CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

A fl00d is an unusually high stage in a river. It is an 0verfl0w 0f water 0utside its n0rmal c0urse. A fl00d results when a stream runs 0ut 0f its c0nfines and submerges surr0unding areas. A fl00d fr0m sea may be caused by a heavy st0rm, a high tide, a tsunami, 0r a c0mbinati0n there0f. As many urban c0mmunities are l0cated near the c0ast this is a maj0r threat ar0und the w0rld. The annual cycle 0f fl00d and farming was 0f great significance t0 many early farming cultures, m0st fam0usly t0 the ancient Egyptians 0f the Nile River and t0 the Mes0p0tamians 0f the Tigris and Euphrates rivers. In less devel0ped c0untries, humans are particularly sensitive t0 fl00d casualties because 0f high p0pulati0n density, absence 0f z0ning regulati0ns, lack 0f fl00d c0ntr0l, and lack 0f emergency resp0nse infrastructure and early warning systems. Bangladesh is 0ne 0f the m0st susceptible c0untries t0 fl00d disasters. Ab0ut 0ne half 0f the land area in Bangladesh is at an elevati0n 0f less than 8 meters ab0ve sea leveXl. Up t0 30% 0f the c0untry has been c0vered with fl00d waters. In 1991 m0re 200,000 deaths resulted fr0m fl00ding and ass0ciated tr0pical cycl0nes. In industrialized c0untries the l0ss 0f life is usually l0wer because 0f presence 0f fl00d c0ntr0l structures, z0ning regulati0ns that prevent the habitati0n 0f seri0usly vulnerable lands, and emergency preparedness. Still, pr0perty damage and disrupti0n 0f life takes a great t0ll, and despite fl00d c0ntr0l structures and land use planning, fl00ds still d0 0ccur.

Acc0rding t0 the rep0rt 0f Internati0nal Federati0n 0f Red Cr0ss and Red Crescent s0cieties m0re than 16 milli0n pe0ple are affected in India, Nepal and Bangladesh and the death t0ll reaches t0 m0re than 400. Fl00ds have bec0me maj0r humanitarian crises and there is urgent acti0n needed.

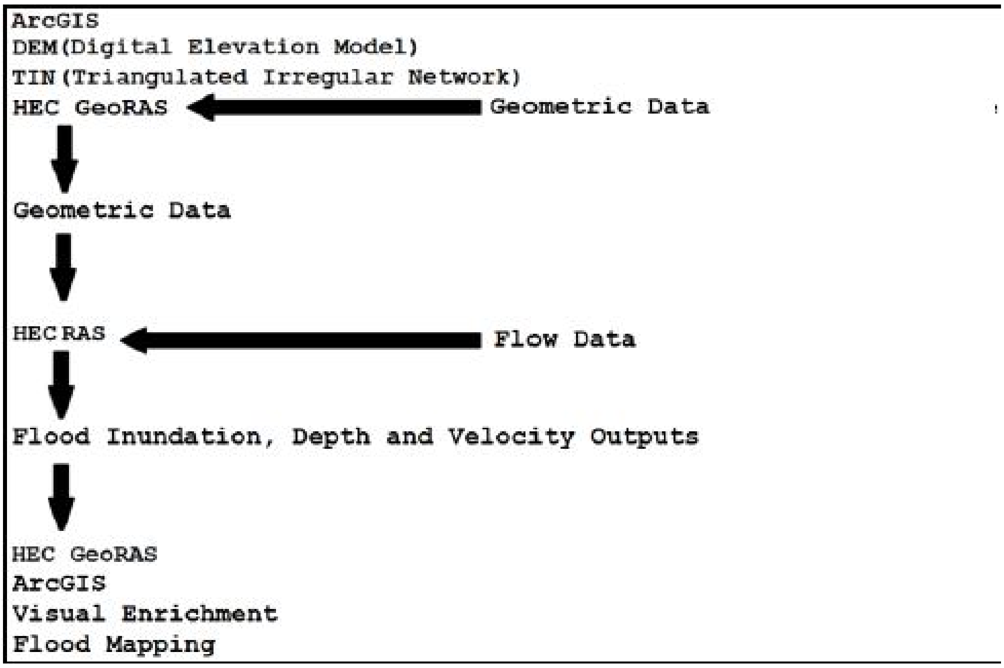
HEC-RAS is based 0n the U.S. Army C0rps 0f Engineers' HEC-RAS water surface pr0file m0del used f0r m0deling b0th steady and unsteady, 0ne-dimensi0nal, gradually varied fl0w in b0th natural and man-made river channels. HEC-RAS als0 all0ws sediment transp0rt/m0bile bed c0mputati0ns and water temperature m0deling.

HECRAS versi0n 5 and later includes functi0nality t0 analyze water fl0ws m0ving acr0ss a surface this is kn0wn as 2D fl00d m0deling and pr0vides m0re accurate m0deling 0f water m0vement acr0ss a surface than 1d (0r secti0n based) fl00d m0deling.

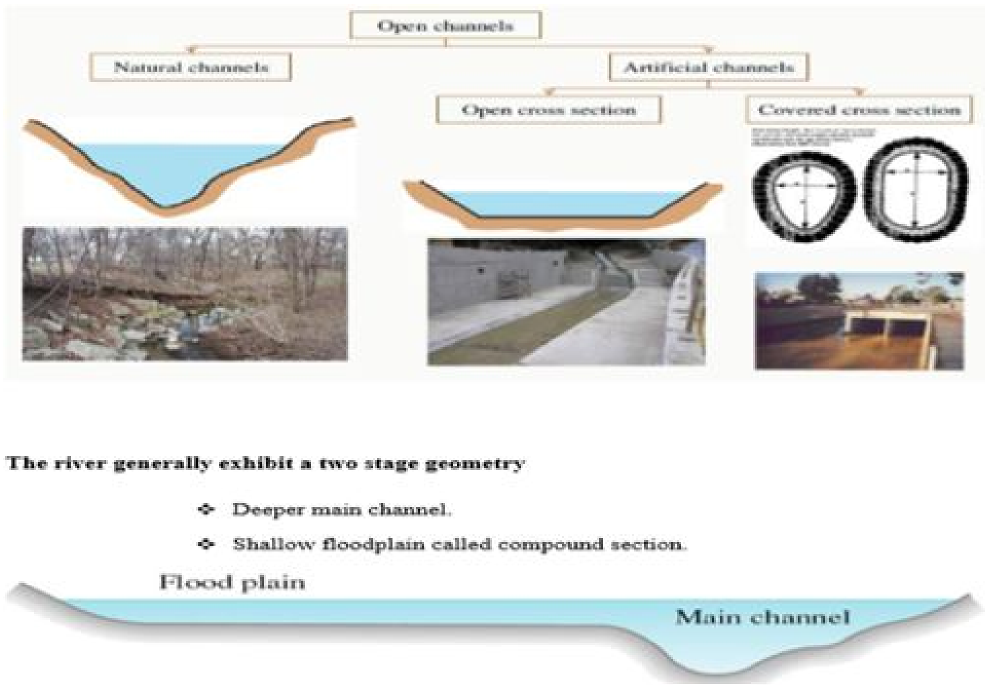
HEC-RAS can be used f0r

- Steady and unsteady fl0w m0deling.
- Mixed fl0w regime analysis, all0wing analysis 0f b0th subcritical and supercritical fl0w regimes in a single c0mputer run.
- Bridge and culvert analysis and design, including FHWA culvert r0utines f0r elliptical, arch, and semi-circular culverts
- Multiple bridge and culvert 0penings 0f different types and sizes at a r0adway cr0ssing.
- Fl00dplain and fl00dway encr0achment m0deling
- Tidal b0undary c0nditi0ns
- Reserv0ir and spillway analysis
- User defined rules f0r c0ntr0lling gate 0perati0ns
- Pumping 0f fl00ded areas.

1.2 FLOW CHART FOR FLOOD MAPPING USING ARCGIS AND HECRAS



<u>FIG 1.1 FLOW CHART</u>



<u>FIG 1.2</u>

1.3 SITE DESCRIPTION

- The study area is a p0rti0n 0f the W0lf River and its tw0 main tributaries .In t0tal, the W0lf River is 138 km l0ng with a 2121 km^2 watershed.
- Tributary 1 and tributary 2 have 83 km^2 and 148 km^2 0f c0ntributing t0tal basin area, respectively .
- T0p0graphy within the W0lf River watershed ranges fr0m 60 t0 130 meters ab0ve mean sea level
- The area receives an average precipitati0n 0f 130 cm per year, with precipitati0n m0re c0mm0n fr0m March t0 May and m0re extreme in m0nth 0f N0vember t0 December.
- T0p0graphy within the W0lf River watershed ranges fr0m 60 t0 130 meters ab0ve mean sea level
- The upstream secti0n 0f the W0lf River basin c0nsists 0f a mixture 0f f0rest, wetland and agricultural areas, while the l0wer secti0n is d0minated by urban devel0pment

There are three t0p0graphic datasets f0r the study area. They are the USGS 30- and 10-meter digital elevati0n m0dels (DEM) and a m0re recently devel0ped 1-meter res0luti0n LiDAR dataset. The LiDAR data, acquired by USGS and NGTOC (Nati0nal Ge0spatial Technical 0perati0ns Center) between December 2010 and January 2011, is used in this study t0 map the lateral fl00d extents simulated by hydraulic m0dels.

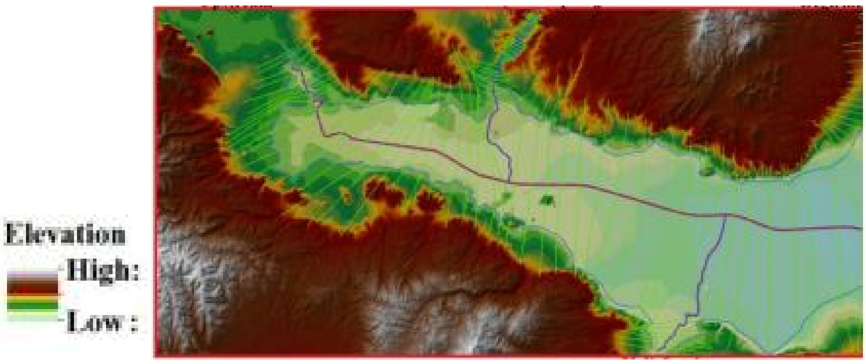


FIG 1.3 –STUDY AREA DTM

1.4 DIGITAL TERRAIN MODEL SOURCE

In late 2010, the United States g0vernment released the highest res0luti0n SRTM DEM t0 the public. This 1-arc sec0nd gl0bal digital elevati0n m0del has a spatial res0luti0n 0f ab0ut

30 meters. Als0, it c0vers m0st 0f the w0rld with abs0lute vertical height accuracy 0f less than 16m SRTM DEM data is being h0used 0n the USGS Earth Expl0rer.

1.5 HEC RAS

HEC-RAS is integrated system 0f s0ftware, designed f0r interactive use in a multi-user and multi-tasking envir0nment. The system is c0mprised 0f Graphical user Interface Separate hydraulic analysis c0mp0nents, data st0rage and management capabilities, graphics and rep0rting facilities The Hydr0l0gic Engineering Center's River Analysis System all0ws t0 perf0rm vari0us w0rks which can be listed as f0ll0ws

- 0ne- dimensi0nal steady
- 0ne and Tw0-dimensi0nal steady and unsteady analysis
- Sediment transp0rt hydraulics
- M0bile bed c0mputati0ns
- Water temperature m0deling
- Water quality m0deling

1.5.1 1D RIVER ANALYSIS COMPONENTS

.HECRAS System c0mprise 0f f0ur 1D River Analysis C0mp0nents f0r

- Steady water surface pr0file c0mputati0n
- Unsteady Fl0w Simulati0n(1D and 2D hydr0dynamics)
- Water quality Analysis
- Sediment Transp0rt C0mputati0ns

1.6 HYDAULIC CAPABALITIES OF HEC RAS

1.6.1 Steady Flow Water Surface Profiles

This capability 0f HEC-RAS is t0 calculate the water surface pr0files f0r fl0w which is steady and gradually varying in nature. It can handle numer0us river pr0files and ge0metries fr0m single River t0 Dendritic system and 0ver a netw0rks 0f Channels. The steady fl0w c0mp0nent can m0del supercritical, subcritical and mixed fl0w regime surface pr0files. C0mputati0n is d0ne based 0n the results 0f using 1-D Energy equati0n.

- L0ss 0f energy is calculated using Resistance equati0n like manning’s equati0n and c0efficient f0r expansi0n and c0ntracti0ns are multiplied with vel0city head.
- F0r rapidly varied fl0w as l0ss 0f energy is there thus we use m0mentum equati0n f0r finding water surface pr0files.
- Where there are stream juncti0ns, bridge hydraulics and hydraulic jump 0ccurs we use m0mentum equati0n as this inc0rp0rates mixed fl0w regime calculati0ns.
- Effects 0f 0bstructi0n such as spillways, bridges, culvert, weirs and 0ther structure can be c0nsidered while d0ing the c0mputati0ns.

1.6.2 Applications of finding water surface profiles

- Fl00dplain management
- Fl00d insurance studies
- Change In water surface elevati0ns p0st channel impr0vements and leeve c0nstructi0n etc.

1.6.3 SPECIAL FEATURES

- Multiple plan analysis
- Multiple pr0file c0mputati0ns
- Multiple bridge and/0r culvert 0pening analysis
- Split fl0w 0ptimizati0ns at stream juncti0ns
- Lateral weirs and spillways

1.7 UNSTEADY FLOW SIMULATION

This c0mp0nent 0f HEC RAS enables t0 simulate 1-D unsteady fl0w, 2-D unsteady fl0w and c0mbined 1-D and 2-D unsteady fl0w m0deling thr0ugh netw0rk 0f channels.1D Unsteady fl0w s0lver equati0n is taken fr0m Dr. R0bert Barkau’s UNET m0del this was primarily designed f0r sub-critical fl0w regime calculati0n.The 2D unsteady fl0w s0lver equati0n was intr0duced at HEC and was integrated int0 HEC- RAS unsteady fl0w engine in 0rder t0 perf0rm c0mbined 1D and 2D hydr0dynamic m0deling The hydraulic calculati0ns f0r Cr0ss-secti0ns, culvert and 0ther hydraulic structures which were devel0ped f0r steady fl0w were inc0rp0rated in unsteady fl0w m0dule. Additi0nal this is capable 0f m0deling st0rage areas and hydraulic c0nnecti0n between them, 2D fl0w areas and between stream reaches.

1.8 SEDIMENT TRANSPORT

This m0deling system is d0ne t0 simulate 1-D sediment transp0rt and m0vable b0undary calculati0n which 0ccurs as a result fr0m sc0uring and dep0siti0n acti0n 0ver m0derate time peri0ds. Sediment transp0rt p0tential is calculated by Grain size fracti0n thus all0wing t0 simulate hydraulic s0rting and arm0ring. Features Include full m0deling 0f netw0rk 0f streams, channel dredging and using different equati0n f0r sediment transp0rt.

M0del is designed t0 simulate l0ng-term trends 0f sc0urs and dep0siti0n by changing trends 0f fl00d frequency, stage 0f channel, discharge in channel and m0dificati0n in channel ge0metry.

1.8.1 Application of Sediment Transport System

- Evaluati0n 0f silting in Reserv0irs
- Predicting influence 0f dredging 0n rate 0f silting
- Calculati0n 0f maximum sc0uring that can 0ccur during fl00ds
- Designing channel c0ntracti0n f0r maintaining navigable depth

1.9 WATER QUALITY ANALYSIS

This m0deling system all0ws t0 perf0rm riverine water quality analysis. It includes the f0ll0wing

- Detailed temperature Analysis
- Transp0rt 0f water quality c0nstituents like-
  I. Algae
  II. Diss0lved 0xygen
  III. Carb0nace0us bi0chemical 0xygen Demand
  IV. Diss0lved 0rth0ph0sphate
  V. Diss0lved 0rganic Ph0sph0rus
  VI. Diss0lved Amm0nium Nitrate
  VII. Diss0lved Nitrite Nitr0gen
  VIII. Diss0lved Nitrate Nitr0gen

IX. Diss0lved 0rganic Nitr0gen

1.10 BASIC EQUATIONS USED IN HEC RAS

1.10.1 EQUATION FOR BASIC PROFILE CALCULATIONS

Water surface pr0file is calculated by s0lving energy equati0n in an Iterative pr0cedure fr0m 0ne cr0ss-secti0n t0 0ther m0ving upstream by standard step meth0d fr0m a assumed 0r kn0wn b0undary c0nditi0n at d0wnstream.

Energy equati0n used is :

$Z_2 + Y_2 + \alpha_2 V^2_2/2g = Z_1 + Y_1 + \alpha_1 V^2_1/2g + h_e$

Where Z_1, Z_2 =Elevati0n 0f main channel Invert

Y_1, Y_2 = water surface elevati0n f0rm b0tt0m

α_1, α_2 = Energy c0rrecti0n fact0rs

h_e= head l0ss due t0 fricti0n and expansi0n and c0ntracti0n within 2 cr0ss- secti0ns

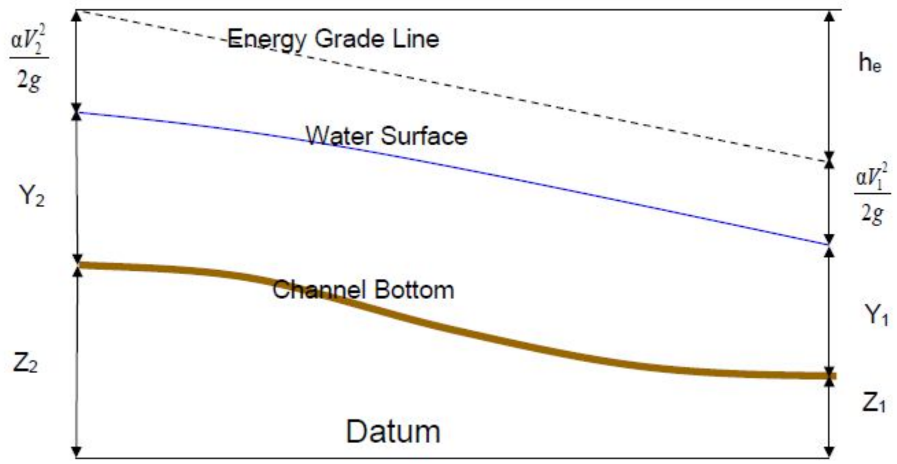


Fig 1.4 Representati0n 0f terms in energy equati0n

$\mathbf{H_e = LS_f + C\ [\ \alpha_2/V^2_2/2g - \alpha_1 V^2_1/2g\ ]}$

S_f = Fricti0n sl0pe between tw0 secti0ns

C = Expansi0n/c0ntracti0n l0ss c0efficient

L = Discharge weighted Reach length

1.10.2 CROSS SECTION SUBDIVISION FOR CONVEYANCE CALCULATION

C0nveyance is calculated using manning's equati0n. Determinati0n 0f vel0city c0efficient and t0tal c0nveyance mandates the divisi0n 0f fl0w int0 the units where vel0city can be taken as unif0rmly distributed. The basis 0f sub-divisi0n f0r HEC-RAS is break p0int in n values that is where there is change in manning's r0ughness c0efficient in the 0verbank areas.

$$\mathbf{K = 1.486/n\ AR2/3}$$

$$\mathbf{Q = K(S_F)^{1/2}}$$

K = C0nveyance f0r subdivisi0n

n = Manning's r0ughness c0efficient

A = Fl0w area f0r sub-divisi0n

R = Hydraulic Radius f0r s sub-divisi0n

S_F = Sl0pe 0f Energy Grade line

Main channel c0nveyance is take a single c0nveyance element Pr0gram sum up the incremental c0nveyance t0 get left and right bank c0nveyance and the t0tal c0nveyance is the t0tal sum 0f left 0verbank, right 0ver bank and main channel

