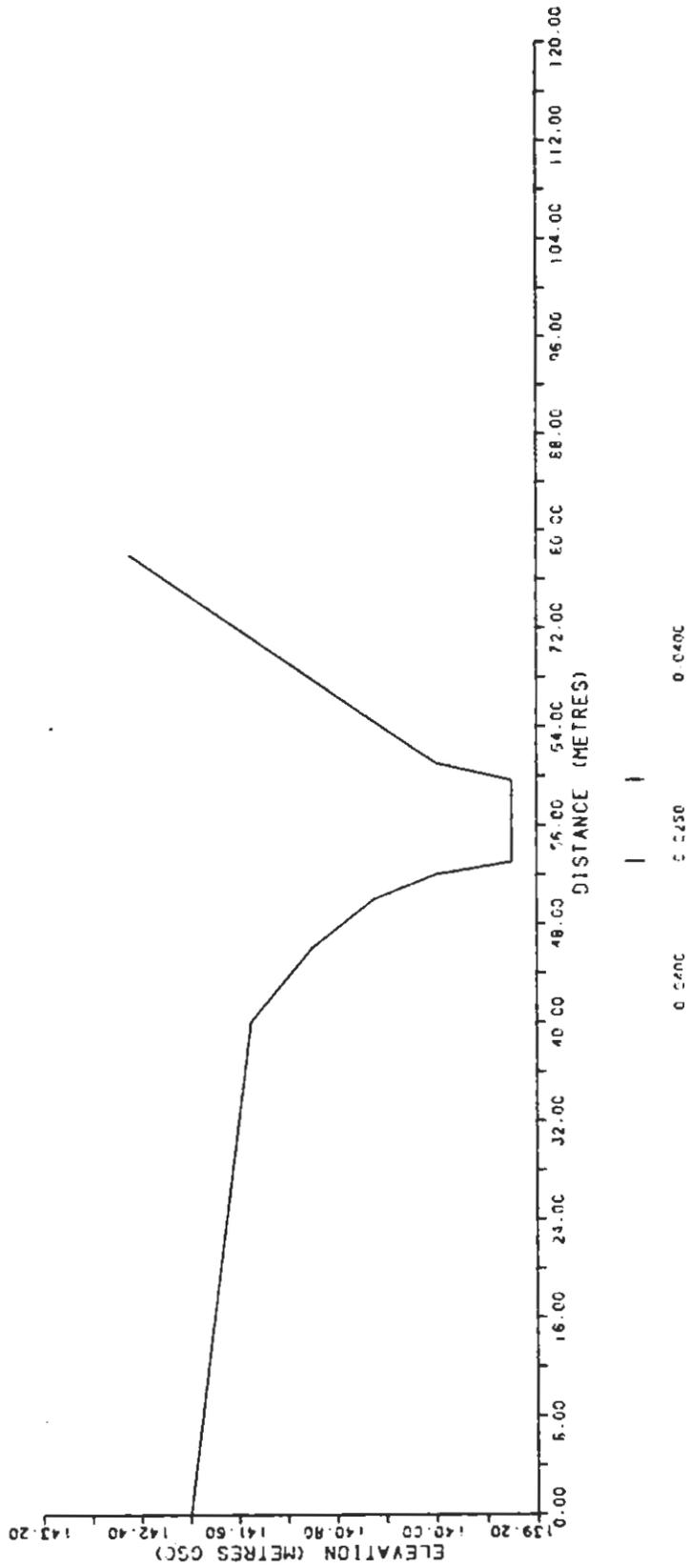


0.0000 0.2500 0.0000

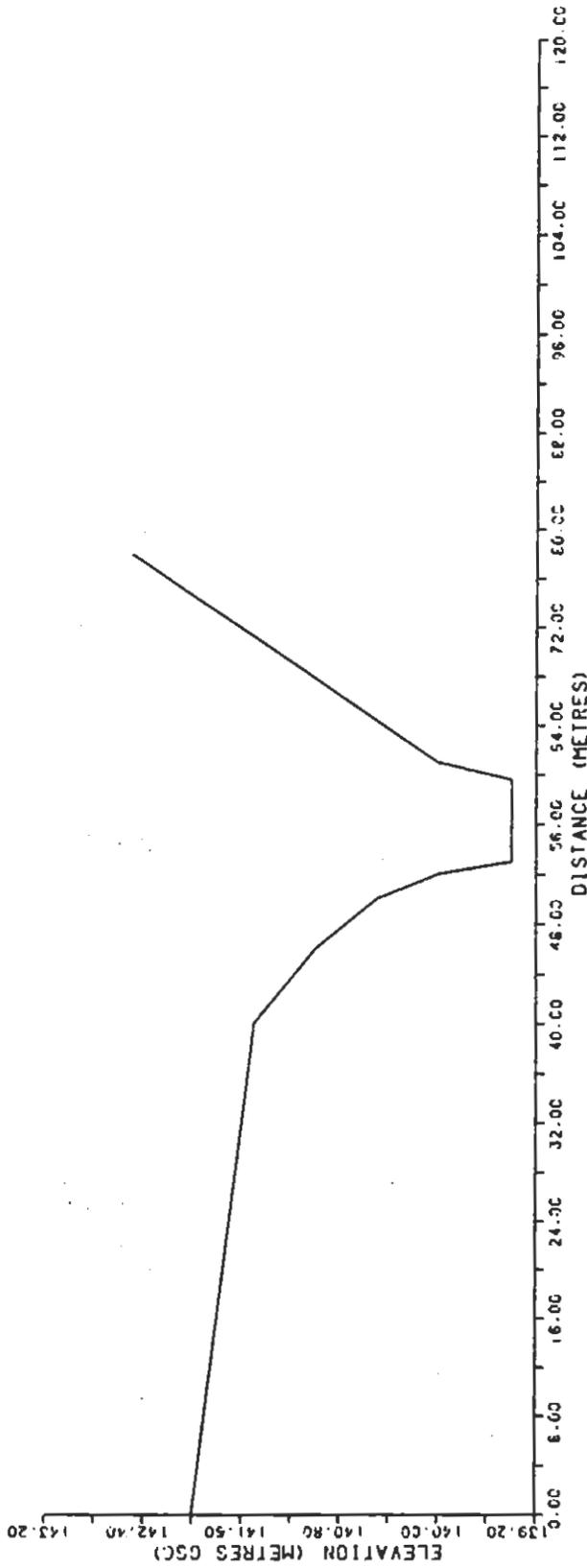
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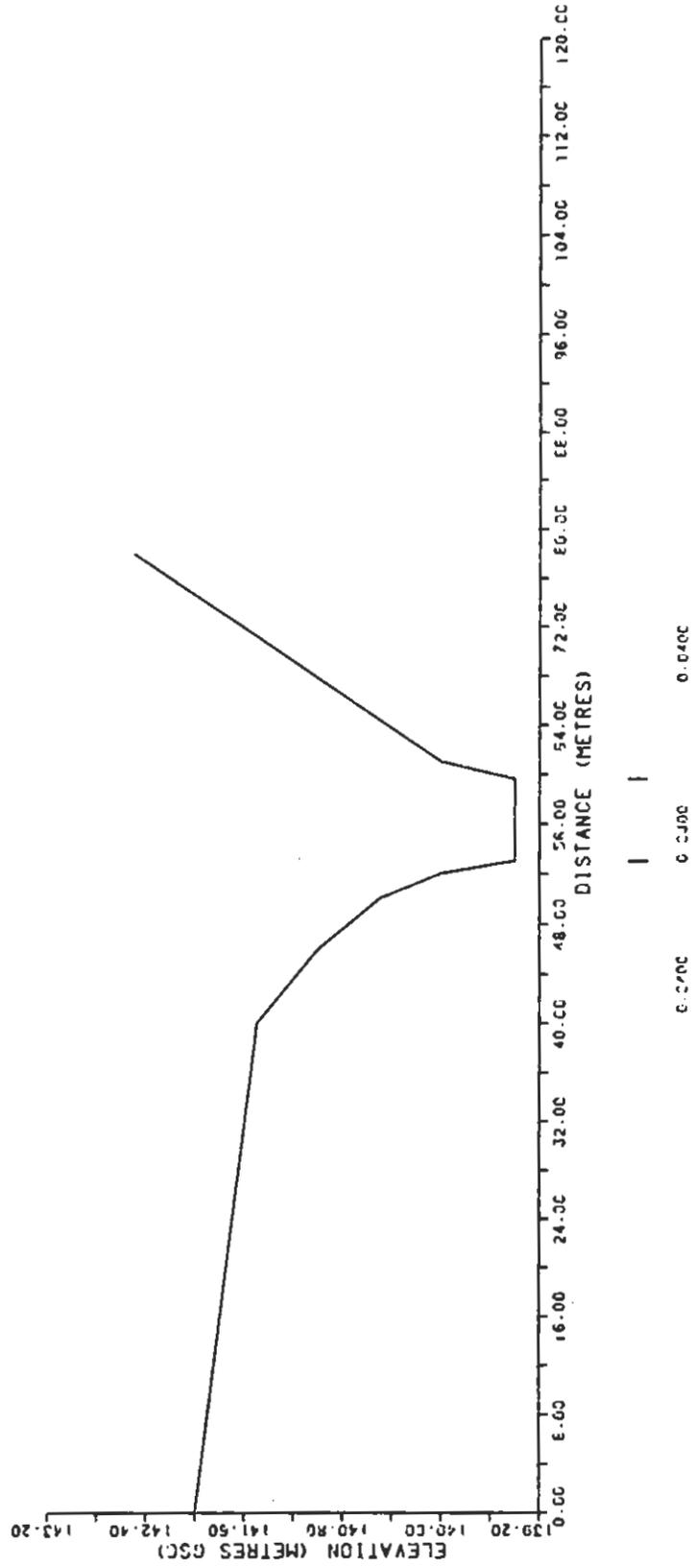
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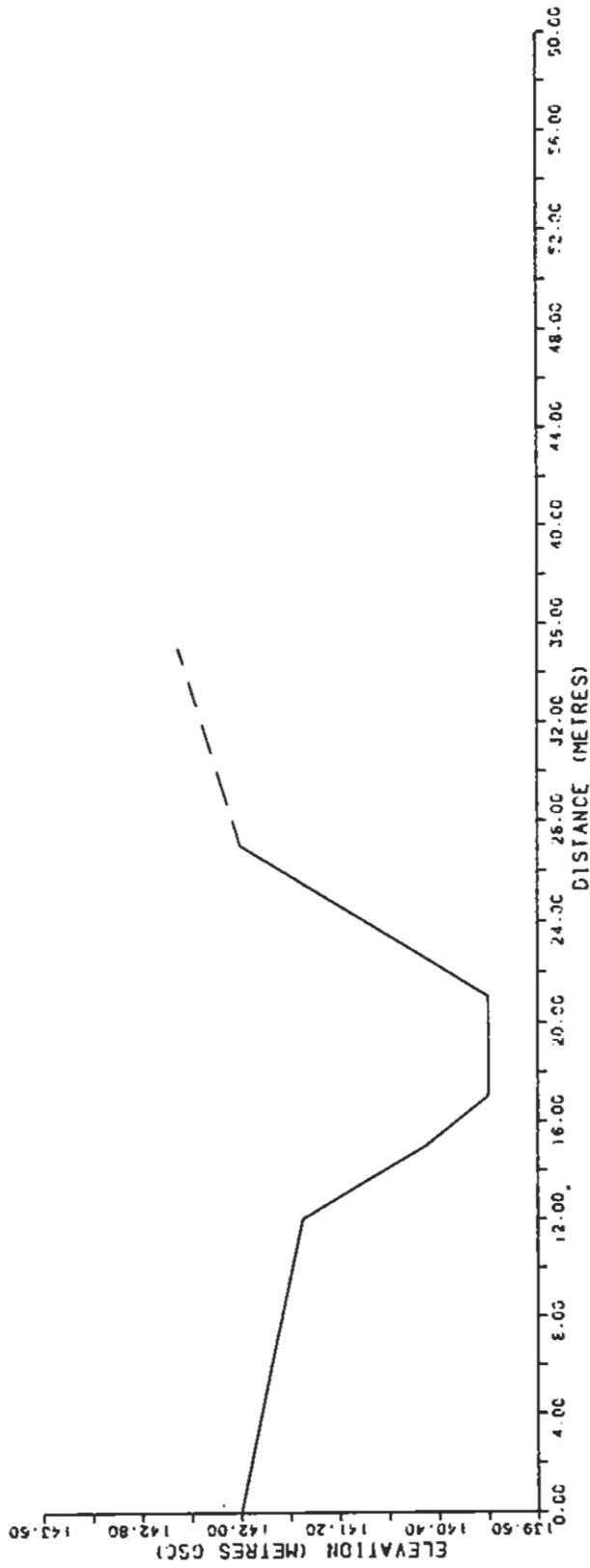
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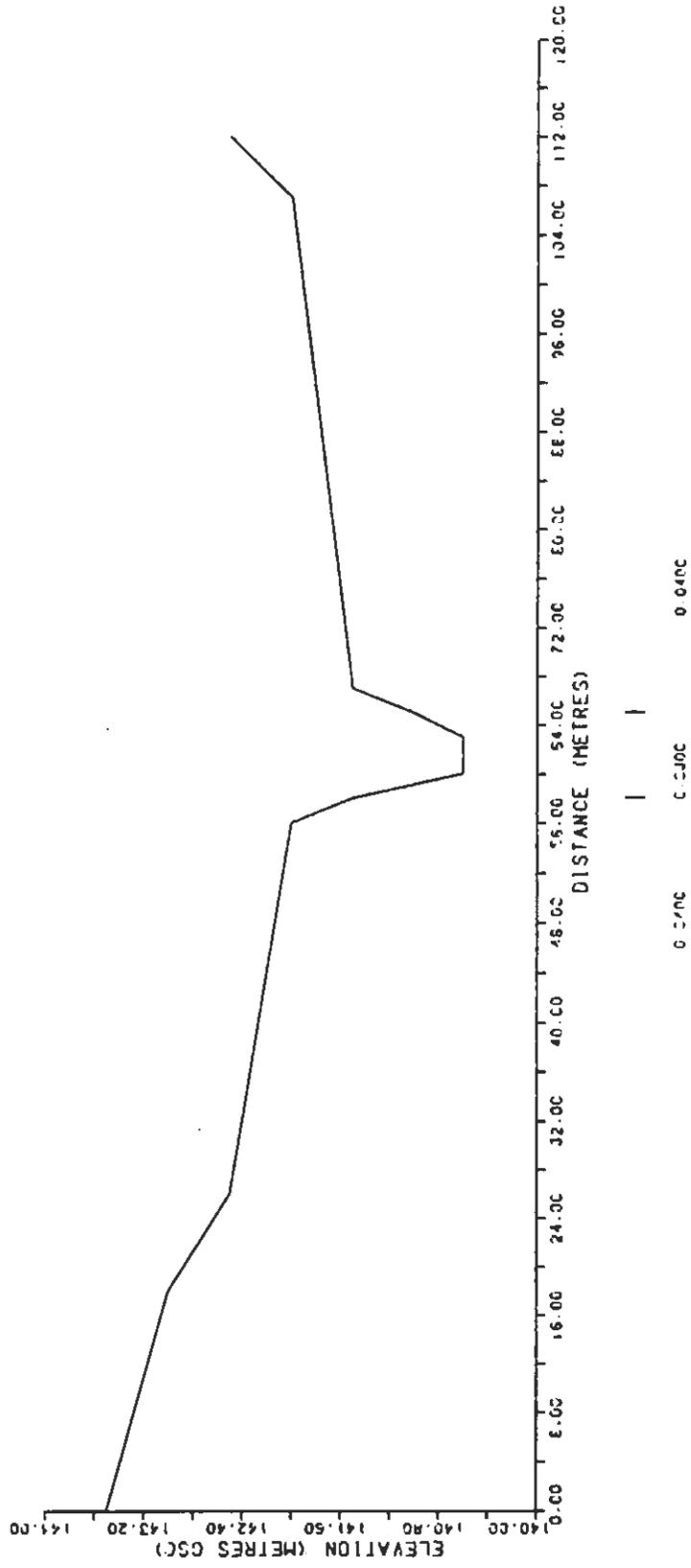
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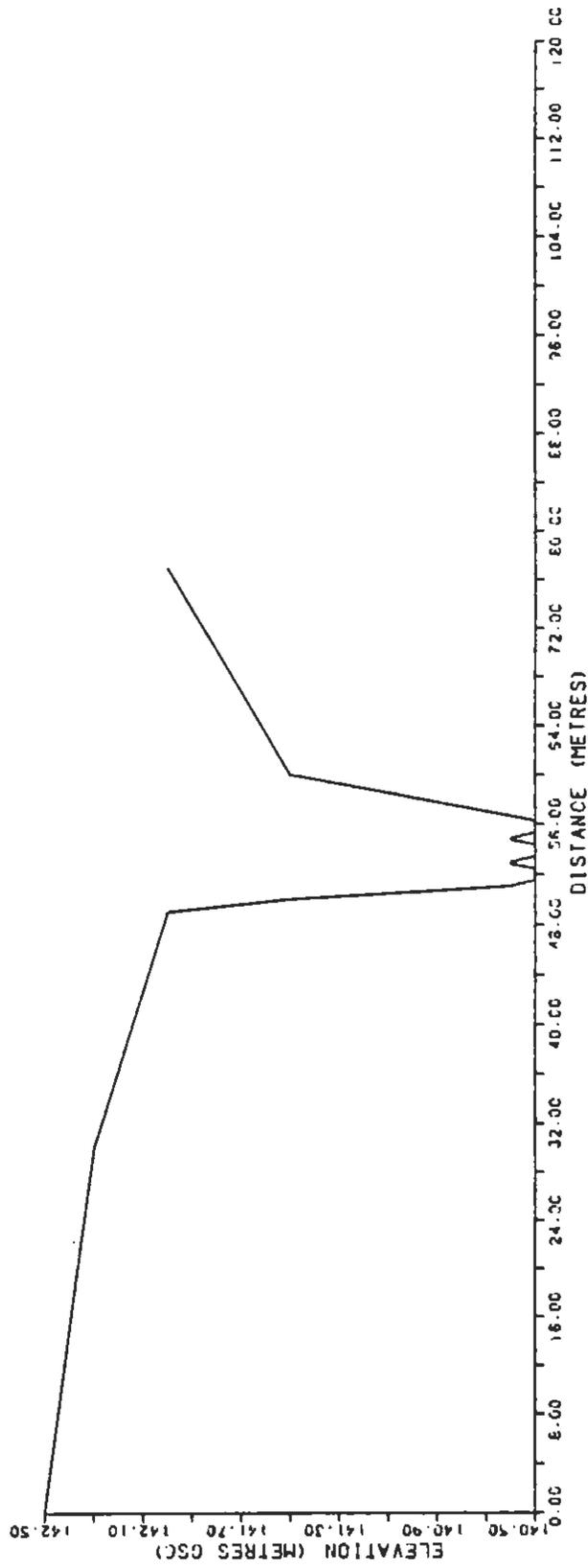
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WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 12717.

