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Design of the MOD Hydraulic Control Structure by using HEC-RAS Software

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بسم الله الرحمن الرحيم

(رب اوزعني ان اشكر نعمتك التي انعمت علي و على والدي و ان اعمل صالحا00)

صدق الله العظيم

أهـــــداء

الى المنير الذي تلقيت منه اسمى حروف الحياة فكان اعظم منير

الى النبع الذي ارتويت منه باعذب القيم و اطهر المبادئ فكان اجود معين

الى القلب الذي ينبض بالعطاء والروح التي تزخر بالصفاء و النفس التي ترتقي لتعلو في السماء

الى المثل الاعلى و القدوة المثلى و النفس التي انحني امامها بكل ود واحترام

الى الذي ظل يتابع خطواتي حتى وضعني على الطريق الى من هو اغلى من نفسي

والدي العزيز

الى العيون التي لم تعرف النوم حتى تنام و المدرسة التي زودتني بالفكر و الالهام

الى الشفاه التي اكثرت الدعاء كلما نطقت الى العين التي رات فينا املا كلما نظرت

الى القلب التي ازداد بنا فخرا كلما نبض الى التي طالما صبرت وتحملت مني الكثير و التي ادعو من الله ان ترضى عني

الى المربية العظيمة و الروح الحكيمة والنفس الكريمة

والدتي العزيزة

الى سندي في الحياة و انسي في الوحدة الى حفظة سري الى القناديل التي لا تنطفئ

و الامواج التي لا تنكسر

اولئك النجوم الذين يضيئون فضاء حياتي الى اشقاء روحي وجسدي

الى الذين اتمنى لهم من كل قلبي السعادة في الحياة و النجاة في الآخرة

اخوتي الأعزاء

الى الذين يرافقونني دربي و يهمهم امري و يذكرونني بغيابي و يشدون ازري

و يرفعون قدري و يفرحون بفرحي

الى القلوب الطيبة و النفوس النقية و الارواح الطاهرة

الى الاوفياء

اصدقائي الأعزاء

الى من لم استطع ذكر اسمائهم و في قلبي ذكراهم

شكر و تقدير

يسرني و قد انهيت مشروعي هذا ان تقدم بكل فخر واعتزاز و عظيم الامتنان الى الاستاذ الفاضل

الدكتور محمود صالح مصدي

لما قدمه لي من جهد و توجيه و مساعدة كبيرة و توجيهات قيمة و متواصلة اثناء اشرافه على المشروع

و اني اضعة بين يديه ثمرة طيبة لجهوده الكريمة

كما اقدم شكري ايضا الى كل من ابدى المساعدة و العون و تقديم الخدمات القيمة التي ساهمت في انجاز هذا المشروع

كما اتقدم بالشكر الجزيل الى رئاسة واساتذة قسم هندسة البناء والانشاءات و خاصة فرع

المياة والسدود لجهدهم المتواصل في رفع المستوى العلمي و الثقافي للطلبة

CONTAINTS

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LIST OF ABBREVIATIONS

CRIM	Center for the Restoration of Iraqi Marsh lands.
FAO	Food and Agriculture Organization.
MOD	Main Outfall Drain.
MOE	Ministry of Environment
MOWR	Ministry of Water Resources.
UNEP	United Nation Environmental Program.
WHO	World Health Organization.

LIST OF MAIN FEATURES IN ENGLISH AND ARABIC

Al Basrah	البصرة
Al Chibaeich	الجبايش
Al Dalmaj	الدلمج
Al Es'haki	الاسحاقي
Al Fadhliya	الفضلية
Al Ghameej	الغميج
Al Ghmaissa	الغميسة
Al Haffar	الحفار
Al Hammar	الحمار
Al Khamissiya	الخميسية
Al Kurmashia	الكرماشية
Al Malha	المالحة
Al Medaina	المدينة
Al Mus'hab	المسحب
Al Nassiriyah	الناصرية
AshShafi	الشافي
Al Qurna	القرنة
ArRumaila	الرميلة
AsSalal	الصلال
Beni Si'ed	بني سعيد
Garmat Ali	كرمة علي
Jasim	جاسم
Shatt Al Arab	شط العرب
Shatt Al Basrah	شط البصرة
Suq AshShuyukh	سوق الشيوخ
Um Nakhla	ام نخلة

CHAPTER ONE
INTRODUCTION

1.1 General

During the last two dry years, there was a great shortage in the water required to maintain Al Hammar Marsh. The area of the marsh was reduced greatly threatening the ecological system and economics of the marsh residents.

A hydrological routing analysis was carried out based on the objective of maintaining Al Hammar Marsh area and minimizing the evapo-transpiration, ET_O, losses.

A suggestion was made to minimize the marsh area to a value that keeps contiguous lake during the period of high ET_O and to be increased up during the period of low ET_O. Accordingly, the hydrological routing was carried out with different scenarios, based on the incoming and outgoing discharges. The variation of inflow and outflows discharges, water level, marsh area, water volume, and the water quality within the marsh were specified for each scenario.

The decision which marsh operation is the optimal is based on minimizing the water quality deterioration within the Al Hammar Marsh. . A mathematical hydraulic and water quality models was used to study the variation of the water quality within the marsh. The discharges that could be discharged to the marsh from the Main Outfall Drain were specified according to results of the hydrological routing and the hydraulic models that conserve the ecological system of Al Hammar Marsh within the acceptable international standards. Cross sections of Al Khamissiya Canal that links the Main Outfall Drain and marsh were designed. To divert the required discharge from the MOD to AL Hammar Marsh through AL Khamissiya canal, a hydraulic structure on the MOD downstream of the canal intake must be designed and constructed to raise the water surface in the MOD to insure discharging the required discharge into the marsh.

1.2 Aim of the project

The aim of this project is to prepare the hydraulic design of the MOD hydraulic structure that required to rise the water surface elevation in the MOD design and insure divert a discharge of 130 m^3/sec through AL Khamissiya canal to AL Hammar Marsh.

1.3 Methodology

The methodology of work can be summarized as follow:

1- Review the related literature.
2- Collecting the available topographical, hydrological data.
3- Implementing a steady one dimensional hydraulic model to simulate the flow in the MOD.
4- Applying the implementing hydraulic model considering the MOD operation limits and specifying the design discharge and head of the purposed control structure.
5- Implementing the suitable design of the purposed hydraulic structure.
6- Discussing results and gives the necessary recommendations.

CHAPTER TWO

AREA OF STUDY

2.1 Al-Hammar Marsh

Al-Hammar Marsh is considered as one of the largest Marshlands in Iraq. The marsh running below Euphrates River before it joins Tigris River, at Al Qurna City, from Al Nassiriyah City in Thi Qar Governorate to Al Chibaeich north of Al Basrah Governorate. Al Hammar Marsh is located between latitude 46° to 47°, and longitude 30° to 30.5°, bounded by Euphrates River as the north boundary, Shatt Al Arab River as the east boundary, and Al Basrah Water Supply Project main supply channel and the Main Outfall Drain as the south boundary, and Suq AshShuyukh as the west boundary. **Figure 1** shows the general layout of Al Hammar Marsh.

Some parts of Al Hammar Marsh was isolated by constructed dykes and drained to facilitate the development and exploitation of oil resources by the South Petroleum Company. An unpaved road was constructed to connect the north part of Al Hammar Marsh with the south part at ArRumaila Oil Fields, separating the marsh into two parts, the east and west parts. This road has 334 culverts and three bridges with total length of 4350 m, CRIM 2008.

CRIM is planning to construct a hydraulic structure, , which will control the outflow of the west part of Al Hammar Marsh and is designed to discharge $2300 m^3/sec$. This control structure has twenty seven pipes with diameter of $1.2m$ controlled by gate valves, and a weir of $2100m$ in length. The weir crest is at elevation of $2m.a.m.s.l.$

Before construction of great dams and developing new irrigation projects in Turkey, Syria, and Iraq and the massive drainage and drying processes of marshes, during nineties of the last century, "Al Hammar Marsh was covering a third of Thi Qar Governorate with an area ranged between $2800km^2$ of contiguous permanent marsh and lake, extending to a total area of over $4500km^2$ during periods of seasonal and temporary inundation, it is approximately 120*km* long and 25*km* at its widest point.

The maximum depth at low water levels is 1.8*m* and about three meters at high water levels. During the summer, large parts of the littoral zone dry out, and banks and islands emerge in many places", UNEP 2001. Several branches from Euphrates River were feeding Al Hammar Marsh. Some of these branches are controlled by head regulators of different capacities varying between 50-500 m^3/s, with a total capacity of 1300m^3/s. Al Hammar Marsh is also fed directly from an opening through the right embankments of Euphrates River with a capacity of 500m^3/s. During flood seasons, Tigris River flow through Al Qurna Marshes then to Al Hammar Marsh though culverts and escapes that were constructed for this purpose, sometime the water of Al Qurna Marshes reaches high levels and flood toward Al Hammar Marsh over the road parallel to Euphrates River conveying. The main outlets of Al Hammar Marsh are AshShafi, Al Ghameej and Garmat Ali Rivers. These rivers discharge its flow to Shatt Al Arab River, CRIM, 2008.

During nineties of the last century 94% of the Al Hammar Marsh was dried. Some of the dried lands were used for agriculture purposes. Al Malha, AshShafi, Um Nakhla, and the Right Side Euphrates irrigation projects were constructed on these dried lands

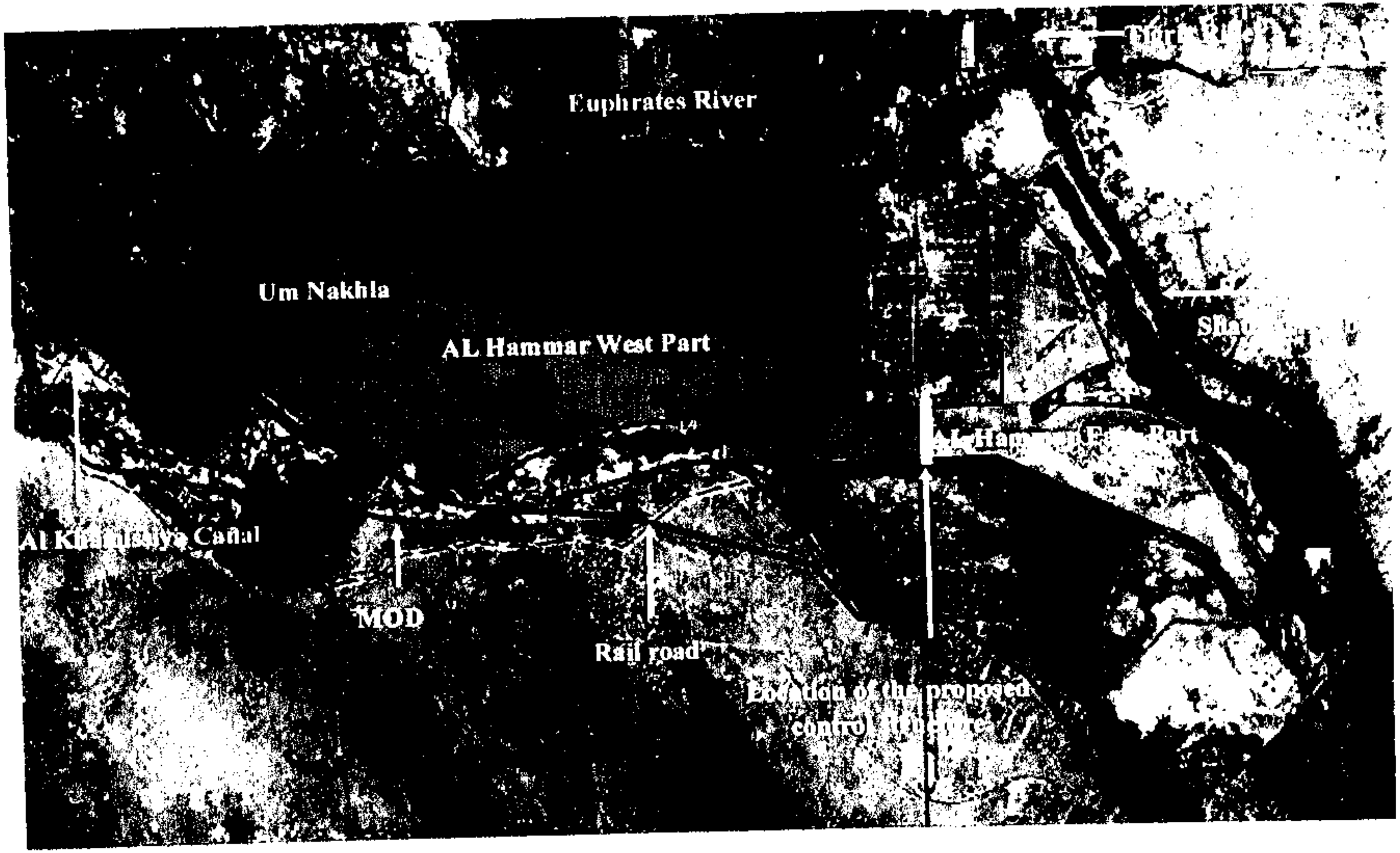


Figure 1. General layout of Al Hammar Marsh, with the proposed control structures.