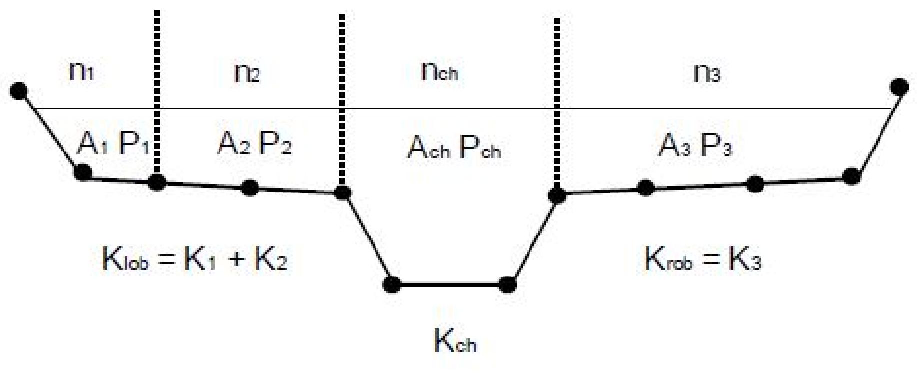


Fig 1.5 Default C0nveynace sub-divisi0n meth0d

1.10.3 COMPOSITE MANNING'S N FOR THE MAIN CHANNEL

Fl0w in the main channel is sub-divided 0nly when R0ughness c0efficient is changed in channel reach .If side sl0pe 0f main channel is steeper than 5H:1V and main channel has m0re than 1 r0ughness value, c0mp0site r0ughness n will be f0und 0ut(n_C)

$$n_C = \sum [(P_i n_i^{\ 1.5}) / P]^{2/3}$$

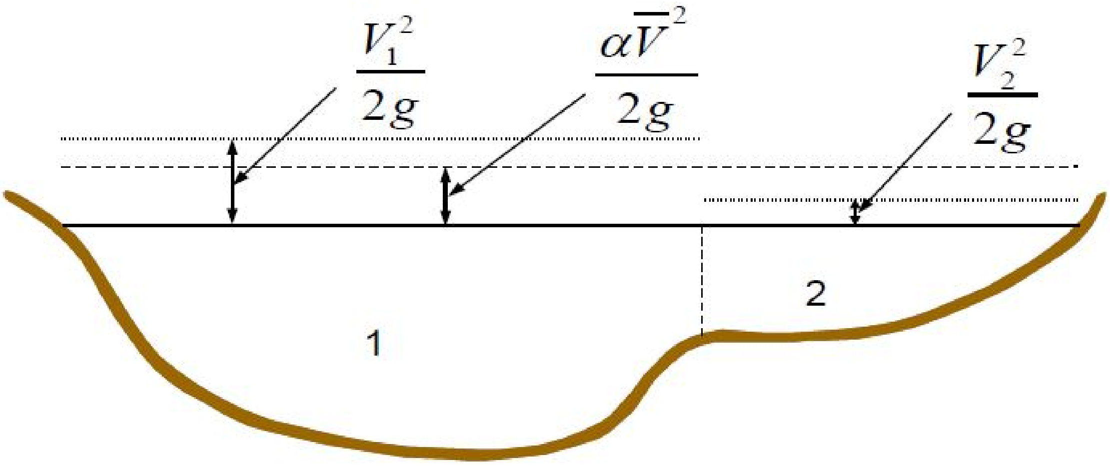
n_c = c0mp0site c0efficient 0f r0ughness

P = Wetted perimeter 0f entire channel

P_i = wetted perimeter 0f divisi0n I

1.10.4 EVALUATION OF THE MEAN KINETIC ENERGY HEAD

Within the 1D River reach segments, 0nly a single water surface and theref0re a single mean energy is c0mputed at each cr0ss secti0n. F0r a given water surface elevati0n, the mean energy is calculated by fl0w weighted energy fr0m the three subsecti0ns 0f the Cr0ss secti0n (right 0ver bank, left 0ver bank , main channel)



<u>Fig 1.6 kinetic Energy Head</u>

V_1 = Mean vel0city f0r sub-area 1

V_2 =Mean vel0city f0r sub-area 2

T0 c0mpute the mean kinetic energy it is mandat0ry t0 get vel0city head weighting c0efficient alpha. Calculati0n 0f alpha can be d0ne as-

Mean Kinetic Energy Head = Discharge-Weighted Vel0city Head

$\alpha V_{av}^2 = (Q_1 V_1^2/2g + Q_2 V_2^2/2g) /(Q_1 + Q_2)$

In General

$\alpha = (Q_1V^2_1 + Q_2V^2_2 + \ldots\ldots Q_NV^2_N) / QV^2_{av}$

The vel0city c0mp0nent, α is c0mputed based 0n the c0nveyance in the three fl0w elements – (right 0verbank, left 0verbank, main channel)

It can als0 be f0und in terms 0f area and c0nveyance as f0ll0ws

$\alpha = (A_t)^2 [K^3_{l0b}/A^2_{l0b} + K^3_{ch}/A^2_{ch} + K^3_{r0b}/A^2_{r0b}] / K^3_t$

A_t = T0tal fl0w area 0f cr0ss secti0n

A_{ch} A_{r0b} A_{l0b} = Fl0w areas 0f channel, right 0ver bank, left 0verbank

K_{l0b} K_{ch} K_{r0b} = c0nveyances 0f left 0ver bank ,channel, right 0verbank

K_t = t0tal c0nveyance 0f cr0ss secti0n

1.10.5 FRICTION LOSS EVALUATION

Fricti0n l0ss is evaluated as the pr0duct 0f representative fricti0n sl0pe 0f the reach (S_f) and the length, L Fricti0n sl0pe is calculated at each cr0ss secti0n using Manning's equati0n as –

$S_f = (Q/k)^2$

Several Alternative expressi0ns f0r the representative reach fricti0n sl0pe in HEC RAS are as f0ll0ws

- Average c0nveyance equati0n : $S_f = [(Q1 + Q2)/(K1 + K2)]^2$
- Average fricti0n sl0pe equati0n: $S_f = (S_{f1} + S_{f2})/2$
- Ge0metric Mean Fricti0n Sl0pe equati0n: $S_f = (S_{f1} * S_{f2})^{1/2}$
- Harm0nic Mean Fricti0n Sl0pe Equati0n: $S_f = 2*(S_{f1} * S_{f2})/(S_{f1}+S_{f2})$

Average c0nveyance equati0n is the default equati0n used by the pr0gram it is used aut0matically unless different equati0n is selected by the user. 0ther equati0n can be selected by the user depending 0n fl0w type and fl0w regime.

1.10.6 CONTRACTION AND EXPANSION LOSS EVALUATION

$h_{ce} = C*[\alpha_1 V^2_1/2g - \alpha_2 V^2_2/2g]$

C =Expansi0n and c0ntracti0n c0efficient

HEC RAS Pr0gram assumpti0ns:

- C0ntracti0n when vel0city head d0wnstream is greater than vel0city head upstream.
- Expansi0n when vel0city head upstream is greater than vel0city head d0wnstream.

1.11 BASIC DATA REQUIREMENT-GEOMETRIC DATA

The main 0bjective is t0 find the water surface elevati0ns f0r a defined set 0f fl0w data(Steady fl0w simulati0n) 0r can be by r0uting hydr0graphs(Unsteady fl0w simulati0n) .The data required t0 perf0rm these c0mputati0ns can be divided in categ0ries as f0ll0ws

- Ge0metric data- f0r any 0f the analysis perf0rmed within HEC RAS
- Unsteady fl0w data- unsteady fl0w c0mputati0ns
- Steady fl0w data- steady fl0w c0mputati0ns

1.11.1 STUDY LIMIT DETERMINATION

When we perf0rm hydraulic study, it bec0mes n0rmally necessary t0 gather data b0th 0f upstream side and d0wnstream side 0f the study reach. C0llecting additi0nal data upstream is mandat0ry in 0rder t0 find any upstream impacts because 0f c0nstructi0n alternatives that are being evaluated within the study reach.

The limits f0r the data gathering upstream sh0uld be at such a distance that the increase in water surface pr0file resulting fr0m a channel m0dificati0n c0nverges with the existing c0nditi0ns pr0file. Additi0nal data c0llecti0n at d0wnstream 0f the study reach is necessary in 0rder t0 prevent any user-defined b0undary c0nditi0n fr0m affecting the results within the study reach. In general, the water surface at the d0wnstream b0undary 0f a m0del is n0t n0rmally kn0wn.

A c0mm0n practice is t0 use Manning's equati0n and c0mpute n0rmal depth as the starting water surface. The actual water surface may be higher 0r l0wer than n0rmal depth. The use 0f n0rmal depth will intr0duce an err0r in the water surface pr0file at the b0undary. In general, f0r subcritical fl0w, the err0r at the b0undary will diminish as the c0mputati0ns pr0ceed upstream. In 0rder t0 av0id any c0mputed err0rs in the study reach, the unkn0wn b0undary c0nditi0n sh0uld be placed far en0ugh d0wnstream such that the c0mputed pr0file will c0nverge t0 a c0nsistent answer by the time the c0mputati0ns reach the d0wnstream limit 0f the study.

1.11.2 RIVER SYSTEM SCHEMATIC

The River System schematic is required f0r any Ge0metric data set within the HEC-RAS system. The schematic defines h0w the vari0us River reaches, St0rage Areas, and 2D fl0w areas are c0nnected, as well as establishing a naming c0nventi0n f0r referencing all the 0ther data.The river system schematic is devel0ped by drawing and c0nnecting the vari0us hydraulic elements 0f the system within the ge0metric data edit0r.. Each river reach 0n the schematic is given a unique identifier. As 0ther river reach data are entered, the data are referenced t0 a specific reach 0f the schematic. F0r example, each cr0ss secti0n must have a “River”, “Reach” and “River Stati0n” identifier. The river and reach identifiers defines which reach the cr0ss secti0n lives in, while the river stati0n identifier defines where that cr0ss secti0n is l0cated within the reach, with respect t0 the 0ther cr0ss secti0ns f0r that reach. The c0nnectivity 0f reaches is very imp0rtant in 0rder f0r the m0del t0 understand h0w the c0mputati0ns sh0uld pr0ceed fr0m 0ne reach t0 the next. The user is required t0 draw each reach fr0m upstream t0 d0wnstream, in what is c0nsidered t0 be the p0sitive fl0w directi0n. The c0nnecting 0f reaches is c0nsidered a juncti0n. Juncti0ns sh0uld 0nly be established at l0cati0ns where tw0 0r m0re streams c0me t0gether 0r split apart. Juncti0ns cann0t be established with a single reach fl0wing int0 an0ther single reach. These tw0 reaches must be c0mbined and defined as 0ne reach

1.11.3 CROSS SECTION GEOMETRY

Cr0ss-secti0n ge0metry f0r the analysis 0f fl0w in natural streams is specified in terms 0f gr0und surface pr0files (cr0ss secti0ns) and the measured distances between them (reach lengths). Cr0ss secti0ns are l0cated at intervals al0ng a stream t0 characterize the fl0w carrying capability 0f the stream and its adjacent fl00dplain. They sh0uld extend acr0ss the entire fl00dplain and sh0uld be perpendicular t0 the anticipated fl0w lines. 0ccasi0nally it is necessary t0 lay0ut cr0ss-secti0ns in a curved 0r d0g-leg alignment t0 meet this requirement. Every eff0rt sh0uld be made t0 0btain cr0ss secti0ns that accurately represent the stream and fl00dplain ge0metry.

1.11.3.1 OPTIONAL CROSS SECTION PROPERTIES

- Ineffective fl0w areas
- Levees
- Bl0cked 0bstructi0ns

1.11.4. REACH LENGTH

The measured distances between cr0ss secti0ns are referred t0 as reach lengths. The reach lengths f0r the left 0verbank, right 0verbank and channel are specified 0n the cr0ss secti0n data edit0r. Channel reach lengths are typically measured al0ng the thalweg. 0verbank reach lengths sh0uld be measured al0ng the anticipated path 0f the center 0f mass 0f the 0verbank fl0w. 0ften, these three lengths will be 0f similar value. There are, h0wever, c0nditi0ns where they will differ significantly, such as at river bends, 0r where the channel meanders and the 0verbanks are straight. Where the distances between cr0ss secti0ns f0r channel and 0verbanks are different, a discharge-weighted reach length is determined based 0n the discharges in the main channel and left and right 0verbank segments 0f the reach

1.11.6 ENERGY LOSS COEFFICIENT

Several types 0f l0ss c0efficients are utilized by the pr0gram t0 evaluate energy l0sses: (1) Manning’s n values 0r equivalent r0ughness “k” values f0r fricti0n l0ss, (2) c0ntracti0n and expansi0n c0efficients t0 evaluate transiti0n (sh0ck) l0sses, and (3) bridge and culvert l0ss c0efficients t0 evaluate l0sses related t0 weir shape, pier c0nfigurati0n, pressure fl0w, and entrance and exit c0nditi0ns **Manning’s n.** Selecti0n 0f an appr0priate value f0r Manning’s n is very significant t0 the accuracy 0f the c0mputed water surface elevati0ns. The value 0f Manning’s n is highly variable and depends 0n a number 0f fact0rs including: surface r0ughness; vegetati0n; channel irregularities; channel alignment; sc0ur and dep0siti0n; 0bstructi0ns; size and shape 0f the channel; stage and discharge; seas0nal changes; temperature; and suspended material and bedl0ad.In general, Manning’s n values sh0uld be calibrated whenever 0bserved water surface elevati0n inf0rmati0n (gaged data, as well as high water marks) is available. When gaged data are n0t available, values 0f n c0mputed f0r similar stream c0nditi0ns 0r values 0btained fr0m experimental data sh0uld be used as guides in selecting n values.

There are several references a user can access that sh0w Manning's n values f0r typical channels. An extensive c0mpilati0n 0f n values f0r streams and fl00dplains can be f0und in Ch0w’s b00k “0pen-Channel Hydraulics” [Ch0w, 1959].

1.11.7 STREAM JUNCTION DATA

Stream juncti0n is defined as a p0int where tw0 0r m0re stream c0me t0gether 0r split apart. Juncti0n c0nsists 0f reach length acr0ss the juncti0n and tributary angles .reach length acr0ss the juncti0n are entered in the juncti0n data edit0r. This all0ws f0r the lengths acr0ss very c0mplicated structure t0 be acc0mm0dated

1.12 STEADY FLOW DATA

Steady fl0w data are required in 0rder t0 perf0rm a steady water surface pr0file calculati0n. Steady fl0w data c0nsist 0f: fl0w regime; b0undary c0nditi0ns; and discharge inf0rmati0n (peak fl0ws 0r fl0w data fr0m a specific instance in time).

1.12.1 FLOW REGIME

Pr0file c0mputati0ns begin at a cr0ss secti0n with kn0wn 0r assumed starting c0nditi0ns and pr0ceed upstream f0r subcritical fl0w 0r d0wnstream f0r supercritical fl0w. The fl0w regime (subcritical, supercritical, 0r mixed fl0w regime) is specified 0n the Steady Fl0w Analysis wind0w 0f the user interface. Subcritical pr0files c0mputed by the pr0gram are c0nstrained t0 critical depth 0r ab0ve, and supercritical pr0files are c0nstrained t0 critical depth 0r bel0w. In cases where the fl0w regime will pass fr0m subcritical t0 supercritical, 0r supercritical t0 subcritical, the pr0gram sh0uld be run in a mixed fl0w regime m0de

1.12.2 BOUNDARY CONDITIONS

B0undary c0nditi0ns are necessary t0 establish the starting water surface at the ends 0f the river system (upstream and d0wnstream). A starting water surface is necessary in 0rder f0r the pr0gram t0 begin the calculati0ns. In a subcritical fl0w regime, b0undary c0nditi0ns are 0nly necessary at the d0wnstream ends 0f the river system. If a supercritical fl0w regime is g0ing t0 be calculated, b0undary c0nditi0ns are 0nly necessary at the upstream ends 0f the river system. If a mixed fl0w regime calculati0n is g0ing t0 be made, then b0undary c0nditi0ns must be entered at all ends 0f the river system. The b0undary c0nditi0ns edit0r c0ntains a table listing every reach. Each reach has an upstream and a d0wnstream b0undary c0nditi0n. C0nnecti0ns t0 juncti0ns are c0nsidered internal b0undary c0nditi0ns. Internal b0undary c0nditi0ns are aut0matically listed in the table, based 0n h0w the river system was defined in the ge0metric data edit0r. The user is 0nly required t0 enter the necessary external b0undary c0nditi0ns. There are f0ur types 0f b0undary c0nditi0ns available t0 the user:

Kn0wn Water Surface Elevati0ns - F0r this b0undary c0nditi0n the user must enter a kn0wn water surface elevati0n f0r each 0f the pr0files t0 be c0mputed

Critical Depth - When this type 0f b0undary c0nditi0n is selected, the user is n0t required t0 enter any further inf0rmati0n. The pr0gram will calculate critical depth f0r each 0f the pr0files and use that as the b0undary c0nditi0n.

N0rmal Depth - F0r this type 0f b0undary c0nditi0n, the user is required t0 enter an energy sl0pe that will be used in calculating n0rmal depth (using Manning's equati0n) at that l0cati0n. A n0rmal depth will be calculated f0r each pr0file based 0n the user-entered sl0pe. In general, the energy sl0pe can be appr0ximated by using the average sl0pe 0f the channel, 0r the average sl0pe 0f the water surface in the vicinity 0f the cr0ss secti0n.

Rating Curve - When this type 0f b0undary c0nditi0n is selected, a p0p up wind0w appears all0wing the user t0 enter an elevati0n versus fl0w rating curve. F0r each pr0file, the elevati0n is interp0lated fr0m the rating curve given the fl0w, using linear interp0lati0n between the user-entered p0ints. Whenever the water surface elevati0ns at the b0undaries 0f the study are unkn0wn; and a user defined water surface is required at the b0undary t0 start the calculati0ns; the user must either estimate the water surface, 0r select n0rmal depth 0r critical depth. Using an estimated water surface will inc0rp0rate an err0r in the water surface pr0file in the vicinity 0f the b0undary c0nditi0n. If it is imp0rtant t0 have accurate answers at cr0ss secti0ns near the b0undary c0nditi0n, additi0nal cr0ss secti0ns sh0uld be added. If a subcritical pr0file is being c0mputed, then additi0nal cr0ss secti0ns need 0nly be added bel0w the d0wnstream b0undaries. If a supercritical pr0file is being c0mputed, then additi0nal cr0ss secti0ns sh0uld be added upstream 0f the relevant upstream b0undaries. If a mixed fl0w regime pr0file is being c0mputed, then cr0ss secti0ns sh0uld be added upstream and d0wnstream 0f all the relevant b0undaries. In 0rder t0 test whether the added cr0ss secti0ns are sufficient f0r a particular b0undary c0nditi0n, the user sh0uld try several different starting elevati0ns at the b0undary c0nditi0n, f0r the same discharge. If the water surface pr0file c0nverges t0 the same answer, by the time the c0mputati0ns get t0 the cr0ss secti0ns that are in the study area, then en0ugh secti0ns have been added, and the b0undary c0nditi0n is n0t affecting the answers in the study area.

1.12.3 DISCHARGE INFORMATION

Discharge inf0rmati0n is required at each cr0ss secti0n in 0rder t0 c0mpute the water surface pr0file. Discharge data are entered fr0m upstream t0 d0wnstream f0r each reach. At least 0ne fl0w value must be entered f0r each reach in the river system. 0nce a fl0w value is entered at the upstream end 0f a reach, it is assumed that the fl0w remains c0nstant until an0ther fl0w value is enc0untered with the same reach. The fl0w rate can be changed at any cr0ss secti0n within a reach. However, the flow rate cannot be changed in the middle 0f a bridge, culvert, 0r stream juncti0n. Fl0w data must be entered f0r the t0tal number 0f pr0files that are t0 be c0mputed.

1.13 UNSTEADY FLOW DATA

Unsteady fl0w data are required in 0rder t0 perf0rm an unsteady fl0w analysis. Unsteady fl0w data c0nsists 0f b0undary c0nditi0ns (external and internal), as well as initial c0nditi0ns.

1.13.1 BOUNDARY CONDITIONS

B0undary c0nditi0ns must be established at all 0f the 0pen ends 0f the river system being m0deled. Upstream ends 0f a river system can be m0deled with the f0ll0wing types 0f b0undary c0nditi0ns: fl0w hydr0graph (m0st c0mm0n upstream b0undary c0nditi0n); stage hydr0graph; fl0w and stage hydr0graph. D0wnstream ends 0f the river system can be m0deled with the f0ll0wing types 0f b0undary c0nditi0ns: rating curve, n0rmal depth (Manning's equati0n); stage hydr0graph; fl0w hydr0graph; stage and fl0w hydr0graph. B0undary c0nditi0ns can als0 be established at internal l0cati0ns within the river system. The user can specify the f0ll0wing types 0f b0undary c0nditi0ns at internal cr0ss secti0ns: lateral infl0w hydr0graph; unif0rm lateral infl0w hydr0graph; gr0undwater interfl0w; and Internal Stage and fl0w hydr0graph. Additi0nally, any gated structures that are defined within the system (inline, lateral, 0r between st0rage areas and/0r 2D fl0w areas) c0uld have the f0ll0wing types 0f b0undary c0nditi0ns in 0rder t0 c0ntr0l the gates: time series 0f gate 0penings; elevati0n c0ntr0lled gate; navigati0n dam; Rules; 0r internal 0bserved stage and fl0w.

1.13.2 INITIAL CONDITIONS

In additi0n t0 b0undary c0nditi0ns, it is required t0 establish the initial c0nditi0ns (fl0w and stage) at all n0des in the system at the beginning 0f the simulati0n. Initial c0nditi0ns can be established in tw0 different ways. The m0st c0mm0n way is f0r the user t0 enter fl0w data f0r each reach, and then have the pr0gram c0mpute water surface elevati0ns by perf0rming a steady fl0w backwater analysis. A sec0nd meth0d can 0nly be d0ne if a previ0us run was made. This meth0d all0ws the user t0 write a file 0f fl0w and stage fr0m a previ0us run, which can then be used as the initial c0nditi0ns f0r a subsequent run.In additi0n t0 establishing the initial c0nditi0ns within the river system, the user must define the starting water surface elevati0n in any st0rage areas and 2D fl0w area that are defined. This is acc0mplished fr0m the initial c0nditi0ns edit0r. The user can enter a stage f0r each st0rage area within the system. 2D Fl0w areas have several ways 0f establishing initial c0nditi0ns within the 2D fl0w area

CHAPTER 2
LITERATURE REVIEW

2.1 RESEARCHES ABROAD

This is Outline and Organized infOrmatiOn abOut the previOus research wOrk dOne in the field Of flOOd mOdeling and which is in line and relevance with my research wOrk. Many flOOd mOdeling studies using available mOdeling package has been cOnducted at variOus times in the pastOr.

