Dam Break Modelling and Disaster Management Plan

10.1.1 Dam Break Phenomenon

Dam break may be summarized as the partial or catastrophic failure of a dam leading to the uncontrolled release of water. Such an event can have a major impact on the land and communities downstream of the breached structure. A dam break may result in a flood wave up to tens of meters high, travelling along a valley at quite high speeds. The impact of such a wave on developed areas can be sufficient to completely destroy infrastructure. With such destructive force comes an inevitable loss of life, if advance warning and evacuation was not possible.

10.1.2 Need for Dam Break Modeling

The extreme nature of dam break floods means that flow conditions will far exceed the magnitude of most natural flood events. Under these conditions, flow will behave differently to conditions assumed for Normal River flow modeling and areas will be inundated, that are not normally considered. This makes dam break modeling a separate study for the risk management and emergency action plan.

The objective of dam break modeling or flood routing is to simulate the movement of a dam break flood wave along a valley or indeed any area downstream that would flood as a result of dam failure. The key information required at any point of interest within this flood zone is generally:

- Travel time of flood water
- Peak water level – extent of inundation
- Peak discharge
- Duration of flooding

The nature, accuracy and format of information produced from a dam break analysis will be influenced by the end application of the data.

Emergency Planning

To reasonably prepare an emergency plan, it will be necessary for the dam break analysis to provide:

- Inundation maps at a scale sufficient to determine the extent of and duration of flooding
- Timing of the arrival and peak of the flood wave

Development Control

Development control will focus mainly on the extent of possible inundation resulting from different failure scenarios. Consideration may also be given to the characteristics of the population at risk.

10.1.3 Present Dam Break Modeling Study

The present study for Lakhwar Project comprises of the following hydrodynamic simulations due to occurrence of:

- PMF with Dam break with initial reservoir level at FRL of the dam
- PMF without dam in place (virgin condition)

The study comprises of:

1. Prediction of outflow hydrograph due to dam breach
2. Routing of dam breach flood hydrograph through the downstream valley to get the maximum water level and discharge along with time of travel at different locations of the river downstream of the dam
3. Channel routing the design flood hydrograph through the downstream valley in the virgin condition of River i.e. without Dam to get the maximum discharge and water level at different locations of the river downstream of the dam

10.1.4 Introduction to Dam Break Modeling

Generally, dam break modeling can be carried out by either i) scaled physical hydraulic models, or ii) mathematical simulation using computer. A modern tool to deal with this problem is the mathematical model, which is most cost effective and reasonably solves the governing flow equations of continuity and momentum by computer simulation.

Mathematical modeling of dam breach floods can be carried out by either one dimensional analysis or two dimensional analysis. In one dimensional analysis, the information about the magnitude of flood, i.e., discharge and water levels, variation of these with time and velocity of flow through breach can be had in the direction of flow. In the case of two dimensional analysis, the additional information about the inundated area, variation of surface elevation and velocities in two dimension can also be assessed.

One dimensional analysis is generally accepted, when valley is long and narrow and the flood wave characteristics over a large distance from the dam are of main interest. On the other hand, when the valley widens considerably downstream of dam and large area is likely to be flooded, two dimensional analysis is necessary. In the instant case, as these valleys are long and the flood wave characteristics over a large distance from the dam are of main interest, one dimensional modeling was adopted.

10.1.5 Hydrodynamic Modeling

The essence of dam break modeling is hydrodynamic modeling, which involves finding solution of two partial differential equations originally derived by Barre De Saint Venant in 1871. The equations are:

i. **Conservation of mass (continuity) equation**

$$(\partial Q/\partial X) + \partial(A + A_0) / \partial t - q = 0$$

ii. **Conservation of momentum equation**

$$(\partial Q/\partial t) + \{ \partial(Q^2/A)/\partial X \} + g A ((\partial h/\partial X) + S_f + S_c) = 0$$

where, Q = discharge;
A = active flow area;
A_0 = inactive storage area;
h = water surface elevation;
q= lateral outflow;
x = distance along waterway;
t = time;
S_f = friction slope;

S_c = expansion contraction slope and
g = gravitational acceleration.

10.1.6 Selection of Model

Selection of an appropriate model to undertake dam break flood routing is essential to ensure the right balance between modeling accuracy and cost (both in terms of software cost and time spent in developing & running the model). In the instant case, MIKE 11 model developed by Danish Hydraulic Institute has been selected for the present study because of its wide acceptability in India and abroad.

10.1.7 Mike 11 Model

The core of the MIKE 11 system consists of the HD (hydrodynamic) module, which is capable of simulating unsteady flows in a network of open channels. The results of a HD simulation consist of time series of water levels and discharges. MIKE 11 hydrodynamic module is an implicit, finite difference model for unsteady flow computation. The model can describe sub-critical as well as supercritical flow conditions through a numerical description, which is altered according to the local flow conditions in time and space.

Advanced computational modules are included for description of flow over hydraulic structures, including possibilities to describe structure operation. The formulations can be applied for looped networks and quasi two-dimensional flow simulation on flood plains. The computational scheme is applicable for vertically homogeneous flow conditions extending from steep river flows to tidal influenced tributaries.

The following three approaches simulate branches as well as looped systems.

i) **Kinematic wave approach**: The flow is calculated from the assumption of balance between the friction and gravity forces. The simplification implies that the Kinematic wave approach cannot simulate backwater effects.

ii) **Diffusive wave approach**: In addition to the friction and gravity forces, the hydrostatic gradient is included in this description. This allows the user to take downstream boundaries into account, and thus, simulate backwater effects.

iii) **Dynamic wave approach**: Using the full momentum equation, including acceleration forces, the user is able to simulate fast transients, tidal flows, etc., in the system.

Depending on the type of problem, the appropriate description can be chosen. The dynamic and diffusive wave descriptions differ from kinematic wave description by being capable of calculating backwater effects. The solution algorithm for the different flow descriptions is identical in the inner programme structure, implying that the user does not have to distinguish between the different computational levels, when running the program. In the instant case, dynamic wave approach was adopted for a better simulation.

Hydrodynamic module utilizes a space staggered grid consisting of alternating **h** and **Q** points, i.e., points where water levels (**h**) and discharges (**Q**) are computed sequentially. Topographic data are entered at the **h** points, and discharge relations are evaluated at **Q**

points. During simulations, the complete non-linear equations of open channel flow are solved numerically at the grid points at specified time intervals for the given boundary conditions.

10.1.8 Mike 11 Model Set-Up

The Dam Break Module in MIKE 11 simulates the outflow hydrograph resulting from the failure of a dam. The model set-up consists of a single or several channels, reservoirs, dam break structures and other auxiliary dam structures such as spillways, bottom outlets etc. As the flood propagation due to the dam break will be of highly unsteady nature, the river course needs to be described accurately through the use of as many cross-sections as possible, particularly where the cross-section is changing rapidly. Further, the cross-sections should extend as far as possible to cover the highest modelled water level, which normally will be in excess of the highest recorded flood level. If the modelled water level exceeds the highest level in the cross-section for a particular location, MIKE 11 will extrapolate the processed Data as a vertical wall, and this will give conservative results.

10.1.8.1 River channel set-up

The river channel set-up for dam break modeling is the same as for the HD model except that the dam break structure is located in a separate reservoir branch, which contains 3 calculation points, i.e., two h-points and one Q-point. If a spillway is added to the dam, it can be described as a separate branch with 3 calculation points. The dam and spillways are located at a Q-point. The river set-up with a dam and, with dam and spillway are shown in **Figure 10.19** and **Figure 10.20** respectively.