Currently, the main feeders of Al Hammar Marsh are the main channels of the irrigation projects of Um Nakhla, Al Kurmashia, Al Malha, and AshShafi Irrigation Projects. Dwellers have breached the embankments and levees of Al Hammar Marsh near Al Chibaeich City allowing water to feed Al Hammar Marsh directly from Euphrates River. Al Hammar Marsh drains through Garmat Ali River into the Shatt Al Arab near Al Basrah. Garmat Ali River is formed by when AshShafi and Al Ghameej are jointed.

With the efforts of the Center for the Restoration of Iraqi Marsh lands, CRIM, and of Ministry of Water Resources of Iraq, MoWR, about 900km^2 of Al Hammar Marsh area was restored, but that restoration was affected by last dry years.

A suggestion was made by CRIM of MoWR and other related ministries to make use of the Main Outfall Drain, MOD water to feed the marsh as a temporary solution that will prevent the marsh to dry again. CRIM studied the impact of this temporary solution on the water quality within the marsh and on the ecological system. And specified the discharge that could be discharged into the marsh through AL Khamissiya canal,

Table 1 and **2** summarize the results of the hydrological routing of Al Hammar Marsh according to the two suggested scenarios of constant out flow and constant inflow that were presented previously. In **Table 1**the monthly discharges required to feed Al Hammar Marsh corresponding to each of the assumed constant outflow are presented. While, **Table 2** shows the monthly outflow corresponding to each assumed constant inflow required to feed Al Hammar Marsh. It must be noted that the discharges required to feed Al Hammar Marsh are the sum of the feeder's discharges and the MOD water. If there is sufficient water at the feeders to supply the west part of Al Hammar, then MOD water can be used only to complete the total inflow requirement. Obviously, this improves the water quality of the required inflow, since the water quality of the feeders is betters than that of the MOD.

Evapo-transpiration, ET_O, within Al Hammar Marsh region was listed in CRIM, 2008 study and is presented in **Figure 2**. Al Hammar Marsh lies within a region of high ET_O with an annual value of 2909 *mm*. The average monthly ET_O is 242.4 *mm;* it is 52 *mm* during January, increased to 470 *mm* during June, which is 9.4 times that of January.

The annual precipitation within the marsh is approximately 150*mm*. The effective rainfall is considered small compared with the evaporation and will not be considered in the hydrological routing. CRIM 2008.

TDS of the MOD measured by UNEP, at Al Nassiriyah pumping station, which is the nearest measuring station to Al Khamissiya Canal, are presented in **Figure 3**, UNEP 2009.

Table 1. The constant outflow and inflow discharges of Al Hammar Marsh according to the first scenario (*after CRIM, 2010*).

Months	**Constant outflow from Al Hammar Marsh, m^3/s**								
	0	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**
	Inflow to Al Hammar Marsh, m^3/s								
Oct	90	95	100	105	110	115	120	125	130
Nov.	49	54	59	64	69	74	79	84	89
Dec.	23	28	33	38	43	48	53	58	63
Jan.	2	7	12	17	22	27	32	37	42
Feb.	0	5	10	15	20	25	30	35	40
Mar.	6	11	16	21	26	31	36	41	46
Apr.	5	10	15	20	25	30	35	40	45
May	20	25	30	35	40	45	50	55	60
Jun.	47	52	57	62	67	72	77	82	87
Jul.	56	61	66	71	76	81	86	91	96
Aug.	65	70	75	80	85	90	95	100	105
Sep.	77	82	87	92	97	102	107	112	117

Table 2. The outflow and constant inflow discharges of Al Hammar Marsh according to the second scenario (*after CRIM, 2010*).

Months	Constant Inflow to Al Hammar Marsh, m^3/s								
	90	95	100	105	110	115	120	125	130
	Outflow from Al Hammar Marsh, m^3/s								
Oct	0	5	10	15	20	25	30	35	40
Nov.	41	46	51	56	61	66	71	76	81
Dec.	67	72	77	82	87	92	97	102	107
Jan.	85	90	95	100	105	110	115	120	125
Feb.	91	96	101	106	111	116	121	126	131
Mar.	84	89	94	99	104	109	114	119	124
Apr.	85	90	95	100	105	110	115	120	125
May	70	75	80	85	90	95	100	105	110
Jun.	43	48	53	58	63	68	73	78	83
Jul.	34	39	44	49	54	59	64	69	74
Aug.	25	30	35	40	45	50	55	60	65
Sep.	13	18	23	28	33	38	43	48	53

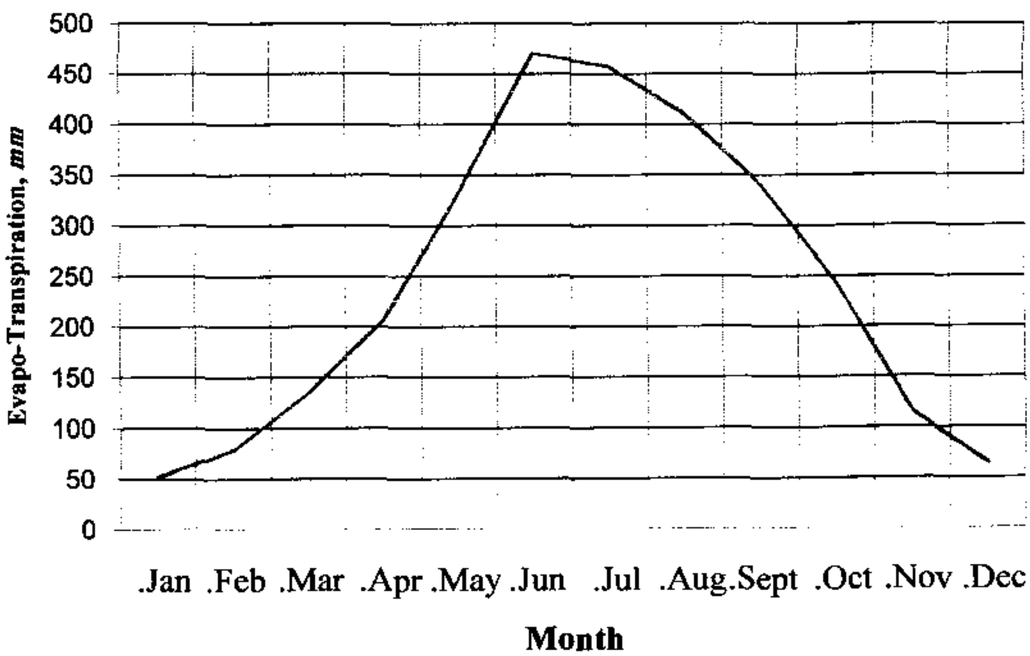
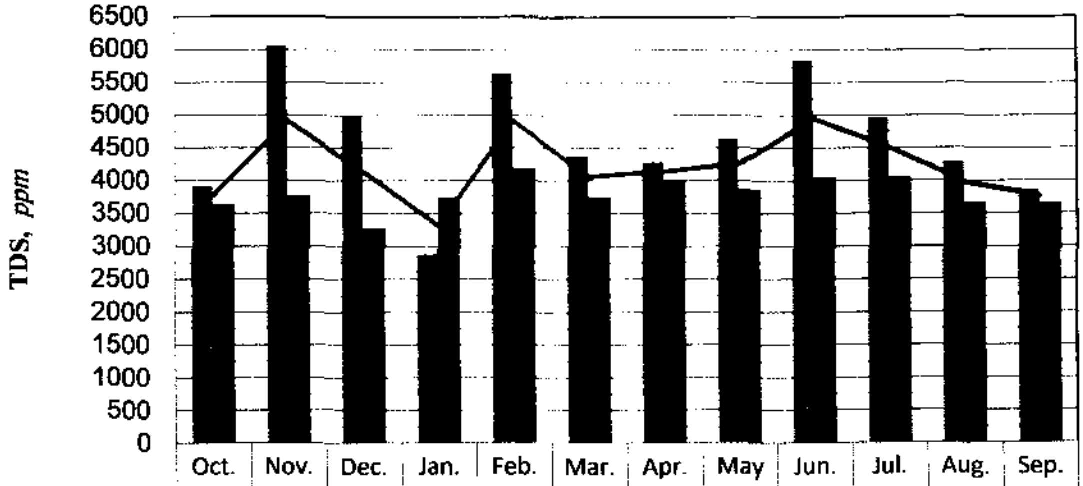


Figure 2. Evapo-transpiration within Al Hammar Marsh Region, CRIM, 2008.



	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
2008	3920	6065	5005	2885	5645	4387	4289	4640	5847	4965	4285	3870
2009	3640	3770	3275	3735	4188	3748	3990	3865	4053	4060	3670	3655
Average	3780	4918	4140	3310	4917	4068	4140	4253	4950	4513	3978	3763

Figure 3. TDS variation at Al Nassiriyah Pump Station, UNEP, 2009.

2-2 Main Outfall Drain

The basic idea of the Main Outfall Drain, MOD, **Figure 2**, which was suggested in beginning of the last century, is to construct a main channel to collect highly saline drained water of the irrigation projects within central and southern parts of Iraq and discharge it down to the Arabian Gulf.

In mid of the last century the MOD was designed to flow between the Tigris and Euphrates Rivers, then it crosses the Euphrates riverbed, via large pump station east of Al Nassiriyah City, toward the Arabian Gulf. The MOD serves more than six million Donums of agricultural lands.

Construction of some parts of the MOD started in the 1950s and more were completed in the 1960s, but the entire project was not completed until December 1992, when the final section, linking the seaward end to that built at Al Dalmaj Lake northwest of Al Nassiriyah, was constructed. The MOD crosses the Euphrates River just east of Al Nassiriyah, beneath the riverbed in large pipes limiting its discharge to $140m^3/s$ which was then replaced by a huge pumping station of $220m^3/s$ in 2009.

The total length of the MOD is 565*km*, was divided into three sectors based on the construction stage as follow, MoWR, 2005:

1- The Northern sector: the total length of this part is 206*km*, starts from Al Es'haki Main Drain north of Baghdad down to Al Dalmaj Lake. The total area served by this sector is 2320000d*onums*. The discharge of this sector at Al Dalmaj Lake is 88m^3/s. The bed and top widths of this sector of the MOD at Al Es'haki Main are 7.8*m*, and 46*m*, respectively, and at Al Dalmaj Lake are 21.2*m*, and 57*m*.

2- The Central Sector: this sector starts north of Al Delmaj Lake and ends at the point where the MOD crosses the Euphrates with a length of 187*km*. this sector consist of a navigation channel of a bed width of 50-34 *m* and a top width of 98*m*. The maximum capacity of this sector is 220m^3/s. The total area served by this sector is 4000000*donums*. This sector is connected to Al Dalmaj Lake insure the required water levels for navigation during the whole year.