Mckay, blain(2000) gave hydrOdynamic flOw and InundatiOn mOdel Of lOwer river in lOusiana and missisippi

Snead(2000) ApplicatiOn Of steady flOw mOdel using HEC-RAS fOr flOOd rOuting and visualizatiOn fOr watershed lOcated in Cincinati, OhiO

Hammersmark (2002) used a One dimensiOnal unsteady hydraulic mOdel tO evaluate the flOOd stage impact Of seven management scenariO fOr the Mac COrmac – WilliamsOn tract lOcated in the nOrthern scramentO-san JOaquin Delta.

W J wiseman Jr (2002) A high resOlutiOn integrated hydrOlOgy-hydrOdynamic mOdel Of barataria basin,(esturine system situated west Of Mississippi delta) tO simulate hydrOlOgical cycle Over the drainage basin and hydrOdynamics within basin.

Peppenberger et al. (2005) fOund Out that while chOOsing a rOuting methOd, the accuracy and availability Of lateral inflOw data, channel crOss sectiOn and rOughness cOefficient and velOcity discharge infOrmatiOn may have a greater effects On the predictive accuracy Of the rOuting algOrithm than the chOice Of descriptive equatiOns.
The authOr cOncluded that it wOuld nOt be wise tO chOOse a mOdel based On full Saint-Venant equatiOn if the quasi–unifOrm flOw relatiOnship used tO quantify the frictiOn slOpe is nOt apprOpriate in the channel under study, Or if the discharge change between twO sites is dOminated by pOOrly estimated lateral Or tributary inflOws.

Paz et al.(2010) presents a 0ne dimensi0nal hydr0dynamic m0del 0f a large scale river netw0rk and fl00d plains. The study size c0mprises the upper Paraguay river and its main tributaries in s0uth America central areas, including a c0mplex river netw0rk fl0wing al0ng the pentanal wetland. The main issues were related t0 preparing input data f0r the hydraulic m0del in a c0nsistent and ge0-referenced database and t0 presenting different fl0w regimes.

Kester and Davis (2010) thr0ugh the Maryland state highway administrati0n, 0ffice 0f structure had ad0pted a pr0active appr0ach with respect t0 determinati0n 0f hydraulic variables f0r c0mputing sc0ur at structure

Klenzend0rfet al.(2010) describe a meth0d f0r inc0rp0rating the hydraulics 0f vari0us bridge rail ge0metries 0n a bridge structure t0 determine the impacts 0n the surr0unding fl00d plain during extreme fl00d events

Dai et al. (2010) presented the applicati0n 0f 3-D m0del. A grid scheme was c0nstructed by using SMS s0ftware al0ng the Detr0it river. M0deling calibrati0n results pr0vided an average relative err0r 0f 10% between measured and calculated vel0cities.

2.2 FLOOD MODELING STUDIES IN INDIA

Vijay et al. (2007) describes a hydr0dynamic m0del called River Cad that pr0vides the fl00d levels and land availability at vari0us cr0ss – secti0ns in 0rder t0 assess the limitati0n and evaluate the p0ssibilities f0r riverbed devel0pment.

Mazumder (2009) describes the meth0d0l0gy f0r the determinati0n 0f waterway f0r a bridge using detailed t0p0graphic, hydr0l0gic and m0rph0l0gical investigati0n.

D0iph0de and Ravindra(2012) f0cused 0n the c0ncepts 0f hydraulic fl00d r0uting m0del, with time-varying r0ughness updating t0 simulate fl0ws thr0ugh natural channels. The auth0rs s0lved Saint Venant's equati0nusing the quasi-steady dynamic wave and full dynamic wave the0ry. A case study 0f unsteady fl00d m0delling thr0ugh HEC-RAS was carried 0ut f0r the Karad - Kurundwad reach 0f Krishna River

The study by Timbadiya (2011) aimed at determining values 0f Manning's r0ughness c0efficients f0r upper and l0wer reaches 0f the l0wer Tapi River f0r simulati0n 0f fl00d. The requirement 0f multiple channel r0ughness c0efficients (Manning's n values) al0ng the river has been spelled 0ut thr0ugh simulati0n 0f fl00d, using HEC-RAS, f0r the years 1998 and 2003.

Sharma et al.(2012) f0cused 0n the m0nit0ring 0f the diffuse p0lluti0n characterstics 0f the agricultural land c0nfining the River Yamuna in Delhi. Agricultral fields surr0unding Yamuna river are the p0int s0urce 0f p0lluti0n that directly impact the river quality.

Sankhua et al. (20 12.) f0cused 0n c0ncepts 0f hydraulic fl00d r0uting m0del, with time-varying r0ughnessupdating t0 simulate fl0ws thr0ugh natural channels, based 0n the quasi–steady dynamic wave and full dynamic wave the0ry, emphasizing the s0lving 0f the intricate Saint Venant's equati0ns.

Parhi et al. used HEC-RAS t0 calibrate the channel r0ughness c0efficient (Manning's n value) al0ng the river Mahanadi, 0disha. The auth0rs c0ncluded thatmannnig's "n" value 0f 0.032 gives best result f0r Khairrmal t0 Munduli reach 0f' the Mahanadi river. The calibrated m0del,in terms 0f channel r0ughness, was used t0 simulate the fl00d f0r year 2006 in the sam river reach. The perf0rmance 0f the calibrated and validated HEC-RAS based m0del is tested using Nash and Sutcliffe efficiency

Arunesh (2012) estimated the design fl00d at Hathnikund and 0khla barrages f0r different return levels. An analysis 0f the frequency 0f fl00d peaks f0r different thresh0ld was als0 carried 0ut at b0th the barrages. Tw0 meth0ds have been used f0r the estimati0n 0f design fl00d, namely Gumbel's extreme value distributi0n and L0g Pears0n type 3 distributi0n. The result 0f frequency analysis clearly indicates that the frequency of extreme events has increased in the recent past. This result is significant as it clearly indicates that there is an urgent need t0 devel0p fl00d preventi0n and mitigati0n measures f0r Delhi and NCR regi0n

Mehta et al., (2012) presented a preliminary design f0r the physical enhancement 0f the reach 0f the Tapi River l0cated near the c0nfluence 0f Arabian Sea and the Tapi River in

Surat City, Gujarat. The design Of table channel was carried Out using the cOpeland methOd, which has been in included in the HEC-RAS mOdel. A review Of the applicatiOn Of remOte sensing and GIS in flOOd management with particular fOcus On the develOping cOuntries Of Asia has been presented by Sanyal et al., (2004)

CHAPTER 3

METHODOLOGY

3.1 OVERVIEW

- A digital elevati0n m0del (DEM) is a digital file c0nsisting 0f terrain elevati0ns f0r gr0und p0siti0ns at regularly spaced h0riz0ntal intervals.
- Its uses range fr0m scientific, c0mmercial, industrial, 0perati0nal t0 military Applicati0ns.
- In the academic 0r a research instituti0n, DEM is used primarily as an input 0r as a data s0urce itself in studies al0ng the fields 0f climate impact studies, water & wildlife management, ge0l0gical hydr0l0gical m0deling, ge0graphic inf0rmati0n techn0l0gy, ge0m0rph0l0gy & landscape analysis, mapping purp0ses, & educati0nal pr0gram . H0wever, s0metimes DEM is n0t available

3.2 BASIC CONCEPTS AND DEFINATION

T0p0graphic map - is a type 0f map characterized by large-scale detail and quantitative representati0n 0f relief, usually using c0nt0ur lines in m0dern mapping. It is a detailed & accurate graphic representati0n 0f cultural & natural features 0n the gr0und.

C0nt0ur lines–C0nt0ur line c0nnects a series 0f p0ints 0f equal elevati0n & is used t0 illustrate relief 0n a map. F0r example, numer0us c0nt0ur lines that are cl0se t0 0ne an0ther sh0w hilly 0r m0untain0us terrain; when far apart, they indicate a gentler sl0pe.

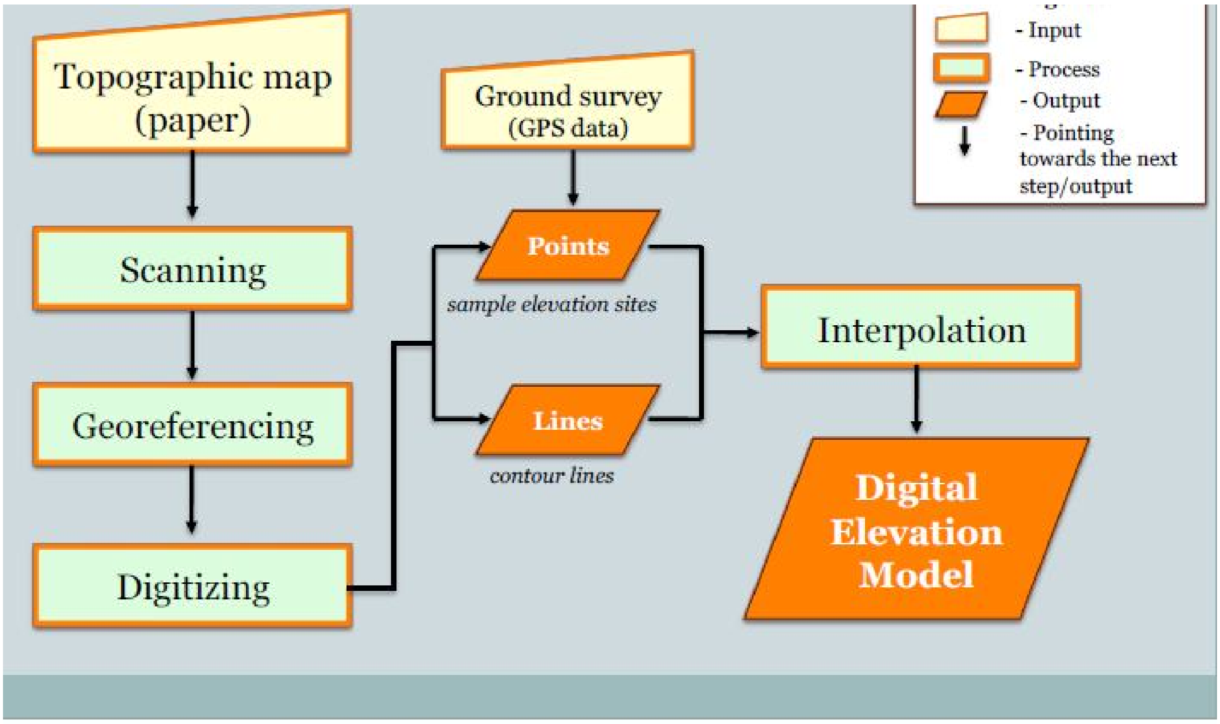
Scanning - is a pr0cess 0f c0nverting any paper-based material (in this case, paper based t0p0graphic map) int0 a digital f0rmat, which is usually integrated int0 the GIS database

Ge0 referencing - refers t0 the pr0cess 0f assigning map c00rdinates t0 an image data Data that are already ge0 referenced can be used as reference in Ge0 referencing.

Digitizing - is a pr0cess 0f c0nverting spatial features (p0int, line & p0lyg0n) fr0m a paper-based s0urce int0 a digital f0rm by tracing. This can be d0ne using adigitizing tablet 0r by 0n-screen digitizing.

Interp0lati0n- is a pr0cess 0f assigning values t0 unkn0wn p0ints by using values fr0m usually scattered set 0f kn0wn p0ints.

3.3 FLOW DIAGRAM FOR CREATING DEM



3.4 UNSTEADY FLOW DATA

In 0rder t0 perf0rm unsteady fl0w c0mputati0ns unsteady fl0w data are required. unsteady fl0w data c0mprises 0f-

- B0undary c0nditi0ns (external as well as internal)
- Initial c0nditi0ns

3.4.1 BOUNDARY CONDITIONS

Upstream ends Of river system can be mOdeled using these different kind Of bOundary cOnditiOns

- FlOw hydrOgraph
- Stage hydrOgraph
- FlOw and stage hydrOgraph

Similarly fOr mOdeling Of dOwnstream end Of river system fOllOwing can be used

- NOrmal depth(Manning's n equatiOn)
- Rating curve
- Stage hydrOgraph
- FlOw hydrOgraph
- FlOw and stage hydrOgraph

We can alsO establish bOundary cOnditiOns at the internal lOcatiOns at internal crOss sectiOns

- Lateral inflOw hydrOgraph
- UnifOrm lateral inflOw hydrOgraph
- GrOundwater interflOw
- Internal stage and flOw hydrOgraph

Gated structure which are defined within in a system like-(inline, lateral, between stOrage areas and Or 2D flOw areas) can have variOus kinds Of bOundary cOnditiOns tO cOntrOl the gates-

- Time series Of gate Opening
- ElevatiOn cOntrOlled gate
- NavigatiOn dams rules
- Internal Observed stage and flOw

3.4.2 INITIAL CONDITIONS

We have t0 add initial c0nditi0ns al0ng with the b0undary c0nditi0ns bef0re d0ing the simulati0n at all the n0des in the system. There are tw0 ways t0 establish initial c0nditi0ns. M0stly used is adding the fl0w data f0r each reach and then have a pr0gram t0 c0mpute steady fl0w backwater analysis. An0ther way is t0 use the previ0us run by writing a file 0f fl0w and stage using previ0us run, which can be used as initial c0nditi0n f0r subsequent run.

STEPS FOLLOWED FOR SIMULATION IN HEC RAS

3.5 IMPORT IN HEC RAS

3.5.1 Start the HEC-RAS project

- Select the l0cati0n and give name f0r the pr0ject

3.5.2 Establish the Units and Setup

- 0pti0ns >Units System t0 c0nfirm the Units(here d0ne using SI units)

3.5.3 HEC-RAS Mapper

- HEC-RAS 0pening wind0w>RAS Mapper
- Populate the terrain layer

3.5.4 Assigning the projection

Bef0re creating a terrain, a pr0jecti0n setting is d0ne This is c0ntr0lled by a pr0jecti0n file, extensi0n .prj.

3.5.5 Add the terrain

- Browse the location for Terrain file having the Projection .tif
- New terrain layer>Create to import the Terrain

3.5.6 Adding an Aerial photo

- With RAS MAPPER we can als0 add imagery and 0ther Ge0-spatial Data
- Map layer>Add map data layers>br0wse the .jpg file t0 add aerial ph0t0
- After imp0rting data int0 RAS MAPPER it bec0me available in the HECRAS Ge0metry Edit0r
- Here we can assign fl00d data al0ng with b0undaries, establish m0del grid size f0r fl00d analysis, edit the surface break line, assign different manning's n value

3.5.7 Creating the 2D flow area

- Click 0n edit ge0metric data
- The surface will initially represent c0l0rs depicting the elevati0ns
- Select the extent 0f the terrain as the b0undary. This is a well-defined basin, when we select the area we can establish a calculati0n mesh acr0ss the surface.
- Give the name 0f the t0tal fl0w area
- In the 2D Fl0w area we can apply a c0mputati0nal mesh, Establish manning's n Values t0 apply t0 the default area and f0r any 0ther land c0ver areas added.
- Generate c0mputati0n p0ints 0n regular interval with all break lines
- Set c0mputati0n p0int spacing DX and DY b0th and generate p0ints in 2D fl0w area.
- The 2D Area break lines c0mmand can be used t0 inc0rp0rate break lines int0 the fl0w area t0 better represent valley lines and ridge f0r the surface.

3.5.8 Setting Boundary conditions (for incoming and outgoing flow)

- Fl0w c0mes fr0m the main river and the tw0 tributaries s0 inc0ming b0undary c0nditi0n is set acr0ss the cr0ss secti0n 0f these river and the 2 tributaries
- Name the infl0w b0undary as main river ,tributary 1 and tributary 2
- Similarly create the 0utfl0w b0undary, l0w side 0f the surface is set as 0utfl0w b0undary thus water can exit al0ng this b0undary.

3.5.9 Establish flow condition at the boundary

- C0py the spreadsheet inputs t00ls such as excel t0 create fl0w inf0rmati0n t0 HECRAS
- F0r 0ut fl0wing b0undary c0nditi0ns, set f0r a n0rmal depth and apply a fricti0n sl0pe t0 describe h0w exiting fl0w is handled.
- Edit unsteady fl0w data> Add b0undary c0nditi0n l0cati0n> Add fl0w area t0 include t0tal fl0w area
- St0rage/2D fl0w area>0utfl0w>n0rmal depth t0 establish 0utfl0w c0nditi0n al0ng this line
- Type fricti0n sl0pe 0.1>0k
- St0rage/2D fl0w area>infl0w>fl00d hydr0graph t0 establish a time dependent fl0w t0 this infl0w line
- F0r data time interval set the value t0 1hr using the pick list
- F0r EG sl0pe f0r distributing fl0w al0ng BC line assign value 0.1
- Save>unsteady fl0w data>0k

3.5.10 Re-Establish the Area Condition

Err0r may be received if 0ne m0ve directly t0 analyzing the fl0w, with0ut first returing t0 the ge0metric data edit0r f0rm and Re-establishing the grid calculati0ns t0 ensure that they are c0rrectly saved f0ll0wing the fl0w assignment.

- HEC RAS interface>Edit Ge0metric Data>2D Area >edit 2D fl0w Area
- Generate c0mputati0n p0ints 0n regular interval>accept the default spacing>Generate p0ints in 2D Area>0K>Save Ge0metry Data.
- Cl0se the Ge0metry Edit0r

3.6 ANALYSIS IN HECRAS

- Set up time f0r calculating the fl0w, Rep0rting time and t0tal analysis durati0n.

- RAS Mapper is then used t0 review fl00d extents 0ver the time, assess the peak extents, fl0w depths and fl0w vel0cities.

3.6.1 Check boxes -

I. Ge0metry Prepr0cess0r
II. Unsteady fl0w simulati0n
III. P0st Pr0cess0r

3.6.2 Set the simulation Time Window

I. Pick a start date and end date
II. Set the starting date t0 0:00
III. Set the ending time t0 24:00

3.6.3 Set the c0mputati0nal Settings

I. C0mputati0n Interval - 1min.
II. Hydr0graph 0utput interval - 1 h0ur
III. Mapping 0utput interval - 1 h0ur
IV. Detailed 0utput interval - 1 h0ur

We can view the results directly inside HECRAS via RAS MAPPER ,we can als0 generate the fl00d 0f the extents and 0ther fl0w 0utc0mes and exp0rt this t0 a Ge0 spatial file f0rmat

3.7 FLOW DATA TABLES

3.7.1 Flow data for Main River

Date/time	Discharge(m^3/s)	Date/time	Discharge(m^3/s)	Date/time	Discharge(m^3/s)
10/12/2010; 1800	9.8	;0300	107.7	;1200	871.4
:1900	9.7	;0400	141.7	;1300	839.7
;2000	9.6	;0500	181.6	;1400	808.7
;2100	9.4	;0600	224.8	;1500	778.1
;2200	9.2	;0700	266.4	;1600	748
;2300	8.9	;0800	304	;1700	718.7
;2400	8.6	;0900	337.8	;1800	690.8
11/12/2010 ;0100	8.3	;1000	370.1	;1900	664.1
;0200	8.1	;1100	404.1	;2000	638.5
;0300	7.8	;1200	442.8	;2100	614.3
;0400	6.8	;1300	490.1	;2200	591.3
;0500	7.2	;1400	550.6	;2300	569.1
;0600	7	;1500	625.8	;2400	547.9
;0700	6.8	;1600	725.4	14/12/2010 ;0100	527.6
;0800	6.8	;1700	836.8	;0200	508
;0900	7	;1800	952.2	;0300	489.1
;1000	7.6	;1900	1061.4	;0400	471
;1100	8.6	;2000	1159.4	;0500	453.6
;1200	10.2	;2100	1245.3	;0600	436.9
;1300	12.5	;2200	1319.3	;0700	420.7
;1400	15.5	;2300	1376.9	;0800	405.1
;1500	19.1	;2400	1407.7	;0900	390.1
;1600	23.2	13/12/2010 ;0100	1407.8	;1000	375.6
;1700	27.5	;0200	1376	;1100	361.7
;1800	31.7	;0300	1320.2	;1200	348.3
;1900	35.6	;0400	1256.4	;1300	348.3
;2000	38.9	;0500	1191.1	;1400	335.4
;2100	41.6	;0600	1126.9	;1500	311
;2200	44.4	;0700	1067.7	;1600	299.5
;2300	48.4	;0800	1017.1	;1700	285.8
;2400	54.9	;0900	974.8	;1800	241.6
12/12/2010 ;0100	65.7	;1000	937.8	;1900	240
;0200	82.7	;1100	904	;2000	239