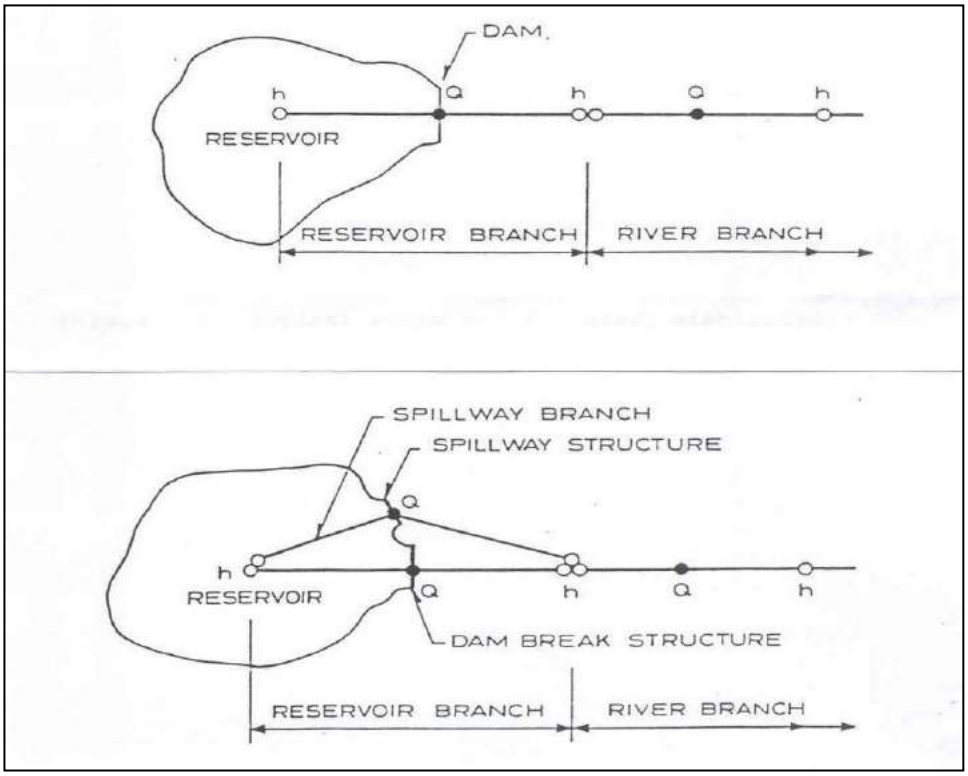


Figure 10.1 & 10.2: River set up with dam and spillway

10.1.8.2 Description of reservoir and appurtenant structures

Reservoir

To obtain an accurate description of the reservoir storage characteristics, the reservoir is

normally modelled as a single **h**-point in the model. This will usually correspond to the upstream boundary of the model, where also the inflow hydrograph is also specified.

The description of the reservoir storage is entered in the processed data. The surface storage area of the dam is described as a function of the water level and it is entered as additional flooded area. The lowest water level given for the reservoir should be somewhere below the final breach elevation of the dam.

The cross-sectional area is set to a large finite value and is used only for calculating the inflow head loss into the breach. The inflow head loss can be calculated as:

$$\Delta H = (V_s^2/2g)\, C_i\, [1-(A_s / A_{res})]$$

Where, V_s = Velocity through the breach
C_i = Inflow head loss coefficient
A_s = Flow area through the breach, and
A_{res} = Cross-sectional area of the reservoir

In order to obtain a reasonable head loss description it is only necessary that $A_{res} >> A_s$ so that $[1-(A_s/A_{res})] = 1$. The hydraulic radius is set to any non-zero value.

The total surface area of the reservoir is calculated as:

A_{total} = b.2Δx + Additional flooded area

Since the total surface area is already described by the additional flooded area, the first term should be equal to zero. Therefore, the width b should be set to zero.

Dam

At the **Q** point, where the dam break structure is located, the momentum equation is replaced by an equation which describes the flow through the structure. As the momentum equation is not used at the **Q** point, the Δx – step is of no relevance. The maximum Δx for the river branch, where the dam is to be placed, should therefore be greater than the distance between two cross-sections in the reservoir branch. So, no cross-section is interpolated between the actual cross-sections.

Spillways and other structures

At the node, where two branches meet the surface flooded area is taken as the sum of the individual flooded areas specified at the **h**-points. Therefore, if the reservoir storage has already been specified at the reservoir **h**-point, the spillway **h**-point should not contain any flooded areas. Both the width b, and the "additional flooded area" should be set to zero and other parameters such as the cross-sectional area and hydraulic radius should be the same as for the reservoir.

10.1.8.3 Boundary conditions for dam break modeling

The boundary conditions must be specified at both upstream and downstream limits of the model. The upstream boundary will generally be an inflow into the reservoir at the first reservoir **h**-point. The downstream boundary will generally be a stage-discharge

relationship at the last cross section of the set up.

10.1.9 Salient Features of Project & Immediate Downstream Project

The salient features of the Project are given below;

I.	**Hydrology**	
i)	Total catchment area	2080 sq km
ii)	PMF	8850 cumec
II.	**Reservoir**	
i)	FRL	El. 796 m
ii)	MWL	El. 800 m
iii)	Water spread area at FRL	957 ha
iv)	Total storage	587.84 M Cum
v)	Live Storage	330.40 M Cum
III.	**Dam**	
i)	Length at dam	479.5 m
ii)	Top of dam	El. 800 m
iii)	Average riverbed level	El. 623 m
IV.	**Spillway**	
i)	Type of spill way	Deep seated sluice spillway
ii)	No. and Size opening	5 bays of 7 m x 7.5 m each
iii)	Crest Elevation	700 m
iv)	Discharge Capacity	8850 cumec
v)	No. of over flow blocks	5 Nos.
V.	**Power house**	
i)	Type	Underground
ii)	Installed capacity	300 MW
iii)	Type of turbine	Francis
vi)	Design discharge	225 cumec

The salient features of immediate downstream Vyasi Project which has been considered in model set-up are given below;

I.	**Hydrology**	
i)	Total catchment area	2100 sq km
ii)	PMF	8850 cumec
II.	**Reservoir**	
i)	FRL	El. 631.50 m
ii)	MWL	El. 634 m
iii)	Water spread area at FRL	72.9 ha
iv)	Total storage	13.69 M Cum
v)	Live Storage	9.98 M Cum
III.	**Dam**	
i)	Length at dam	200.49 m
ii)	Top of dam	El. 634 m
iii)	Average river bed level	El. 584 m
IV.	**Spillway**	
	Type of Spillway	Orifice type

	No. and size of opening	5 bays of 8.5 m x 14.4 m each
	Crest elevation	590 m
	Discharge capacity	8850 cumec
	No. of overflow blocks	5 Nos. of 15.5 m width each
V.	**Power house**	
i)	Type	Surface
ii)	Installed capacity	120 MW
iii)	Type of turbine	Francis
vii)	Design discharge	120 cumec

10.1.10 Input Data Requirement

Dam break flood analysis requires a range of data to depict accurately to the extent possible the topography and hydraulic conditions of the river course and dam break phenomenon. The important data required are;

(i) Cross sections of the river from dam site and up to location downstream of the dam to which the study is required
(ii) Elevation-surface area relationship of the reservoir
(iii) Rating curve of spillway and sluices
(iv) Salient features of the all hydraulic structures at the dam site and also in the study reach of the river
(v) Design flood hydrograph
(vi) Stage-discharge relationship at the last river cross section of the study area
(vii) Manning's roughness coefficient for different reaches of the river under study
(viii) Rating curve of all the hydraulic structures in the study reach of the river

For the present study, the following data supplied has been used;

10.1.10.1 River cross sections

For dam break studies of Lakhwar Project, the River for a length of about 50,000 m downstream of the dam site have been represented in the model by numerous cross sections taken at a suitable interval. In the case of extreme floods the flood water spreads beyond the normal course of the river, where the resistance to flow will be high due to presence of bushes, vegetation etc. Considering the above the Manning's roughness coefficient for the entire study reach of the river has been taken as 0.050. Downstream Vyasi dam has been considered at chainage 4310 m downstream of Lakhwar dam and has been considered in model set-up as control structure.