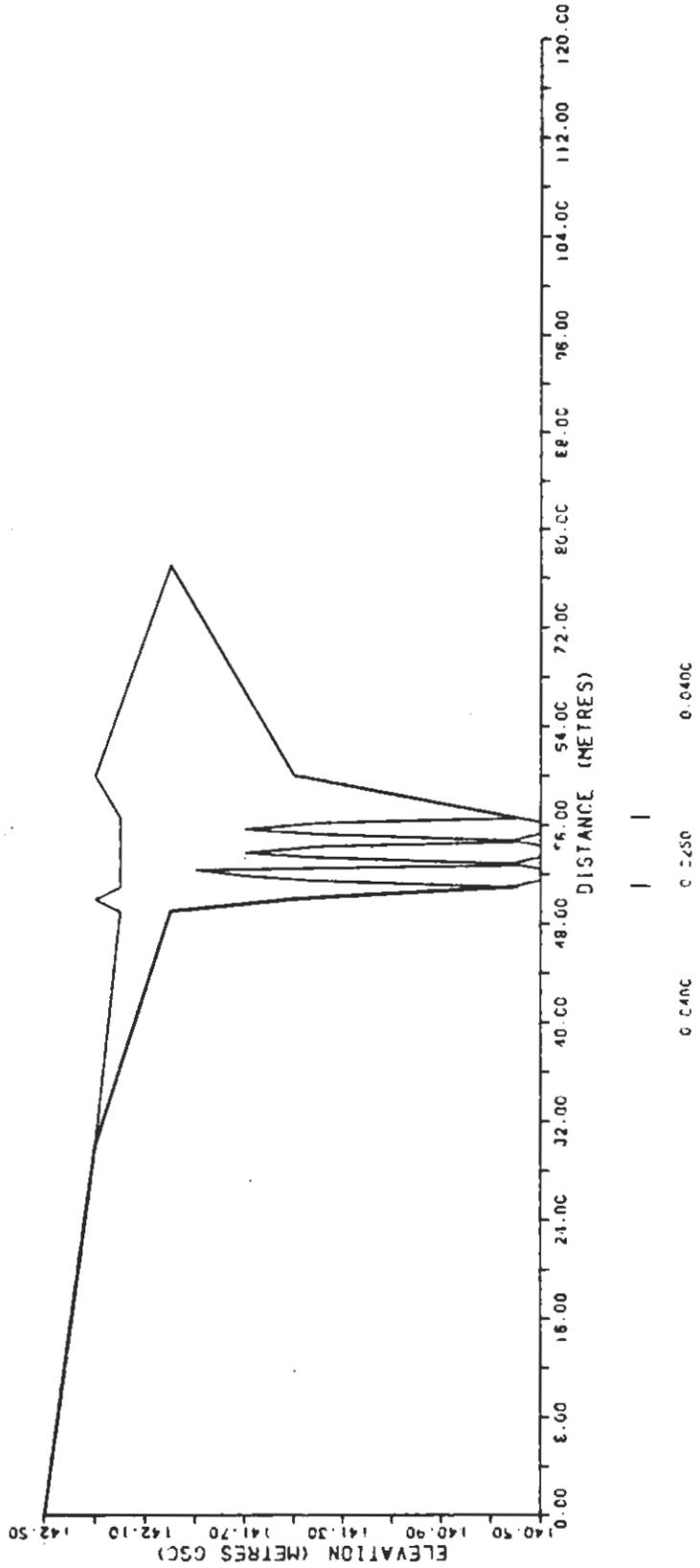


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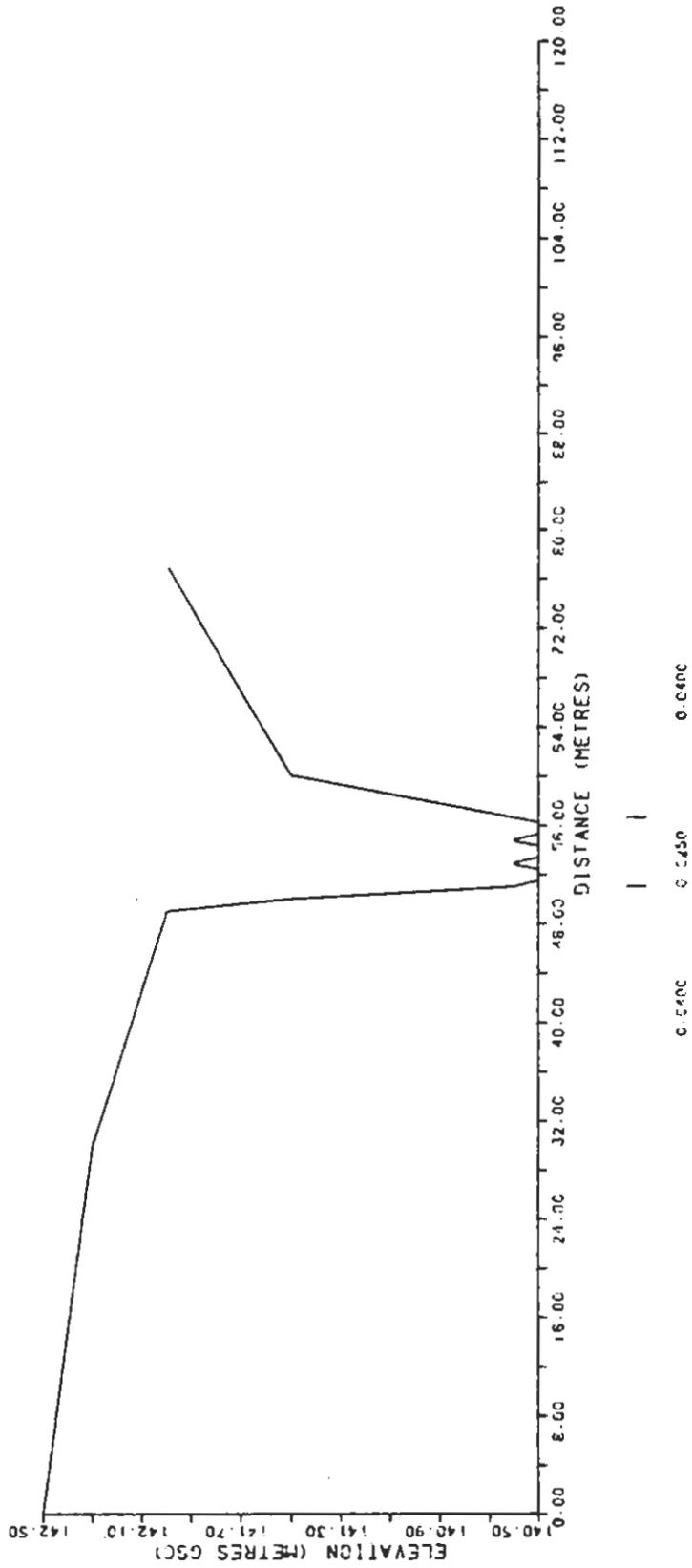


0.0400 0.0400

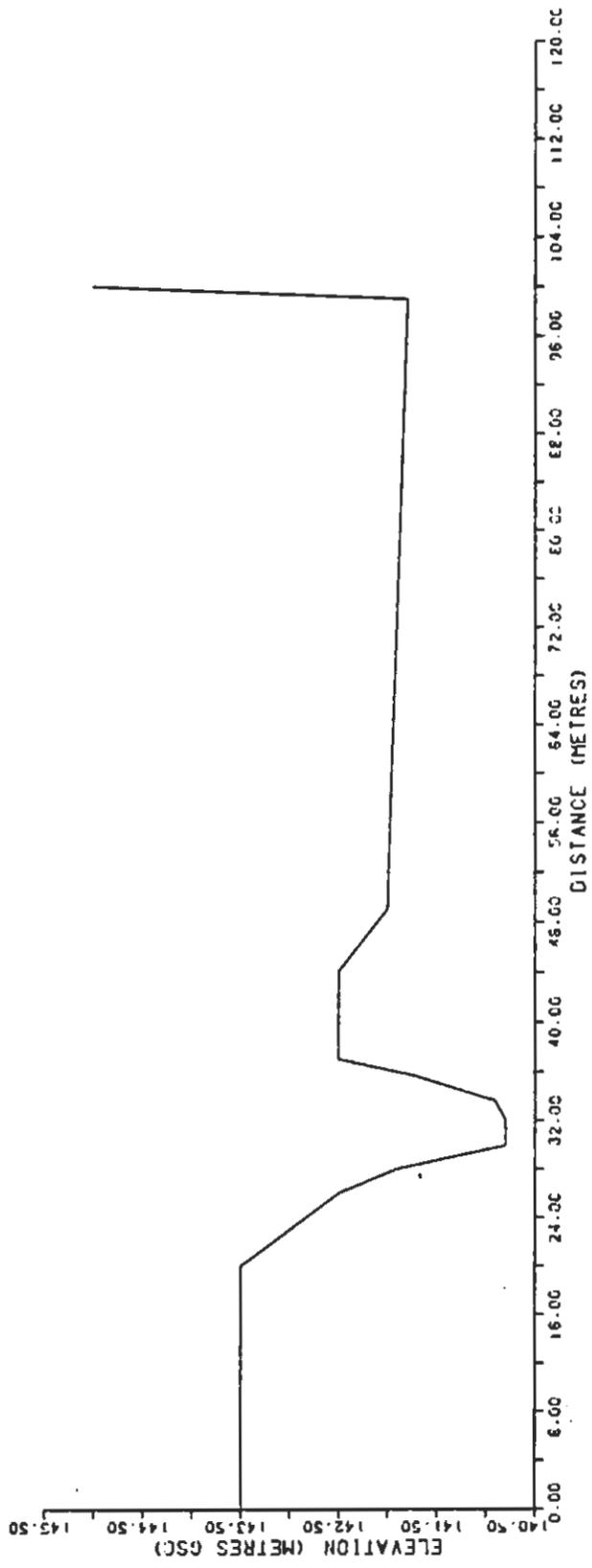
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CROSS SECTION NUMBER 12735.



WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 12747.

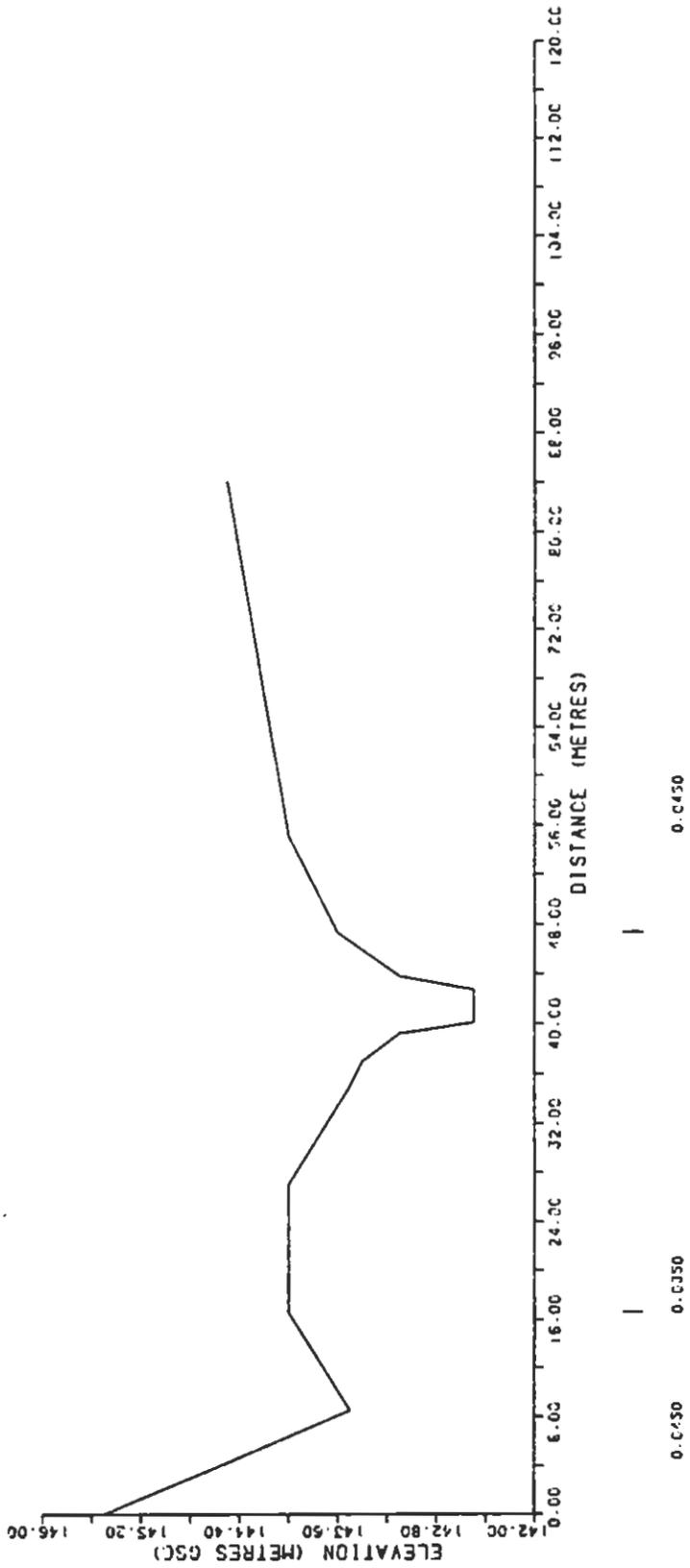


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CROSS SECTION NUMBER 12763.