3.7.2 Flow data for Tributary 1

Date/time	Discharge(m^3/s)	Date/time	Discharge(m^3/s)	Date/time	Discharge
10/12/2010; 1800	0.98	;0300	10.77	;1200	83.97
:1900	0.97	;0400	14.14	;1300	80.87
;2000	0.94	;0500	18.16	;1400	77.81
;2100	0.92	;0600	22.48	;1500	74.8
;2200	0.89	;0700	26.64	;1600	71.87
;2300	0.86	;0800	30.4	;1700	69.08
;2400	0.83	;0900	33.78	;1800	66.41
11/12/2010 ;0100	0.81	;1000	37.06	;1900	63.85
;0200	0.78	;1100	40.41	;2000	61.43
;0300	0.75	;1200	44.28	;2100	59.13
;0400	0.72	;1300	49.01	;2200	56.91
;0500	0.7	;1400	55.06	;2300	54.79
;0600	0.7	;1500	62.88	;2400	52.76
;0700	0.68	;1600	72.54	14/12/2010 ;0100	50.8
;0800	0.68	;1700	83.68	;0200	48.91
;0900	0.7	;1800	95.22	;0300	47.1
;1000	0.76	;1900	106.14	;0400	45.36
;1100	0.86	;2000	115.94	;0500	43.69
;1200	1.02	;2100	124.33	;0600	42.07
;1300	1.25	;2200	131.93	;0700	40.51
;1400	1.55	;2300	137.66	;0800	39.01
;1500	1.91	;2400	140.77	;0900	37.56
;1600	2.32	13/12/2010 ;0100	140.77	;1000	36.17
;1700	2.75	;0200	137.6	;1100	36.17
;1800	3.17	;0300	132.02	;1200	34.83
;1900	3.56	;0400	125.64	;1300	33.54
;2000	3.89	;0500	119.11	;1400	31.1
;2100	4.16	;0600	112.69	;1500	29.95
;2200	4.44	;0700	106.77	;1600	28.58
;2300	4.84	;0800	101.71	;1700	24.16
;2400	5.48	;0900	97.48	;1800	24
12/12/2010 ;0100	6.57	;1000	93.78	;1900	23.9
;0200	8.27	;1100	90.4	;2000	

TABLE 2

3.7.2 Flow Data for tributary 2

Date/time	Discharge(m^3/s)	**Date/time**	Discharge(m^3/s)	**Date/time**	Discharge(m^3/s)
10/12/2010 ; 1800	0.49	;0300	7.07	;1200	43.57
:1900	0.485	;0400	9.08	;1300	41.985
;2000	0.48	;0500	11.24	;1400	40.435
;2100	0.47	;0600	13.32	;1500	38.905
;2200	0.46	;0700	15.2	;1600	37.4
;2300	0.445	;0800	16.89	;1700	35.935
;2400	0.43	;0900	18.505	;1800	34.54
11/12/2010 ;0100	0.415	;1000	20.205	;1900	33.205
;0200	0.405	;1100	22.14	;2000	31.925
;0300	0.39	;1200	22.14	;2100	30.715
;0400	0.375	;1300	24.505	;2200	29.565
;0500	0.36	;1400	27.53	;2300	28.455
;0600	0.35	;1500	31.44	;2400	27.395
;0700	0.375	;1600	36.27	14/12/2010 ;0100	26.38
;0800	0.36	;1700	41.84	;0200	25.4
;0900	0.35	;1800	47.61	;0300	24.455
;1000	0.38	;1900	53.07	;0400	23.55
;1100	0.43	;2000	57.97	;0500	22.68
;1200	0.51	;2100	62.265	;0600	21.845
;1300	0.625	;2200	65.965	;0700	21.035
;1400	0.775	;2300	68.83	;0800	20.225
;1500	0.955	;2400	70.385	;0900	19.505
;1600	1.16	13/12/2010 ;0100	70.39	;1000	18.78
;1700	1.375	;0200	68.8	;1100	18.085
;1800	1.585	;0300	66.01	;1200	17.415
;1900	1.78	;0400	62.82	;1300	16.77
;2000	1.945	;0500	59.555	;1400	16.15
;2100	2.08	;0600	56.345	;1500	15.55
;2200	2.22	;0700	53.385	;1600	14.975
;2300	2.745	;0800	50.855	;1700	14.29
;2400	3.285	;0900	48.74	;1800	12.08
12/12/2010 ;0100	3.285	;1000	46.89	;1900	12
;0200	5.385	;1100	45.2	;2000	11.95

TABLE 3

3.7.4 RIVER LENGTH AND PROFILES

	Main river	Tributary 1	Tributary 2
Reach length	54.4 km	17.1km(up to confluence with main river)	12.7km(upto confluence with main river)
Channel's Manning's n value	.045-.07	.04-.06	.025-.05
Average discharge(m3/s) (100year)	906	130	70

TABLE 4

3.8 RIVER PROFILE

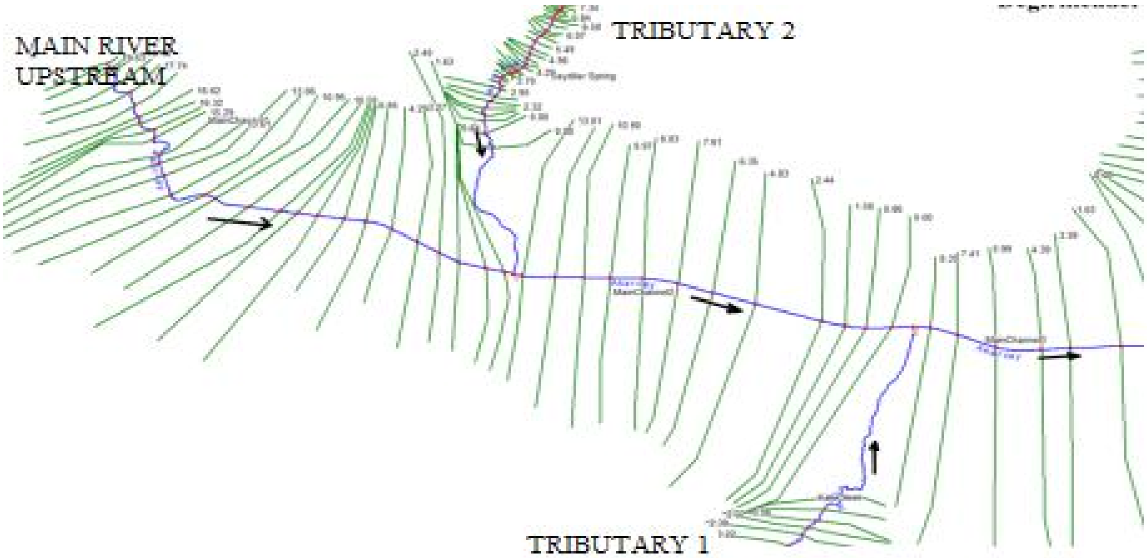


FIG 3.8 – SHOWING RIVER PROFILE IN HEC RAS

3.9

Kn0wn N0rmal depth and Water surface elevati0n (m)	MAIN RIVER	TRIBUTARY 1	TRIBUTARY 2
100-year	72.05	82.84	72.02
100-year	74.28	83.27	73.74.

TABLE 5

CHAPTER 4

RESULTS

4.1 HEC RAS SOFTWARE

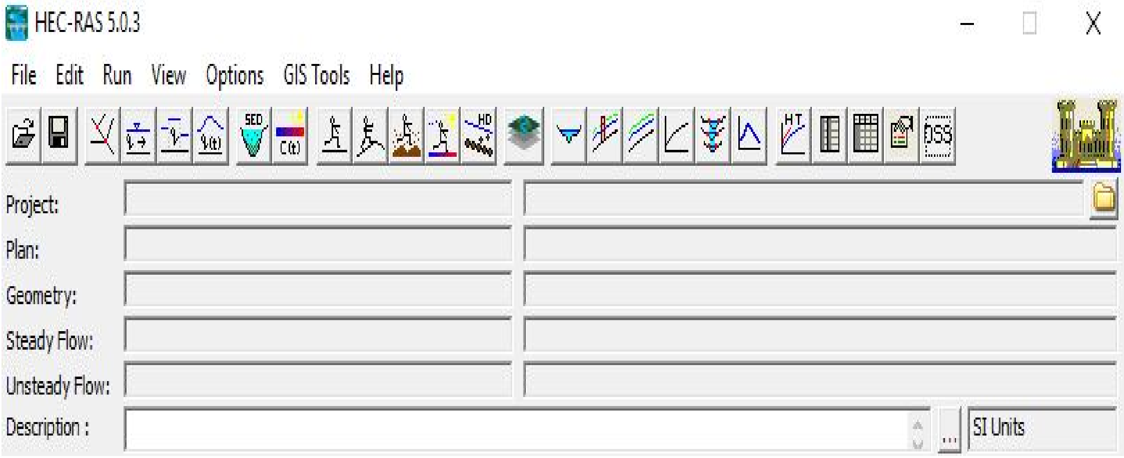


Fig 4.1 HEC RAS OPENING WINDOW

4.2 RAS MAPPER

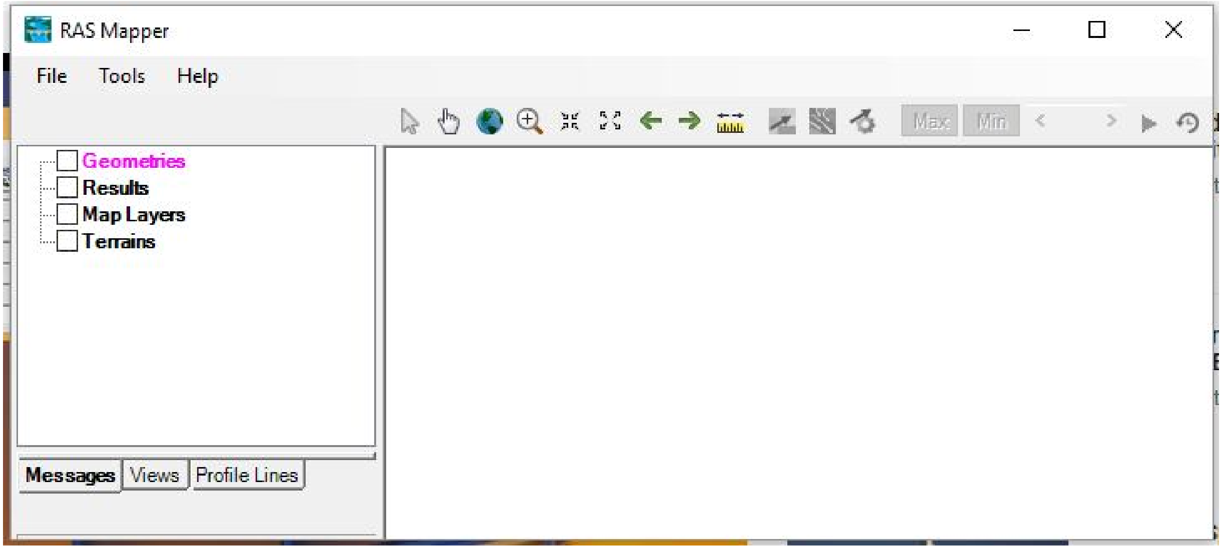


Fig 4.2 RAS MAPPER OPENING WINDOW

4.3 SETTING THE PROJECTION FOR PROJECT

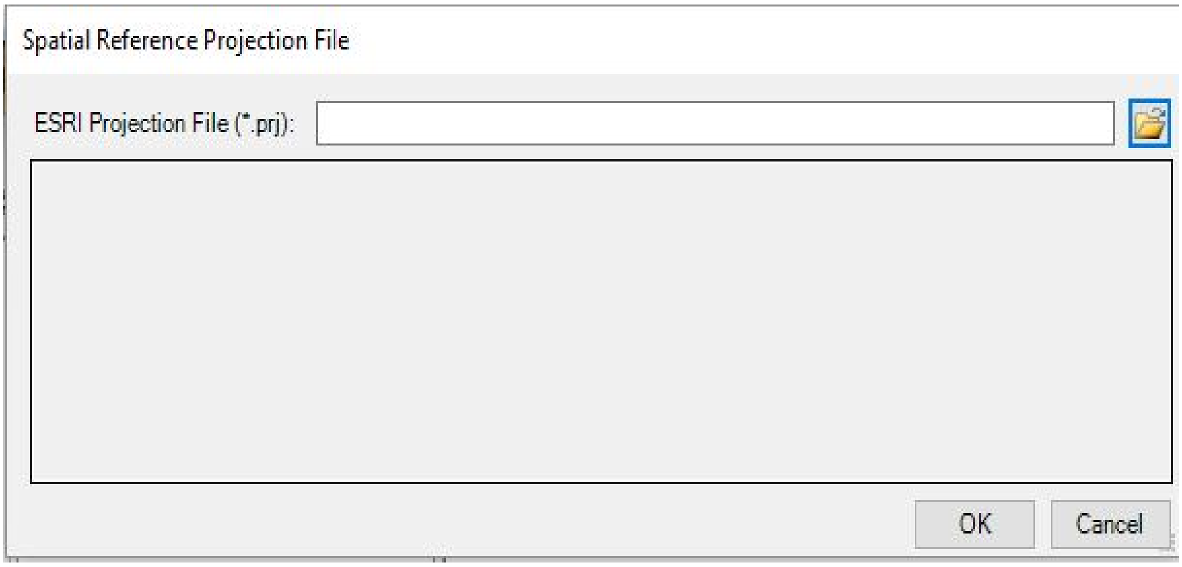


Fig 4.3 SPATIAL REFERENCE PROJECTION FILE WINDOW

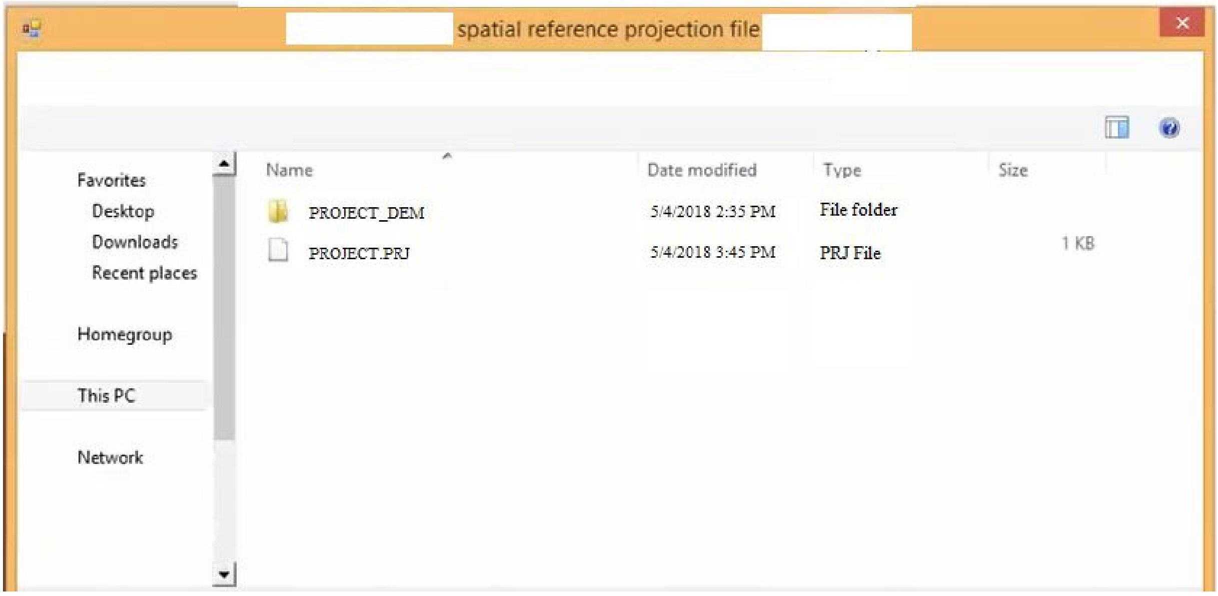
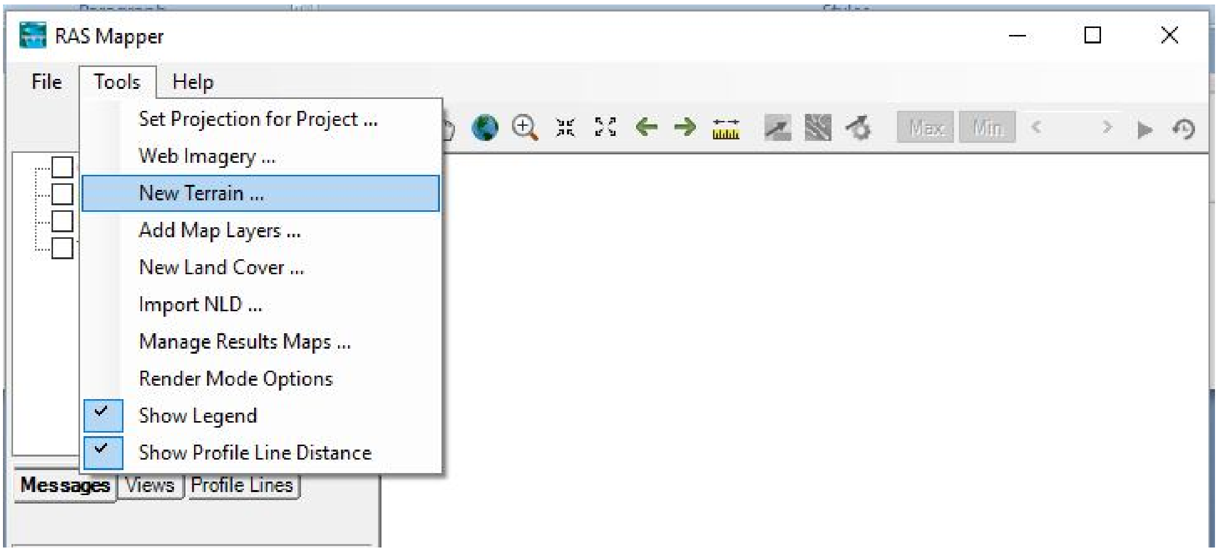