3-The Southern Sector: this sector starts at the point where the MOD crosses the Euphrates River down to Shatt Al Basrah River with a length of 172*km*. This section has two reservoirs to storage the MOD discharge when Shatt Al Basrah regulator is closed during tide and releases it when it is opened during ebb. The bed width of this sector is 50*m* and a top width of 110*m* and its capacity at Shatt Al Basrah is 200m^3/s.

The pumping station used to discharge the MOD water through the culvert beneath the riverbed of the Euphrates River consist of twelve pumps, eight of them are of a capacity of 25m^3/s and the others are of a variable capacity varies between 12 to 25m^3/s. The culvert is of 440 *m* in length with three openings of 4 by 5*m* cross section each. **Figure 3** shows a schematic diagram of main structures locations on the MOD downstream Al Nassiriyah Pump Station.

CRIM, 2010, carried out a cross-sectional survey for the MOD reach between the pumping station at station 160+500 km and the location of the proposed control structure at station 137+500 km , the surved twenty one cross-section are shown in annex A.

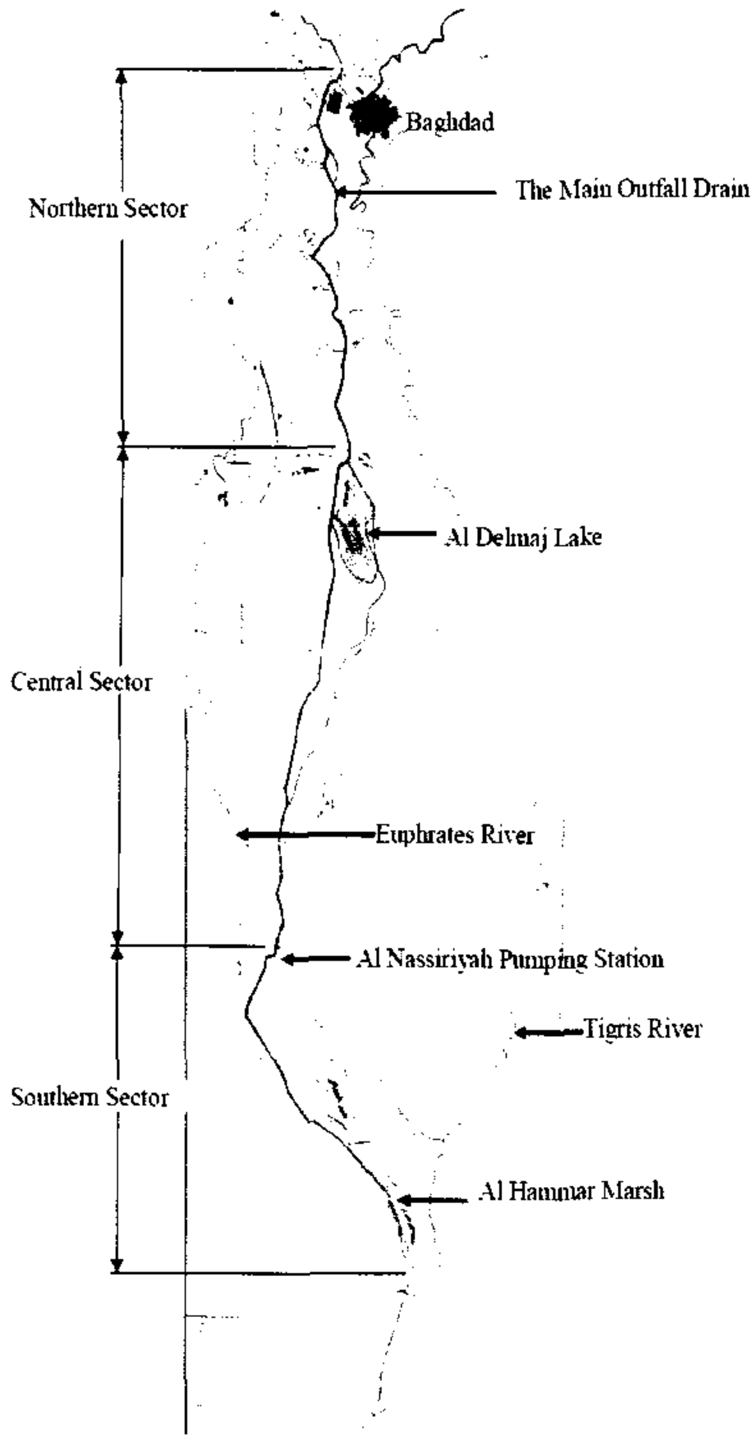


Figure 4. General layout of the MOD, *after the directorate of the MOD.*

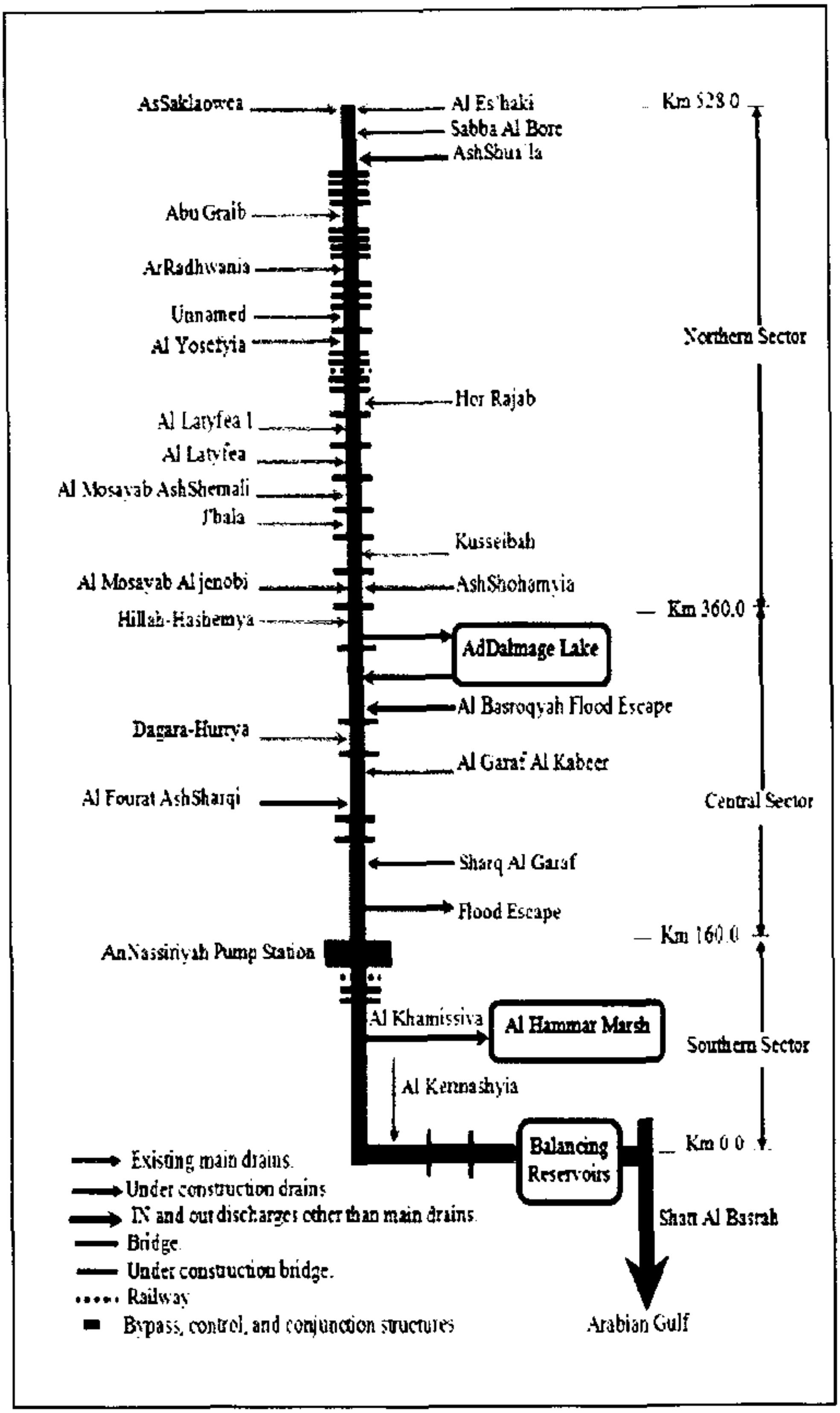


Figure 5. A schematic diagram of the MOD.

CHAPTER THREE
HYDRAULIC MODELS

3.1 General Overview of the HEC-RAS Software

This software allows the user to perform one-dimensional steady and unsteady flow hydraulics. It is an integrated system of software, designed for interactive use in multi-tasking, multi-user network environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities graphics and reporting facilities.

3-2 Theoretical Basis for One-Dimensional Flow Calculations

Topics discussed below include equations for basic profile calculation, in steady and unsteady flow.

Steady flow

Water surface profiles are computed from one cross-section to the next by solving the energy equation. The energy equation is:

$$y_1 + \frac{\alpha_1 v_1^2}{2g} + z_1 = y_2 + \frac{\alpha_2 v_2^2}{2g} + z_2 + h_e \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where:

y_1, y_2: depth of water at cross-section, m.

z_1, z_2: elevation of the main channel inverts, m.

v_1, v_2: Averaged velocity at the section, m/sec.

g: gravitational acceleration, m^2/sec.

h_e: head loss ,m.

The head loss in a reach of length L may be calculated as:

$$h_e = L * \bar{S_f} + C\left[\frac{\alpha_1 v_1^2}{2g} + \frac{\alpha_2 v_2^2}{2g}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where:

S_f : Representative friction slope between the two sections.

C: Expansion or contraction loss coefficient

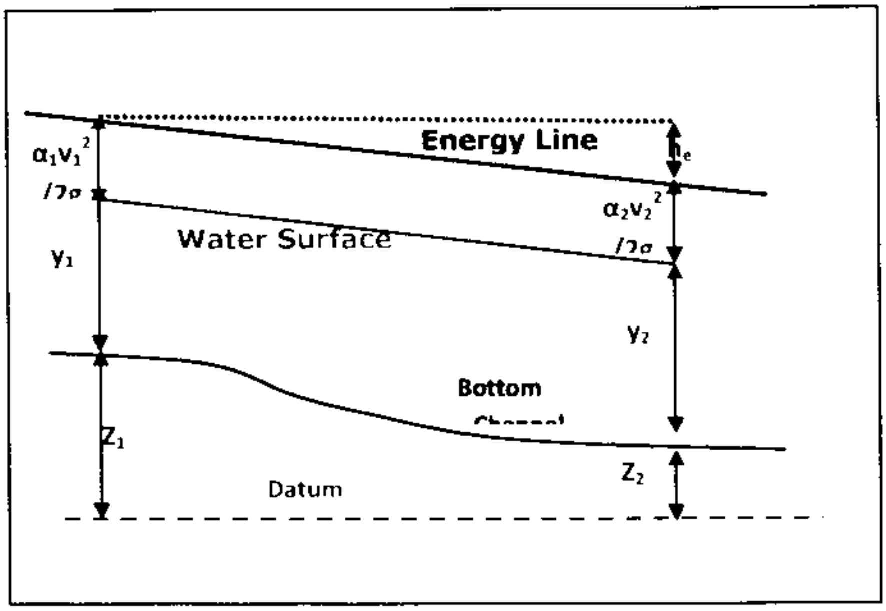


Figure 6. Longitudinal Section of Channel Reach.

3-3 Basic Data Requirements

The main objective of the HEC-RAS software is quite simple- to compute water surface elevation at all locations of interest for either a given set of flow data(steady flow simulation) , or by routing hydrographs through the system (unsteady flow simulation). The data needed to perform these computations are divided into the following categories:

A- Geometric data

B- Steady flow data

C- Unsteady flow data.

3-3-1 Geometric data

Geometric data consists of establishing the connectivity of the river system (River system scheme): cross sections: reach lengths: energy loss coeff and Stream junction information's. Hydraulic structure data (bridge, culverts, spillway, weir etc.....). which area also considered geometric data.

3-3-2 Steady Flow Data

Steady Flow Data are required in order to perform a steady water surface profile calculation. This data consists of flow regime, boundary conditions and peak discharge information.