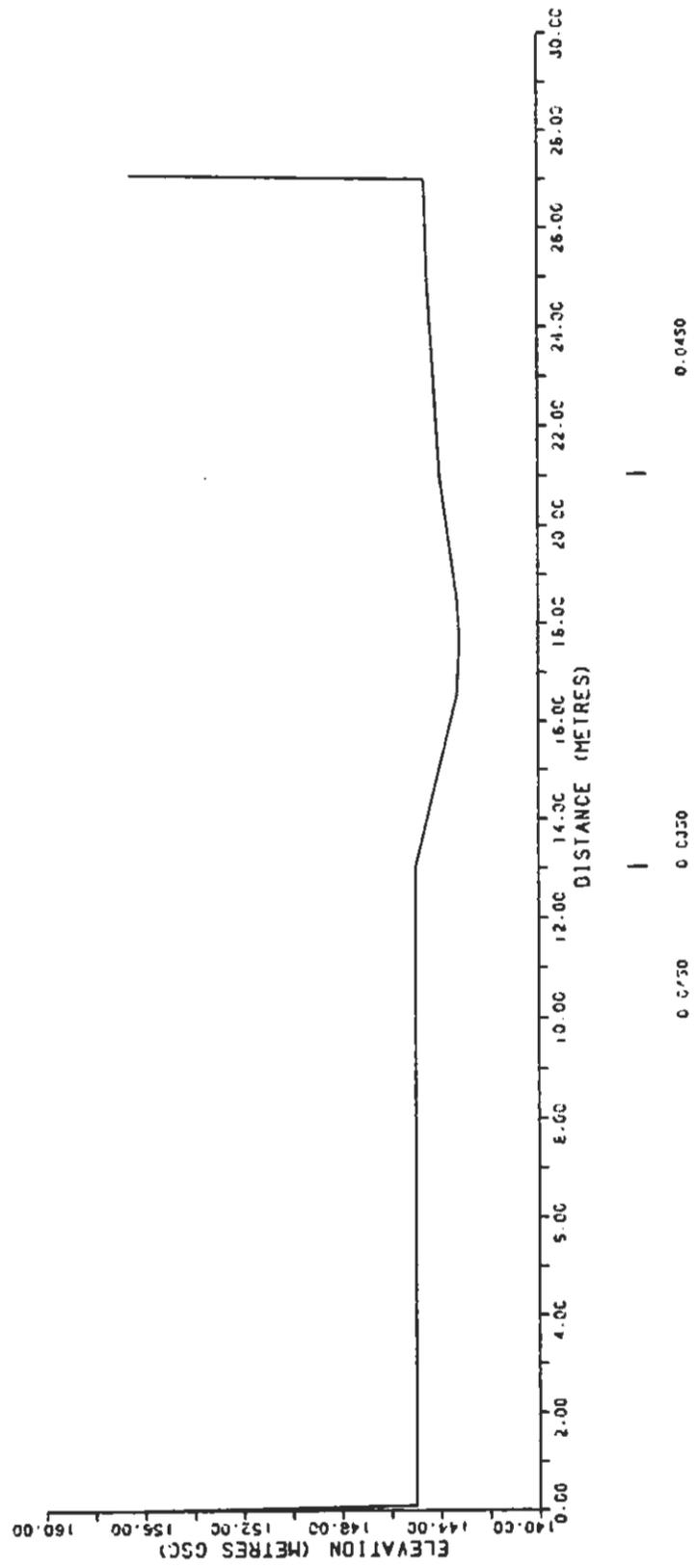


0.0450 0.0350 0.0450

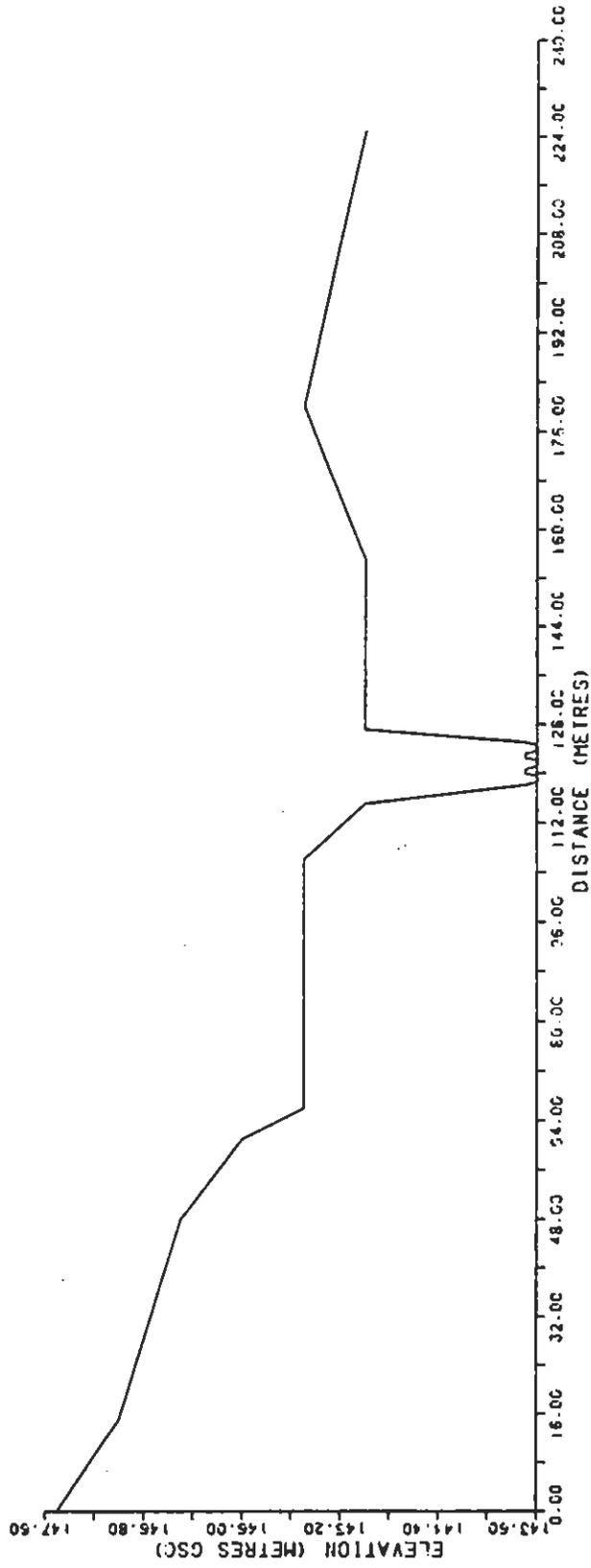
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CROSS SECTION NUMBER 13002.



WATERFORD RIVER HEC-2 MODEL
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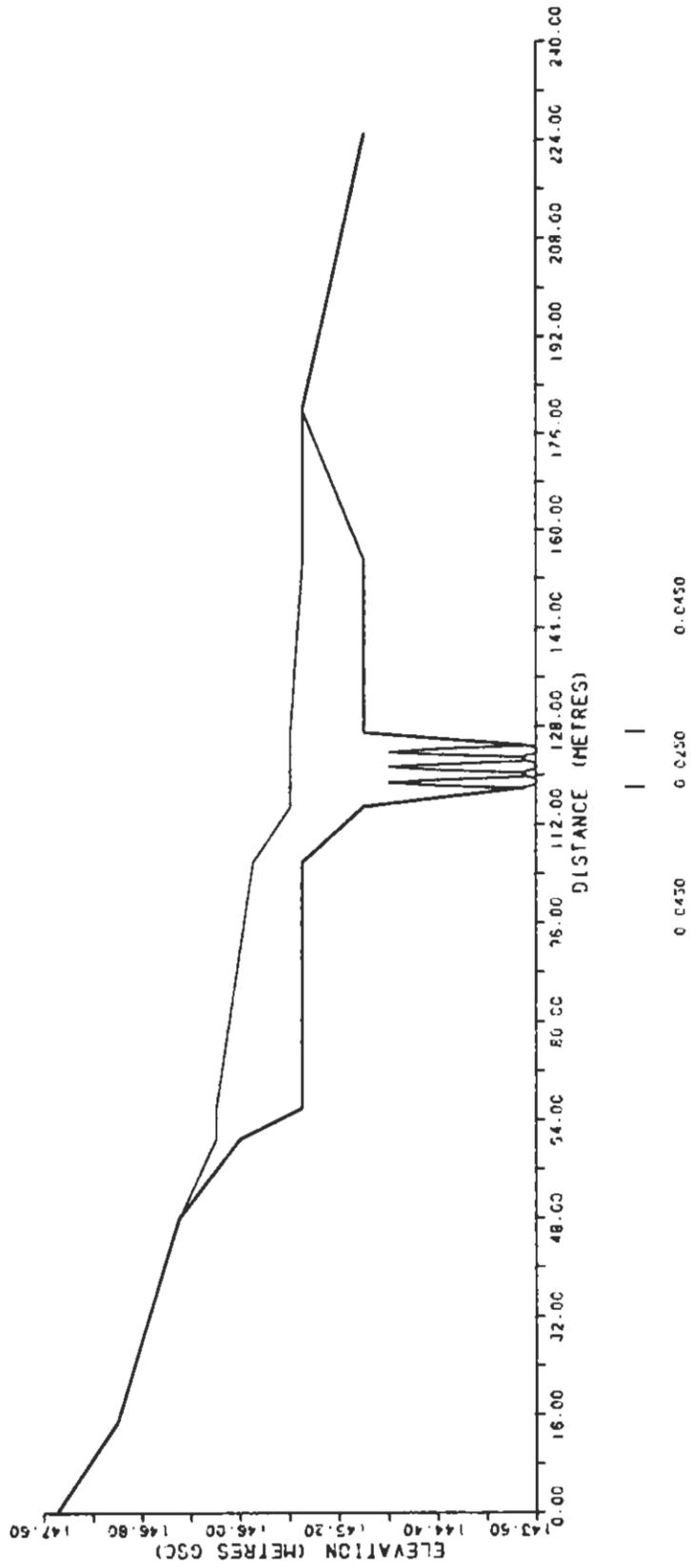


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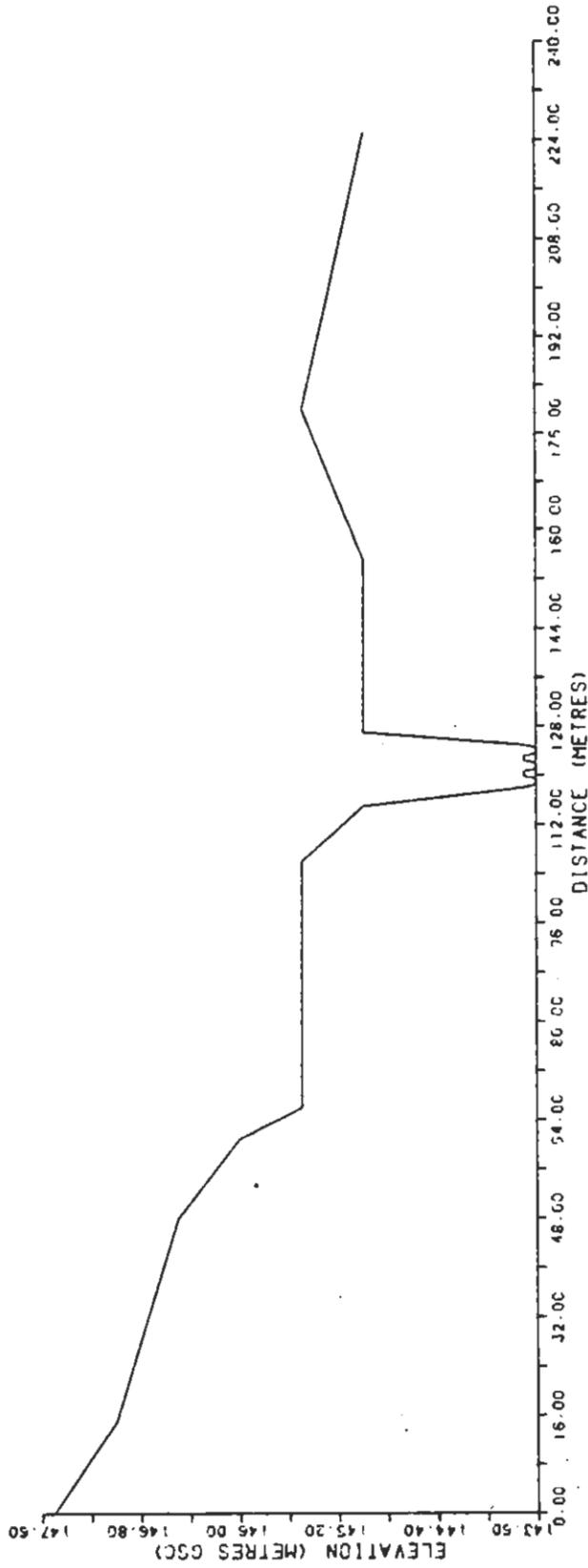


0.6450 0.6350 0.6450

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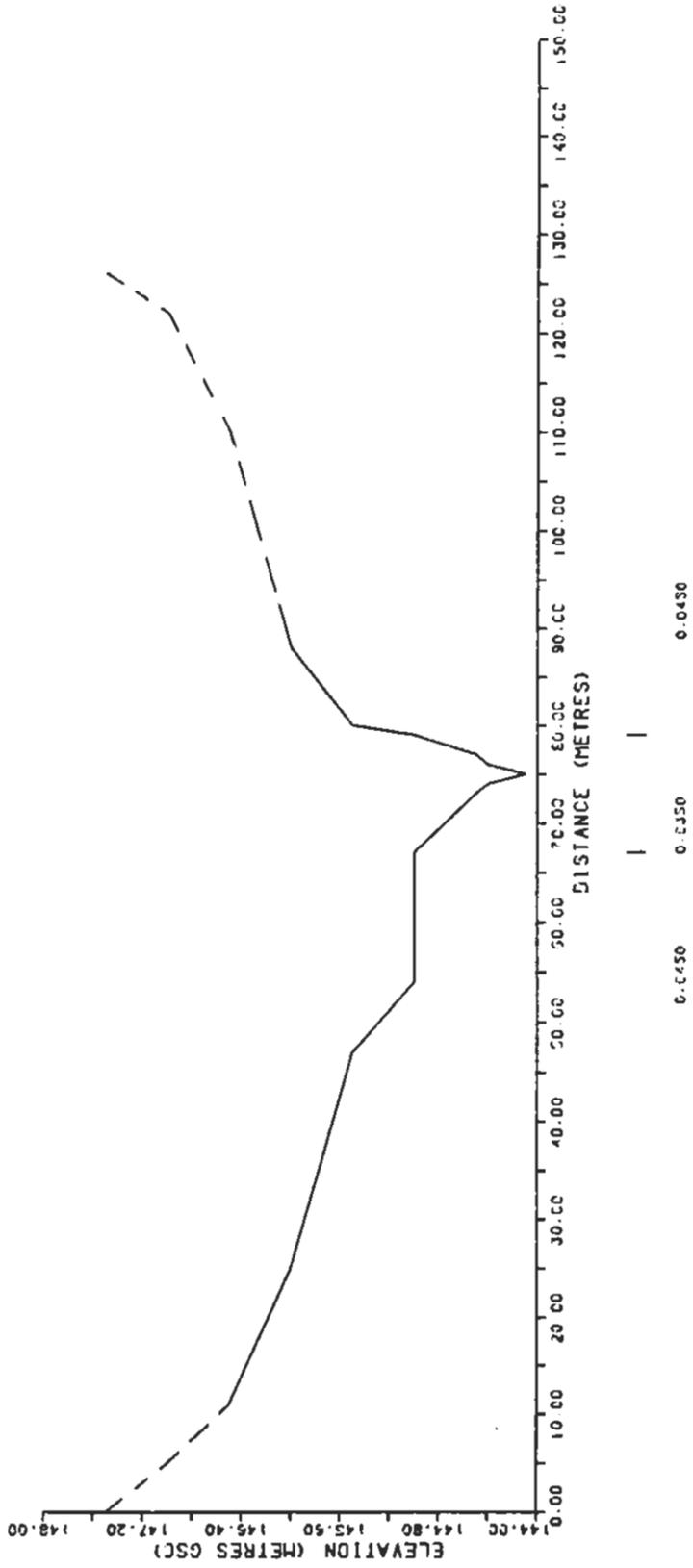


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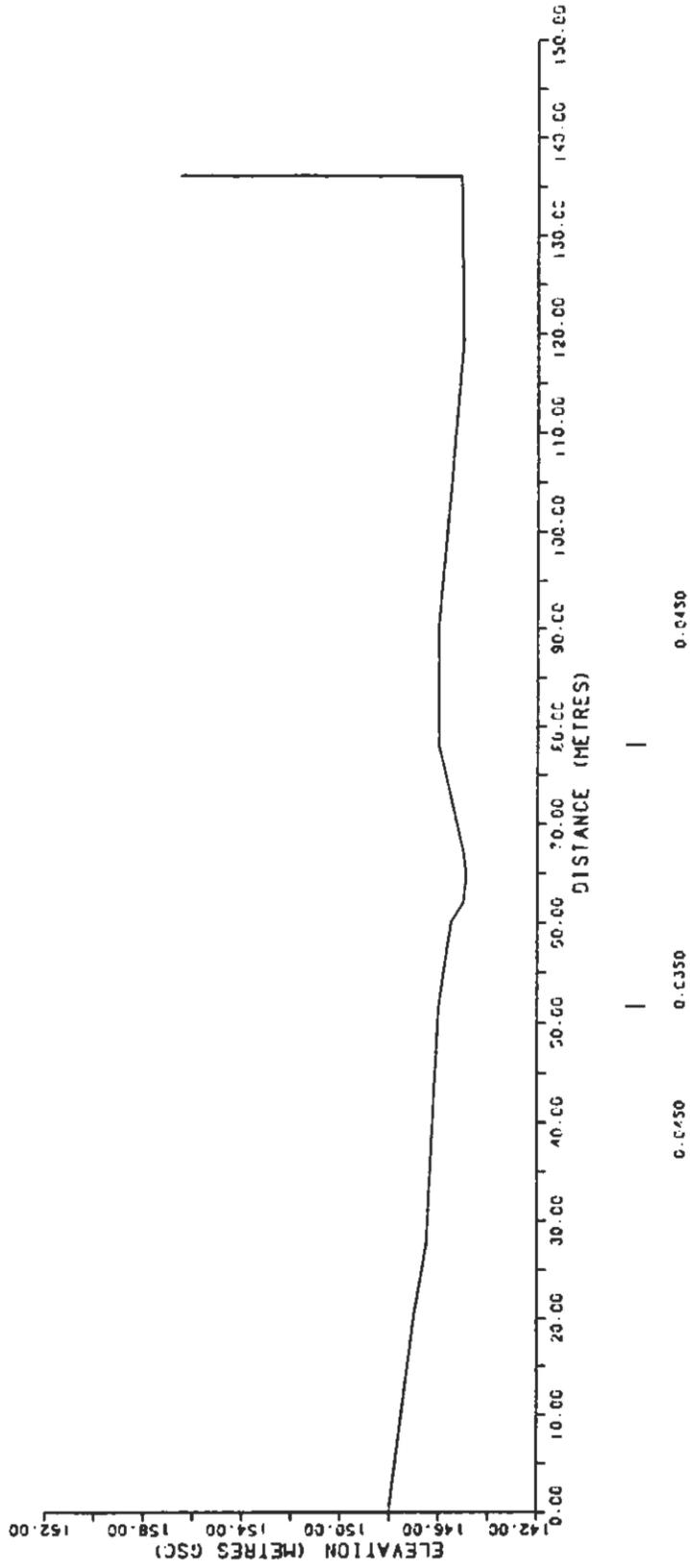


0.0450 0.0450 0.0450

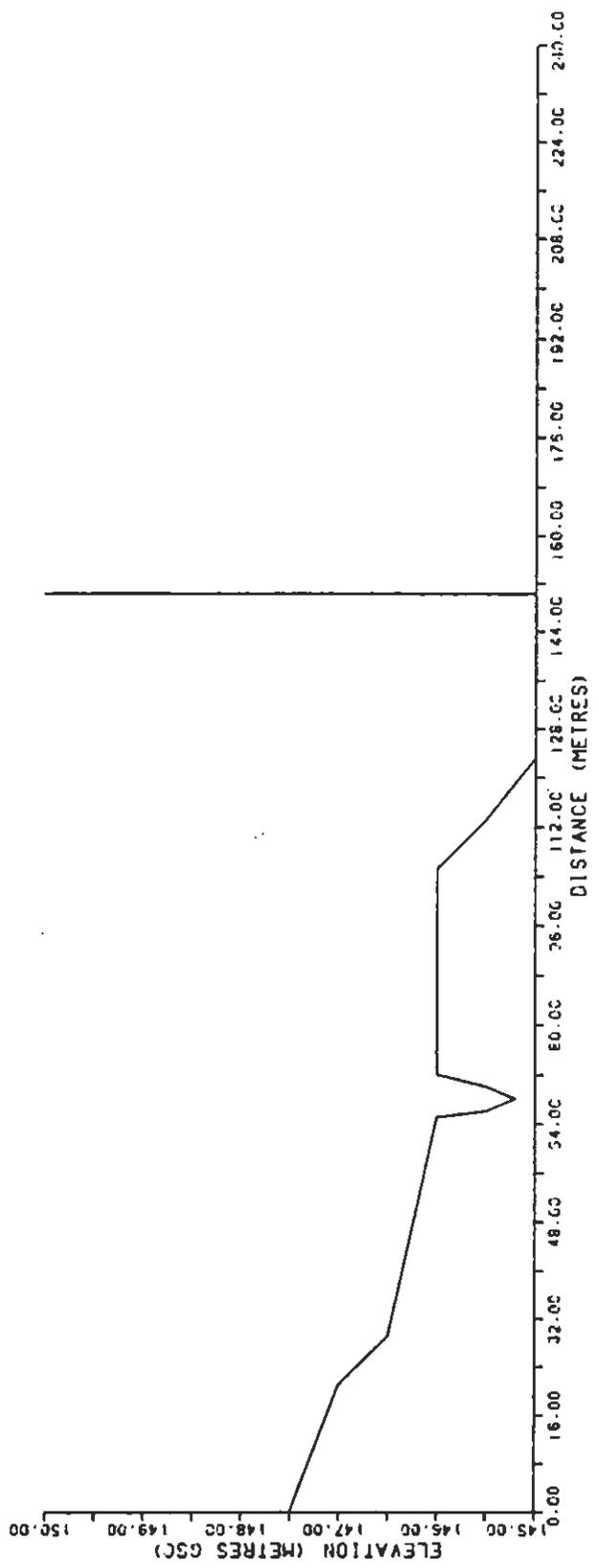
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CROSS SECTION NUMBER 13146.



WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 13200

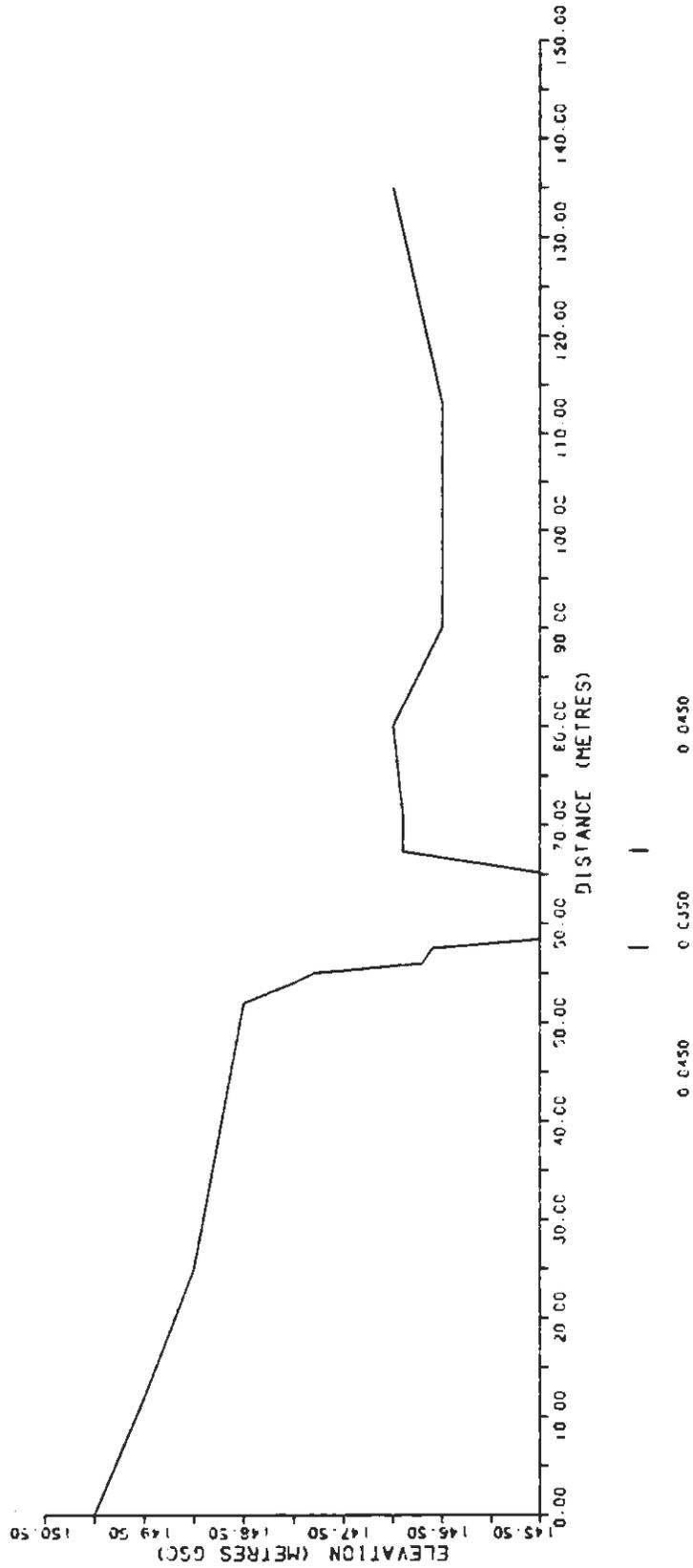


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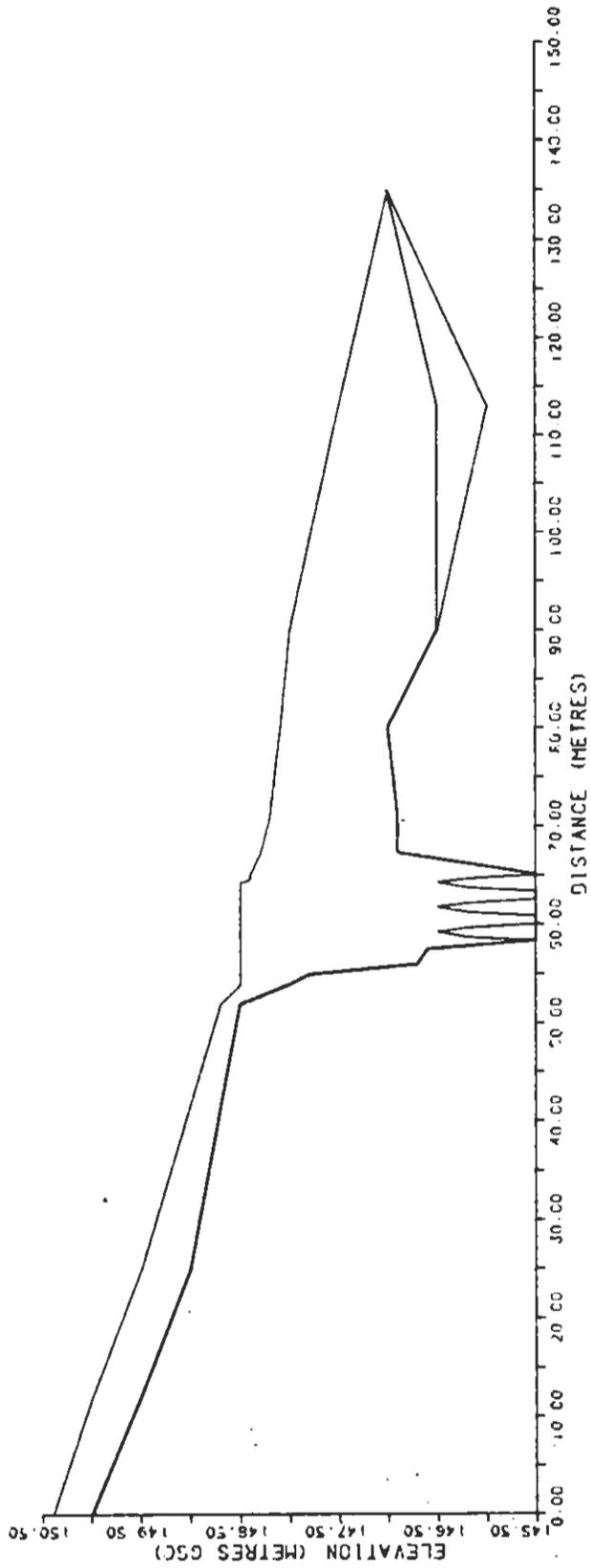


0.0430 0.0350 0.0430

WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 13244.

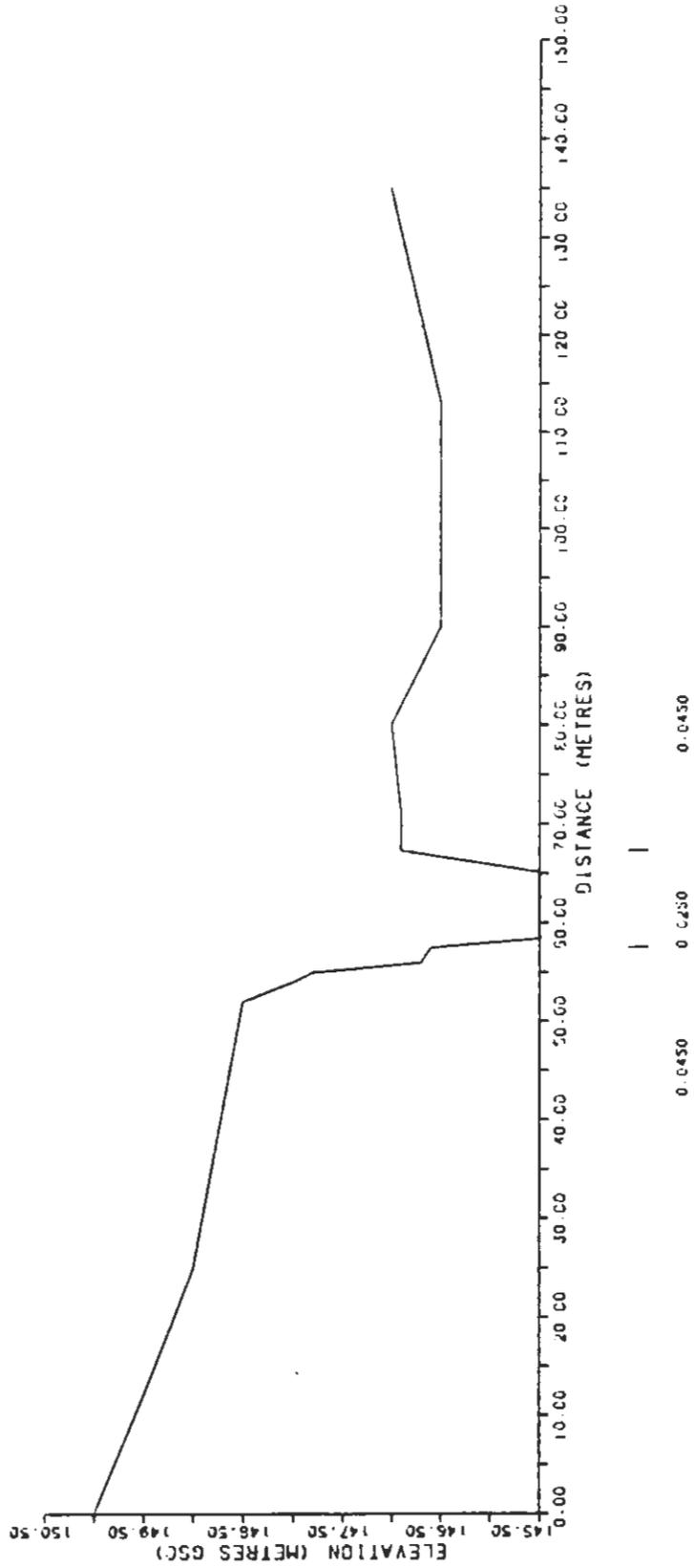


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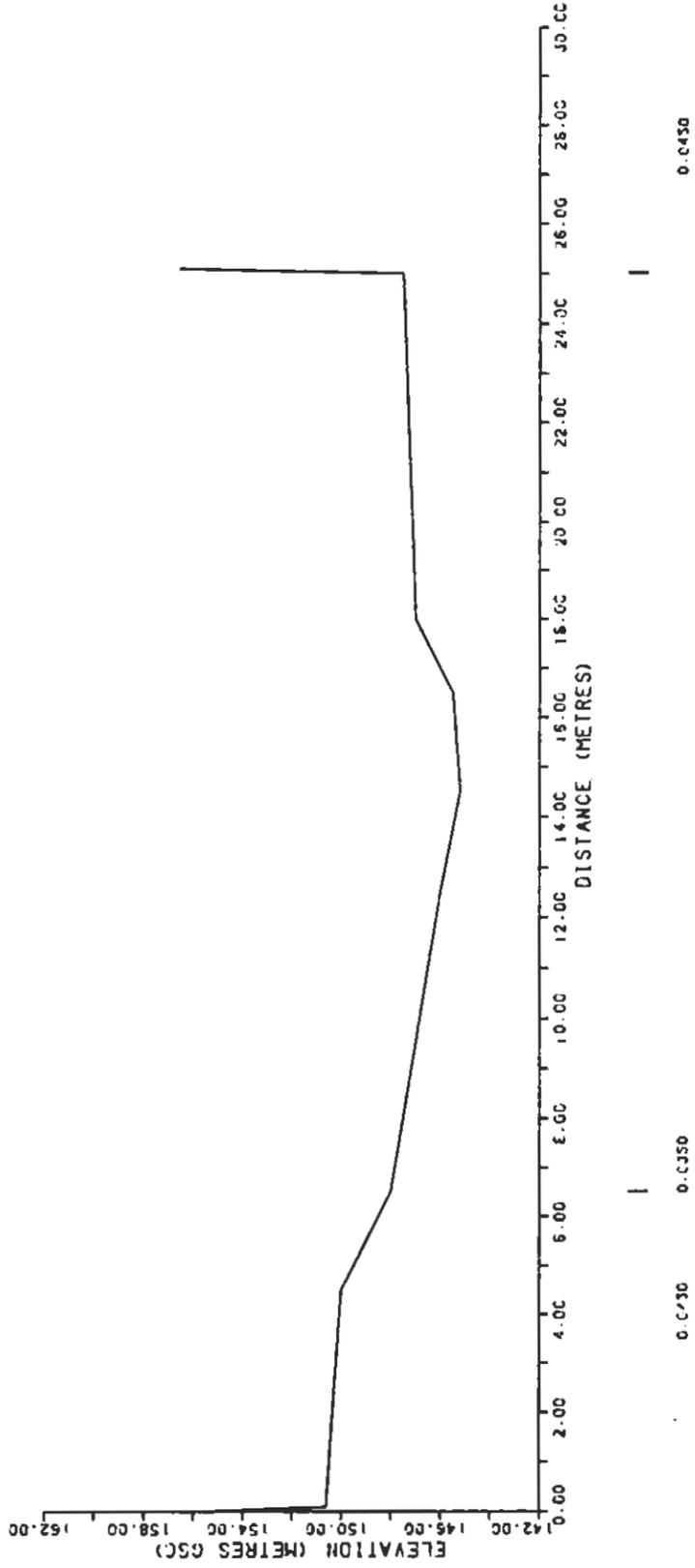