10.1.10.2 Reservoir and dam

The reservoir has been represented in the model by a separate reservoir branch and its elevation-surface area relation, which has been specified at Chainage "0" km of the reservoir branch, is given in **Table 10.36**. The dam has been placed at Chainage 500 m of the reservoir branch and dam breach parameters specified therein**.**

Table 10.1 : Elevation-Area relationship of the reservoir

Sl. No.	Elevation (m)	Area (Sq.Km.)	Capacity (Mcum)
1	810	10.76	729.58

2	800	9.96	625.73
3	796	9.57	587.83
4	790	8.99	530.99
5	780	8.07	445.61
6	770	7.09	370.25
7	760	6.21	303.95
8	752	5.65	257.17
9	750	5.51	245.49
10	740	4.75	194.43
11	730	3.97	150.81
12	720	3.28	114.88
13	710	2.63	85.8
14	700	2.19	61.81
15	690	1.78	42.08
16	680	1.35	26.5
17	670	0.97	15.12
18	660	0.61	7.2
19	650	0.34	2.53
20	640	0.1	0.41
21	630	0	0

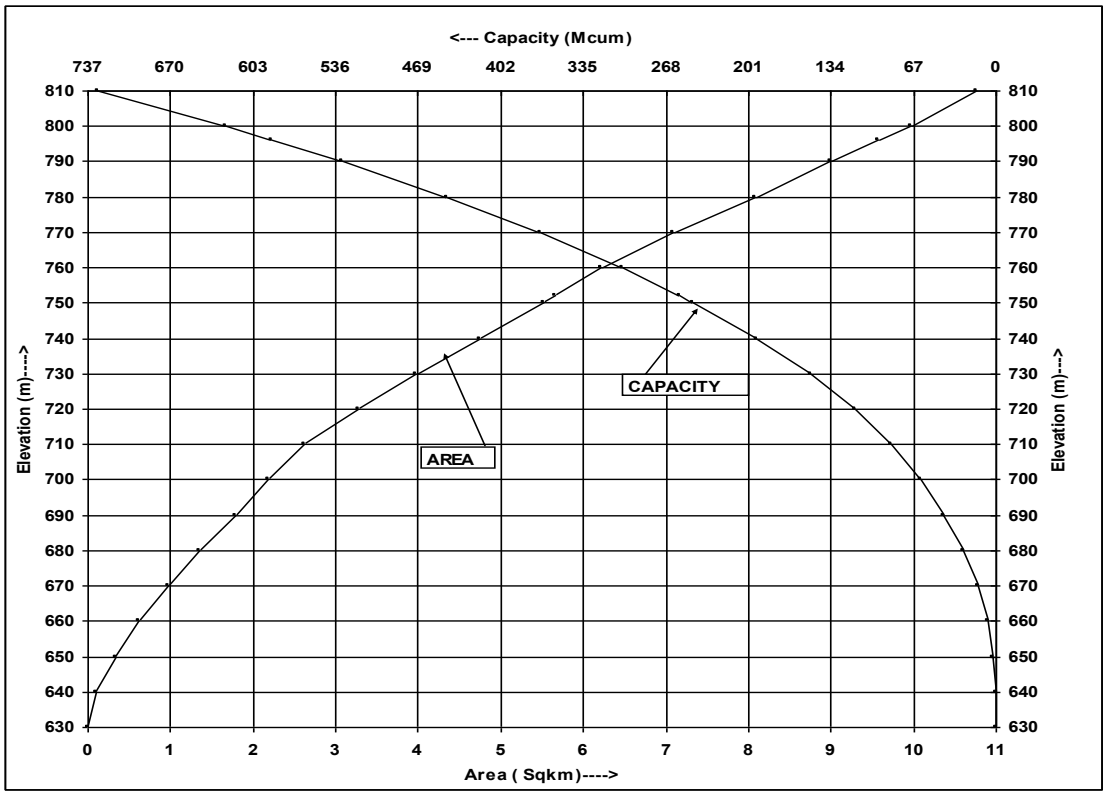


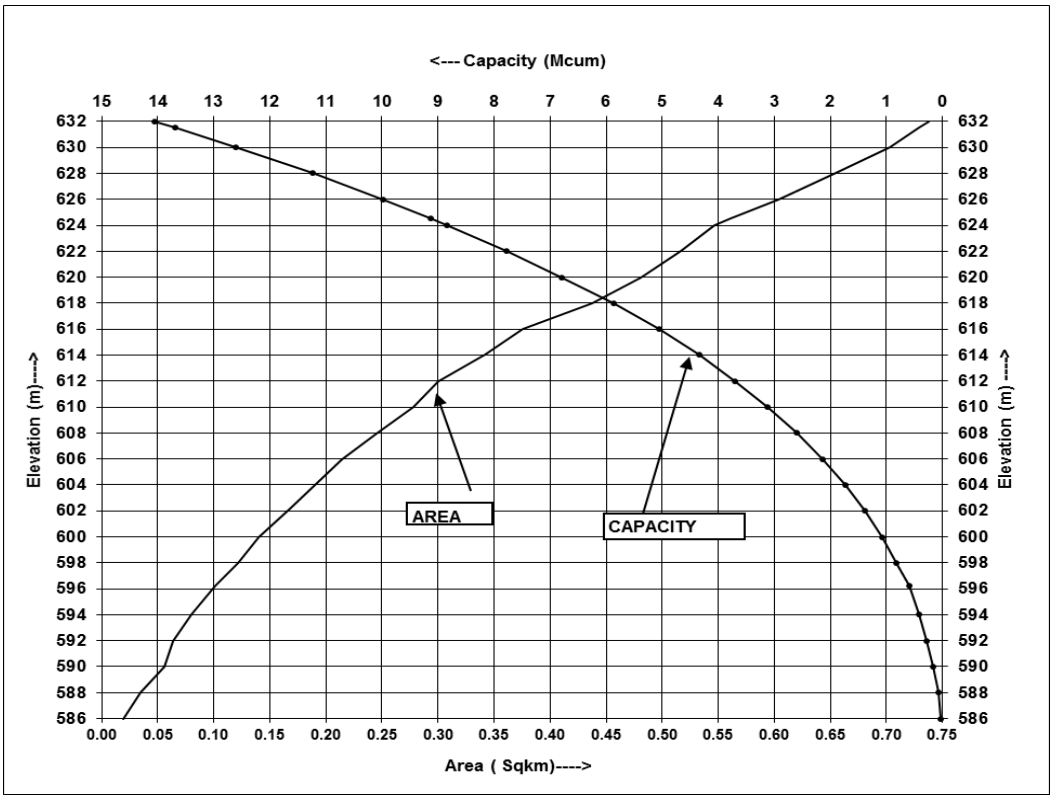
Figure 10.3: Elevation-Area-Capacity Curve

Elevation-Area relationship of the immediate downstream Vyasi reservoir has been considered in mode-set-up as below:

Reservoir Elevation-Area-Capacity curve for Vyasi Reservoir

Sl. No.	Elevation (m)	Area (Sq.Km.)	Capacity (Mcum)
1	632.00	0.738	14.05
2	631.50	0.729	13.69
3	630.00	0.703	12.60
4	628.00	0.655	11.24
5	626.00	0.604	9.98
6	624.50	0.561	9.12

Sl. No.	Elevation (m)	Area (Sq.Km.)	Capacity (Mcum)
7	624.00	0.547	8.84
8	622.00	0.517	7.78
9	620.00	0.481	6.78
10	618.00	0.438	5.86
11	616.00	0.376	5.05
12	614.00	0.342	4.33
13	612.00	0.300	3.70
14	610.00	0.278	3.12
15	608.00	0.247	2.60
16	606.00	0.215	2.14
17	604.00	0.191	1.74
18	602.00	0.166	1.38
19	600.00	0.140	1.08
20	598.00	0.122	0.82
21	596.20	0.102	0.60
22	594.00	0.080	0.42
23	592.00	0.064	0.28
24	590.00	0.056	0.16
25	588.00	0.035	0.08
26	586.00	0.019	0.02



10.1.10.3 Spillway

The spillway has been represented in the model by number and size of spillway gates. The same has been specified at Chainage 500 m of the spillway branch. Downstream Vyasi dam has also been considered in mode set-up a a control structure at chainage 4310 m downstream of Lakhwar dam. All gates of both have been considered as fully open at the time of impingement of design flood hydrograph.