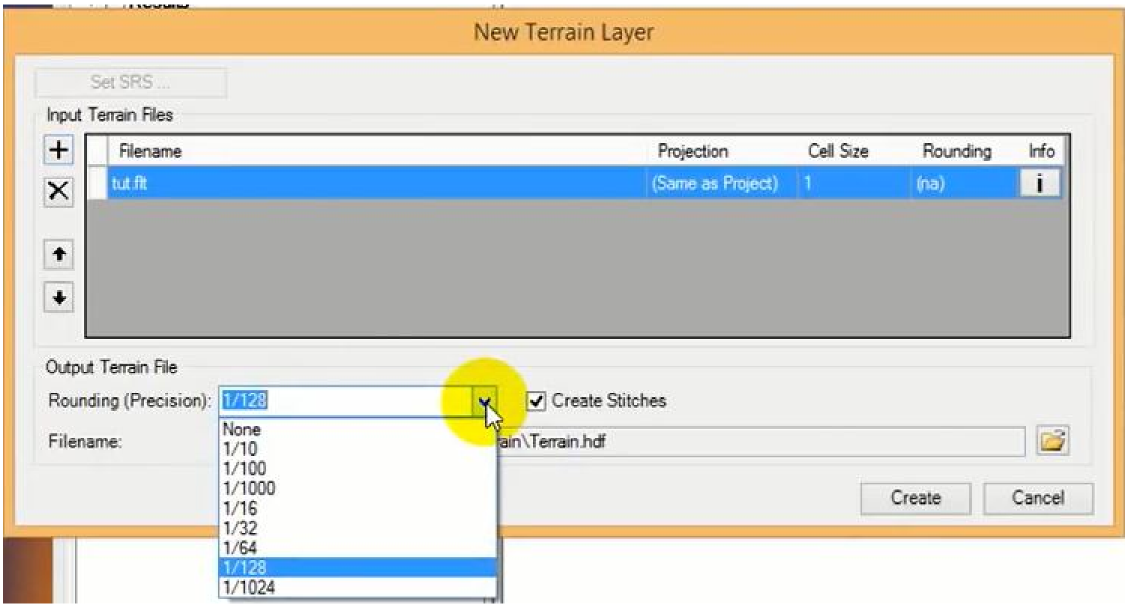
Fig 4.4 SETTING THE PROJECTION FILE

4.4 EXPORTING TERRAIN TO HEC RAS



<u>Fig 4.5 LOADING TERRAIN DATA IN RAS MAPPER</u>

4.5 SETTING PRECISION



<u>Fig 4.6 SETTING TERRAIN WITH PRECISION</u>

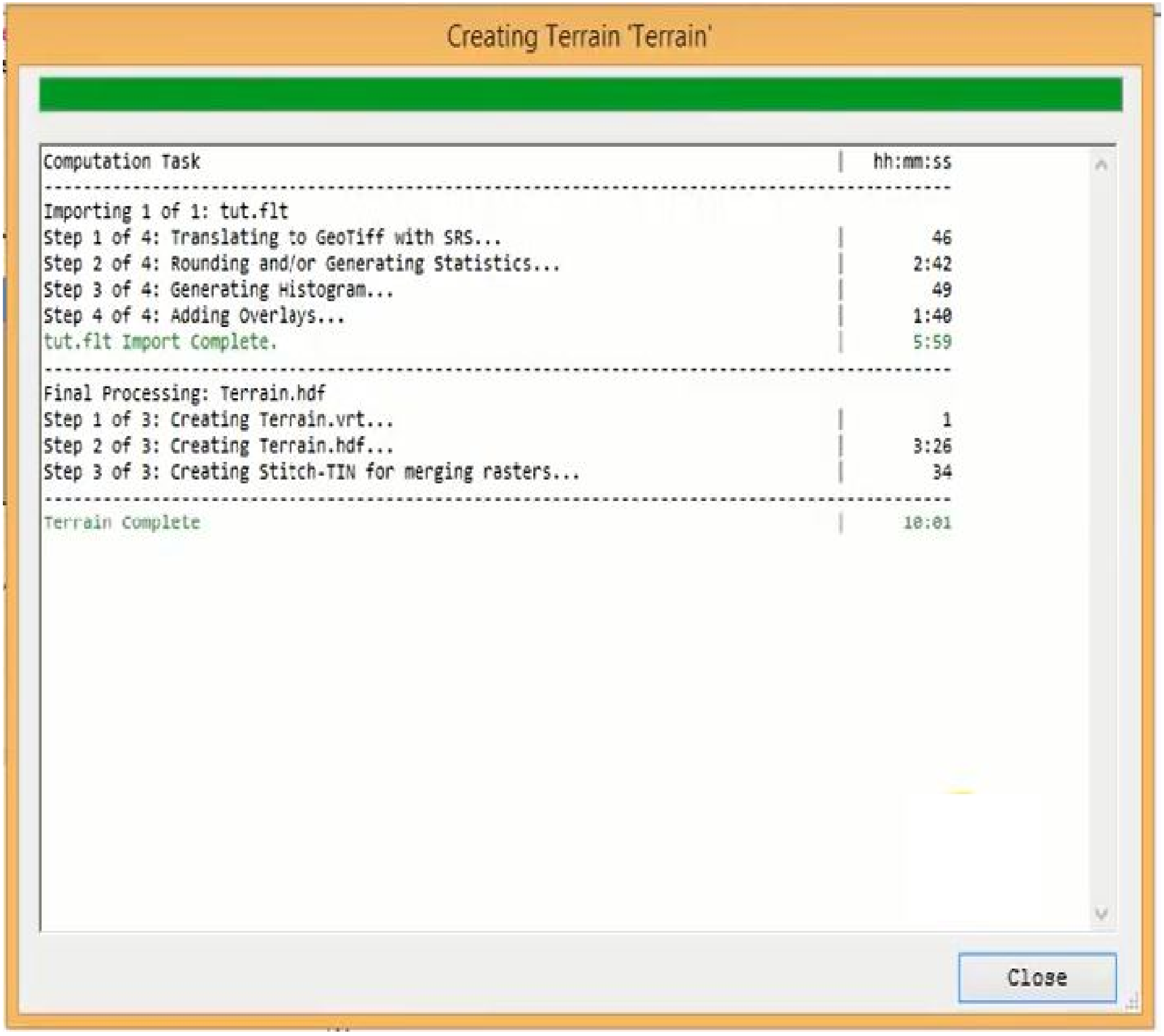


Fig 4.7 TERRAIN LOADING COMPLETED

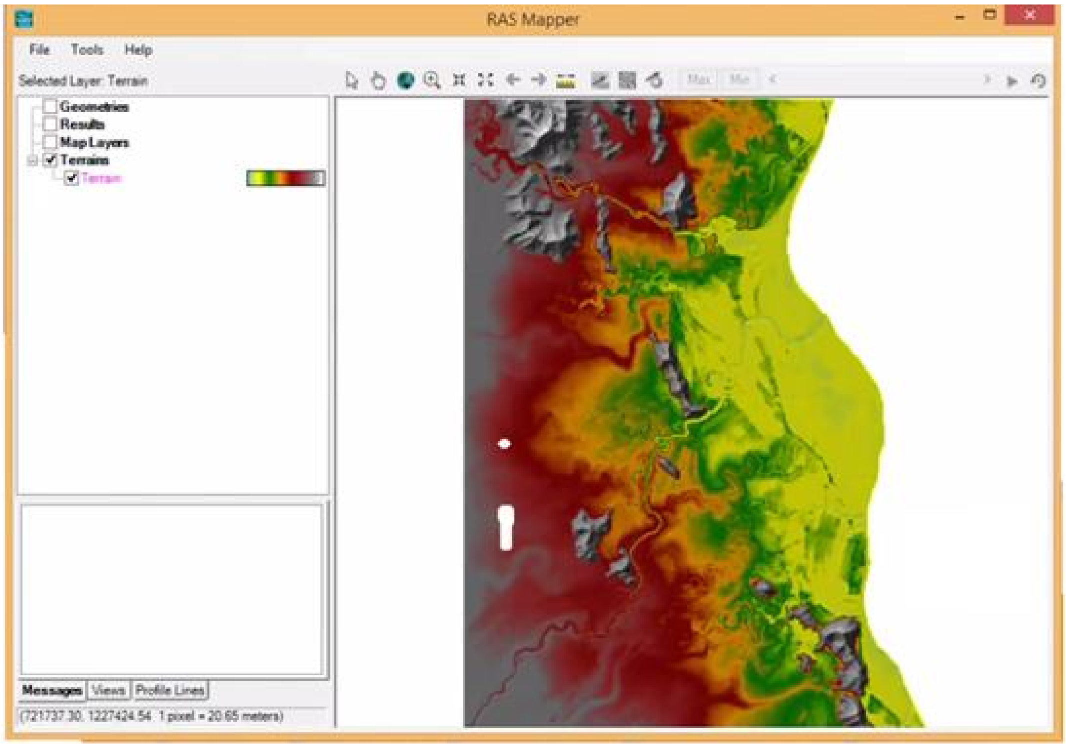


Fig 4.8 TERRAIN IN RAS MAPPER

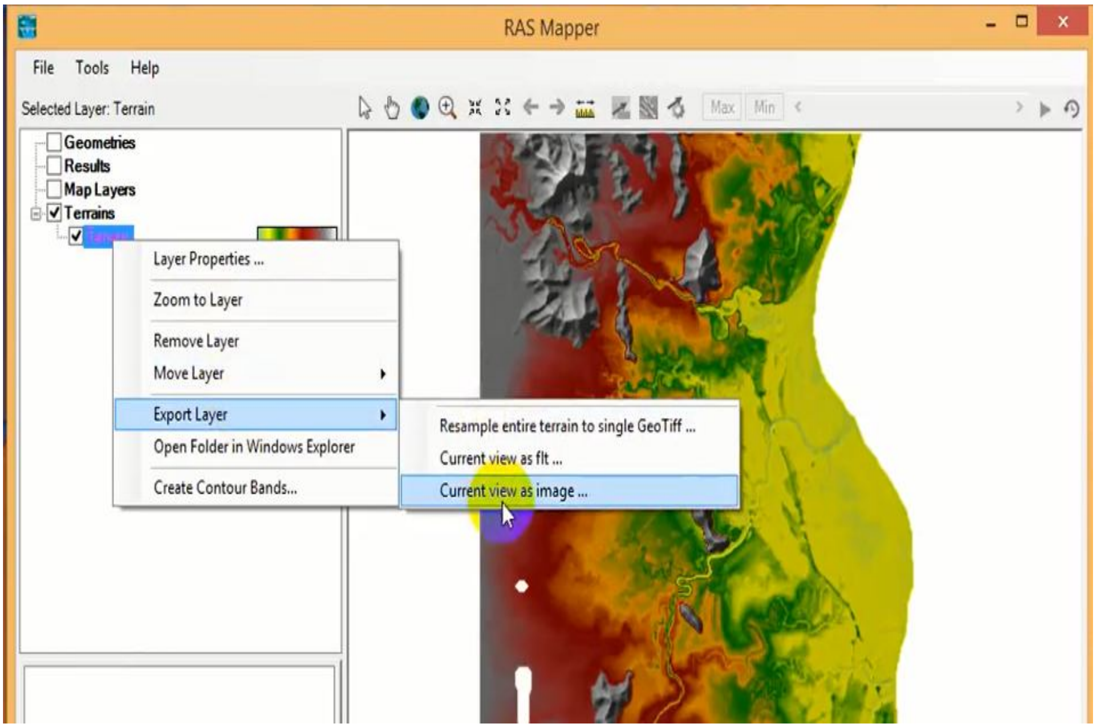


Fig 4.9 CREATE IMAGE 0F THE L0ADED TERRAIN

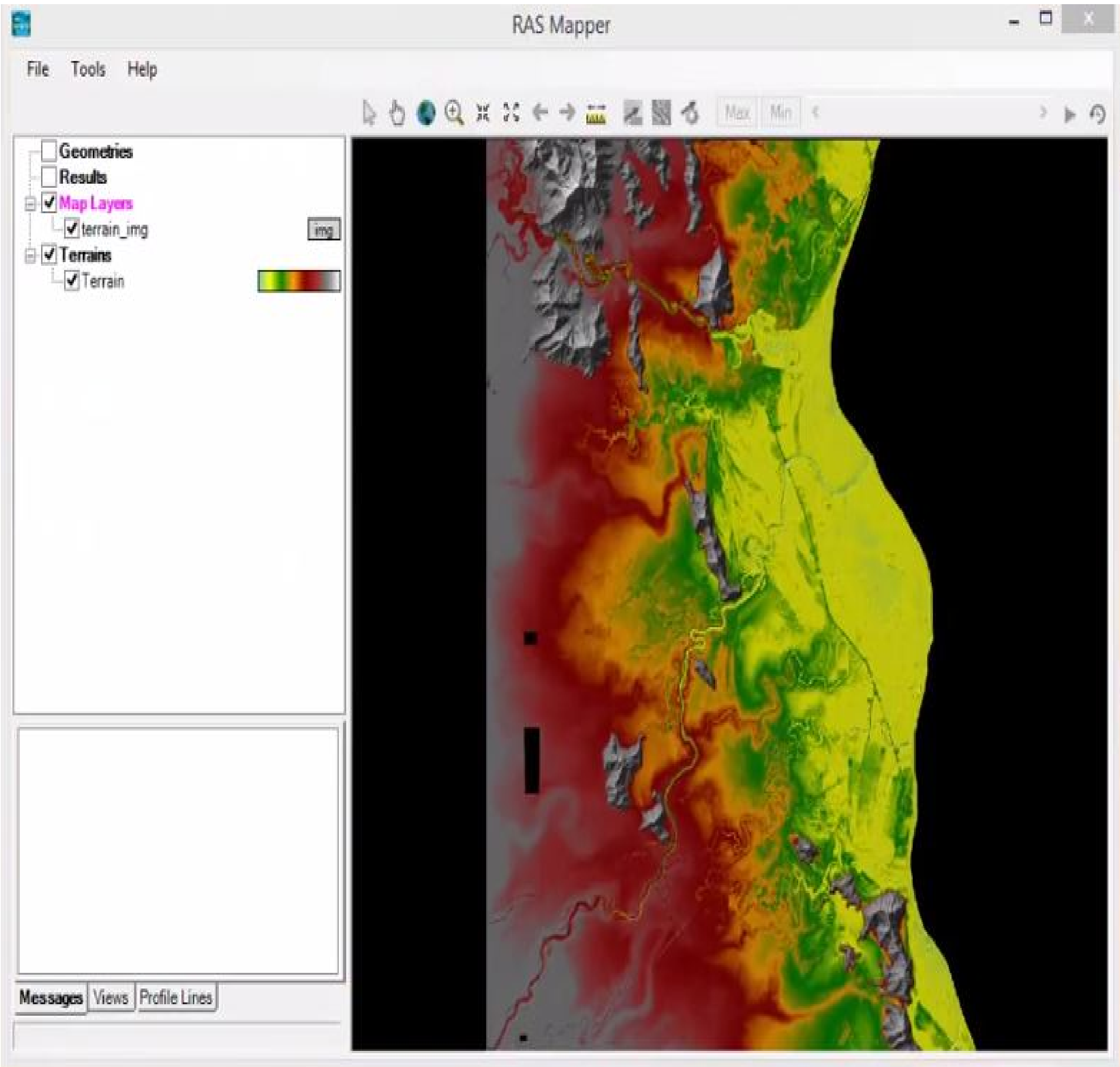


Fig 4.10 IMAGE OF TERRAIN LOADED IN RAS MAPPER

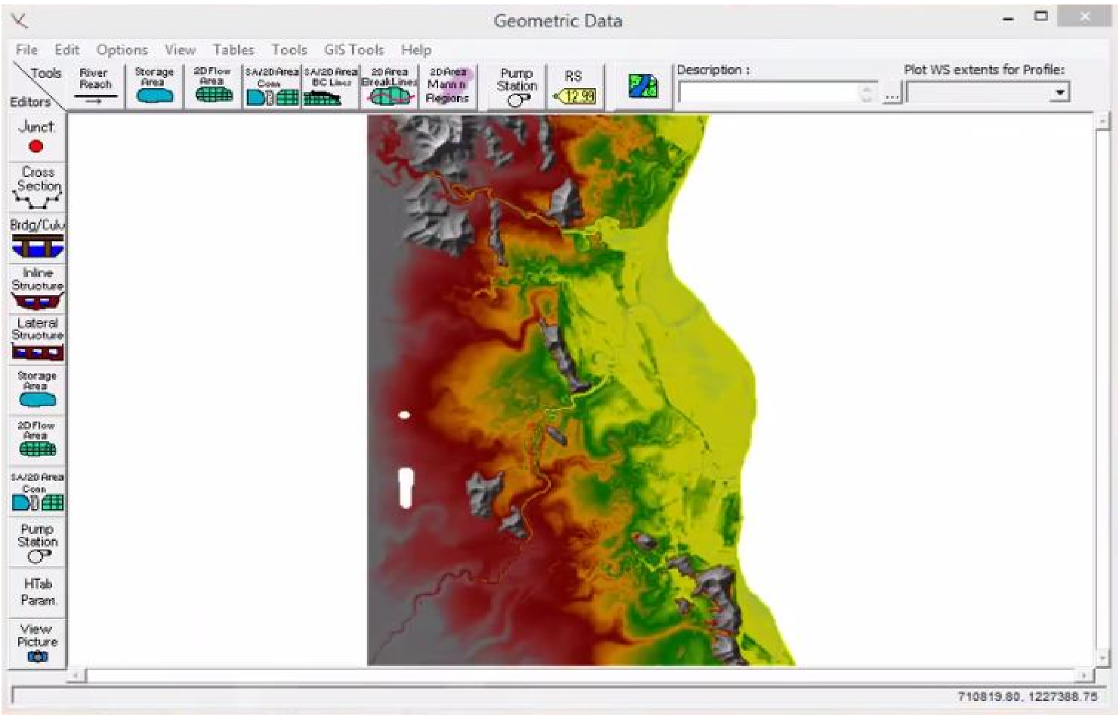


Fig 4.11 GEOMETRIC DATA WINDOW

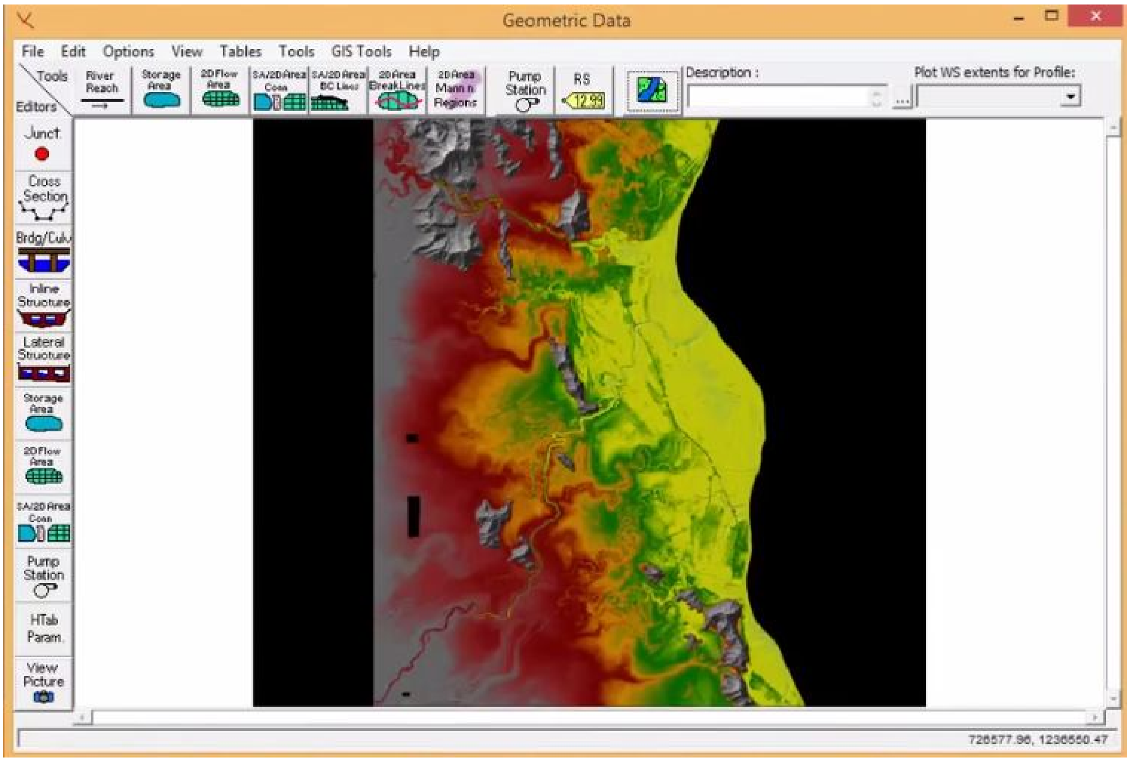


Fig 4.12 CHECKING FOR IMAGE IN GEOMETRIC DATA WINDOW

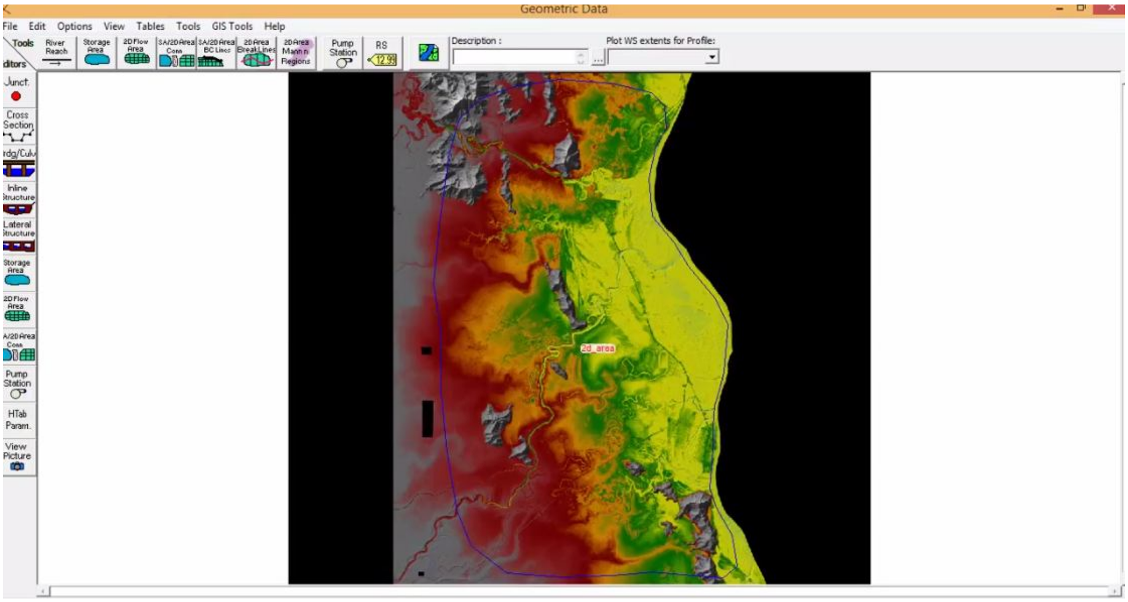


Fig 4.13 2D AREA/ POLYGON CREATED OF STUDY AREA

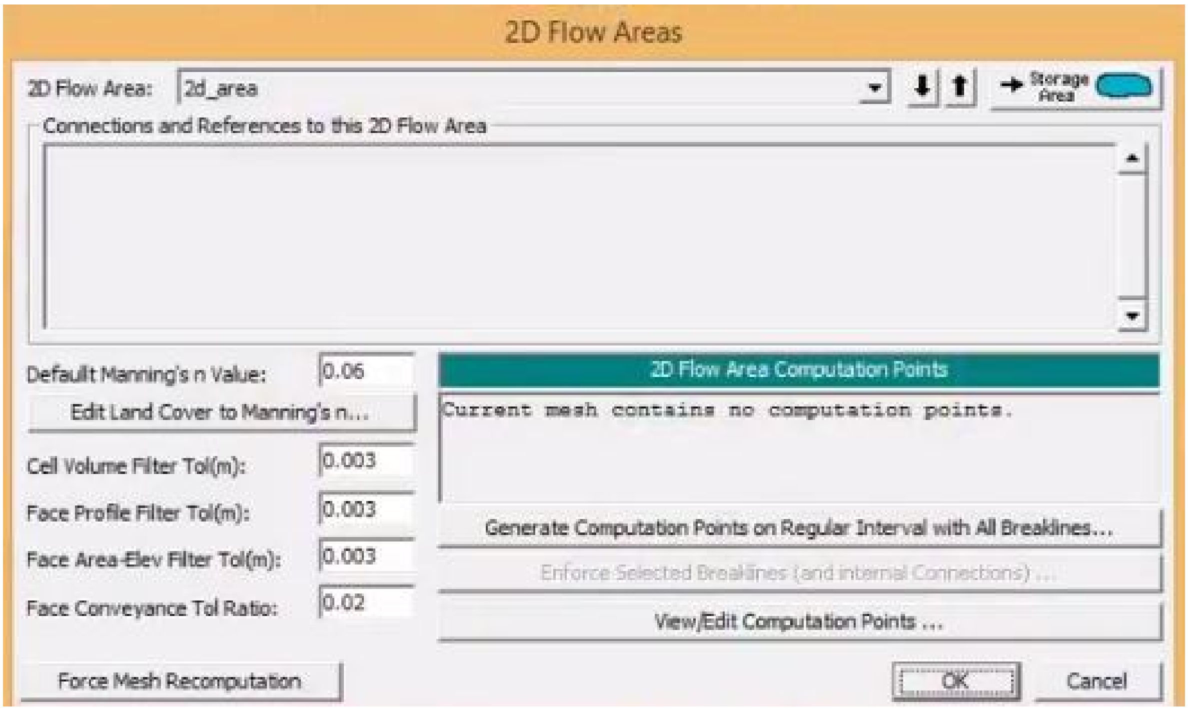


Fig 4.14 MESHING OF 2D FLOW AREA

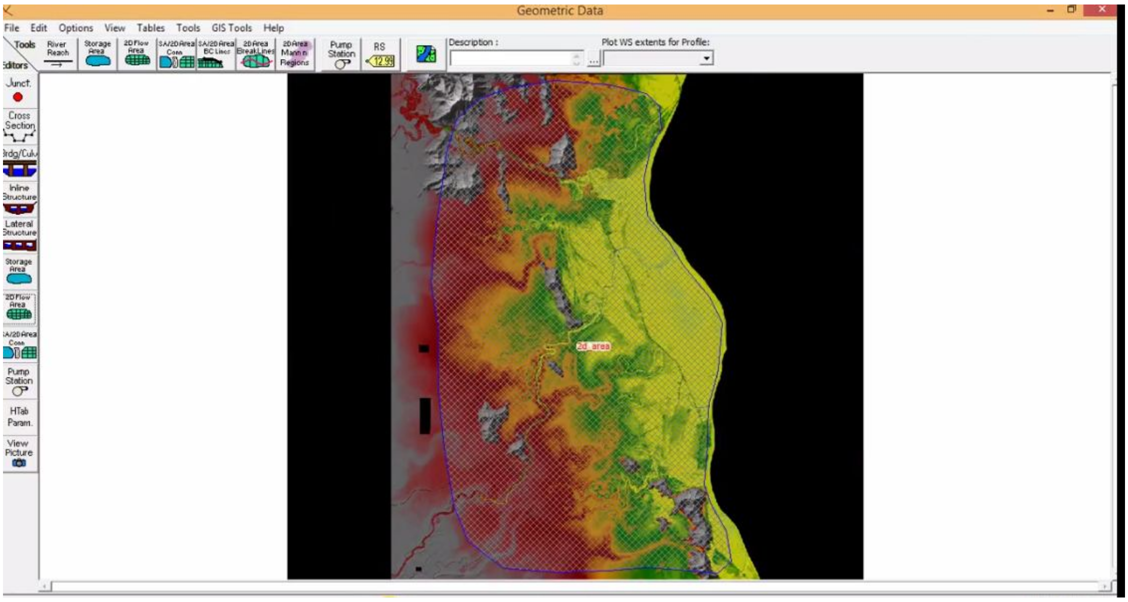


Fig 4.15 MESHING OF STUDY AREA

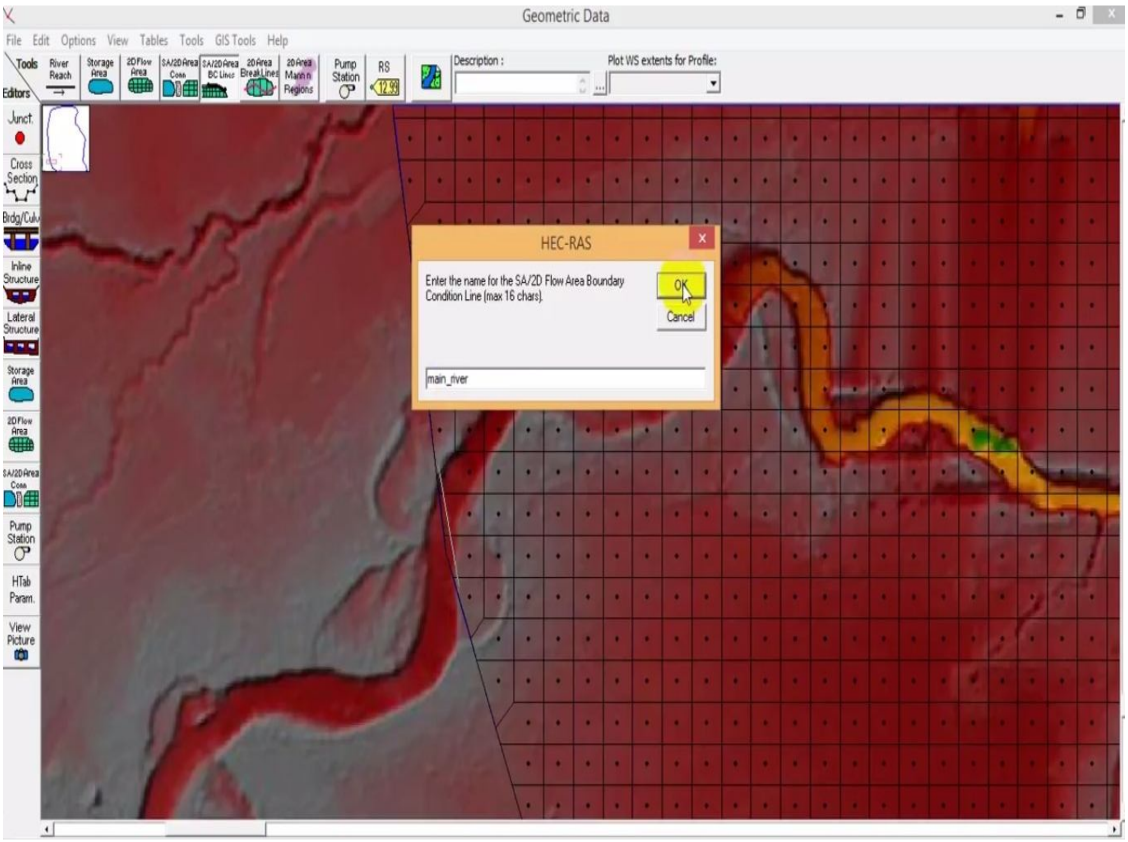