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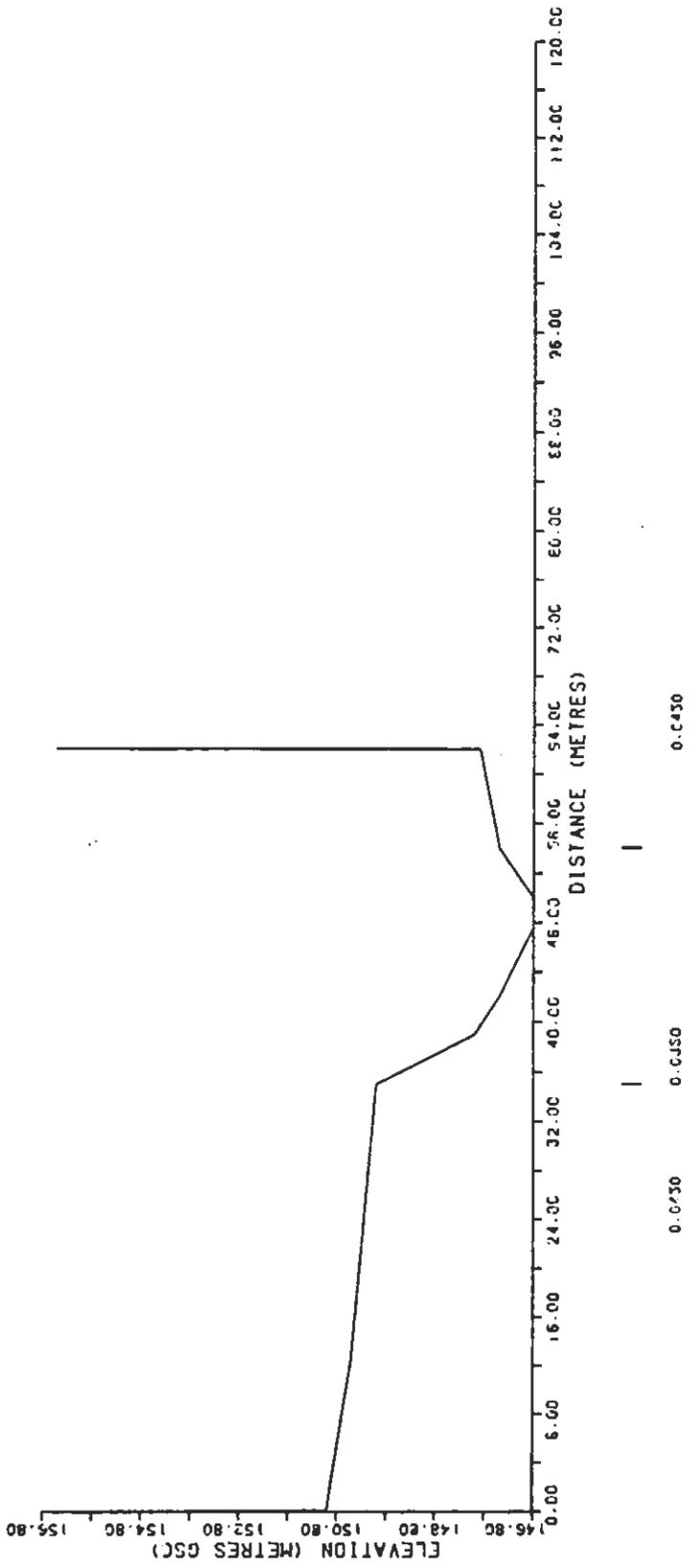
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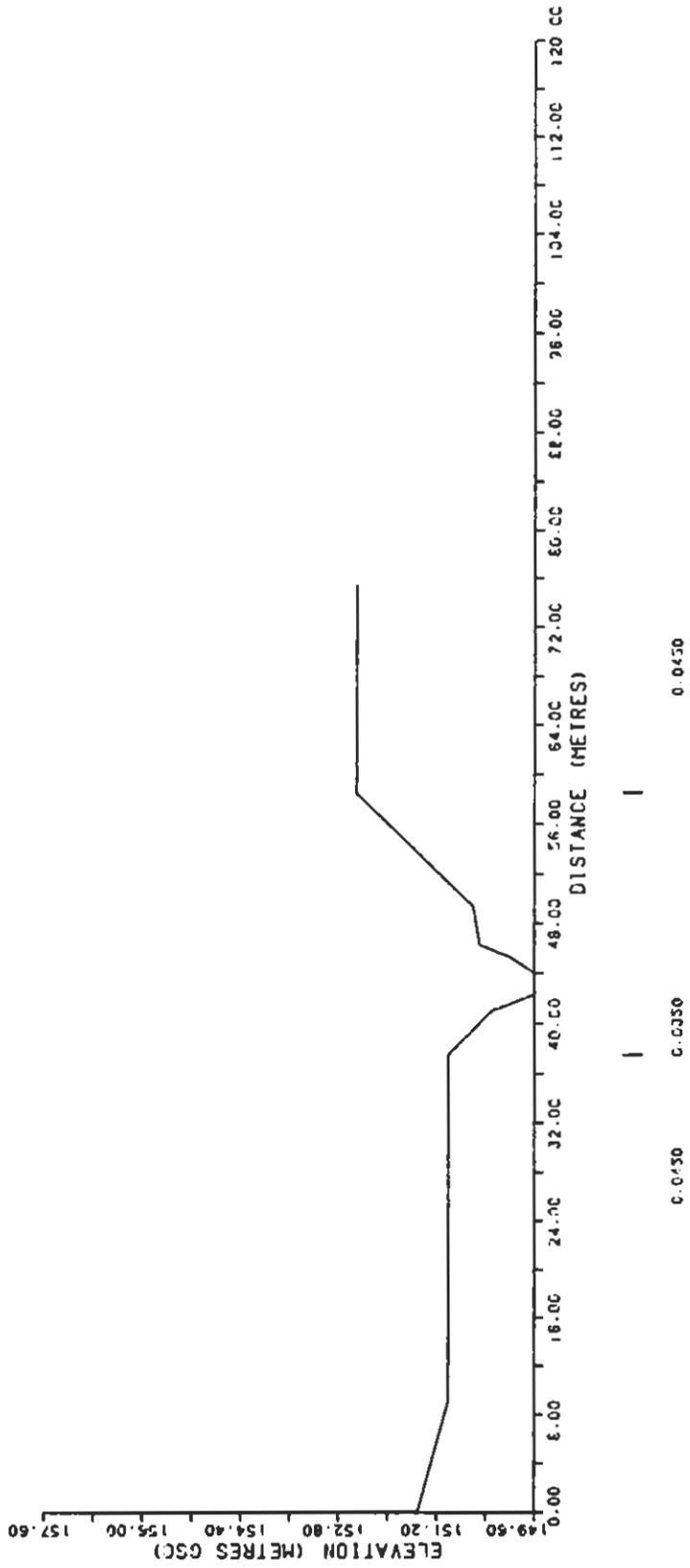
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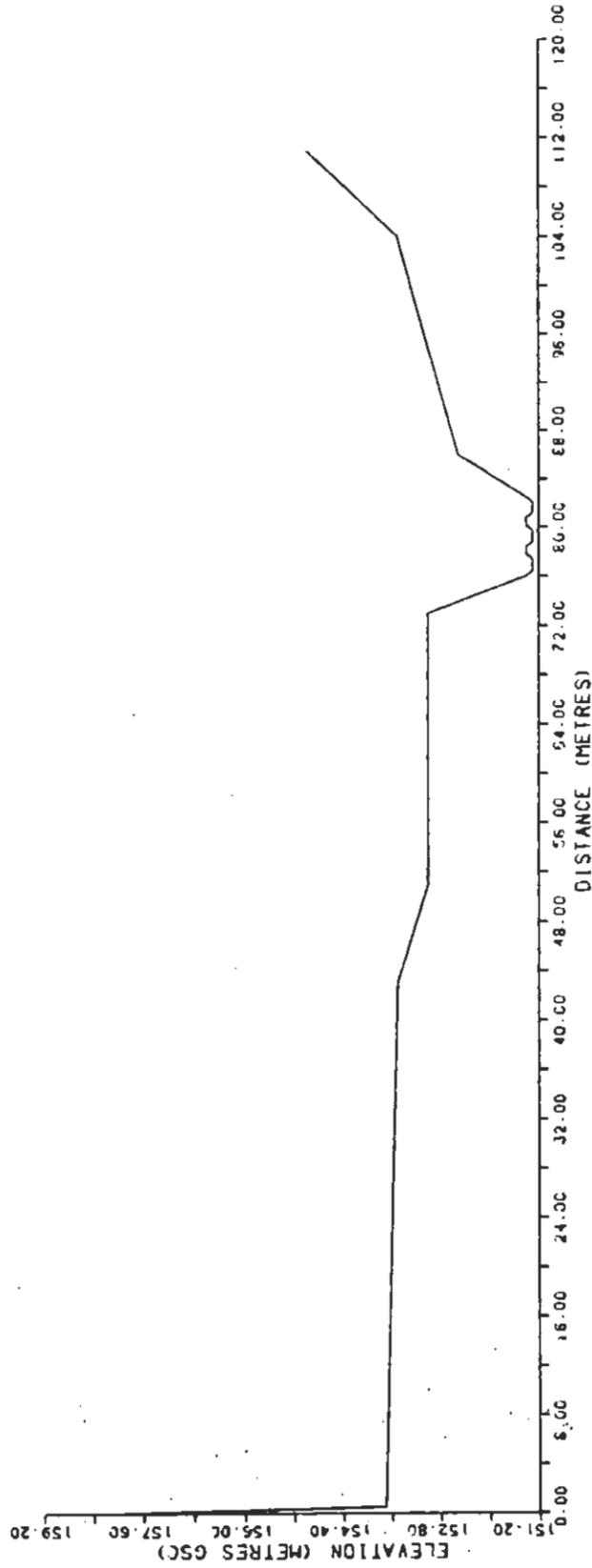
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WATERFORD RIVER HEC-2 MODEL
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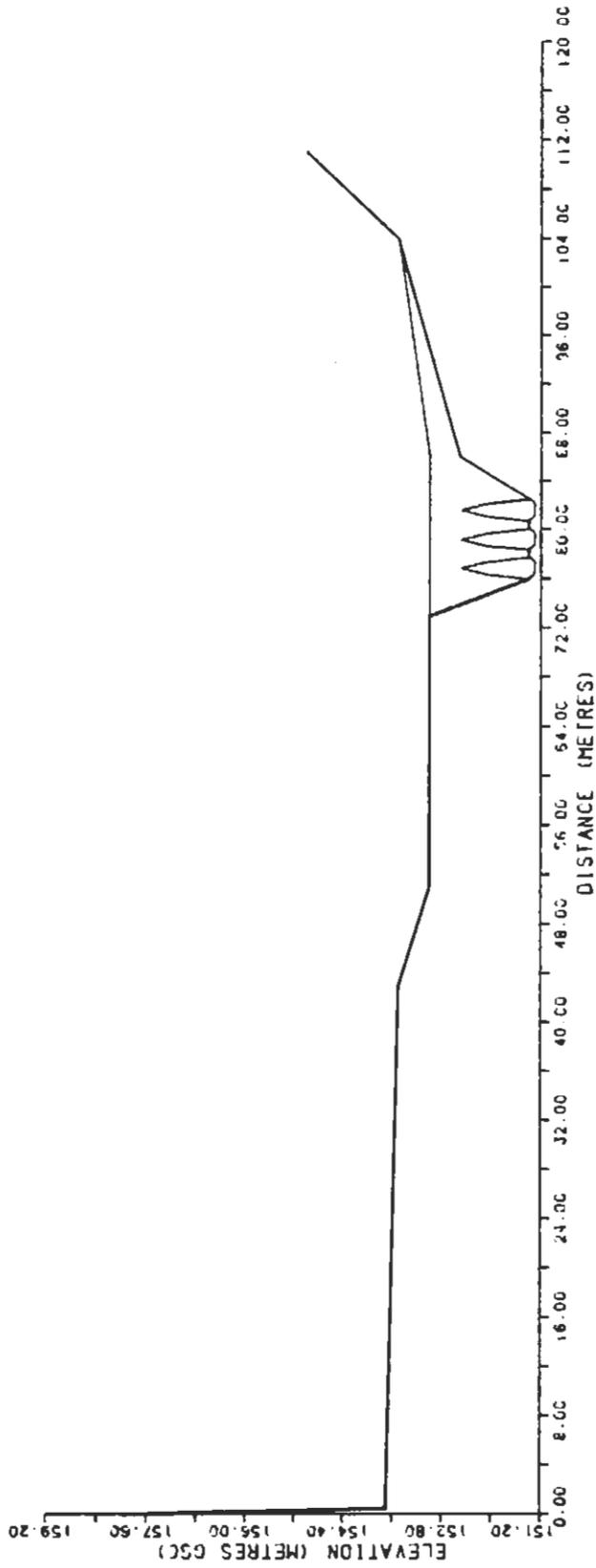


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CROSS SECTION NUMBER 13470.



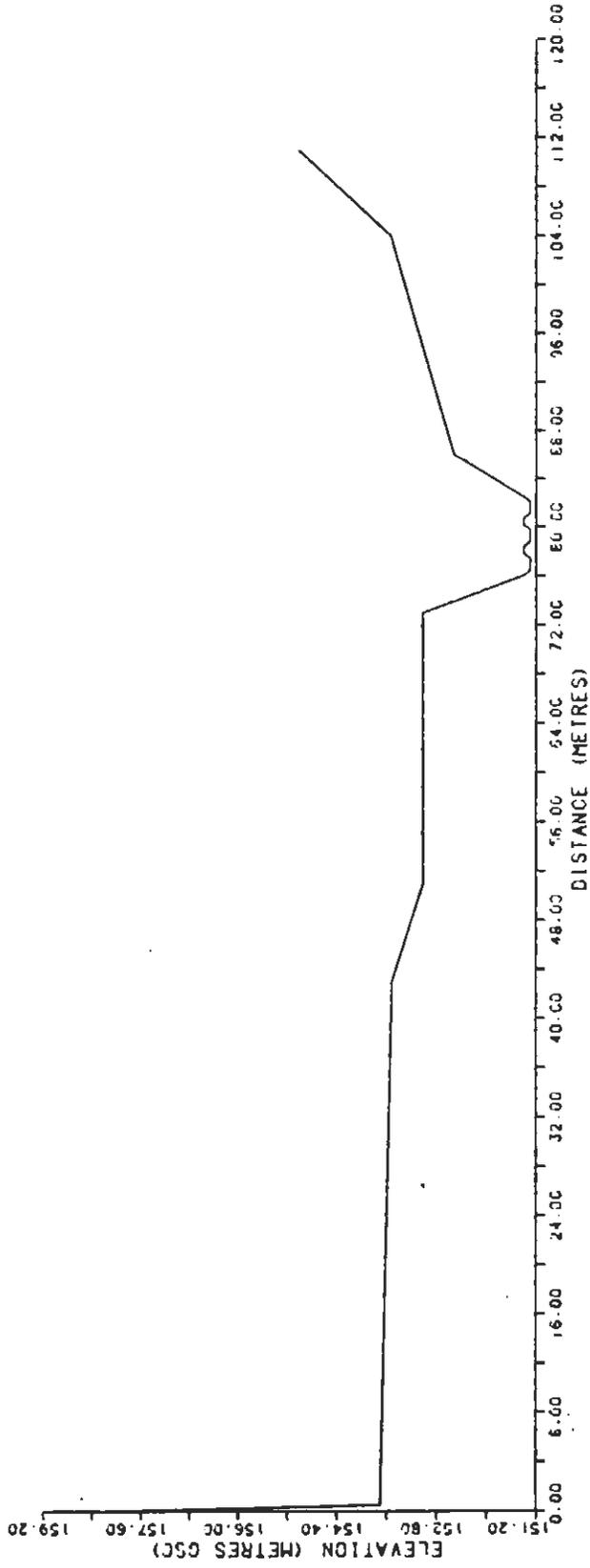
G. 0450
G. 0350
0. 0450

WATERFORD RIVER
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CROSS SECTION NUMBER 13470.



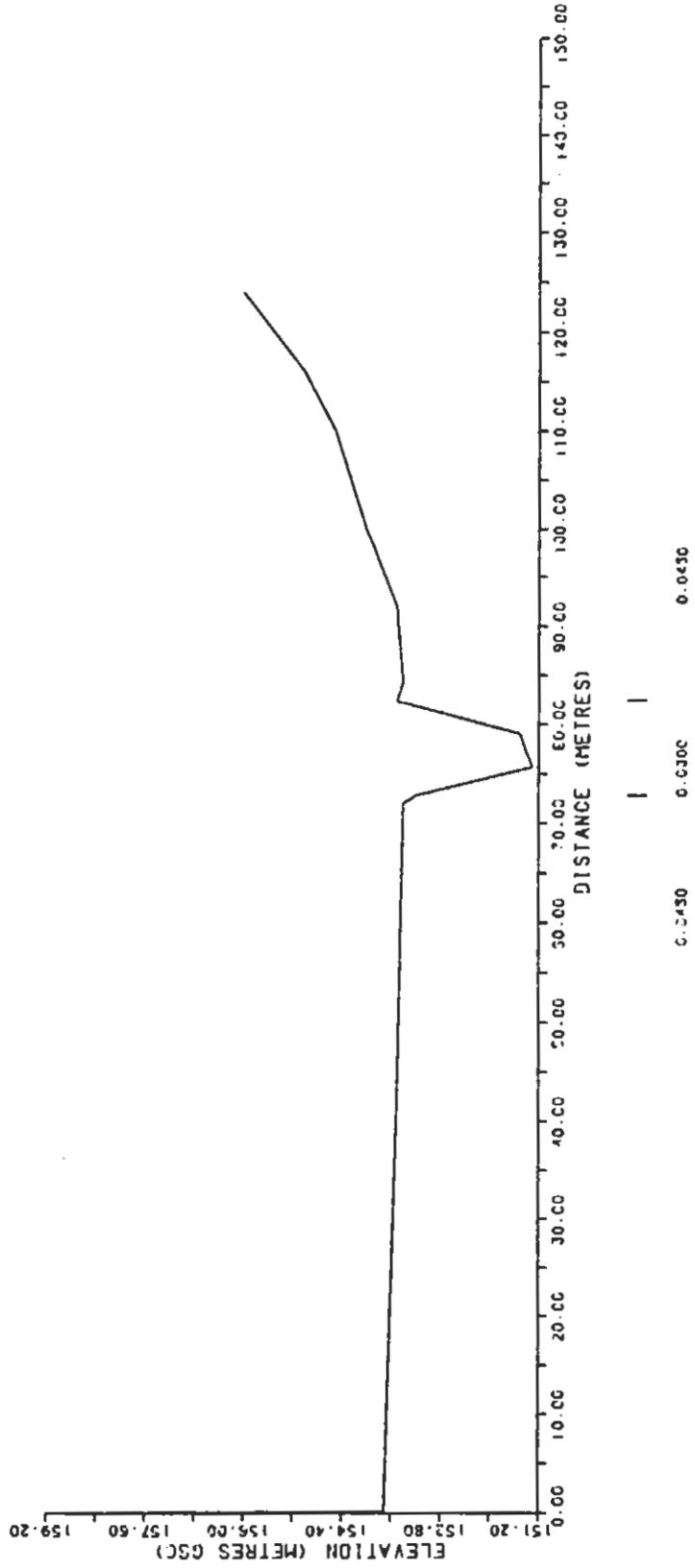
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CROSS SECTION NUMBER 13550.