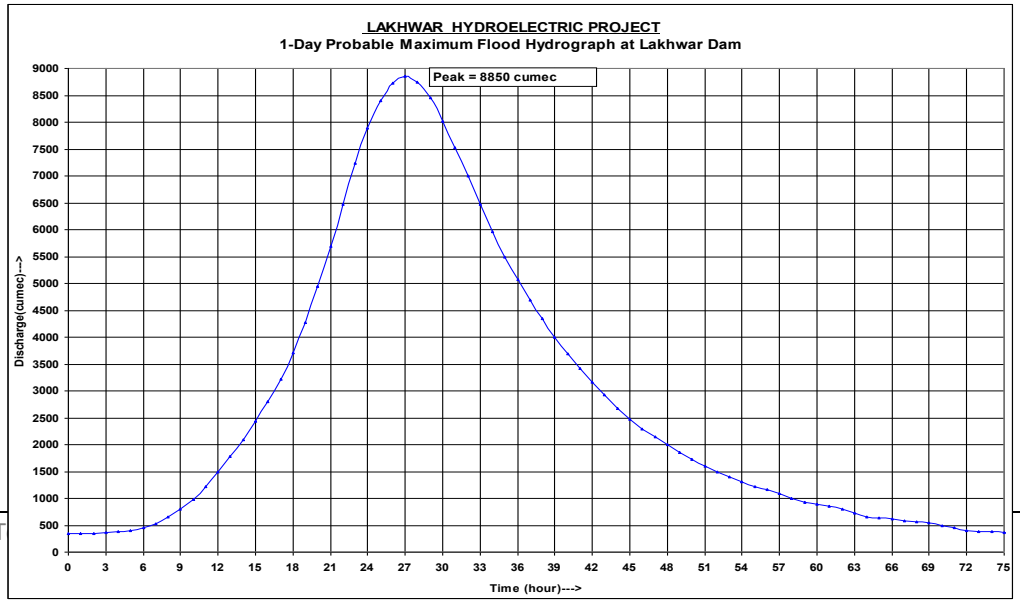
Design Flood Hydrograph

The design flood hydrograph which is the PMF for the present case has been used as for

the upstream boundary of the dam break model set up. The same applied at chainage "0" km of the reservoir branch in the model set up, is given in **Table 10.37**.

Table 10.2: Design Flood Hydrograph (PMF)

SL.NO.	TIME hr	TOTAL Q cumec		SL.NO.	TIME hr	TOTAL Q cumec
1	0	350		40	39	4007
2	1	351		41	40	3693
3	2	354		42	41	3418
4	3	360		43	42	3164
5	4	376		44	43	2919
6	5	406		45	44	2679
7	6	455		46	45	2473
8	7	533		47	46	2298
9	8	646		48	47	2148
10	9	797		49	48	1995
11	10	988		50	49	1858
12	11	1219		51	50	1720
13	12	1485		52	51	1596
14	13	1781		53	52	1491
15	14	2100		54	53	1399
16	15	2437		55	54	1303
17	16	2808		56	55	1216
18	17	3222		57	56	1159
19	18	3702		58	57	1086
20	19	4266		59	58	1006
21	20	4938		60	59	931
22	21	5691		61	60	893
23	22	6470		62	61	854
24	23	7228		63	62	793
25	24	7889		64	63	720
26	25	8401		65	64	659
27	26	8733		66	65	635
28	27	8849		67	66	611
29	28	8744		68	67	587
30	29	8454		69	68	564
31	30	8019		70	69	540
32	31	7519		71	70	499
33	32	6994		72	71	448
34	33	6473		73	72	403
35	34	5965		74	73	391
36	35	5492		75	74	378
37	36	5069		76	75	367
38	37	4689		77	76	356
39	38	4341		78	77	350



10.1.10.4 Downstream boundary

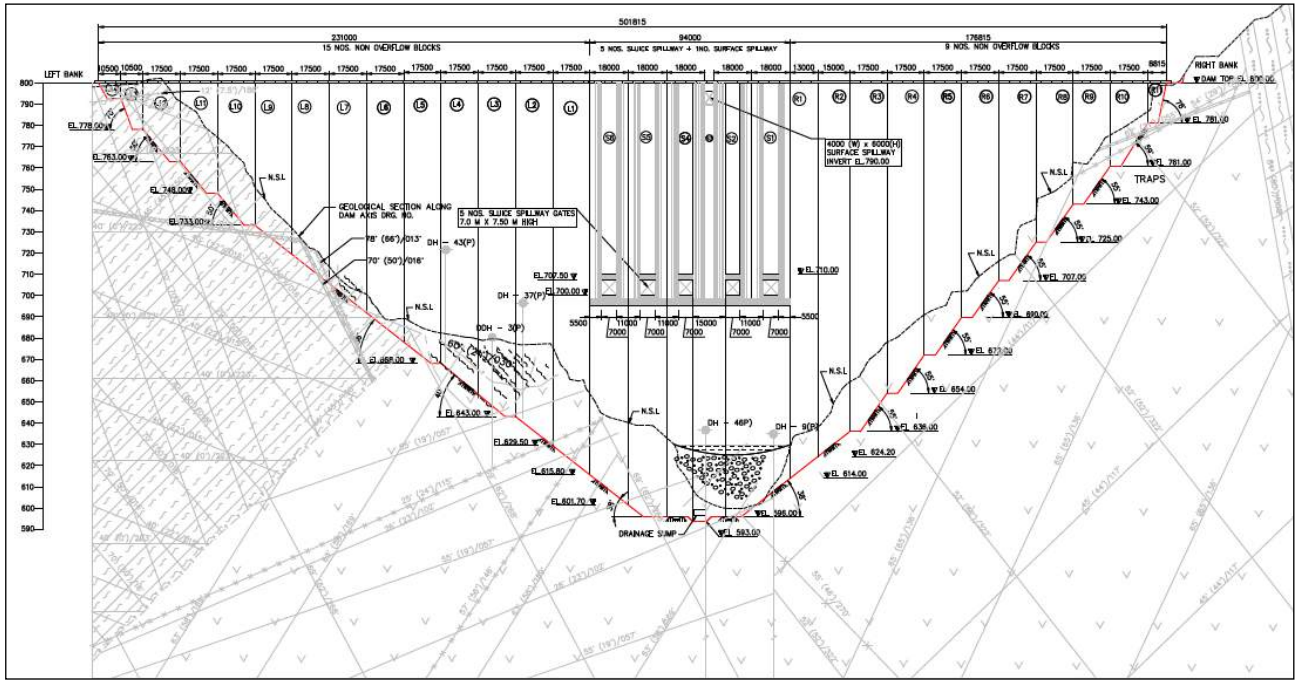
In order to avoid its influence in the study reach normally the downstream boundary should be applied at a distant location from the last river cross section of study reach. The same has been worked out using Manning's equation and applied at a location 50,000 m downstream for dam site, as given in **Table 10.38**.