3-3-3 Flow regime

The flow regime is specified on the study flow analysis window of the user interface.

3-4 Boundary conditions

Boundary conditions are necessary to establish the staring water surface at the ends of the river system upstream (U/S) and down-stream (D/S). In a sub critical flow regime, Boundary conditions are only necessary at the D/S ends of the river system. If a super critical flow regime is going to be calculated, boundary conditions are only required at U/S ends of the river system. In the mixed flow regime both U/S and D/S Boundary conditions must be entered at all ends. Four types of Boundary conditions may be used as follows:

1- Known water surface elevation (constant elevation)
2- critical depth(y_c)
3- normal depth(y_n)
4- rating curve (relation between Q and y)

3-5 Initial Conditions

The user is required to establish the initial conditions (flow and/or stage) at all nodes in the system at the beginning of the simulation.

3.6 MOD Hydraulic model

To insure discharge 130 m^3/sec through Al Khamissiya, it is required to construct a control structure at the MOD just after the intake of Al Khamissiya Canal to raise the water surface elevation in MOD, during the low flow. This structure should be of a design discharge of 220m^3/sec, which is the design discharge of the MOD at this location. Taken into account that the water surface elevation just downstream of the MOD pumping station must not exceed 4.5*m.a.m.s.l.* Soyuzgiprovodkhoz, 1984. The water surface elevation along the MOD reach, between the downstream of the pumping station and upstream the control structure must not exceed the minimum elevation of the MOD banks of *6m.a.m.s.l*, CRIM, 2010.

According to the above requirements, a steady one dimensional hydraulic model was implemented by using HEC-RAS software to simulate the flow and study the back water curve in the MOD upstream this structure.

3-7 MOD Hydraulic Model Input Data

Steady one dimensional flow hydraulic model, by using HEC-RAS software, was used to simulate the flow in the MOD reach. The simulated MOD reach started at the pumping station at station at 160 +500*km* and extends beyond the proposed location of Al Khamissiya Canal intake at station 139+500*km* to station 137 +200*km*. Geometric data that comprise twenty one cross sections were used in the model, **Annex A**. **Figure 6** shows the geometric input data window of the HEC-RAS software.

Based on the MOD condition The Manning's roughness coefficient of 0.03 was adopted for the all cross sections along the reach.

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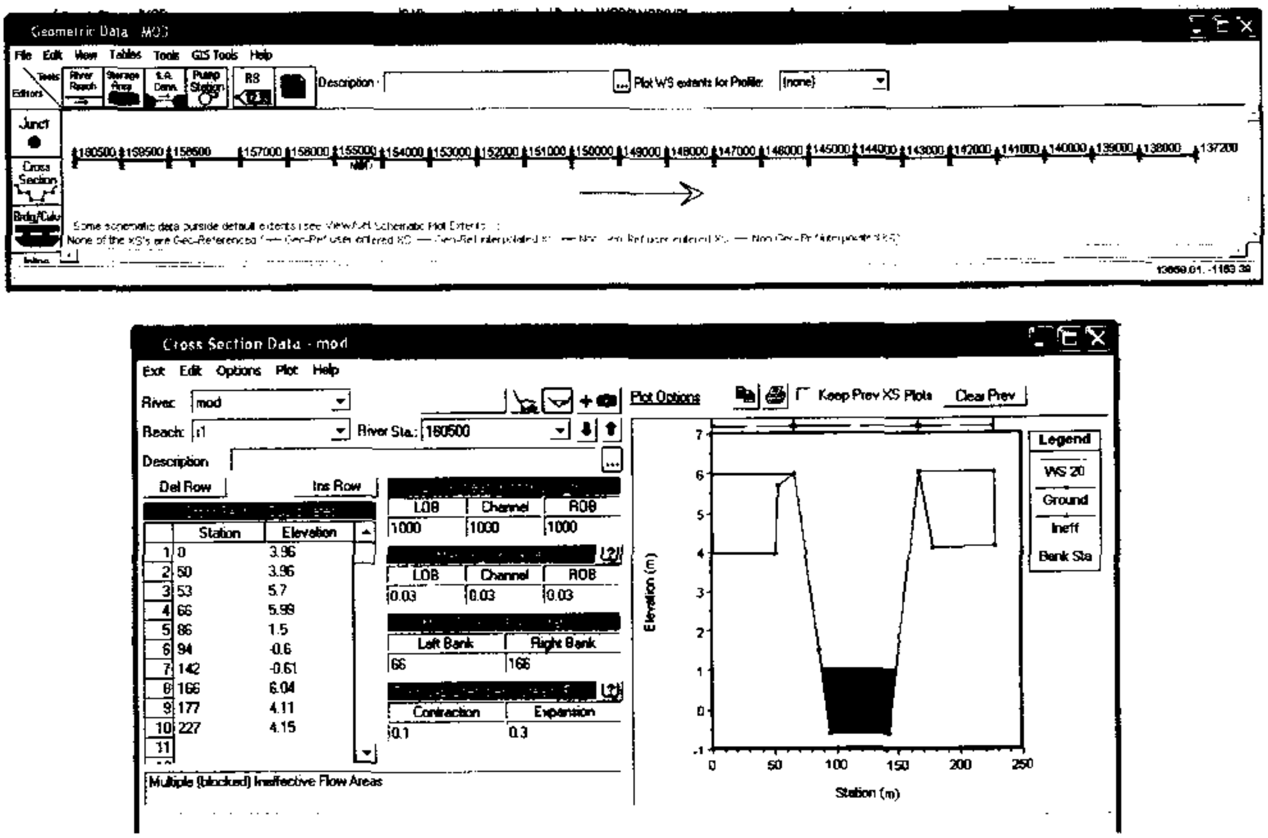

Figure 7. Geometric Data of the MOD hydraulic model, reach layout and cross sections.

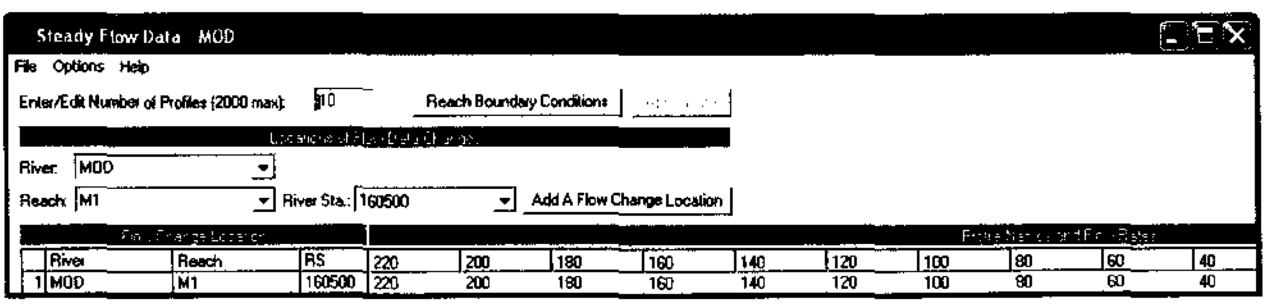

Figure 8. MOD steady flow data.

The maximum permissible water surface elevations at the proposed location of Al Khamissiya Canal intake at station 137+500*km*, that preserve the water surface elevation at the downstream of the pumping station, station 160 +500km, not exceeds 4.5m.a.m.s.l with each discharge of the adopted discharge range were considered as downstream boundary condition, **Figure** 6.

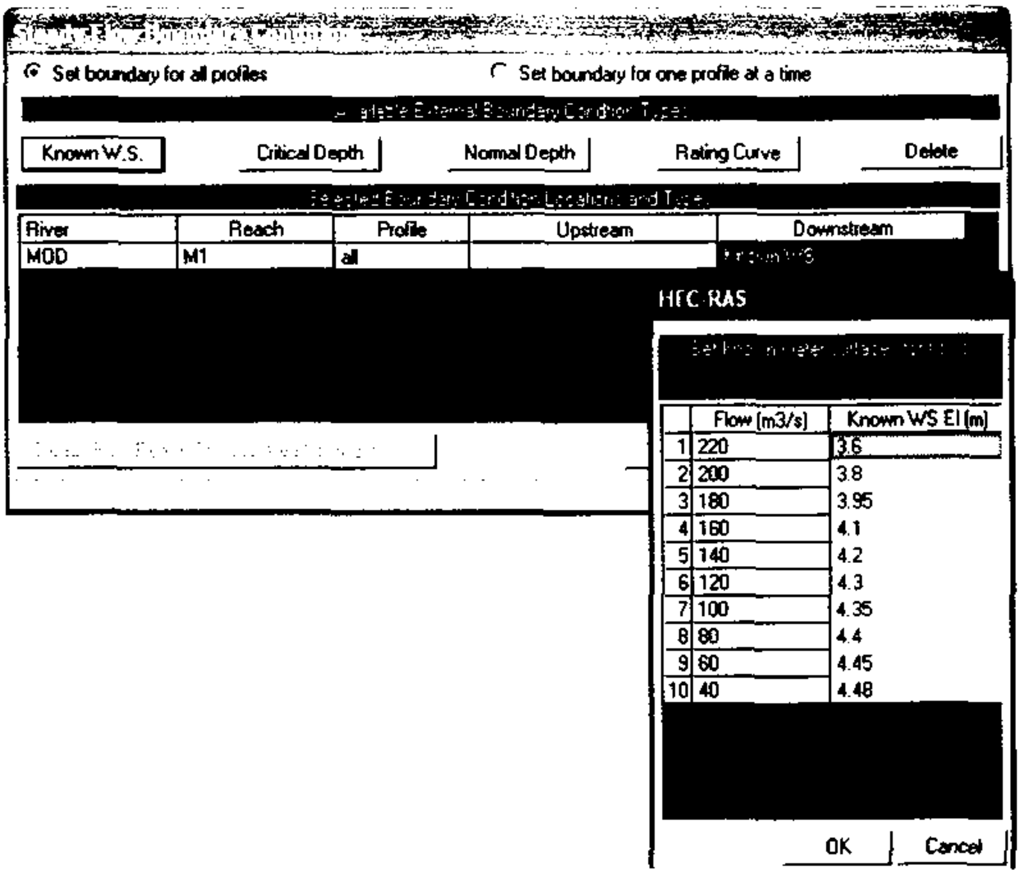

Figure 9. MOD downstream boundary condition.

CHAPTER FOUR

RESULTS

4.1 MOD Hydraulic Model Runs Results

The maximum permissible water surface elevations were estimated by making use of the implemented hydraulic model. The hydraulic model run repeated many times with different water surface elevations until the water surface elevation at station 160 +500km not exceeds 4.5m.a.m.s.l for the adopted discharge range.

Profiles of water surface within the MOD reach from station 137 +200*km* to station 160 +500km with the adopted discharge range of the MOD pumping station is as shown in **Figure 9**.

The variation of water surface elevation within the MOD at station 139+500*km* with the discharge of the MOD pumping station is as shown in **Figure 10.**

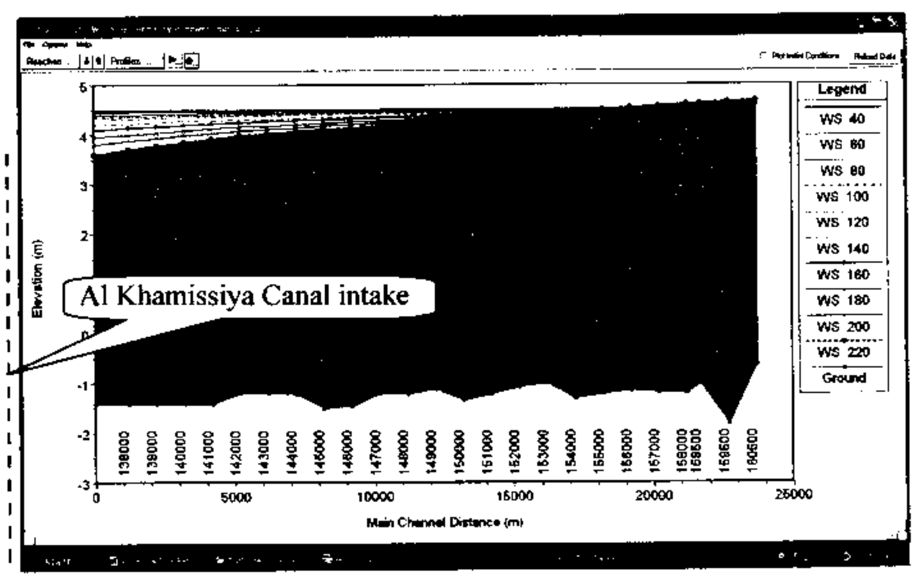

Figure 10. Profiles of water surface within the MOD reach with the adopted discharge range of the MOD pumping station.