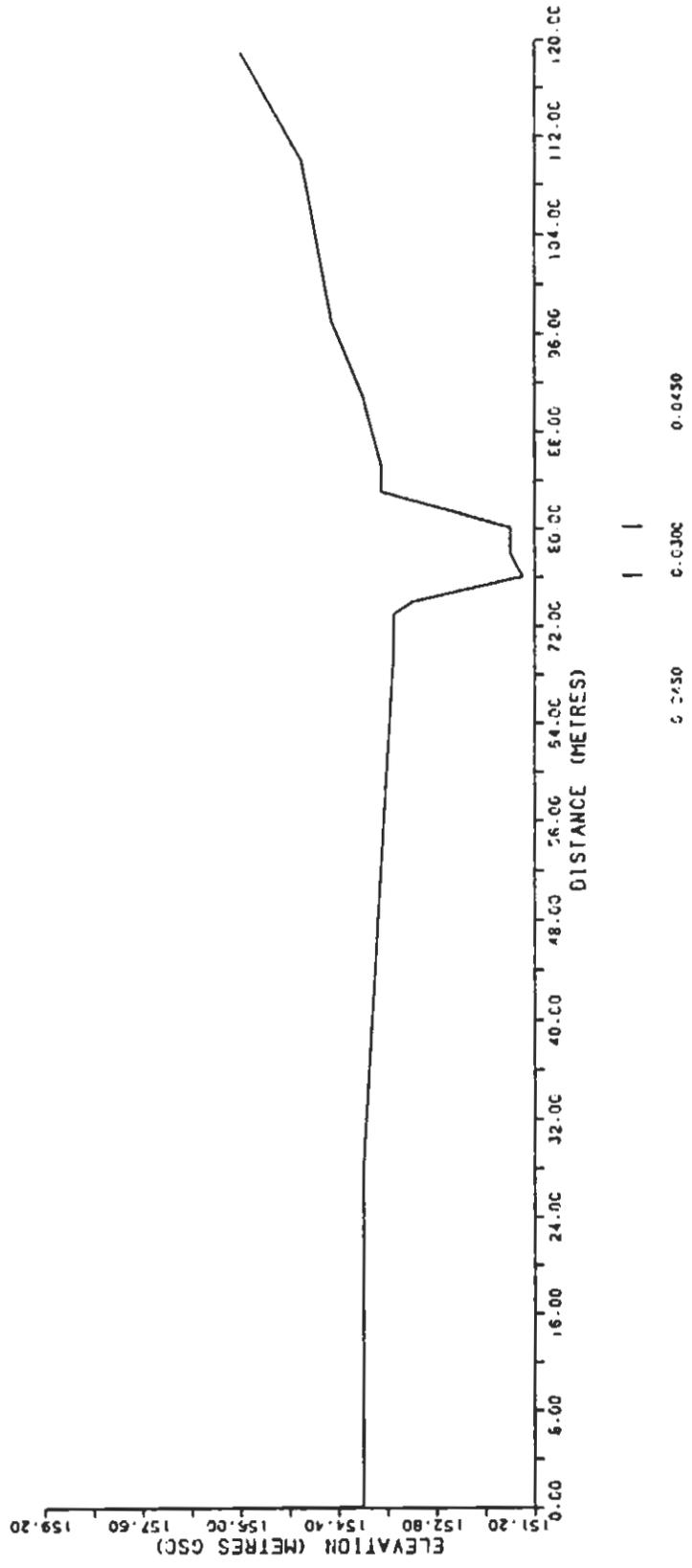


0.0450
0.0450
0.0450

WATERFORD RIVER HEC-2 MODEL
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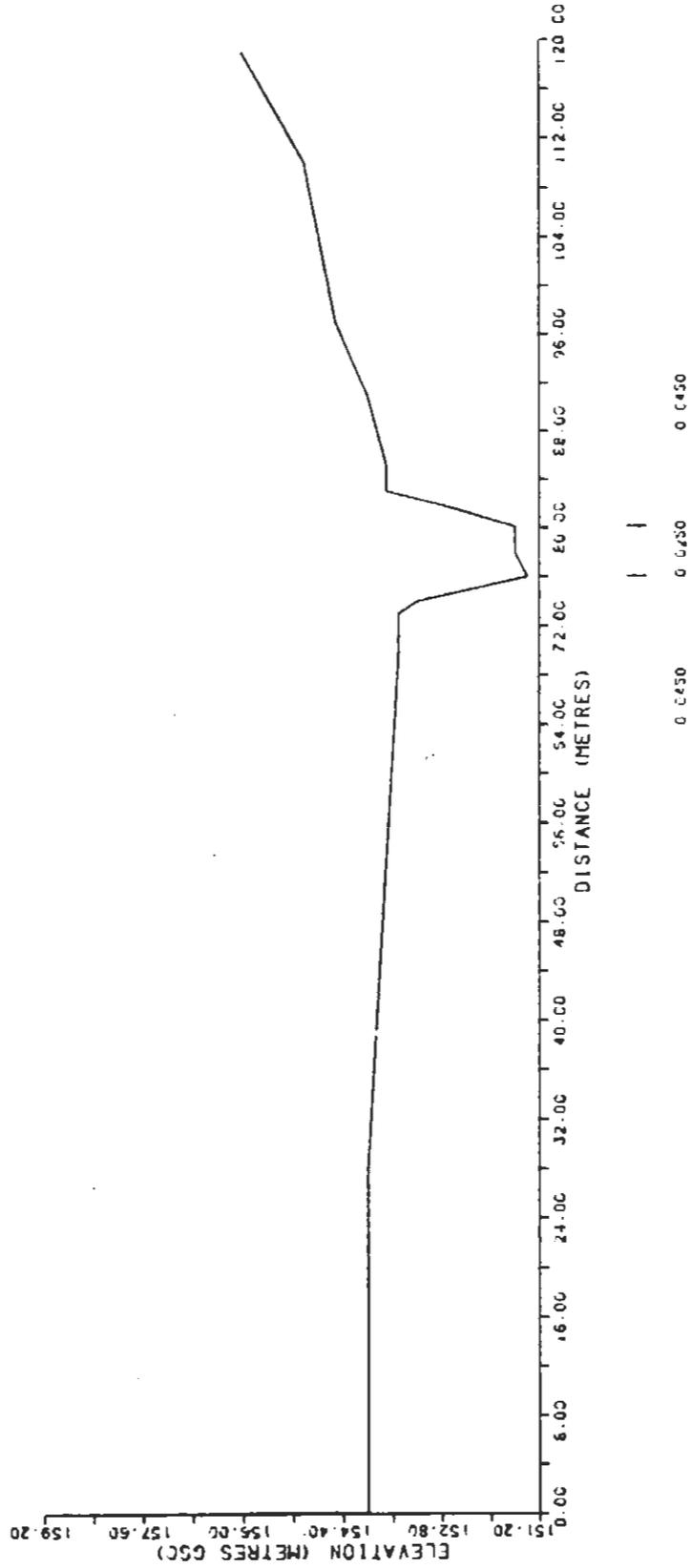


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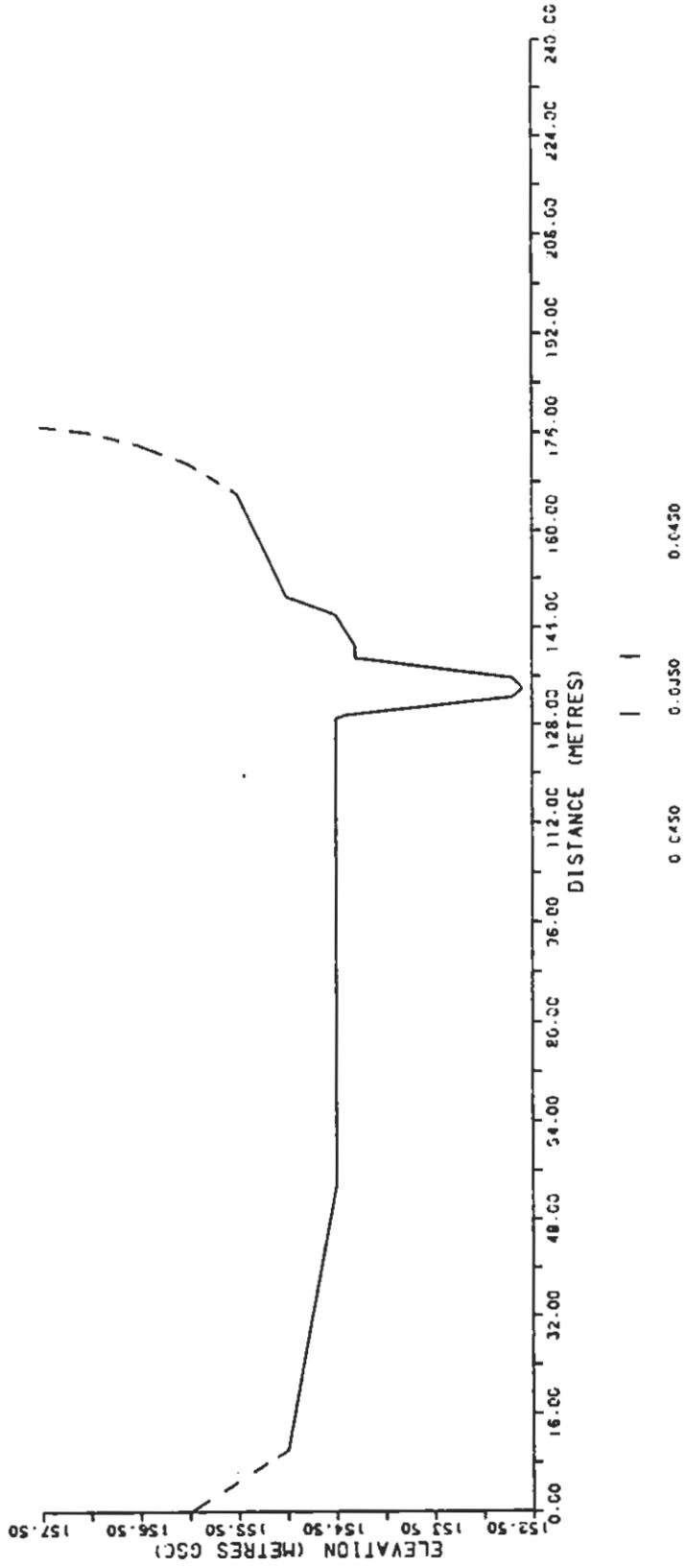


0.0450
 0.0300

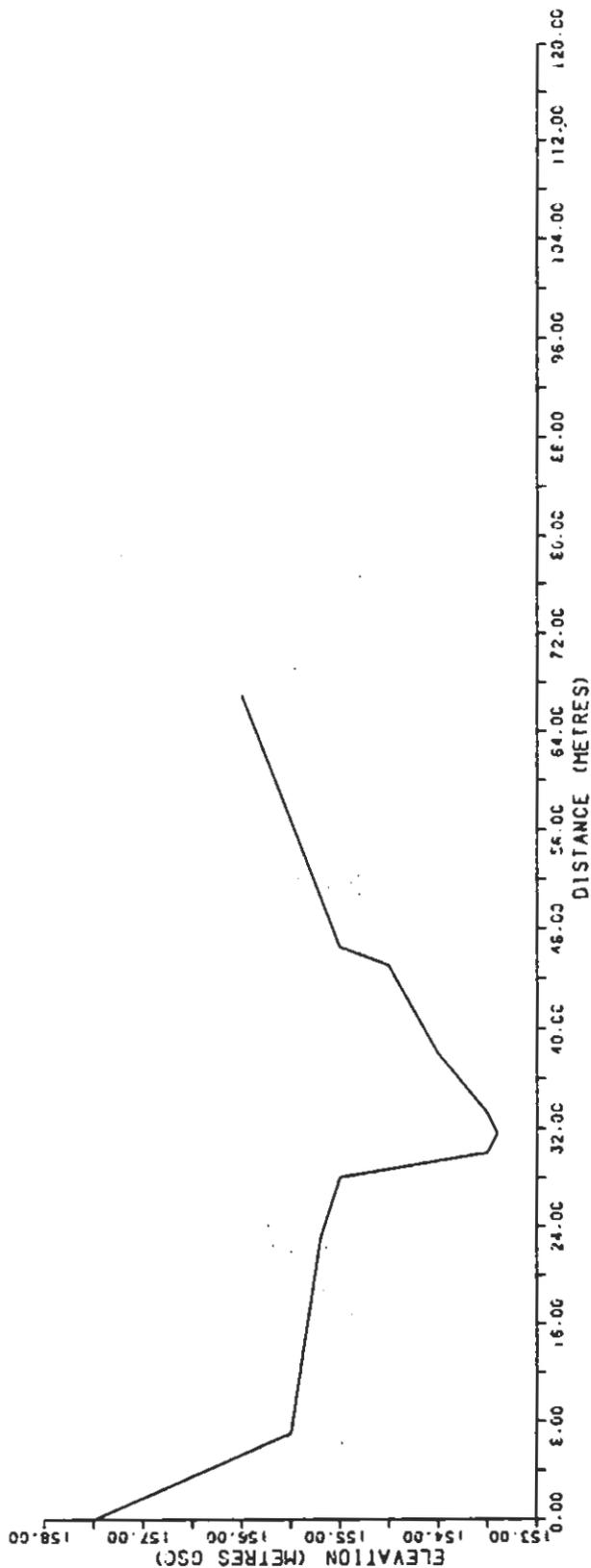
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CROSS SECTION NUMBER 13597.



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 13607.

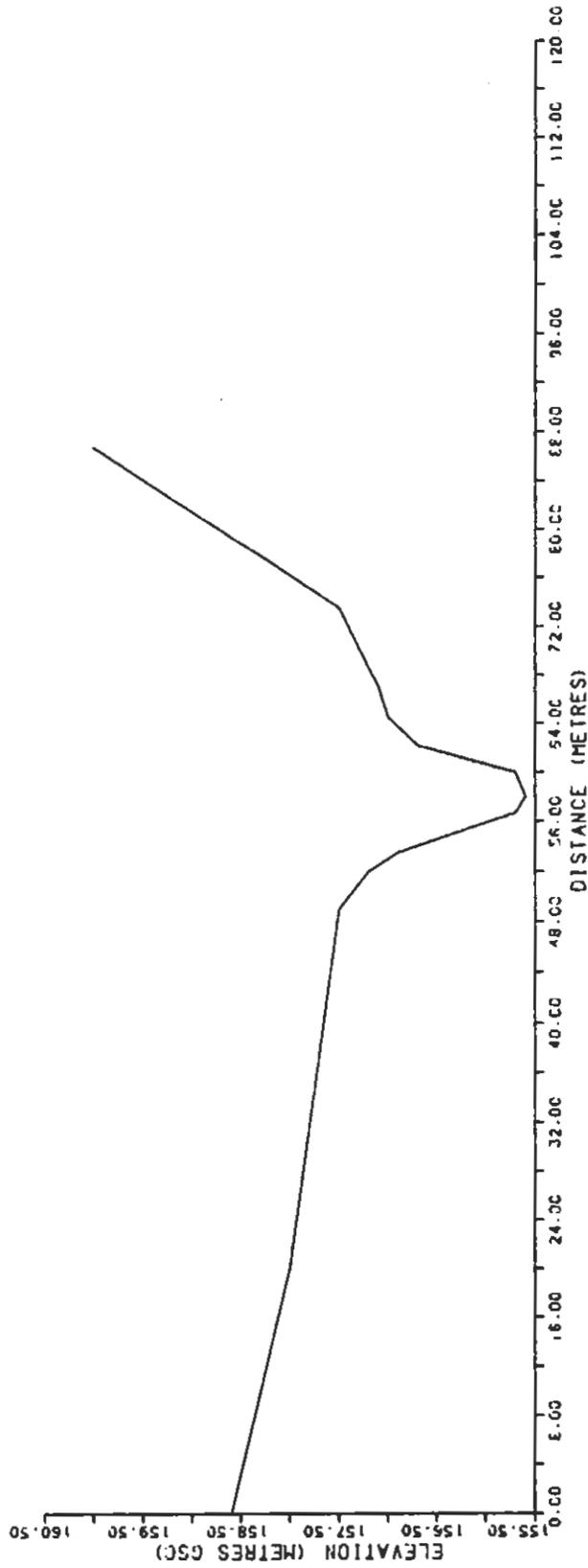


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 13629.



C.C450 0.0350 0.0450

WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 13720.