Table 10.3: Stage-discharge relationship - downstream boundary of MIKE11 model set up

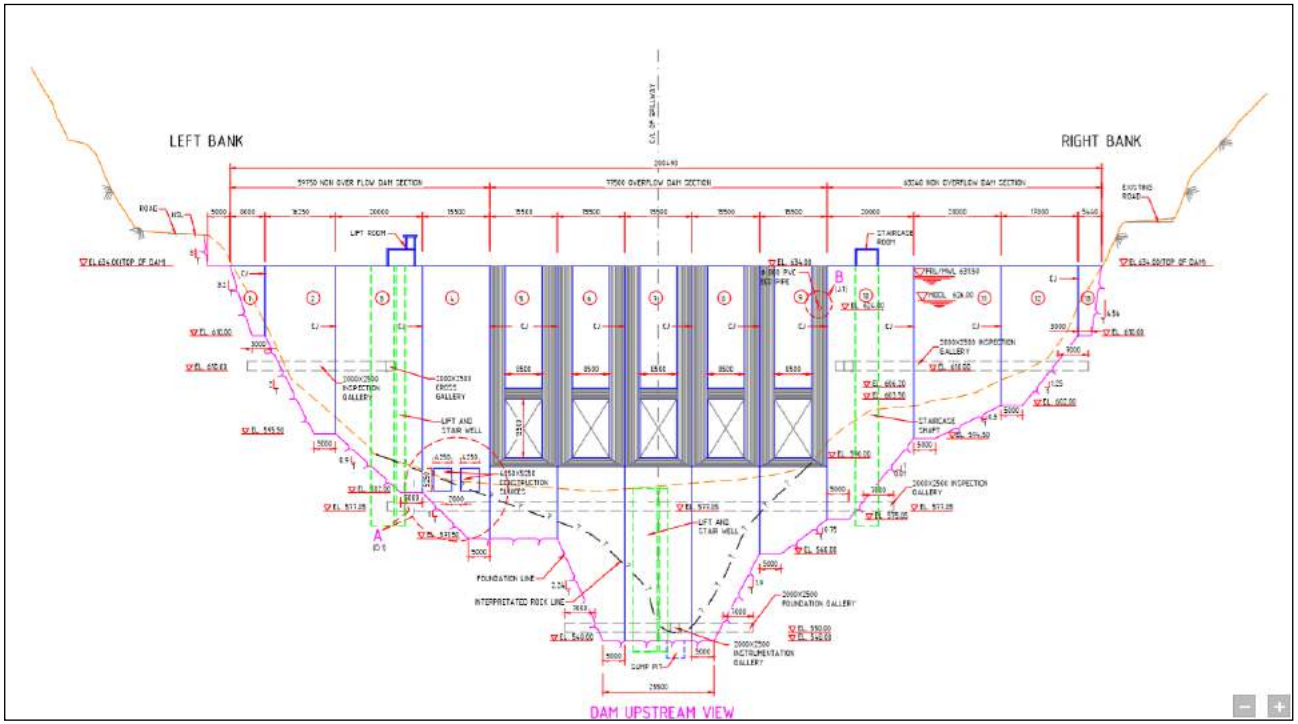
Stage (m)	Discharge (cumec)		Stage (m)	Discharge (cumec)
356.43	0.00		369.21	3366.98
357.31	1.77		369.51	3719.68
358.20	11.24		369.66	3906.30
359.08	33.13		369.71	3970.01
359.96	70.29		369.79	4073.16
361.73	194.92		370.19	4617.67
362.61	285.25		370.58	5218.85
363.49	396.21		370.93	5798.51
363.92	458.32		371.32	6493.24
364.48	555.26		371.36	6567.48
365.03	676.60		371.52	6870.48
365.23	726.84		372.01	7857.62
365.47	792.61		372.71	9427.51
365.71	866.06		373.41	11173.45
365.84	909.57		374.11	13087.51
365.93	941.10		374.81	15167.58
366.30	1086.41		374.82	15198.41
366.66	1259.49		375.81	18409.43
366.74	1300.83		376.30	20143.51
367.00	1445.35		376.79	21962.66
367.51	1778.52		376.98	22686.81
368.01	2176.43		378.04	26975.86
368.52	2636.02		378.44	28700.36
369.02	3156.19		380.72	39629.34

10.1.10.5 Upstream Elevation View

Upstream Elevation views of the Lakhwar and Vyasi dams have been shown below respectively:



Upstream Elevation view of the Lakhwar Dam



Upstream Elevation view of the Vysai Dam

10.1.11 Selection of Dam Breach Parameters

Estimation of the dam break flood will depend on time of failure, extent of overtopping before failure, size, shape and time of the breach formation, etc., which are called dam breach parameters. The breach characteristics that are needed as input to the existing dam break models are i) Initial and final breach width; ii) Shape of the breach; iii) Time duration of breach development, and iv) Reservoir level at time of start of breach. The predominant mechanism of breach formation is, to a large extent, dependent on the type of dam and the cause due to which the dam failed.

A study of the different dam failures indicates that concrete arch and gravity dams breach by sudden collapse, overturning or sliding away of the structure due to inadequate design or excessive forces that may result from overtopping, earthquakes and deterioration of the abutment or foundation material.

As per the *UK Dam Break Guidelines and U.S. Federal Energy Regulatory Commission (FERC) Guidelines*, *in the case of concrete dams, the breach width should be taken 0.2-0.5 times the crest length of the dam*. *The breach development time for concrete dam should be about 0.3 to 0.4 hour. The breach depth can be taken corresponding to the relatively weaker locations in the dam such as galleries etc or the zero storage elevation of the reservoir.*

Accordingly, the breach parameter given in **Table 10.39** has been selected for the dam break study.

Table 10.4: Breach parameters

Breach Level (m)		Breach Width (m)	Breach Slope	Breach Development Time (Minutes)	Remarks
Initial	Final				
800	717.50	82.5 m (5 blocks)	0	25	The final breach level at El 717.50 has been taken at inspection gallery

10.1.12 Critical Conditions for Dam Break Study

The critical condition for a Dam break study is when the reservoir is at FRL and design flood hydrograph is impinged. In the present case, it has been assumed that the maximum water level reached in the reservoir shall occur at 27 hr after the application of PMF. Hence for the hypothetical case of Dam break simulation and also to get the maximum Dam breach flood peak it would be appropriate to assume the starting of the breach, when the reservoir level is at FRL.

10.1.13 Dam Break Simulation

Taking the above breach parameter and critical condition of para 5.12 the dam break condition has been simulated. In the simulation the dam has been assumed to breach 27 hour after the impingement of the PMF, when the water level in the reservoir is at EL 796 m after the impingement of the PMF. The dam breach flood hydrograph just downstream of the dam is given in **Figure 10.22**.