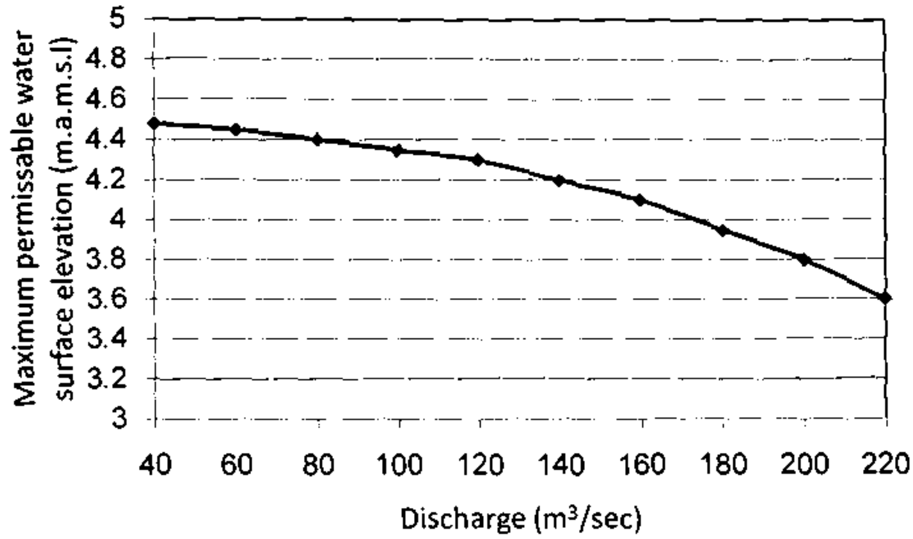

Figure 11. Maximum permissible water surface elevations at MOD station 139+500*km*, with the discharges of the MOD pumping station at station 160+500 km.

4.2 Proposed Design of the MOD Control Structure

Many trial mathematical model runs and checking process were carried out to obtain the proposed MOD control structure. The proposed MOD is a barrage of rectangular cross section with 100.0*m* width, 4.50*m* height, 0.50 *m.a.m.s.l* bed elevation, 5.00 *m.a.m.s.l* crest elevation and 20 sluice gates with 3.0m width, 2.5m height and 1.0 *m.a.m.s.l* invert elevation, as shown by **Figure 11**.

Accordingly, results of the implemented MOD simulation model showed that the maximum water surface elevation in the studied MOD reach at the downstream of the MOD pumping station, with high flow discharge of $220m^3/sec$, was 4.5*m.a.m.s.l*, **Figure 12**.

The MOD cross sections along a distance of 72*m* and 43*m* upstream and downstream the control structure, respectively, were modified to satisfy the transition to avoid the effect of flow turbulence, Pencol, 1983, these modified cross sections are shown in **Annex B** .

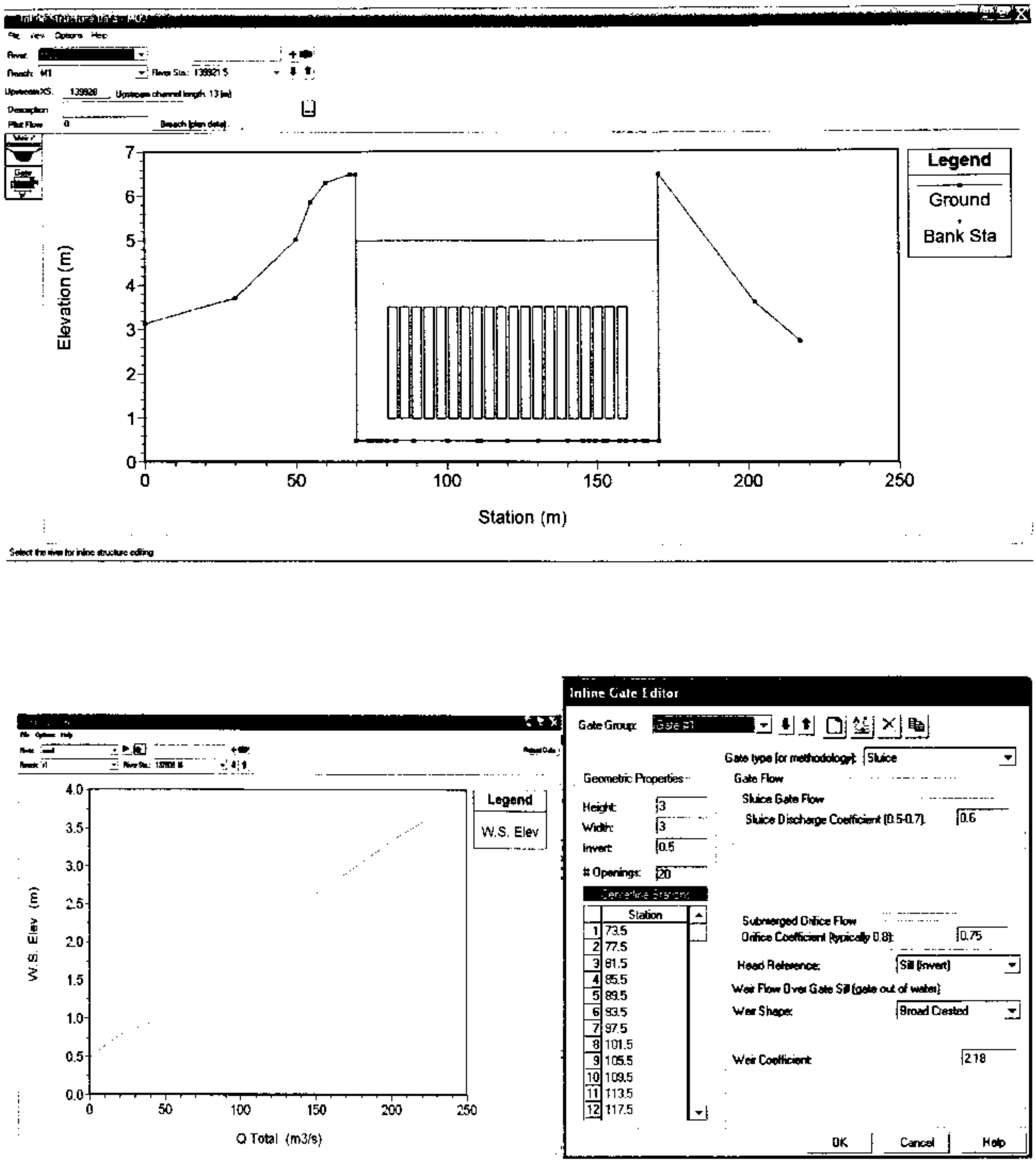

Figure 12. Dimension and properties of the designed control structure.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Design the hydraulic structure to regulate discharge water from MOD to Al Hammar Marsh required constructing a control structure. Constructing this Hydraulic structure required studying the hydraulic flow in the MOD. Accordingly; a steady one dimensional hydraulic model was implemented by using HEC-RAS software to simulate the flow in the MOD.

The required geometric, flow, and boundary conditions data were input. The results of applying this model considering the required discharge from MOD to Al Hammar Marsh, 130m^3/sec. Showed that the water surface elevation must be not greater than 3.9 m.a.m.s.l. and to discharge 220m^3/sec through the proposed hydraulic control structure on the MOD the water surface elevation at the upstream of this control structure must not exceed 3.6 m.a.m.s.l. The high flow discharge of the MOD pumping station, 220 and 200m^3/sec usually occurred during the wet years. At such years it is not required to feed the marsh from MOD. Therefore, the water surface elevation, 3.9 m.a.m.s.l., corresponds to MOD pumping station discharge of 180m^3/sec, can be accepted to discharge the 130m^3/sec into the marsh and the upstream water surface elevation at the control structure must not exceed of 3.6 m.a.m.s.l. during the high flow. Therefore the control structure must be designed to discharge 220m^3/sec with upstream water surface elevation 3.6 m.a.m.s.l..

The implemented hydraulic model was used to design the hydraulic control structure. The designed hydraulic structure is of 20 slues gate, the width of the control structure (broad crested weir) is 100 m, height of the gate is 3 m, width 3 m and invert 0.5m

The MOD cross sections along a distance of 72m and 43m upstream and downstream the control structure, respectively, were modified to satisfy the transition to avoid the effect of flow turbulence.

5.2 Recommendations

1. The water surface elevation, 3.9 m.a.m.s.l., corresponds to MOD pumping station discharge of 180m^3/sec, can be accepted to discharge the 130m^3/sec into the marsh and the upstream water surface elevation at the control structure must not exceed of 3.6 m during the high flow, 220m^3/sec.
2. The proposed MOD control structure must be designed to discharge 220m^3/sec with upstream water surface elevation 3.6 m.a.m.s.l..
3. The cross sections of the canal must be designed as shown in annex B.
4. Canal cross sections along a distance of 200*m* downstream the control structure were modified to satisfy the transition to avoid the effect of flow turbulence.
5. The MOD control structure must be fully opened when the flow discharge of the MOD pumping station is, 220 and 200m^3/sec to insure that the water surface elevation is less than 3.9 m.a.m.s.l. at the upstream of the MOD control structure.

REFERANCES

1. Arcement, G. J., and Schreider, V. R., 2002, *Guide for Selecting Manning's Roughness Coefficient for Natural Channels and Flood Plains*, U.S.G.S., Water Supply Paper 2339, U.S.A.
2. CRIM, 2007, *Restoration of Al Hammar Marsh Study.*
3. CRIM, 2008, *Study of Improving the Environmental Present Condition of Southern Marshes.*
4. CRIM, 2010. *Topographical survey data of the proposed Al Khamissiya Canal.*
5. Donnel, Barbara ed., 2001. *Users Guide to RMA4 Version 4.5.* USACE Waterways Experiment Station, Vicksburg, MS.
6. Donnell, B. P., 2004, *User Guide to WES-RMA2 Version 4.5, Water Ways Experiment Station*, Costal and Hydraulics Laboratory, California, Davis, U.S.A.
7. Engineering and Hydro systems Inc. 2006, *Mathematical Model Study For Design Prepared By Pakistan,* PJR Consulting, Inc.
8. FAO: Ayres, R. S. and D. W. Westcott. 1994. *Water Quality for Agriculture.* FAO Irrigation and Drainage Paper 29 Rev 1.
9. Italian Ministry of Environment and Territory, 2006, *Overview of present conditions and current use of the water in the marshlands area*, book 4. Iraq Foundation.
10. MOWR, 2005, *Encyclopedia of Irrigation Services in Iraq, since March 1918 to March 200.*
11. Ruthven, T. and Ramsey, J., 2002, *Feasibility Study To Improve Tidal circulation In Windmill Cove, Osterville, Massachusetts*, Applied Coastal Research and Engineering, Inc.
12. Pencol Engineering Consultants, 1983. *Design Manual for Irrigation and Drainage*, Ministry of Irrigation- Baghdad Iraq.

13. Soyuzgiprovodkhoz, 1984, *Tigris – Euphrates Main Outfall Drain- Detailed Project Report,* Volume 1, Moscow.

14. Ubaid, Shimaa K., 2008, *Al Huwayza Marsh Operation Effects on the Velocity Profiles and Water Quality Distribution.* M. Sc. Dissertation, College of Engineering, University of Baghdad.