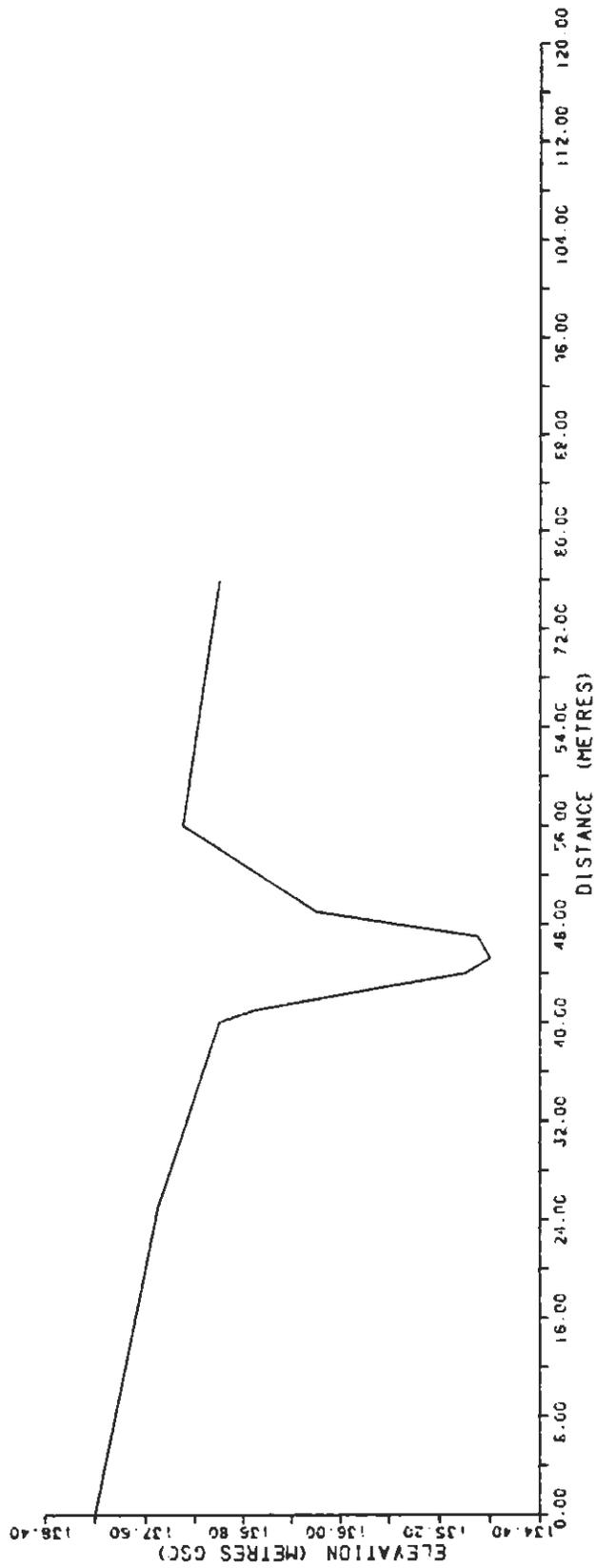
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WATERFORD RIVER

WEST BRANCH

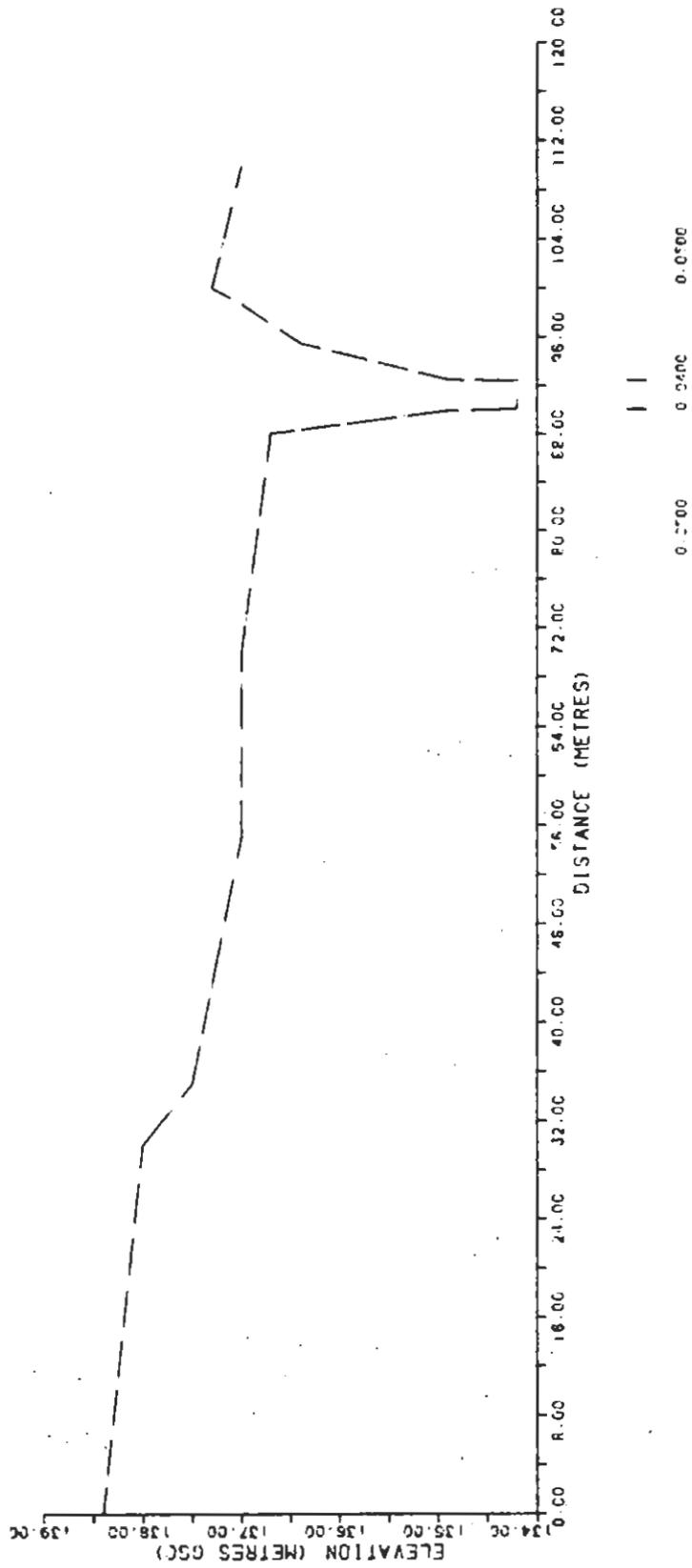
Sections From Downstream of
Railroad Line at Donovans
Industrial Park to the
Trans-Canada Highway

WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 12355.

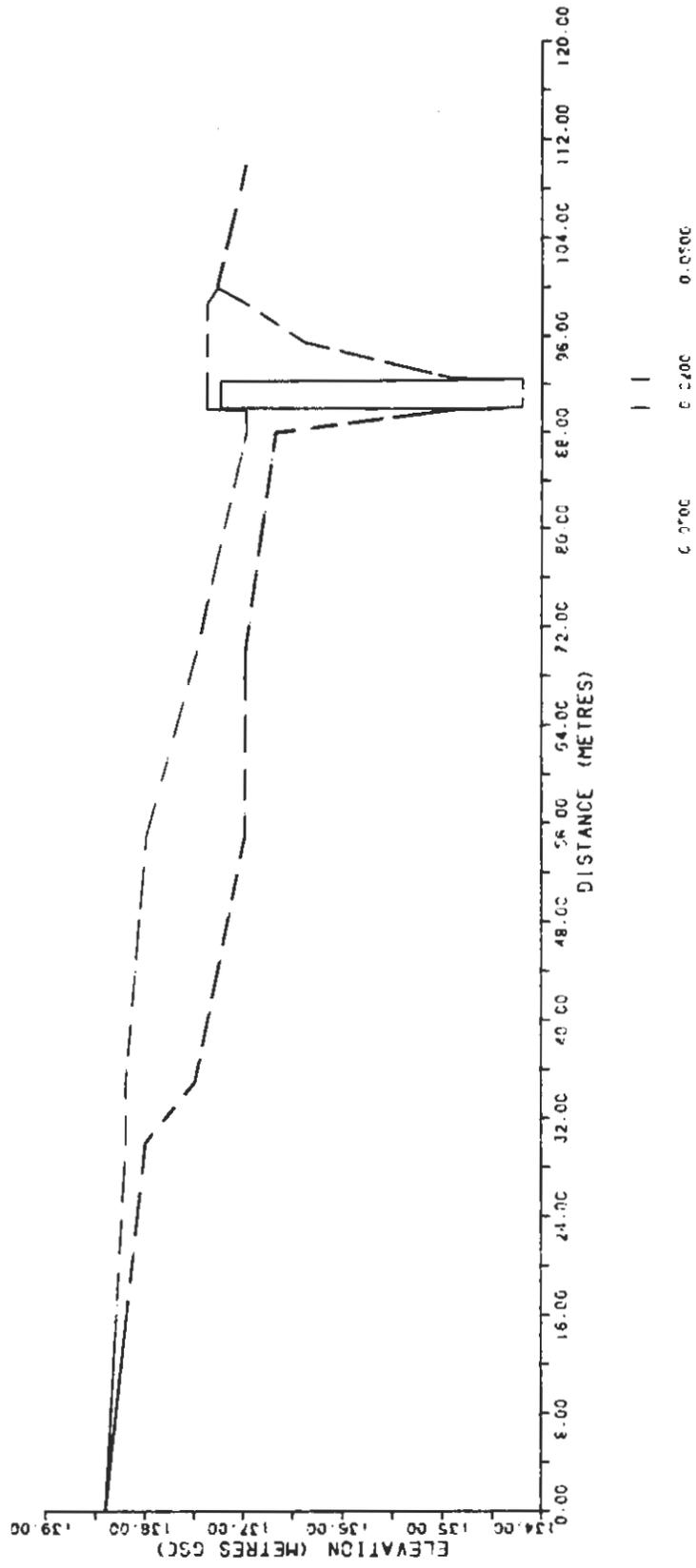


C 0.000 0.2400 0.0500

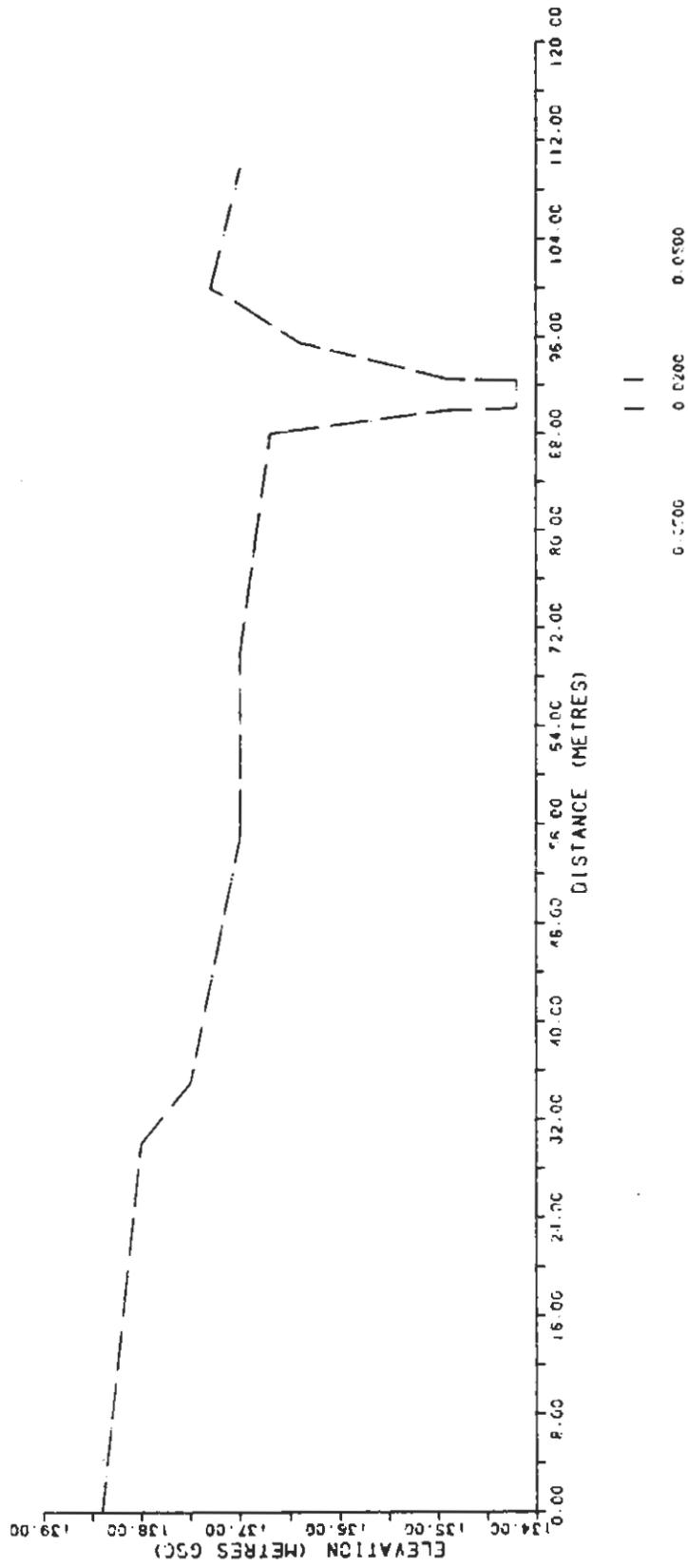
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CROSS SECTION NUMBER 12365.



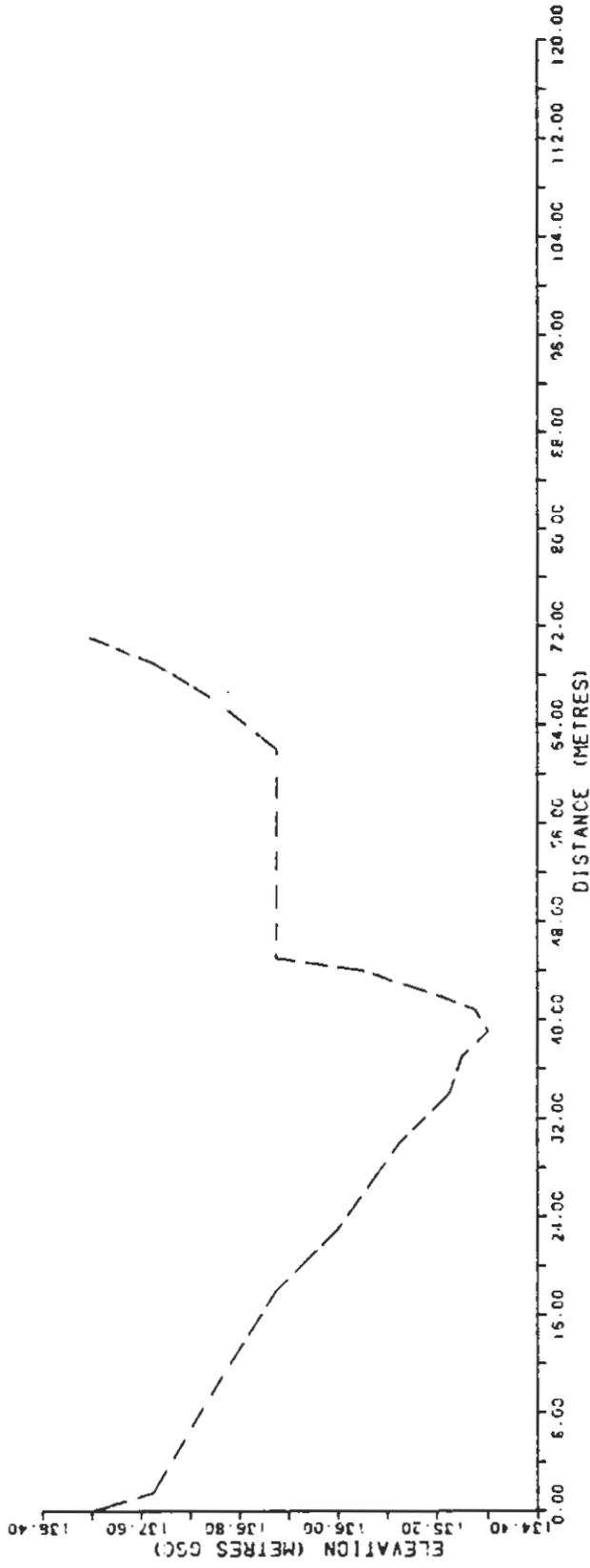
WATERFORD RIVER
 HEC-2 MODEL
 CROSS SECTION NUMBER 12366.



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 12369.

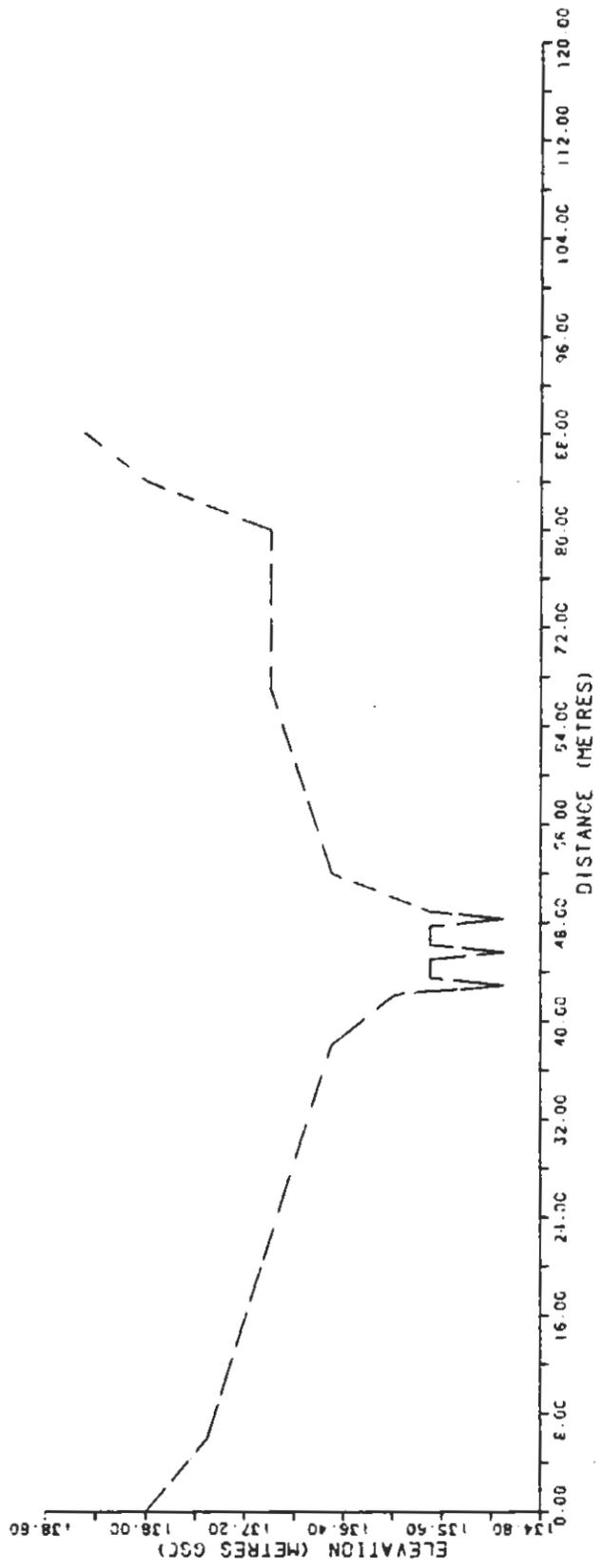


WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 12384.