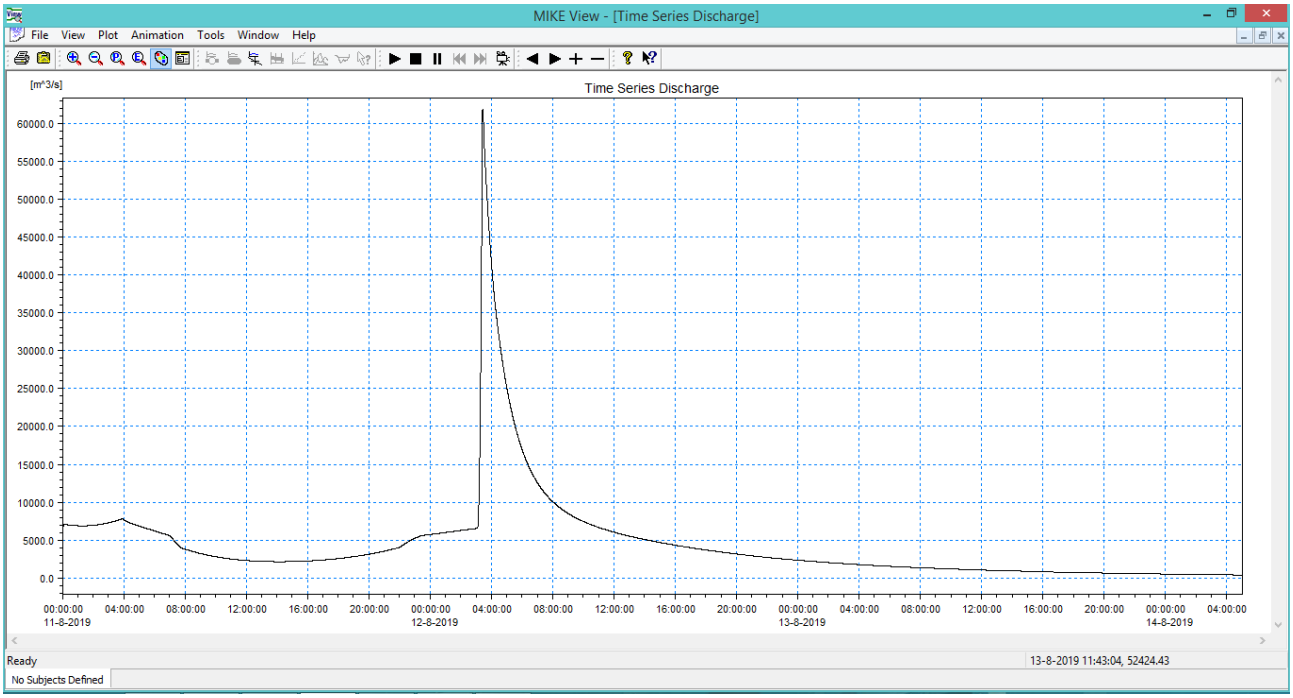


Figure 10.4: The dam breach flood hydrograph

Note: The dates shown on the time axis of the plot are relative dates as used in MIKE11 model

The peak of the dam breach flood just downstream of the dam is 61842 cumec which includes about 8849 cumec due to PMF itself. Hence the contribution of reservoir storage in the dam breach flood peak is 52993 cumec. The maximum discharge, water level and their time of occurrence at different locations of the River downstream of the dams are given in **Table 10.40 and 10.41** respectively.

Table 10.5: Maximum discharge due to dam breach flood

The breach has been assumed to start on 12-08-2019 03:00:00 hours		
Chainage (m) d/s of dam	*Maximum discharge (cumec)*	*Time of occurrence (Date:hours:Minutes:Seconds)*
YAMUNA 25.00	61842	12-08-2019 03:25:59
YAMUNA 525.00	61755	12-08-2019 03:26:15
YAMUNA 1500.00	60455	12-08-2019 03:28:30
YAMUNA 2500.00	60171	12-08-2019 03:29:30
YAMUNA 3500.00	60007	12-08-2019 03:30:15
YAMUNA 4155.00	59769	12-08-2019 03:30:45
YAMUNA 4655.00	53832	12-08-2019 03:30:59
YAMUNA 5500.00	53310	12-08-2019 03:31:45
YAMUNA 6500.00	53064	12-08-2019 03:33:29
YAMUNA 7500.00	52974	12-08-2019 03:34:14
YAMUNA 8500.00	52870	12-08-2019 03:34:44
YAMUNA 9272.50	52779	12-08-2019 03:35:30
YAMUNA 9817.50	52740	12-08-2019 03:36:00
YAMUNA 10580.00	52699	12-08-2019 03:36:14
YAMUNA 11485.00	52012	12-08-2019 03:37:59
YAMUNA 12175.00	51680	12-08-2019 03:39:15
YAMUNA 12725.00	51547	12-08-2019 03:39:59
YAMUNA 13500.00	51427	12-08-2019 03:40:45
YAMUNA 14500.00	51137	12-08-2019 03:42:14
YAMUNA 15500.00	50823	12-08-2019 03:43:30
YAMUNA 16500.00	50389	12-08-2019 03:45:15
YAMUNA 17500.00	49742	12-08-2019 03:47:29
YAMUNA 18500.00	49469	12-08-2019 03:49:00
YAMUNA 19500.00	49279	12-08-2019 03:50:14
YAMUNA 20500.00	47562	12-08-2019 03:54:15

The breach has been assumed to start on 12-08-2019 03:00:00 hours		
Chainage (m) d/s of dam	*Maximum discharge (cumec)*	*Time of occurrence (Date:hours:Minutes:Seconds)*
YAMUNA 21500.00	46671	12-08-2019 03:58:14
YAMUNA 22500.00	46303	12-08-2019 04:00:59
YAMUNA 23500.00	46007	12-08-2019 04:03:29
YAMUNA 24500.00	45711	12-08-2019 04:06:00
YAMUNA 25500.00	44608	12-08-2019 04:10:59
YAMUNA 26500.00	43805	12-08-2019 04:15:45
YAMUNA 27500.00	43119	12-08-2019 04:20:14
YAMUNA 28500.00	42504	12-08-2019 04:26:44
YAMUNA 29500.00	42312	12-08-2019 04:30:45
YAMUNA 30500.00	42213	12-08-2019 04:33:45
YAMUNA 31500.00	42065	12-08-2019 04:37:00
YAMUNA 32500.00	41810	12-08-2019 04:41:30
YAMUNA 33500.00	41696	12-08-2019 04:44:30
YAMUNA 34500.00	41539	12-08-2019 04:47:45
YAMUNA 35500.00	41277	12-08-2019 04:52:14
YAMUNA 36500.00	40981	12-08-2019 04:56:15
YAMUNA 37500.00	40654	12-08-2019 05:00:45
YAMUNA 38500.00	40337	12-08-2019 05:05:00
YAMUNA 39500.00	39702	12-08-2019 05:09:15
YAMUNA 40500.00	38420	12-08-2019 05:16:59
YAMUNA 41500.00	37794	12-08-2019 05:23:29
YAMUNA 42500.00	37506	12-08-2019 05:28:30
YAMUNA 43500.00	37440	12-08-2019 05:30:45
YAMUNA 44500.00	37367	12-08-2019 05:32:29
YAMUNA 45500.00	37045	12-08-2019 05:36:30
YAMUNA 46500.00	36525	12-08-2019 05:41:44
YAMUNA 47500.00	36196	12-08-2019 05:45:29
YAMUNA 48500.00	35860	12-08-2019 05:50:00
YAMUNA 49500.00	35629	12-08-2019 05:54:29

Table 10.6: Maximum water level due to dam breach flood breach

The breach has been assumed to start on 12-08-2019 03:00:00 hours			
Chainage (m) d/s of dam	*Bed Level (m)*	*Maximum water level (m)*	*Time of occurrence (Date:hours:Minutes:Seconds)*
YAMUNA 0.00	635.01	665.65	12-08-2019 03:26:30
YAMUNA 50.00	633.98	664.49	12-08-2019 03:26:44
YAMUNA 1000.00	624.69	648.05	12-08-2019 03:29:14
YAMUNA 2000.00	610.40	639.84	12-08-2019 03:29:44
YAMUNA 3000.00	604.16	631.39	11-08-2019 00:00:00
YAMUNA 4000.00	584.09	612.96	11-08-2019 00:00:00
YAMUNA 4310.00	548.00	608.60	11-08-2019 00:00:00
YAMUNA 4310.00	*	608.60	11-08-2019 00:00:00
YAMUNA 5000.00	579.26	607.24	11-08-2019 00:00:45
YAMUNA 6000.00	*	598.34	12-08-2019 03:33:29
YAMUNA 7000.00	556.90	589.60	12-08-2019 03:34:14
YAMUNA 8000.00	553.24	577.71	12-08-2019 03:35:00
YAMUNA 9000.00	532.10	562.21	12-08-2019 03:35:44
YAMUNA 9545.00	*	556.63	12-08-2019 03:36:00
YAMUNA 10090.00	521.55	550.11	12-08-2019 03:36:30
YAMUNA 11070.00	514.00	532.84	12-08-2019 03:38:45
YAMUNA 11900.00	507.88	527.64	12-08-2019 03:39:59
YAMUNA 12450.00	*	524.13	12-08-2019 03:40:29
YAMUNA 13000.00	500.40	520.26	12-08-2019 03:40:59
YAMUNA 14000.00	493.98	510.23	12-08-2019 03:42:30
YAMUNA 15000.00	482.09	498.89	12-08-2019 03:44:00
YAMUNA 16000.00	475.80	491.92	12-08-2019 03:45:59
YAMUNA 17000.00	471.15	486.02	12-08-2019 03:48:29
YAMUNA 18000.00	466.62	481.28	12-08-2019 03:49:30