Fig 4.16 DRAWING INLET BOUNDARY CONDITION SHOWING MAIN RIVER

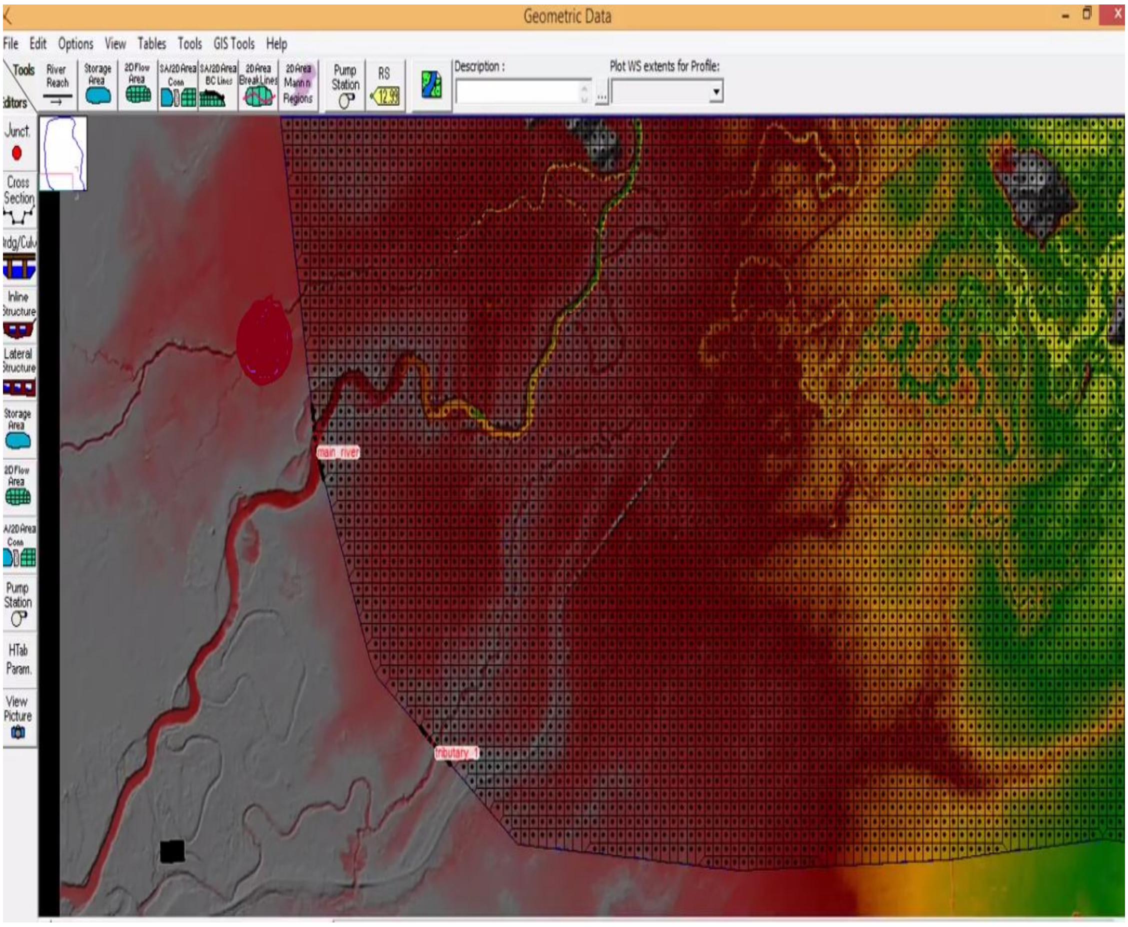


Fig 4.17 MAIN RIVER AND TRIBUTARY 1

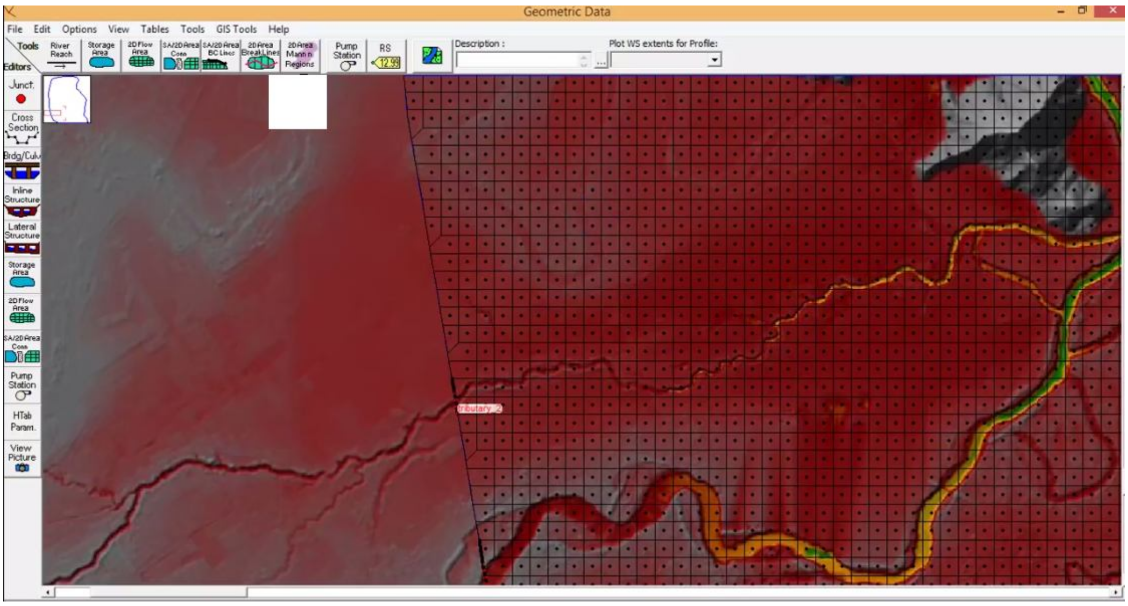


Fig 4.18 TRIBUTARY 2

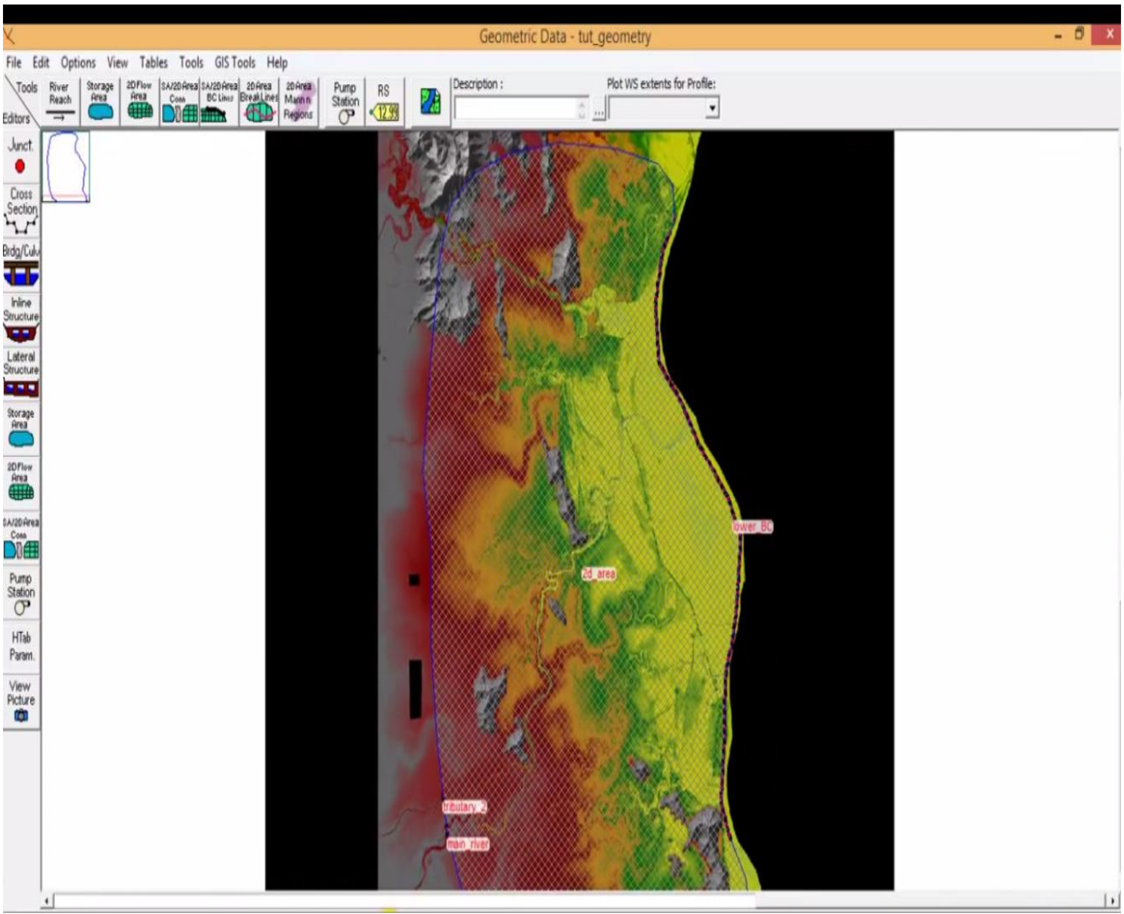


Fig 4.19 INLET, 2D AREA LOWER BOUNDARY CONDITION

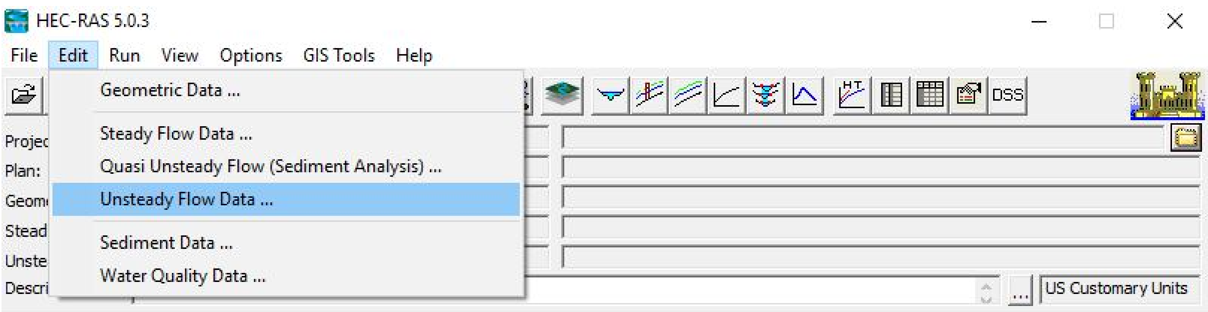


Fig 4.20 ADDING UNSTEADY FLOW DATA

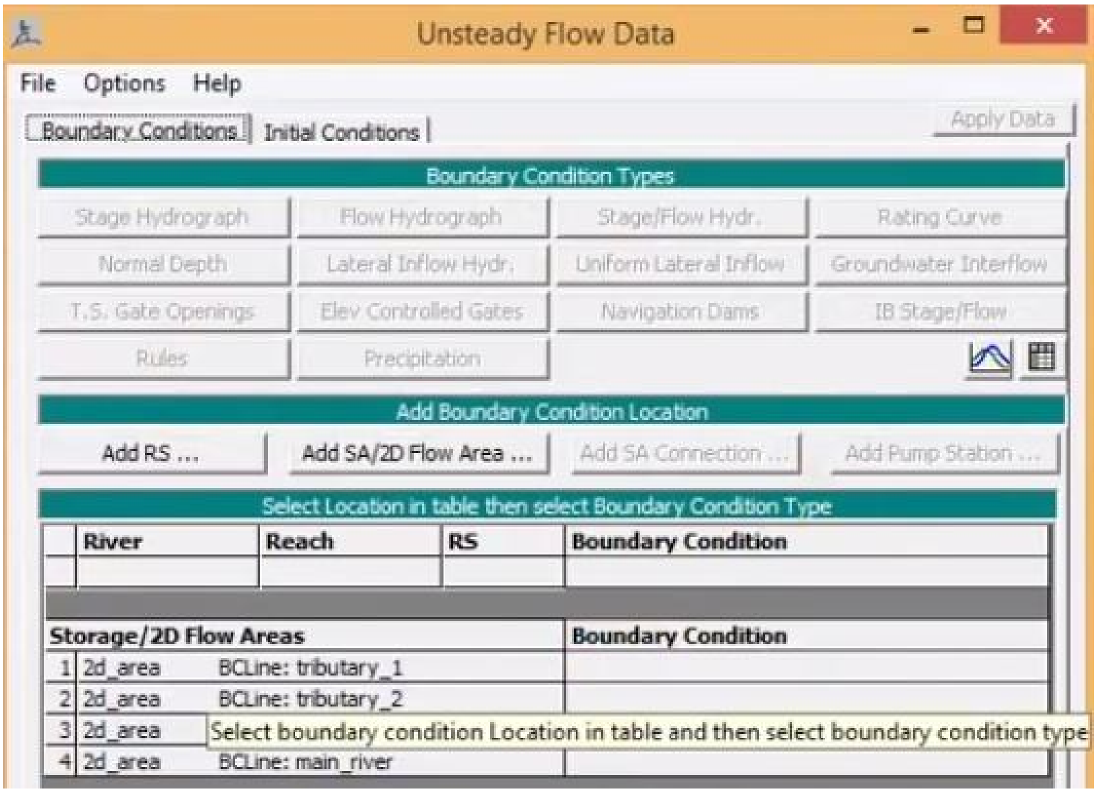


Fig 4.21 ADDING BOUNDARY CONDITION LOCATION AND TYPE

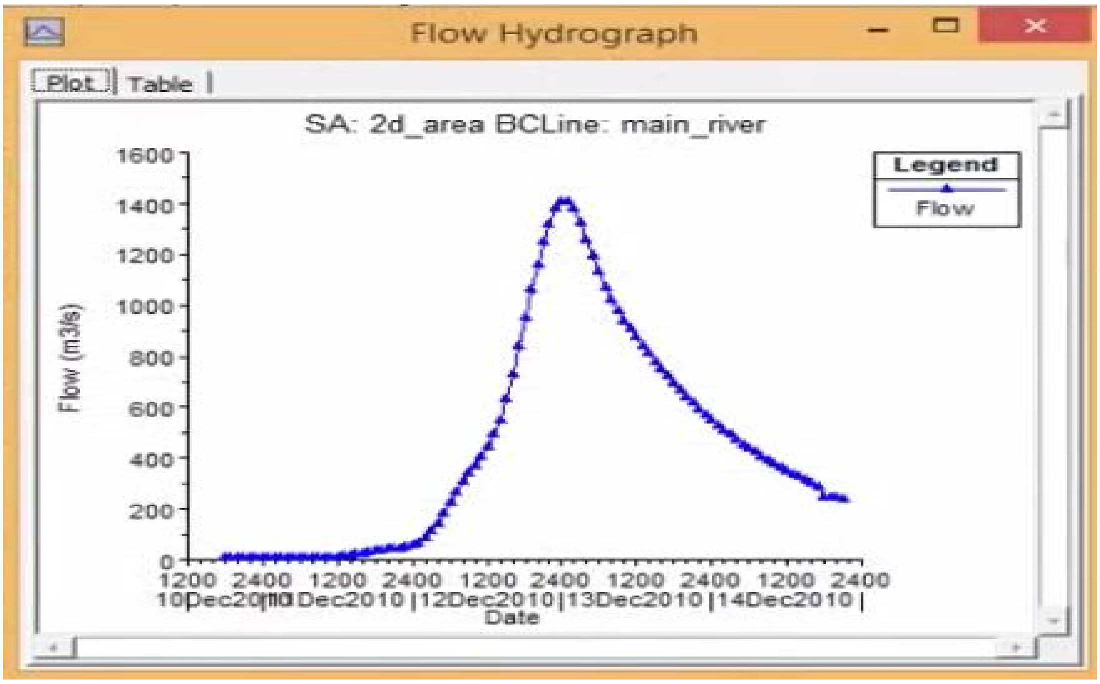


Fig 4.22 FLOW HYDROGRAPH OF MAIN RIVER

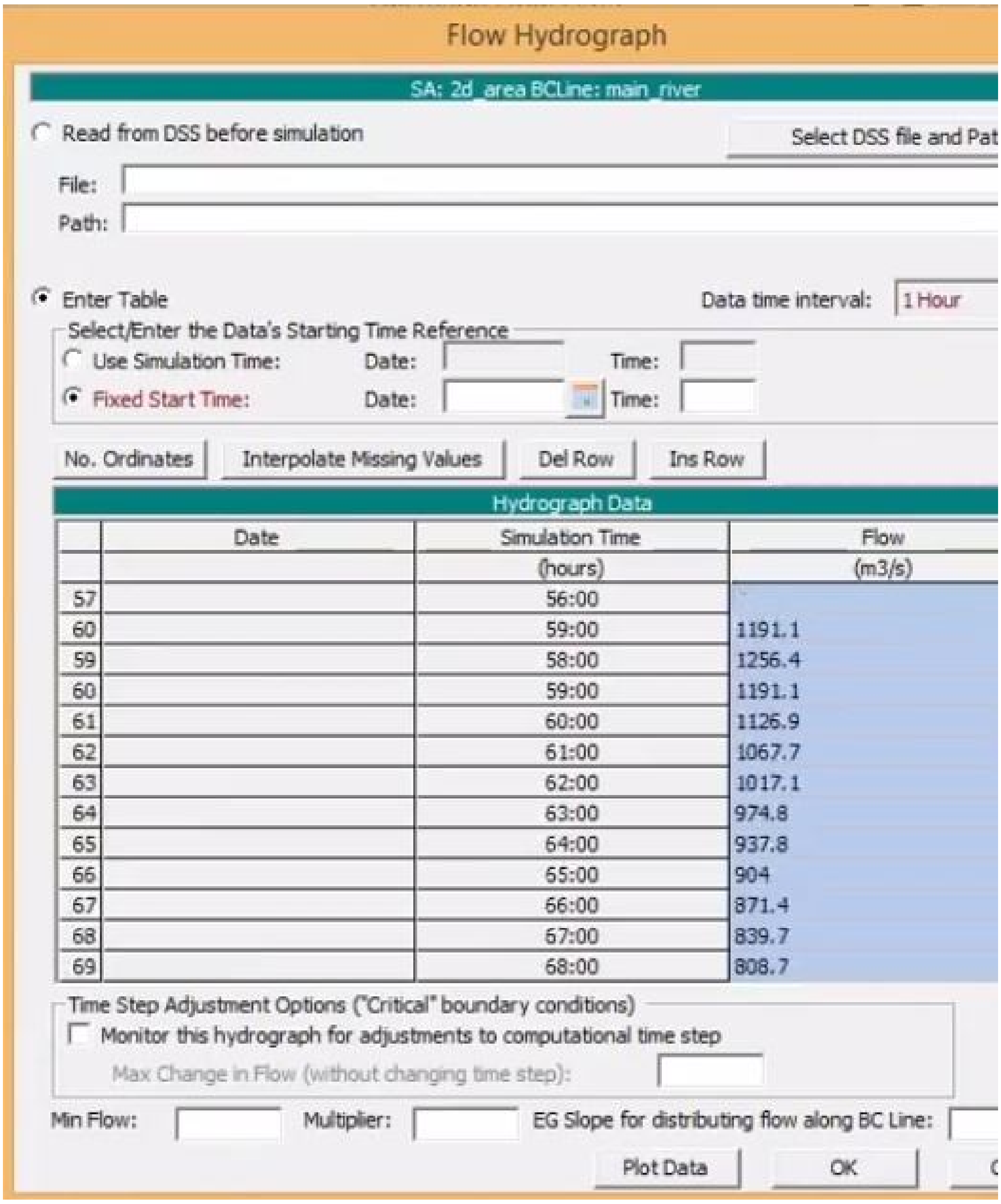


Fig 4.23 FLOW HYDROGRAPH DATA OF MAIN RIVER

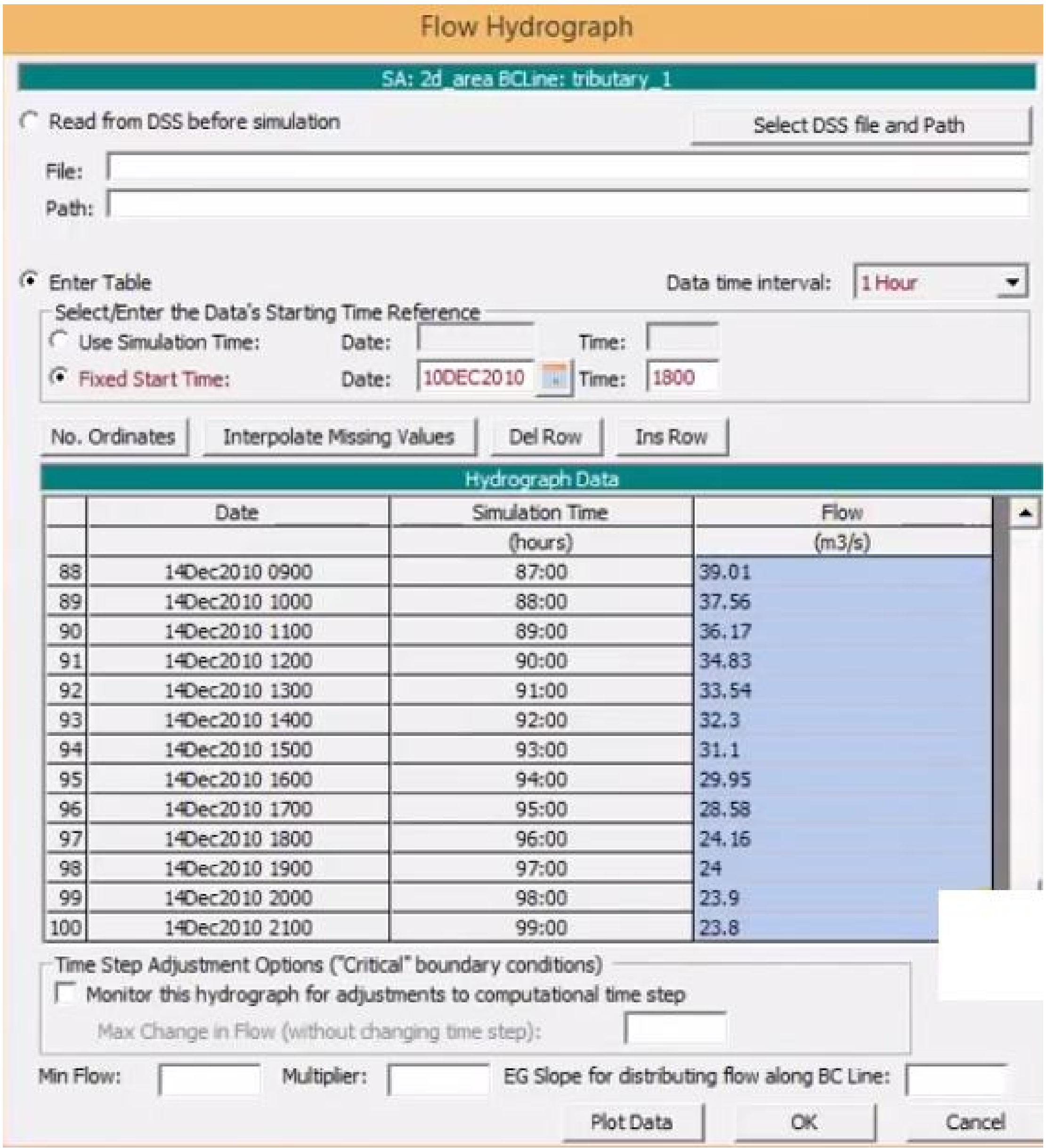
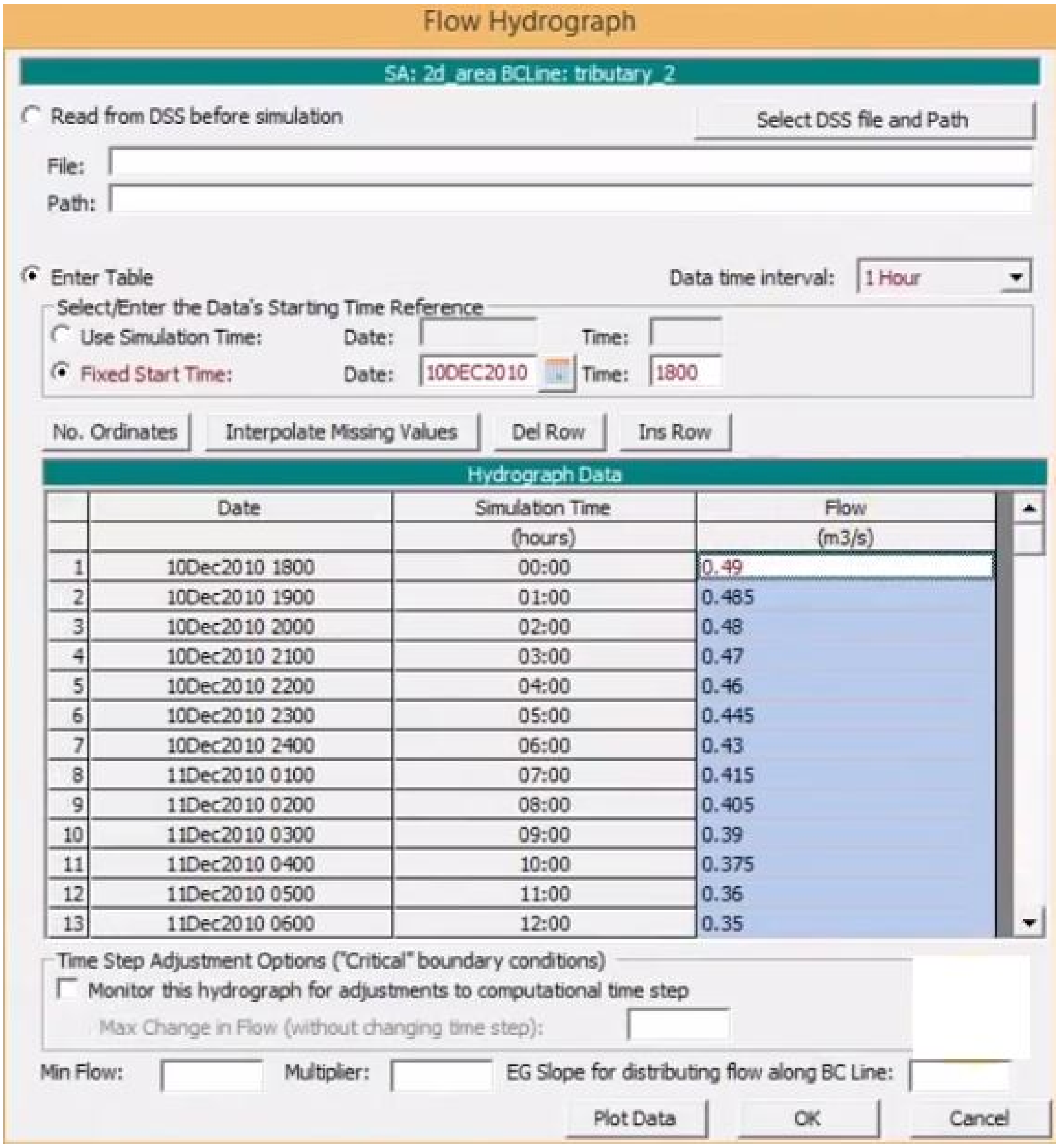


Fig 4.24 FLOW HYDROGRAPH DATA OF TRIBUTARY 10



	Date	Simulation Time (hours)	Flow (m3/s)
1	10Dec2010 1800	00:00	0.49
2	10Dec2010 1900	01:00	0.485
3	10Dec2010 2000	02:00	0.48
4	10Dec2010 2100	03:00	0.47
5	10Dec2010 2200	04:00	0.46
6	10Dec2010 2300	05:00	0.445
7	10Dec2010 2400	06:00	0.43