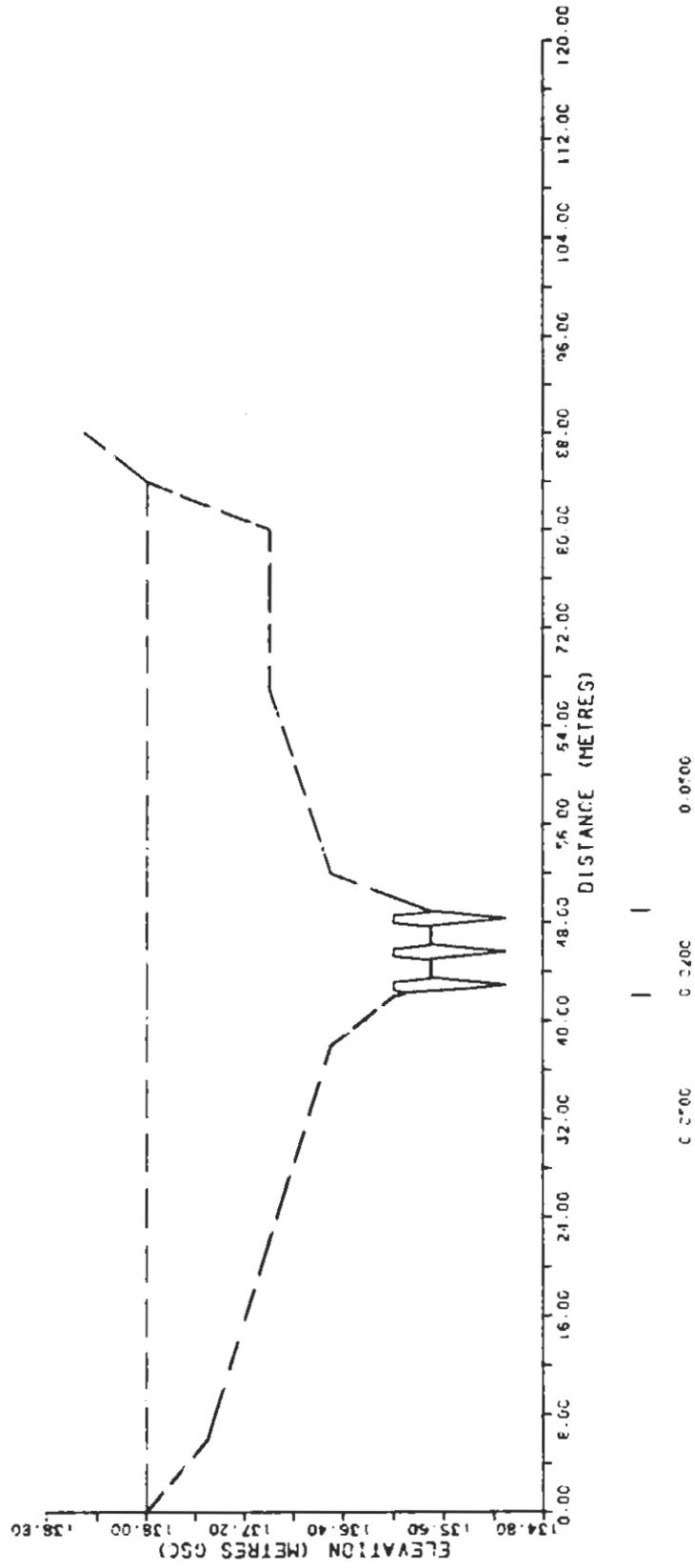
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WATERFORD RIVER
HEC-2 MODEL
CROSS SECTION NUMBER 12408.

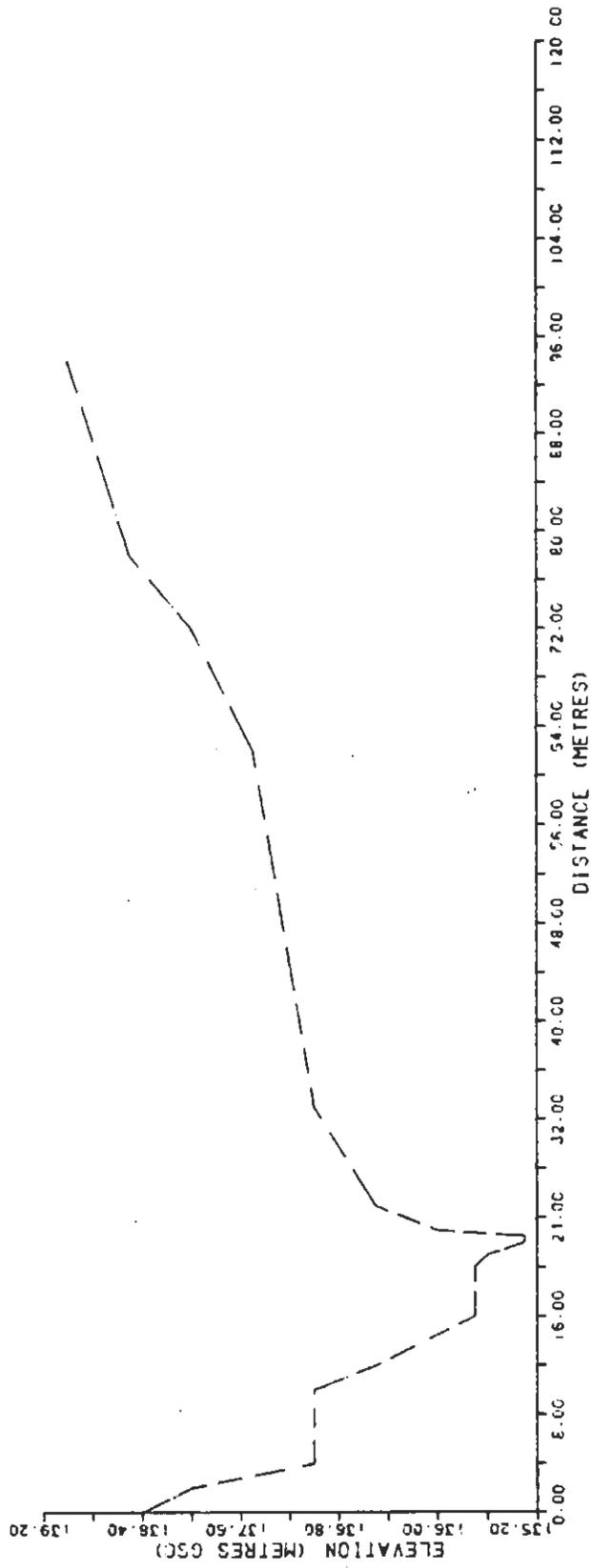


0.0000 0.0000 0.0500

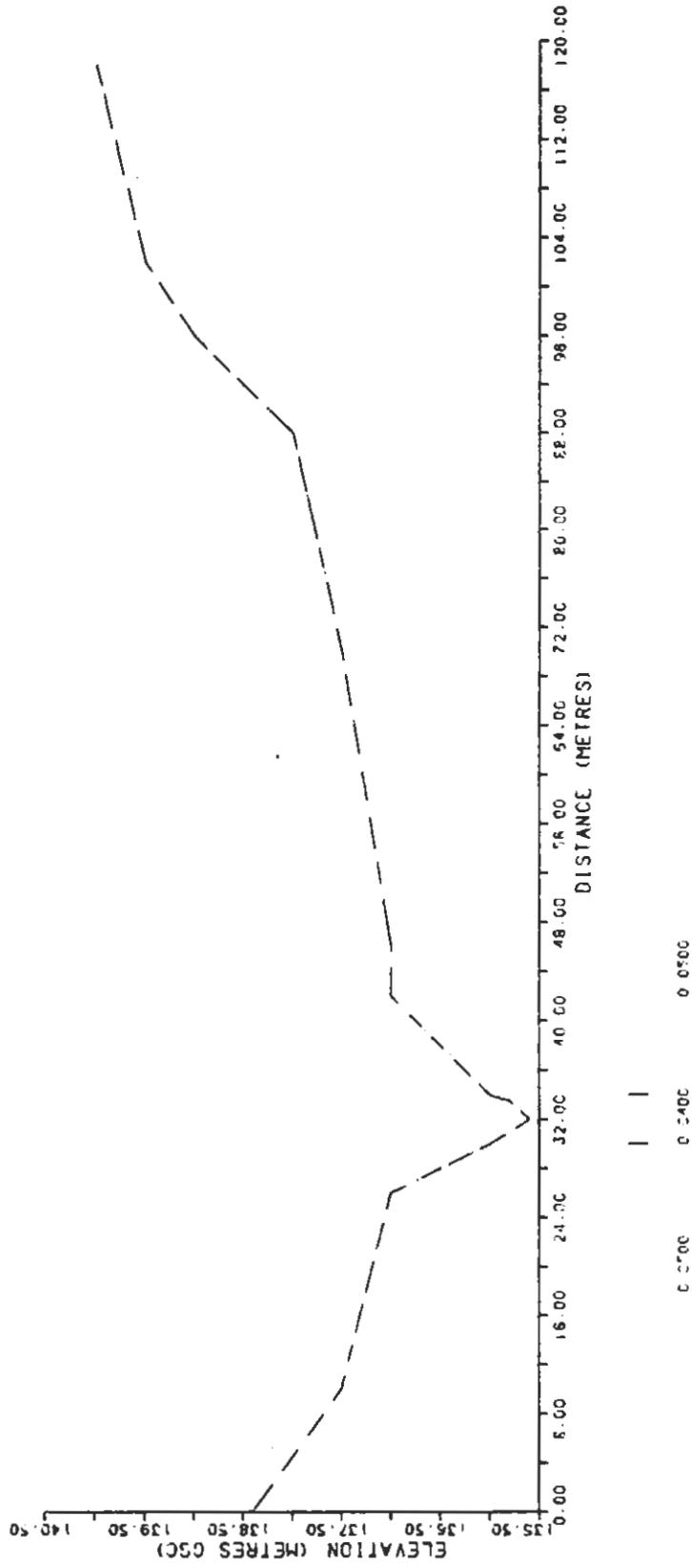
WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 12418.



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 12429.



WATERFORD RIVER HEC-2 MODEL
CROSS SECTION NUMBER 12570.



APPENDIX D

TIDE LEVEL FREQUENCY ANALYSIS

Maximum Annual Instantaneous Levels



STATION NAME=st John's waterlevel (max. instantaneous)

<u>MONTH</u>	<u>YEAR</u>	<u>DATA (m gscd)</u>	<u>ORDERED</u>	<u>RANK</u>	<u>PROB.</u>	<u>RET. PERIOD</u>
(1)	(2)	(3)	(4)	(5)	(6) (%)	(7) (YEARS)
1	1962	1.210	1.600	1	2.48	40.333
1	1963	1.230	1.540	2	6.61	15.125
1	1964	1.360	1.480	3	10.74	9.308
1	1965	1.110	1.480	4	14.88	6.722
1	1966	1.400	1.400	5	19.01	5.261
1	1967	1.210	1.380	6	23.14	4.321
1	1968	1.310	1.360	7	27.27	3.667
1	1969	1.380	1.360	8	31.40	3.184
1	1970	1.280	1.360	9	35.54	2.814
1	1971	1.360	1.340	10	39.67	2.521
1	1972	1.270	1.310	11	43.80	2.283
1	1973	1.480	1.310	12	47.93	2.086
1	1974	1.540	1.280	13	52.07	1.921
1	1975	1.310	1.270	14	56.20	1.779
1	1976	1.360	1.260	15	60.33	1.658
1	1977	1.480	1.260	16	64.46	1.551
1	1978	1.170	1.230	17	68.60	1.458
1	1979	1.200	1.220	18	72.73	1.375
1	1980	1.340	1.210	19	76.86	1.301
1	1981	1.260	1.210	20	80.99	1.235
1	1982	1.200	1.200	21	85.12	1.175
1	1983	1.600	1.200	22	89.26	1.120
1	1984	1.220	1.170	23	93.39	1.071
1	1985	1.260	1.110	24	97.52	1.025

FREQUENCY ANALYSIS - THREE-PARAMETER LOGNORMAL DISTRIBUTION
 9999 at John's waterlevel

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.314	0.122	0.093	0.697	3.526
LN X SERIES	0.269	0.091	0.337	0.496	3.282
LN(X-A) SERIES	-0.989	0.311	-0.314	-0.033	3.305
X(MIN)=	1.110			TOTAL SAMPLE SIZE=	24
X(MAX)=	1.600			NO. OF LOW OUTLIERS=	0
LOWER OUTLIER LIMIT OF X=	1.046			NO. OF ZERO FLOWS=	0

SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD

3LN PARAMETERS: A= 0.925 M=-0.989 S= 0.311

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	0.997	1.08
1.050	0.952	1.15
1.250	0.800	1.21
2.000	0.500	1.30
5.000	0.200	1.41
10.000	0.100	1.48
20.000	0.050	1.54 ✓
50.000	0.020	1.63
100.000	0.010	1.69 ✓
200.000	0.005	1.75
500.000	0.002	1.83

FREQUENCY ANALYSIS - GENERALIZED EXTREME VALUE DISTRIBUTION
 9999 at John's waterlevel

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.314	0.122	0.093	0.697	3.526
LN X SERIES	0.269	0.091	0.337	0.496	3.282
X(MIN)=	1.110			TOTAL SAMPLE SIZE=	24
X(MAX)=	1.600			NO. OF LOW OUTLIERS=	0
LOWER OUTLIER LIMIT OF X=	1.046			NO. OF ZERO FLOWS=	0

SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD

DISTRIBUTION IS UPPER BOUNDED AT (U+A/K)= 0.3205E+01
 GEV PARAMETERS: U= 1.26 A= 0.099 K= 0.051

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	0.997	1.08
1.050	0.952	1.15
1.250	0.800	1.21
2.000	0.500	1.30
5.000	0.200	1.40
10.000	0.100	1.47
20.000	0.050	1.53
50.000	0.020	1.61
100.000	0.010	1.67
200.000	0.005	1.72
500.000	0.002	1.79

FREQUENCY ANALYSIS - LOG PEARSON TYPE III DISTRIBUTION
 9999 at John's waterlevel

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.314	0.122	0.093	0.697	3.526
LN X SERIES	0.269	0.091	0.337	0.496	3.282
X(MIN)=	1.110			TOTAL SAMPLE SIZE=	24
X(MAX)=	1.600			NO. OF LOW OUTLIERS=	0
LOWER OUTLIER LIMIT OF X=	1.046			NO. OF ZERO FLOWS=	0

SOLUTION OBTAINED VIA MAXIMUM LIKELIHOOD

LP3 PARAMETERS: A= 0.2859E-01 B= 9.801 LOG(M)=-0.1100E-01
 M = 0.9891

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	0.997	1.09
1.050	0.952	1.15
1.250	0.800	1.21
2.000	0.500	1.30
5.000	0.200	1.41
10.000	0.100	1.47
20.000	0.050	1.54
50.000	0.020	1.62
100.000	0.010	1.68
200.000	0.005	1.74
500.000	0.002	1.82

FREQUENCY ANALYSIS - WAKEBY DISTRIBUTION
 9999 at John's waterlevel

SAMPLE STATISTICS

	MEAN	S.D.	C.V.	C.S.	C.K.
X SERIES	1.314	0.122	0.093	0.697	3.526
LN X SERIES	0.269	0.091	0.337	0.496	3.282
X(MIN)=	1.110			TOTAL SAMPLE SIZE=	24
X(MAX)=	1.600			NO. OF LOW OUTLIERS=	0
LOWER OUTLIER LIMIT OF X=	1.046			NO. OF ZERO FLOWS=	0

THE FOLLOWING WAKEBY PARAMETERS WERE OBTAINED BY ASSUMING M TO BE NON-ZERO. THE ITERATION ALGORITHM WAS NOT REQUIRED.

M= 0.808 A= 0.396 B= 21.96 C= 1.394 D= 0.084

FLOOD FREQUENCY REGIME

RETURN PERIOD	EXCEEDANCE PROBABILITY	FLOOD
1.003	0.997	0.83
1.050	0.952	1.07
1.250	0.800	1.23
2.000	0.500	1.29
5.000	0.200	1.41
10.000	0.100	1.50
20.000	0.050	1.60
50.000	0.020	1.75
100.000	0.010	1.86
200.000	0.005	1.99
500.000	0.002	2.16