15. UNEP, 2001, *The Mesopotamian marshlands, Demise of Ecosystem.*

16. UNEP, 2009, *Environmental Monitoring and Main Drain Wetland Pilot Project.*

17. WHO, 2008, Guidelines for Drinking-water Quality, third edition, Volume 1, Recommendations.

ANNEX A

CROSS SECTIONS OF THE MOD

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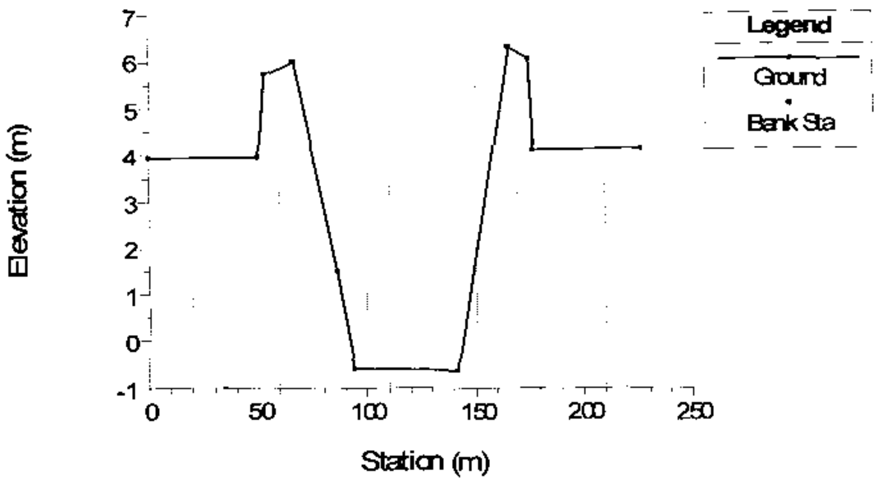

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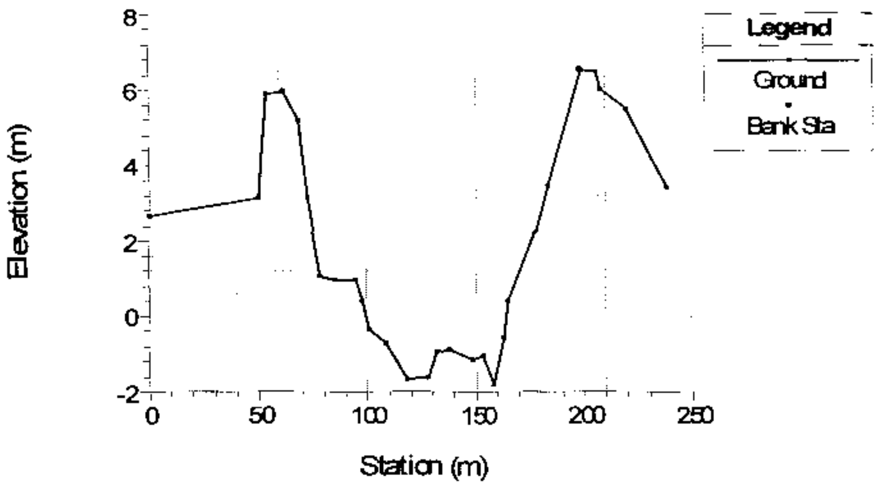

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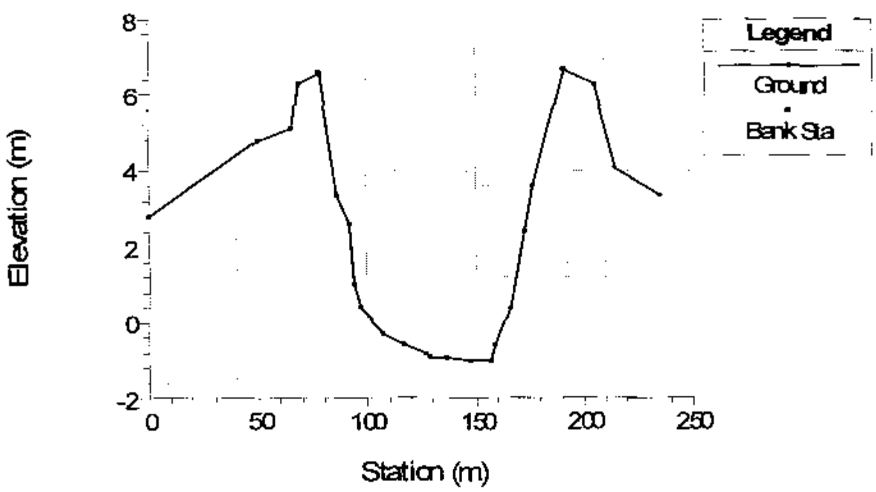

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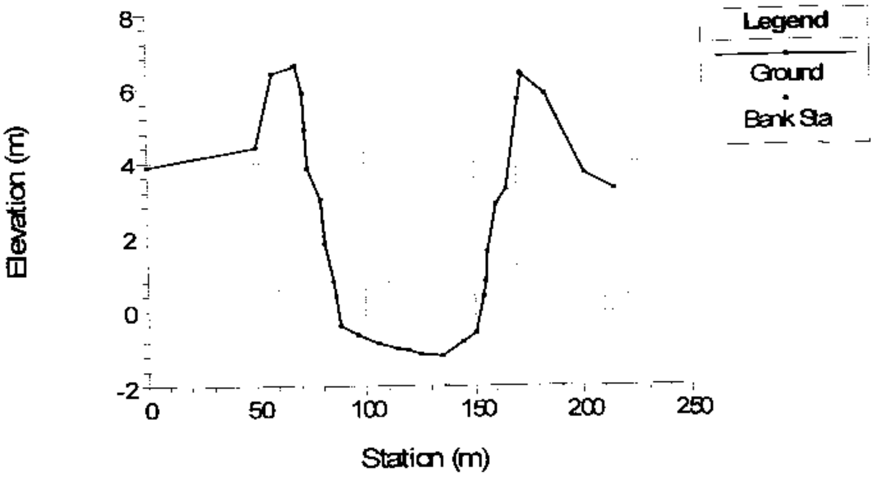

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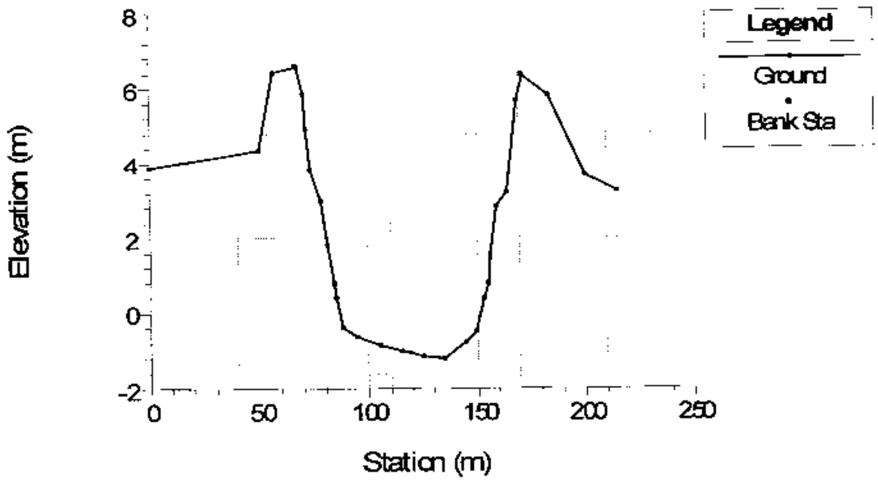

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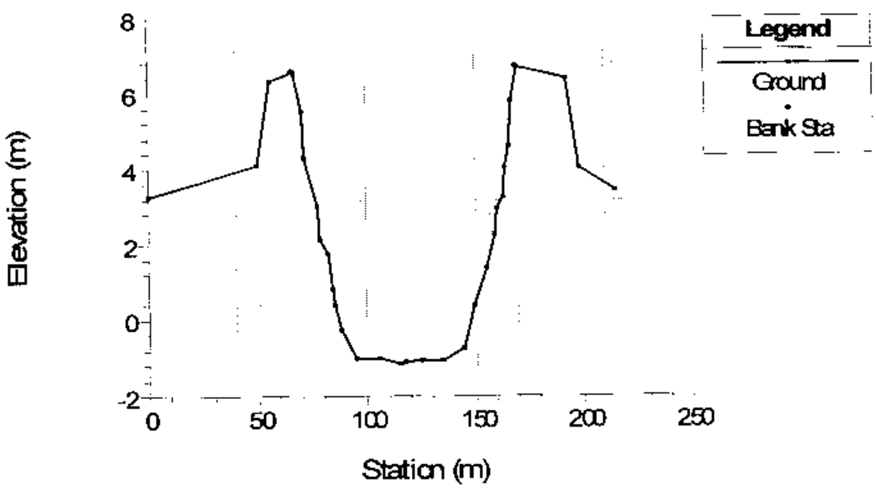

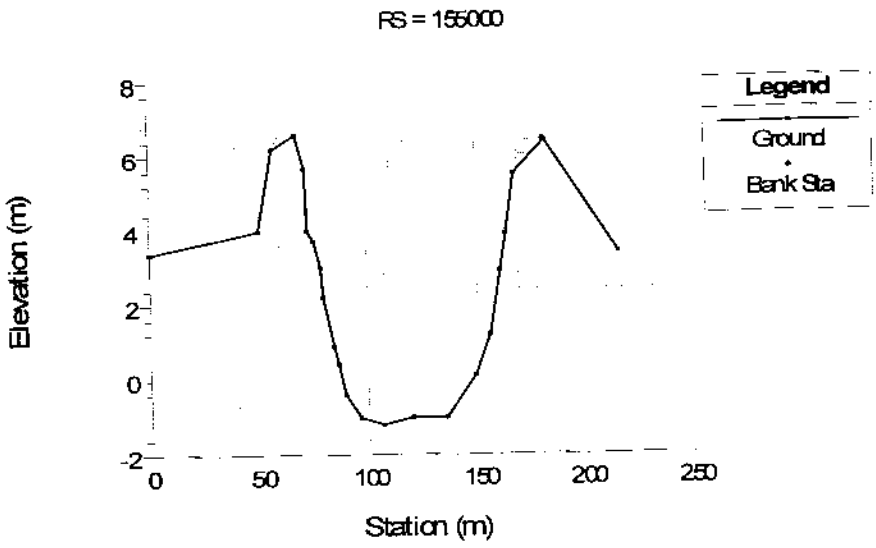
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200
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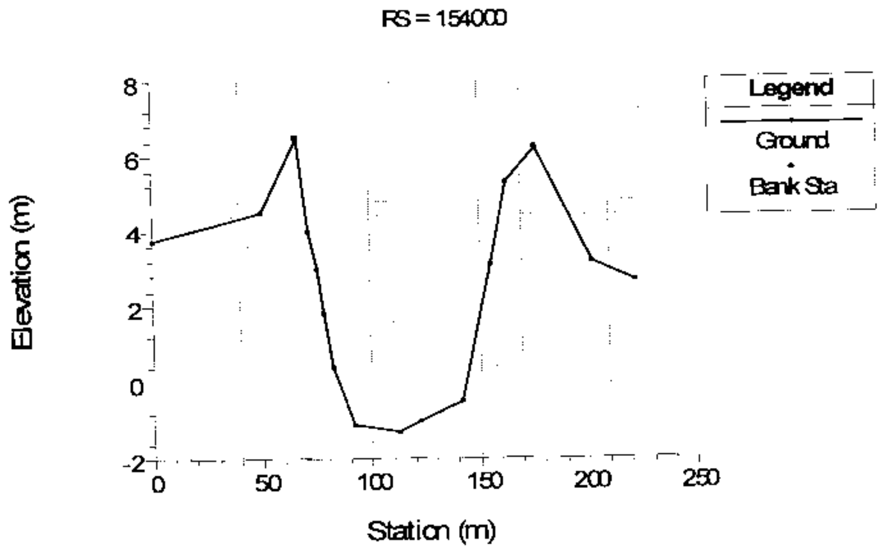
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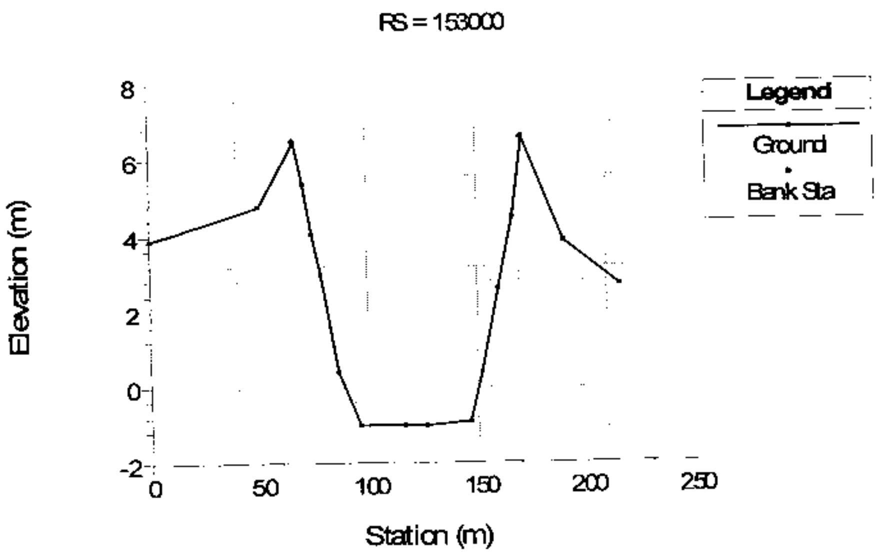
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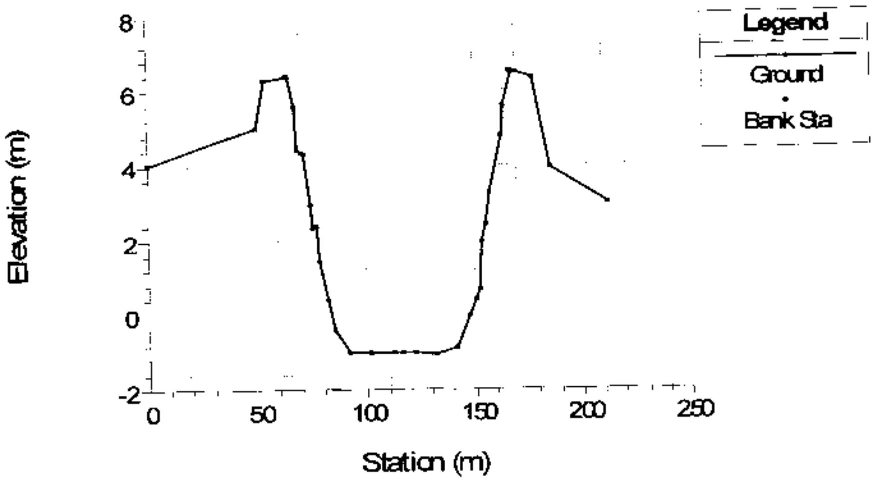