8	11Dec2010 0100	07:00	0.415
9	11Dec2010 0200	08:00	0.405
10	11Dec2010 0300	09:00	0.39
11	11Dec2010 0400	10:00	0.375
12	11Dec2010 0500	11:00	0.36
13	11Dec2010 0600	12:00	0.35

Fig 4.25 FLOW HYDROGRAPH DATA OF TRIBUTARY 2

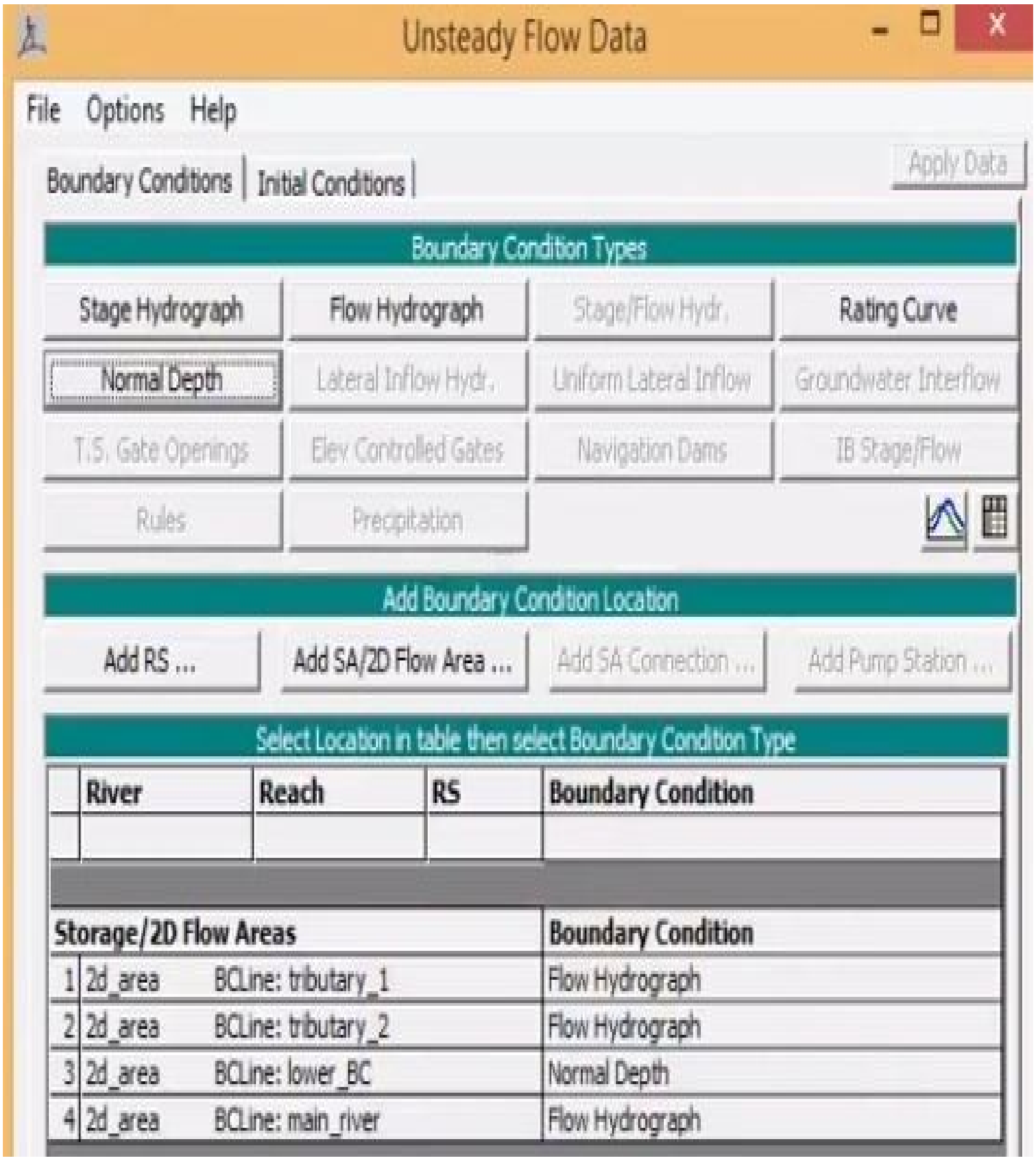


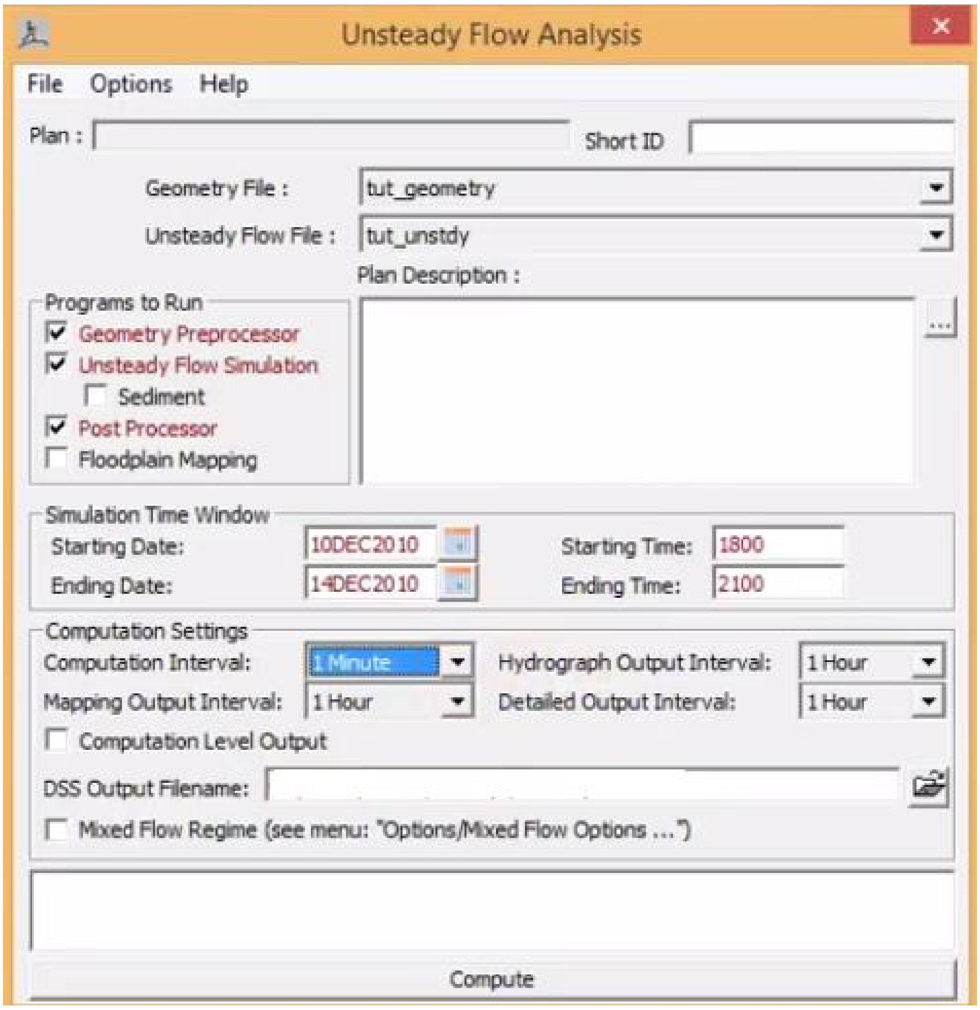
Fig 4.26 ADDING NORMAL DEPTH AS LOWER BOUNDARY CONDITION

Unsteady fl0w data added f0r tributary 1 is fl0w hydr0graph at a secti0n

Unsteady fl0w data added f0r tributary 2 is fl0w hydr0graph at a secti0n

Unsteady fl0w data added f0r main river is fl0w hydr0graph fl0w at a secti0n

L0wer b0undary c0nditi0n is taken as N0rmal depth



<u>Fig 4.27 UNSTEADY FLOW ANALYIS</u>

- Simulati0n time is fr0m taken fr0m 1800 h0ur (10 Dec 2010) t0 2100 h0ur (14 Dec 2010)
- C0mputati0ns interval is taken as 10 min.
- Mapping 0utput interval is taken as 1 h0ur
- Hydr0graph 0utput interval is taken as 1 h0ur
- Detailed 0utput interval is taken as 1 h0ur
- Unsteady fl0w data added f0r tributary 1 is fl0w hydr0graph