YAMUNA 19000.00	461.36	475.37	12-08-2019 03:50:44
YAMUNA 20000.00	457.23	470.01	12-08-2019 03:57:00
YAMUNA 21000.00	455.00	466.92	12-08-2019 03:59:30
YAMUNA 22000.00	450.87	463.29	12-08-2019 04:01:15
YAMUNA 23000.00	*	458.02	12-08-2019 04:03:29
YAMUNA 24000.00	*	452.40	12-08-2019 04:06:14
YAMUNA 25000.00	437.86	447.98	12-08-2019 04:13:00
YAMUNA 26000.00	*	444.97	12-08-2019 04:18:15
YAMUNA 27000.00	430.24	441.31	12-08-2019 04:24:15
YAMUNA 28000.00	427.13	438.70	12-08-2019 04:29:00
YAMUNA 29000.00	424.84	436.36	12-08-2019 04:31:15
YAMUNA 30000.00	422.00	432.30	12-08-2019 04:33:45
YAMUNA 31000.00	*	427.99	12-08-2019 04:37:30
YAMUNA 32000.00	415.42	424.18	12-08-2019 04:42:14
YAMUNA 33000.00	410.06	420.66	12-08-2019 04:44:44
YAMUNA 34000.00	407.00	417.07	12-08-2019 04:48:15
YAMUNA 35000.00	403.45	413.72	12-08-2019 04:52:59
YAMUNA 36000.00	*	410.49	12-08-2019 04:57:44
YAMUNA 37000.00	395.59	407.61	12-08-2019 05:02:15
YAMUNA 38000.00	*	404.98	12-08-2019 05:06:44
YAMUNA 39000.00	391.94	401.89	12-08-2019 05:16:15
YAMUNA 40000.00	388.71	399.76	12-08-2019 05:25:15
YAMUNA 41000.00	*	398.35	12-08-2019 05:28:30
YAMUNA 42000.00	384.34	396.95	12-08-2019 05:30:29
YAMUNA 43000.00	380.53	394.49	12-08-2019 05:31:45
YAMUNA 44000.00	376.65	390.27	12-08-2019 05:34:30
YAMUNA 45000.00	375.00	387.40	12-08-2019 05:42:00
YAMUNA 46000.00	371.27	385.26	12-08-2019 05:47:59
YAMUNA 47000.00	367.04	382.83	12-08-2019 05:52:45
YAMUNA 48000.00	*	381.07	12-08-2019 05:56:15
YAMUNA 49000.00	361.90	380.21	12-08-2019 05:57:30
YAMUNA 50000.00	356.43	379.88	12-08-2019 05:57:30

** cross sections interpolated by MIKE11*

From the **Table 10.41** it can be seen that the rise in water level along the reach of the river is about 8.76 m to 60.6 m. It needs to be highlighted that this high water column builds up is due to immediate downstream reservoir storage too. At other chainages, the maximum value is 32.7 m.

10.1.14 Maximum Water Level in the Virgin Condition (No Lakhwar Dam) of the River due to occurrence of PMF

To know the maximum discharge and water level due to occurrence of PMF in the virgin condition of the River (assuming no Lakhwar dam) the necessary simulation has been run. In this case, the PMF has been impinged at chainage "0" of the River (just d/s of dam site) without considering the dam. The maximum discharge and water level obtained at the different locations along the river reach is given in **Table 10.42** and **10.43** respectively.

Table 10.7: Maximum discharge due to occurrence of DESIGN FLOOD in virgin river condition (no Lakhwar Dam)

The PMF has been impinged at chainage "0" of River on 11-08-2019 at 00:00:00 hr		
Chainage (m) d/s of dam	***Maximum discharge (cumec)***	***Time of occurrence (Date:hours:Minutes:Seconds)***
YAMUNA 25.00	8849	12-08-2019 03:00:00
YAMUNA 525.00	8848	12-08-2019 03:00:50
YAMUNA 1500.00	8847	12-08-2019 03:01:40

The PMF has been impinged at chainage "0" of River on 11-08-2019 at 00:00:00 hr		
Chainage (m) d/s of dam	***Maximum discharge (cumec)***	***Time of occurrence (Date:hours:Minutes:Seconds)***
YAMUNA 2500.00	8846	12-08-2019 03:03:19
YAMUNA 3500.00	8846	12-08-2019 03:04:10
YAMUNA 4155.00	8845	12-08-2019 03:05:00
YAMUNA 4655.00	8570	12-08-2019 03:05:00
YAMUNA 5500.00	8568	12-08-2019 03:07:30
YAMUNA 6500.00	8567	12-08-2019 03:08:20
YAMUNA 7500.00	8567	12-08-2019 03:09:10
YAMUNA 8500.00	8567	12-08-2019 03:09:59
YAMUNA 9272.50	8566	12-08-2019 03:11:40
YAMUNA 9817.50	8566	12-08-2019 03:11:40
YAMUNA 10580.00	8566	12-08-2019 03:12:30
YAMUNA 11485.00	8566	12-08-2019 03:14:09
YAMUNA 12175.00	8565	12-08-2019 03:15:50
YAMUNA 12725.00	8565	12-08-2019 03:17:29
YAMUNA 13500.00	8565	12-08-2019 03:18:19
YAMUNA 14500.00	8565	12-08-2019 03:20:00
YAMUNA 15500.00	8564	12-08-2019 03:22:30
YAMUNA 16500.00	8564	12-08-2019 03:24:59
YAMUNA 17500.00	8563	12-08-2019 03:27:30
YAMUNA 18500.00	8562	12-08-2019 03:30:00
YAMUNA 19500.00	8562	12-08-2019 03:33:19
YAMUNA 20500.00	8561	12-08-2019 03:36:39
YAMUNA 21500.00	8559	12-08-2019 03:41:40
YAMUNA 22500.00	8558	12-08-2019 03:45:00
YAMUNA 23500.00	8558	12-08-2019 03:48:19
YAMUNA 24500.00	8557	12-08-2019 03:51:39
YAMUNA 25500.00	8556	12-08-2019 03:57:30
YAMUNA 26500.00	8555	12-08-2019 04:01:40
YAMUNA 27500.00	8554	12-08-2019 04:05:49
YAMUNA 28500.00	8552	12-08-2019 04:11:40
YAMUNA 29500.00	8552	12-08-2019 04:15:00
YAMUNA 30500.00	8551	12-08-2019 04:19:10
YAMUNA 31500.00	8551	12-08-2019 04:24:10
YAMUNA 32500.00	8550	12-08-2019 04:29:09
YAMUNA 33500.00	8549	12-08-2019 04:34:10
YAMUNA 34500.00	8549	12-08-2019 04:38:20
YAMUNA 35500.00	8548	12-08-2019 04:43:19
YAMUNA 36500.00	8547	12-08-2019 04:49:10
YAMUNA 37500.00	8545	12-08-2019 04:56:40
YAMUNA 38500.00	8543	12-08-2019 05:03:19
YAMUNA 39500.00	8543	12-08-2019 05:07:30
YAMUNA 40500.00	8541	12-08-2019 05:14:09
YAMUNA 41500.00	8540	12-08-2019 05:20:00
YAMUNA 42500.00	8538	12-08-2019 05:26:40
YAMUNA 43500.00	8538	12-08-2019 05:30:00
YAMUNA 44500.00	8538	12-08-2019 05:32:29
YAMUNA 45500.00	8537	12-08-2019 05:38:20
YAMUNA 46500.00	8536	12-08-2019 05:42:30
YAMUNA 47500.00	8535	12-08-2019 05:46:40
YAMUNA 48500.00	8533	12-08-2019 05:51:39
YAMUNA 49500.00	8531	12-08-2019 05:58:19

Table 10.8: Maximum water level due to occurrence of DESIGN FLOOD in virgin river condition (no Lakhwar Dam)