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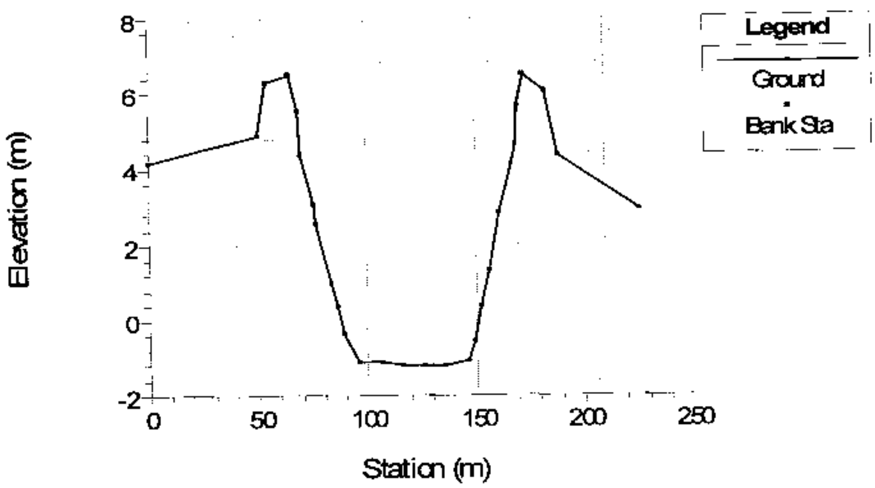

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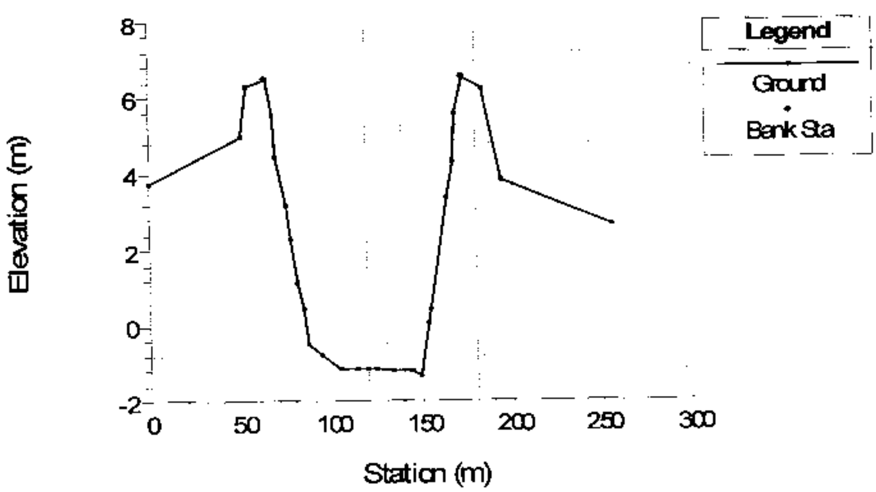

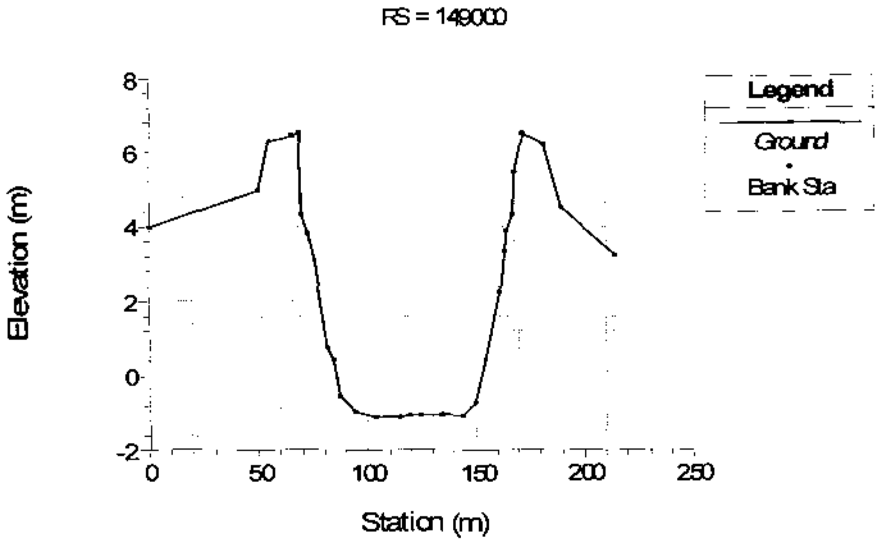
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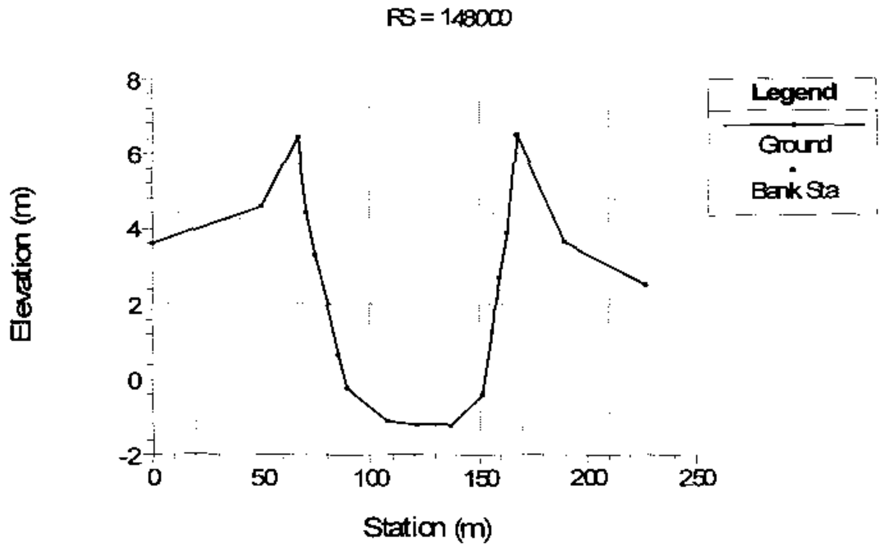
Ground
Bank Sta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Station (m)
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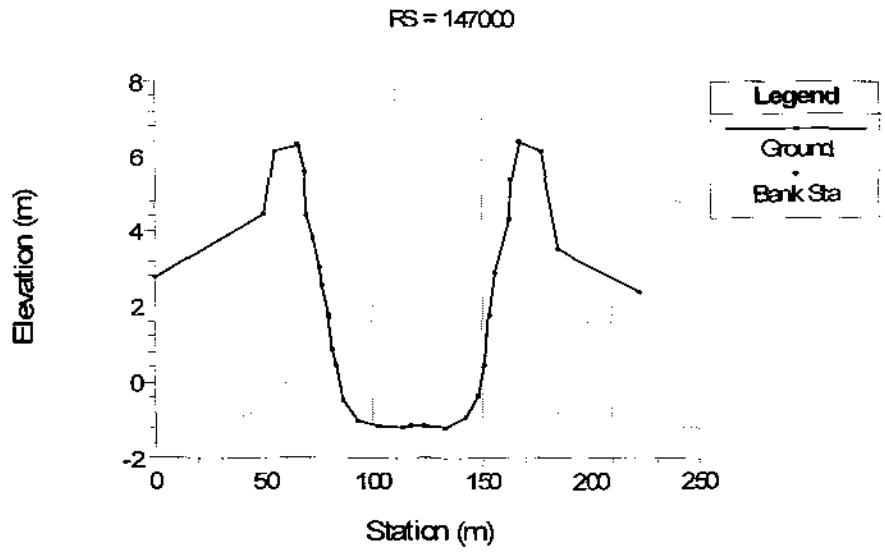
Ground
Bank Sta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Station (m)
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Ground
Bank Sta

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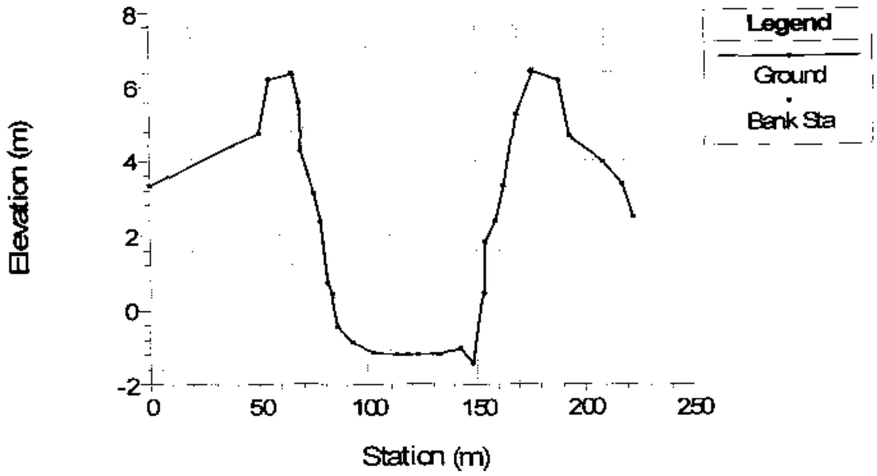