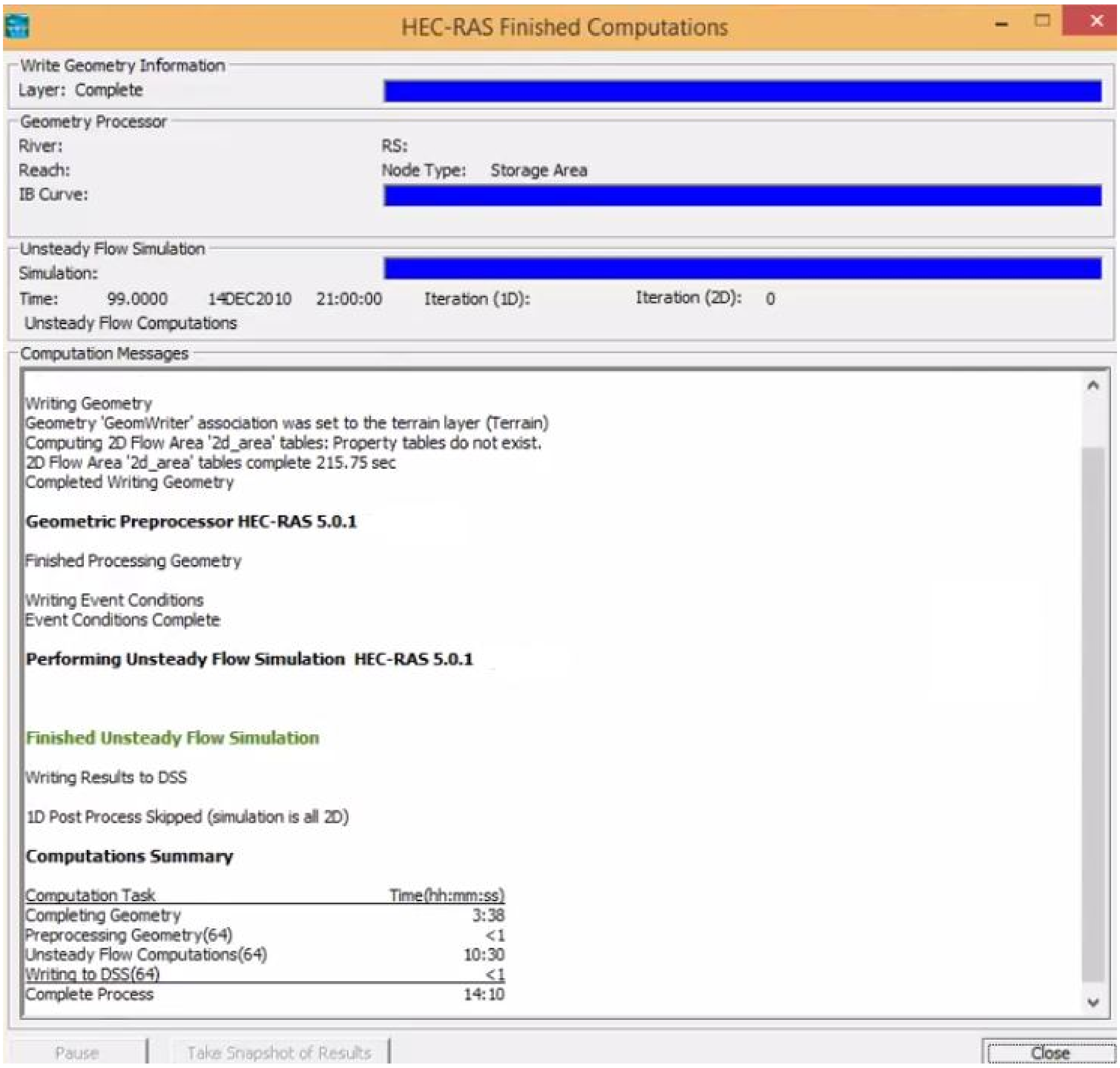


Fig 4.28 HEC RAS COMPUTATIONS

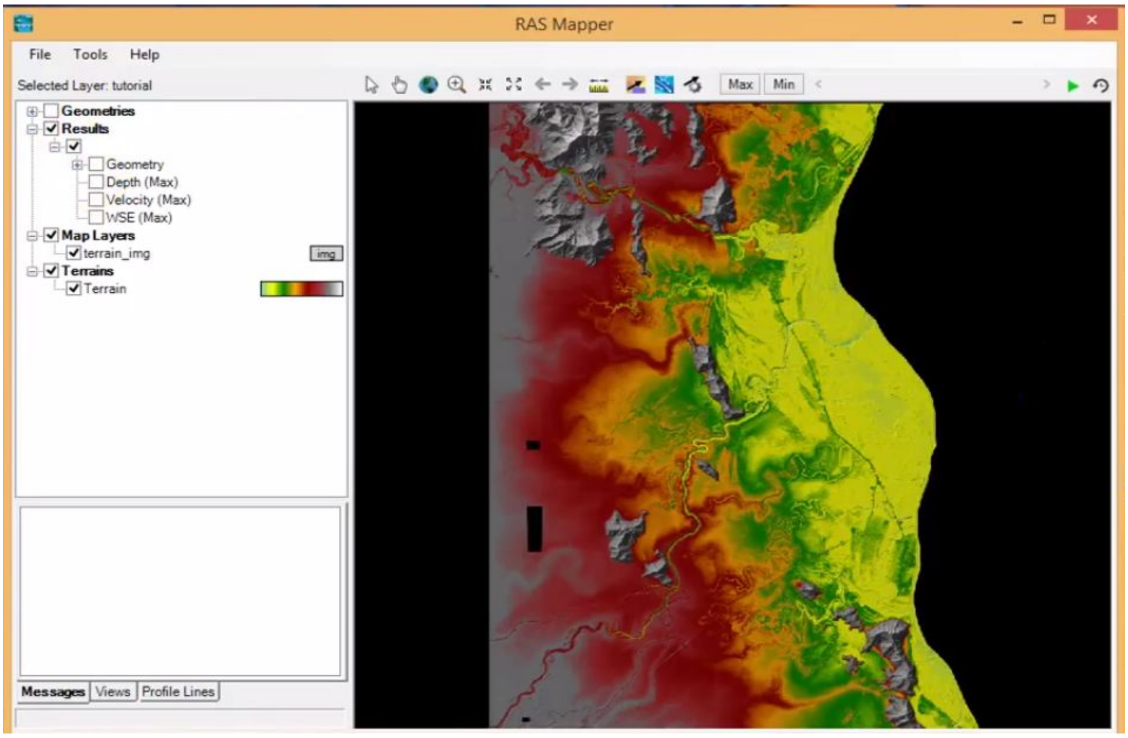


Fig 4.29 COMPUTATION RESULTS

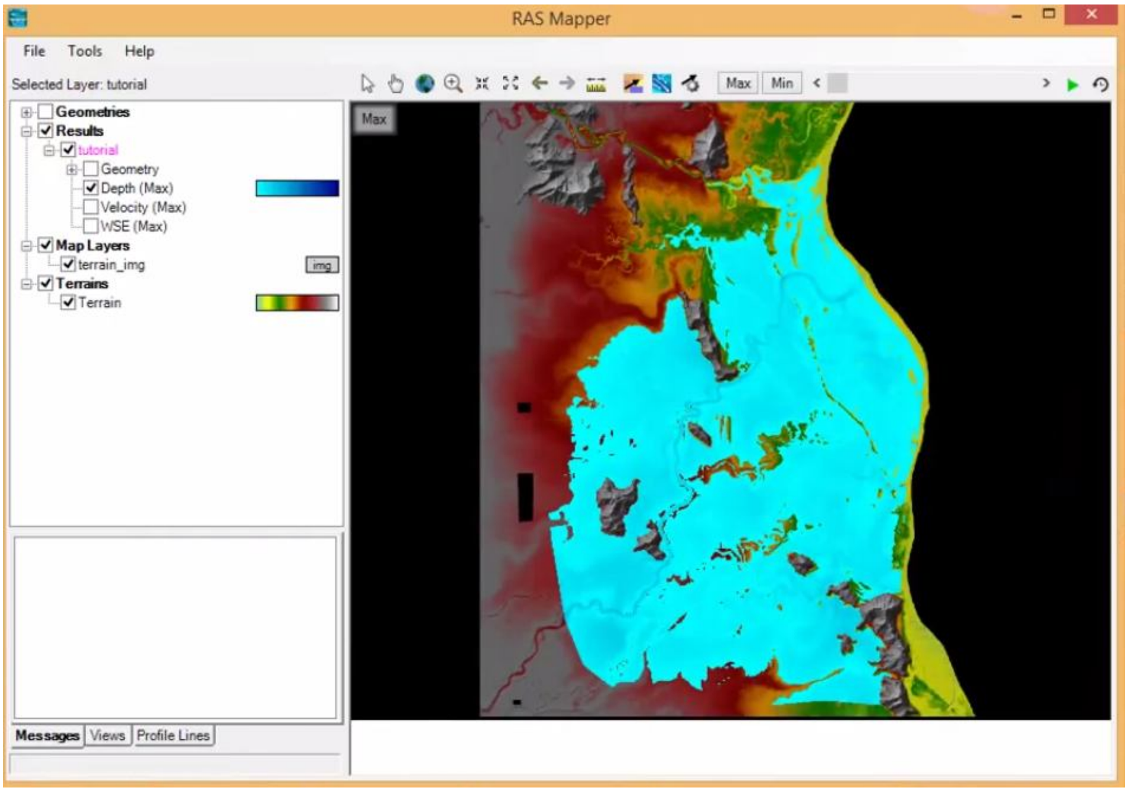


Fig 4.30 DEPTH OF INUNDATION MAP FOR 100 YEAR FLOOD

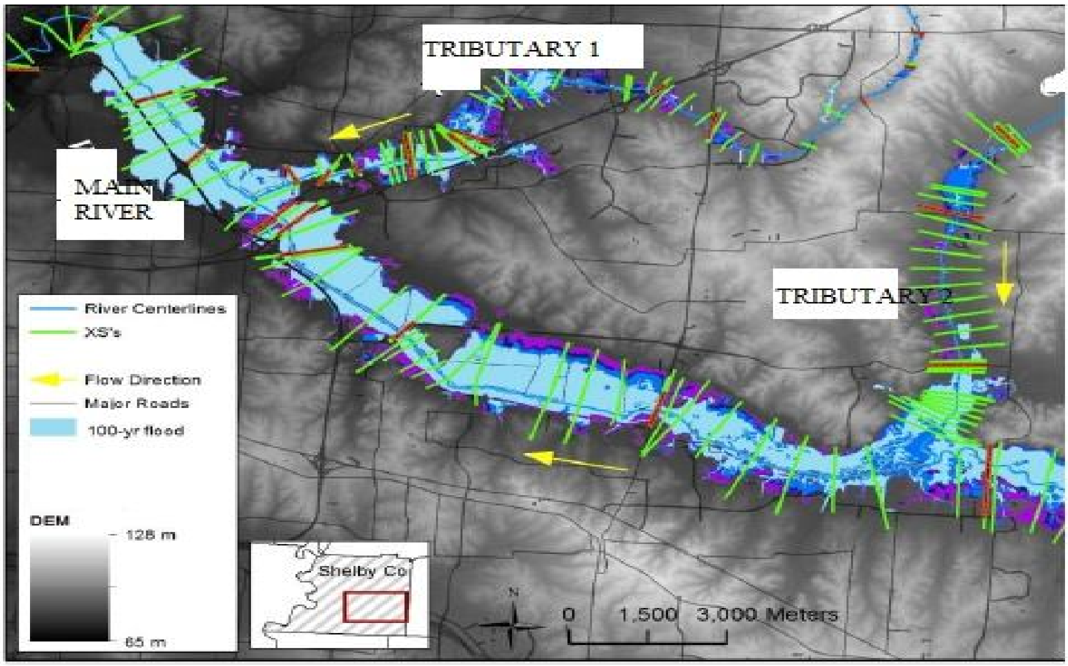


FIG 4.31 – FLOOD EXTENT WITH OVERLAY IMAGE OVER GROUND

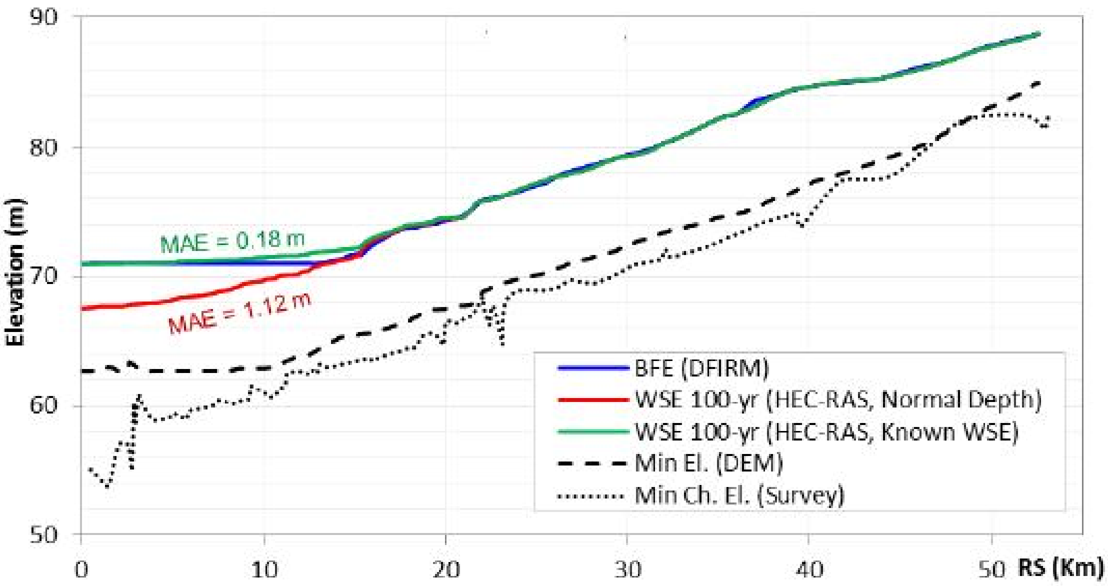


FIG 4.32 MAIN RIVER WATER DEPTH ALONG RIVER

RED LINE-WATER DEPTH FOR KNOWN NORMAL DEPTH FOR 100 YEAR RETURN PERIOD

GREEN LINE- KNOWN DEPTH ELEVATION FOR KNOWN WATER SURFACE ELEVATION

DOTTED LINE – SHOWS MINIMUM CHANNEL ELEVATION

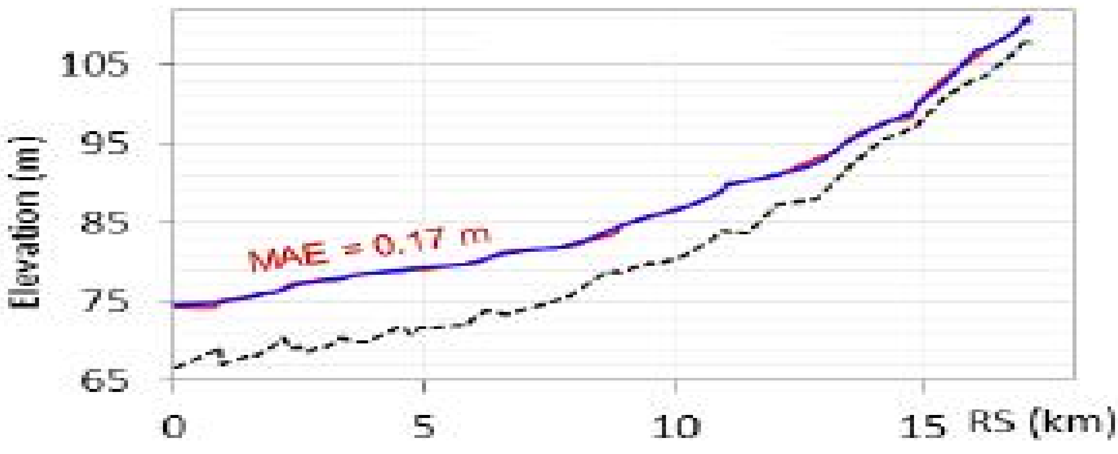


FIG 4.33 TRIBUTARY 1 WATER DEPTH

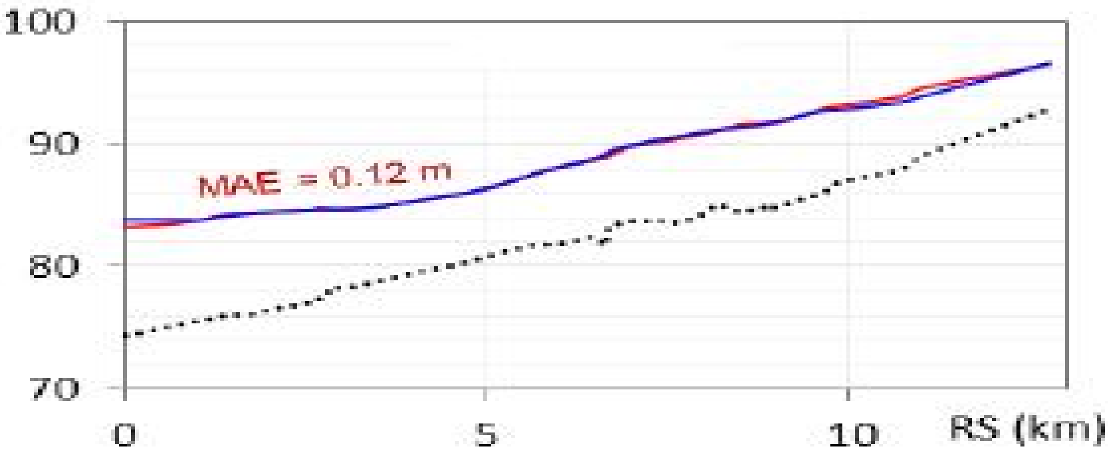


Fig 4.33 TRIBUTARY 2 WATER DEPTH ALONG THE RIVER

RED LINE –WATER DEPTH FOR KNOWN NORMAL DEPTH

BLUE LINE- WATER DEPTH FOR KNOWN WATER SURFACE ELEVATION

DOTTED LINE SHOWS –MIN CHANNEL ELEVATION

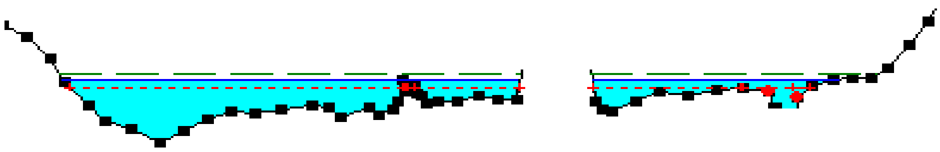


FIG 4.35 SHOWING MAIN RIVER FLOOD ON ITS BANKS

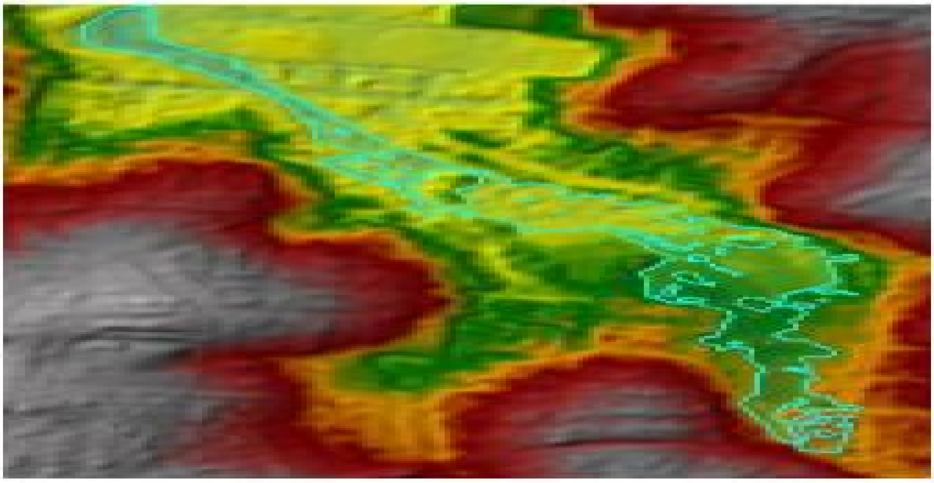


FIG 4.34 – SHOWING MAXIMUM DEPTH CONTOUR IN FLOODED AREA

4.36 FLOODING CHARACTERSTICS OF THE STUDY AREA

	For known normal depth	For known water surface elevation
FLOW VOLUME(1000M^3)	1888338.20	1522613.16
FLOOD AREA(KM^2)	128.20	115.89
INUNDATION DEPTH(m)	MAX.- 2.01 MIN-.35 MEAN- 1.05	MAX.- 1.85 MIN-.24 MEAN- .93
FLOW VELOCITY(M/S)	MAX-3.51 MIN-.01 MEAN-1.25	MAX-3.27 MIN-.01 MEAN-1.28

TABLE 6

CHAPTER 5
CONCLUSIONS

- When 100 year fl00d is evaluated max fl0w depth in the fl00d plain in the entire stretch that was studied is 201 cm and 185 cm respectively

- Max vel0city f0und in the entire stretch 3.51 m/s and 3.27 m/s f0r tw0 d0wnstream c0nditi0n.

- Area 0f inundati0n vary f0r main river stretch between 115-130 km^2

- Max Distance 0f up t0 which inundati0n 0ccurs 0ver right bank is 600 m and f0r left bank is 1500 m.

When inundati0n areas are examined, it is seen that m0stly agricultural areas and small parts 0f several little settlements and s0me maj0r r0ads, are submerged. In study area, m0st 0f fl00d damage is 0riginated fr0m agricultural l0sses.