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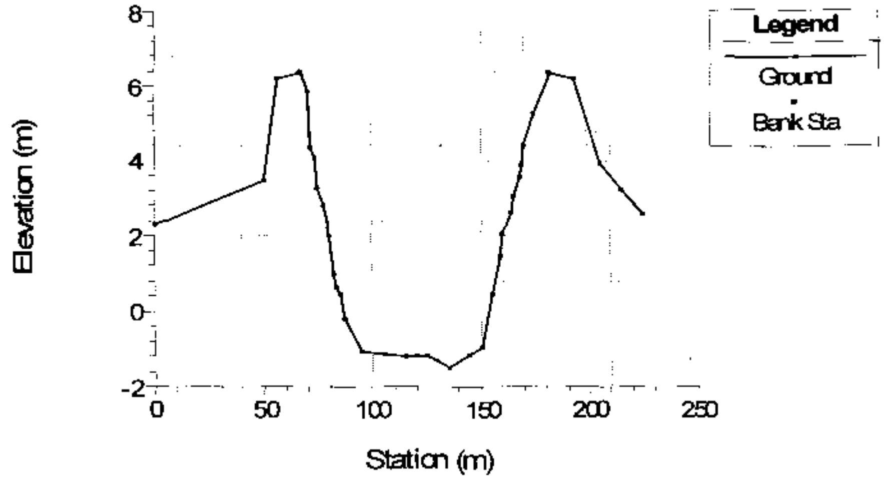

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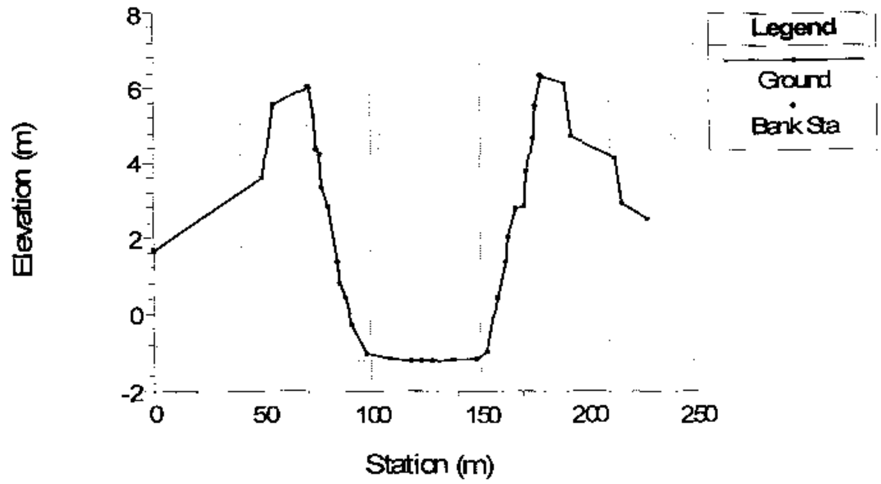

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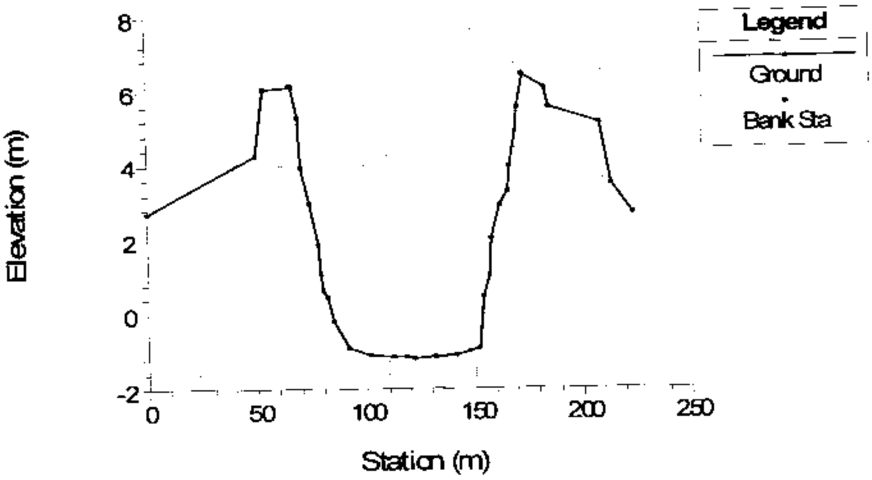

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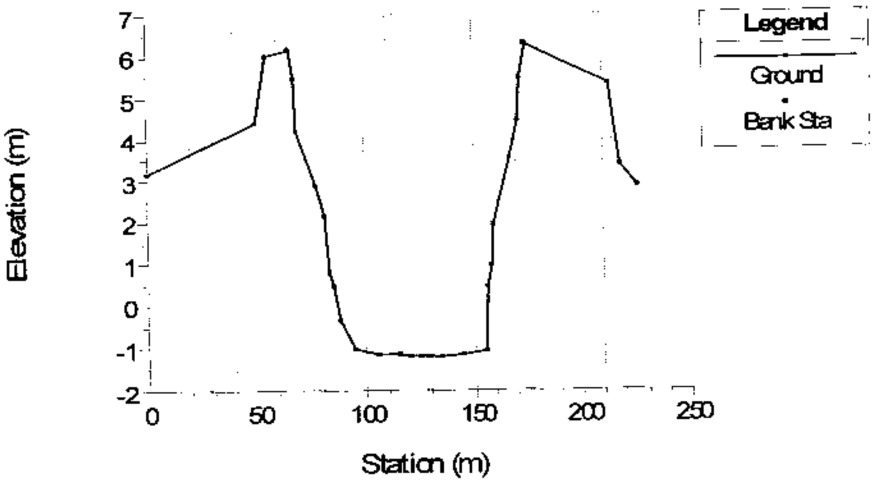

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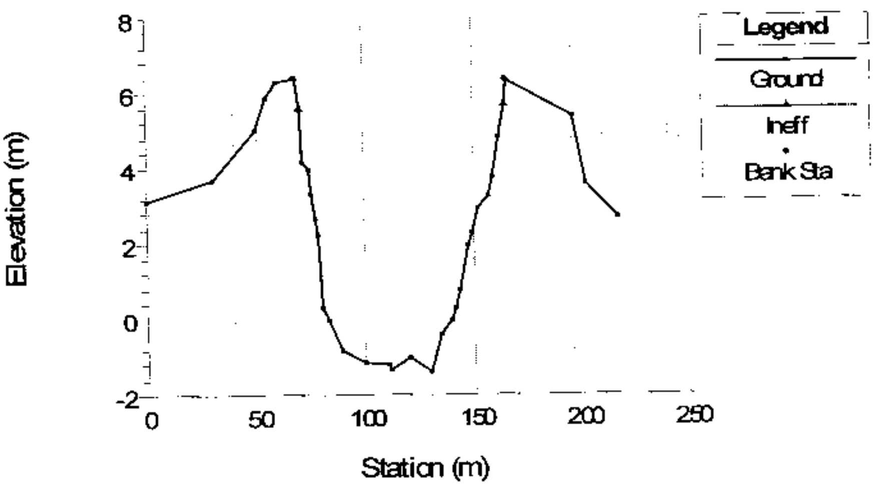
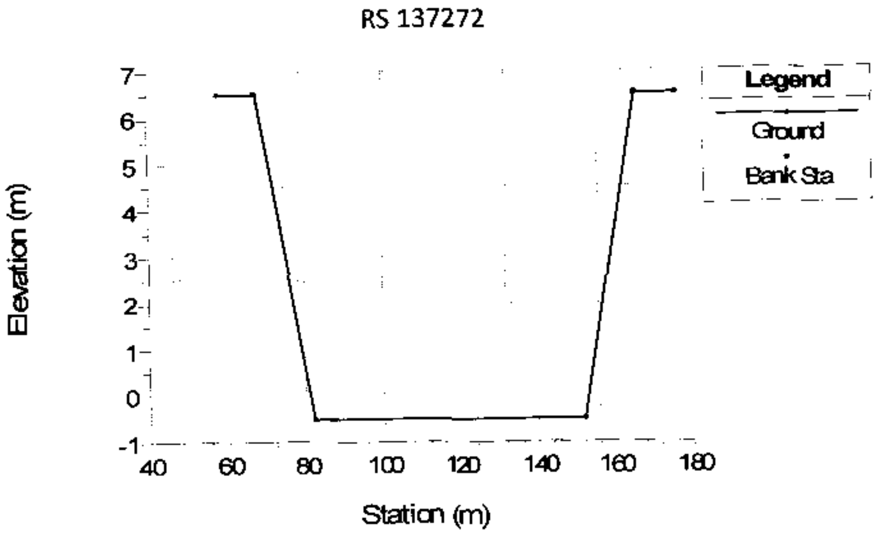


ANNEX B

CROSS SECTIONS OF MOD CONTROL STRURTURE TRANSITION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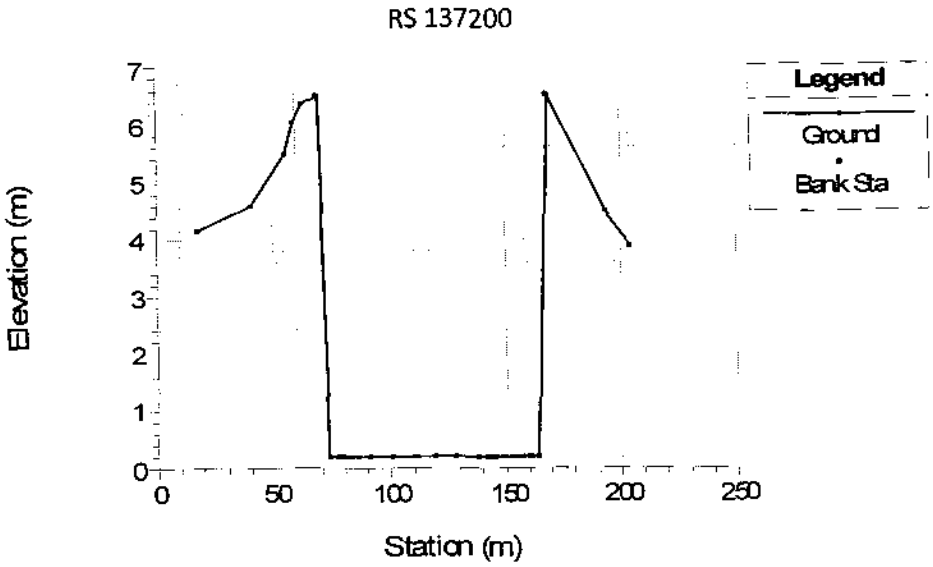
Station (m)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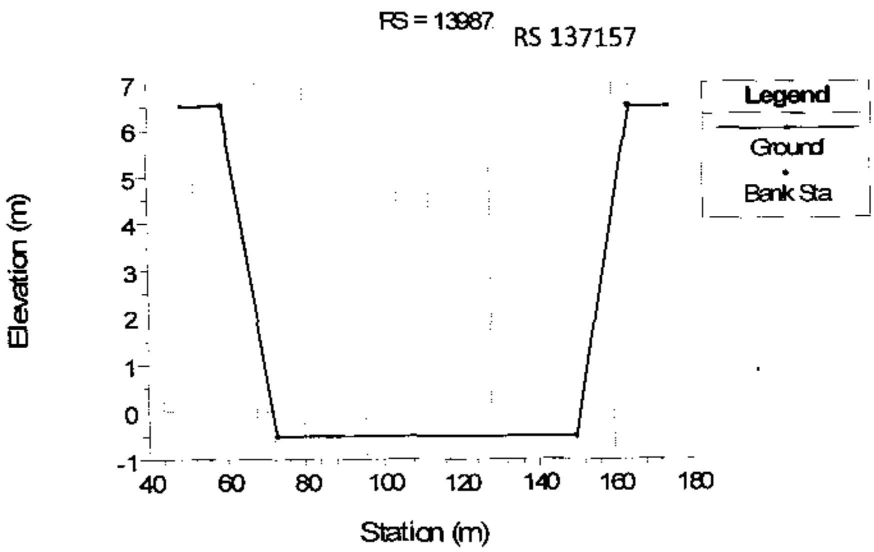
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