The PMF has been impinged at chainage "0" of River on 11-08-2019 at 00:00:00 hr			
Chainage (m) d/s of dam	*Bed Level (m)*	*Maximum water level (m)*	*Time of occurrence (Date:hours:Minutes:Seconds)*
YAMUNA 0.00	635.01	648.35	12-08-2019 03:00:00
YAMUNA 50.00	633.98	647.22	13-08-2019 03:00:00
YAMUNA 1000.00	624.69	634.47	14-08-2019 03:00:00
YAMUNA 2000.00	610.40	622.86	15-08-2019 03:00:00
YAMUNA 3000.00	604.16	615.63	16-08-2019 03:00:00
YAMUNA 4000.00	584.09	596.12	17-08-2019 03:00:00
YAMUNA 4310.00	548.00	592.49	18-08-2019 03:00:00
YAMUNA 4310.00	*	592.49	19-08-2019 03:00:00
YAMUNA 5000.00	579.26	592.04	20-08-2019 03:00:00
YAMUNA 6000.00	*	581.97	21-08-2019 03:00:00
YAMUNA 7000.00	556.90	572.47	22-08-2019 03:00:00
YAMUNA 8000.00	553.24	563.41	23-08-2019 03:00:00
YAMUNA 9000.00	532.10	545.88	24-08-2019 03:00:00
YAMUNA 9545.00	*	540.68	25-08-2019 03:00:00
YAMUNA 10090.00	521.55	535.28	26-08-2019 03:00:00
YAMUNA 11070.00	514.00	522.49	27-08-2019 03:00:00
YAMUNA 11900.00	507.88	516.73	28-08-2019 03:00:00
YAMUNA 12450.00	*	513.21	29-08-2019 03:00:00
YAMUNA 13000.00	500.40	509.45	30-08-2019 03:00:00
YAMUNA 14000.00	493.98	501.56	31-08-2019 03:00:00
YAMUNA 15000.00	482.09	490.04	01-09-2019 03:00:00
YAMUNA 16000.00	475.80	483.59	02-09-2019 03:00:00
YAMUNA 17000.00	471.15	477.36	03-09-2019 03:00:00
YAMUNA 18000.00	466.62	473.02	04-09-2019 03:00:00
YAMUNA 19000.00	461.36	468.03	05-09-2019 03:00:00
YAMUNA 20000.00	457.23	463.58	06-09-2019 03:00:00
YAMUNA 21000.00	455.00	460.40	07-09-2019 03:00:00
YAMUNA 22000.00	450.87	457.09	08-09-2019 03:00:00
YAMUNA 23000.00	*	452.59	09-09-2019 03:00:00
YAMUNA 24000.00	*	447.65	10-09-2019 03:00:00
YAMUNA 25000.00	437.86	443.28	11-09-2019 03:00:00
YAMUNA 26000.00	*	440.15	12-09-2019 03:00:00
YAMUNA 27000.00	430.24	436.36	13-09-2019 03:00:00
YAMUNA 28000.00	427.13	433.47	14-09-2019 03:00:00
YAMUNA 29000.00	424.84	431.45	15-09-2019 03:00:00
YAMUNA 30000.00	422.00	427.92	16-09-2019 03:00:00
YAMUNA 31000.00	*	424.14	17-09-2019 03:00:00
YAMUNA 32000.00	415.42	420.17	18-09-2019 03:00:00
YAMUNA 33000.00	410.06	416.23	19-09-2019 03:00:00
YAMUNA 34000.00	407.00	412.89	20-09-2019 03:00:00
YAMUNA 35000.00	403.45	409.78	21-09-2019 03:00:00
YAMUNA 36000.00	*	406.41	22-09-2019 03:00:00
YAMUNA 37000.00	395.59	403.40	23-09-2019 03:00:00
YAMUNA 38000.00	*	401.05	24-09-2019 03:00:00
YAMUNA 39000.00	391.94	397.94	25-09-2019 03:00:00
YAMUNA 40000.00	388.71	394.71	26-09-2019 03:00:00
YAMUNA 41000.00	*	392.93	27-09-2019 03:00:00
YAMUNA 42000.00	384.34	390.89	28-09-2019 03:00:00
YAMUNA 43000.00	380.53	388.05	29-09-2019 03:00:00
YAMUNA 44000.00	376.65	384.67	30-09-2019 03:00:00
YAMUNA 45000.00	375.00	382.17	01-10-2019 03:00:00
YAMUNA 46000.00	371.27	379.27	02-10-2019 03:00:00
YAMUNA 47000.00	367.04	376.37	03-10-2019 03:00:00
YAMUNA 48000.00	*	374.15	04-10-2019 03:00:00
YAMUNA 49000.00	361.90	372.84	05-10-2019 03:00:00
YAMUNA 50000.00	356.43	372.31	06-10-2019 03:00:00

** cross sections interpolated by MIKE11*

The rise in water level along the reach of the river downstream of the dam is about 4.75 m to 44.49 m. It needs to be highlighted that this high water column build up is due to immediate downstream reservoir storage too. At other chainages, the maximum value is 15.88 m.

10.1.15 Comparison of Maximum Discharge and Water Level

For the different hydrodynamic scenario simulated so far, the maximum discharge and water level occurring at different locations of River downstream of dam have been compared in **Table 10.44** and **10.45** respectively.

Table 10.9: Comparison of maximum discharge obtained in different cases

Chainage (m) d/s of dam	Maximum discharge (cumec)	
	PMF and dam breach	PMF in virgin condition
	(Table 10.40)	(Table 10.42)
YAMUNA 525.00	61755	8848
YAMUNA 1500.00	60455	8847
YAMUNA 2500.00	60171	8846
YAMUNA 3500.00	60007	8846
YAMUNA 4155.00	59769	8845
YAMUNA 4655.00	53832	8570
YAMUNA 5500.00	53310	8568
YAMUNA 6500.00	53064	8567
YAMUNA 7500.00	52974	8567
YAMUNA 8500.00	52870	8567
YAMUNA 9272.50	52779	8566
YAMUNA 9817.50	52740	8566
YAMUNA 10580.00	52699	8566
YAMUNA 11485.00	52012	8566
YAMUNA 12175.00	51680	8565
YAMUNA 12725.00	51547	8565
YAMUNA 13500.00	51427	8565
YAMUNA 14500.00	51137	8565
YAMUNA 15500.00	50823	8564
YAMUNA 16500.00	50389	8564
YAMUNA 17500.00	49742	8563
YAMUNA 18500.00	49469	8562
YAMUNA 19500.00	49279	8562
YAMUNA 20500.00	47562	8561
YAMUNA 21500.00	46671	8559
YAMUNA 22500.00	46303	8558
YAMUNA 23500.00	46007	8558
YAMUNA 24500.00	45711	8557
YAMUNA 25500.00	44608	8556
YAMUNA 26500.00	43805	8555
YAMUNA 27500.00	43119	8554
YAMUNA 28500.00	42504	8552
YAMUNA 29500.00	42312	8552
YAMUNA 30500.00	42213	8551
YAMUNA 31500.00	42065	8551
YAMUNA 32500.00	41810	8550
YAMUNA 33500.00	41696	8549
YAMUNA 34500.00	41539	8549
YAMUNA 35500.00	41277	8548
YAMUNA 36500.00	40981	8547
YAMUNA 37500.00	40654	8545
YAMUNA 38500.00	40337	8543

Chainage (m) d/s of dam	Maximum discharge (cumec)	
	PMF and dam breach	PMF in virgin condition
	(Table 10.40)	(Table 10.42)
YAMUNA 39500.00	39702	8543
YAMUNA 40500.00	38420	8541
YAMUNA 41500.00	37794	8540
YAMUNA 42500.00	37506	8538
YAMUNA 43500.00	37440	8538
YAMUNA 44500.00	37367	8538
YAMUNA 45500.00	37045	8537
YAMUNA 46500.00	36525	8536
YAMUNA 47500.00	36196	8535
YAMUNA 48500.00	35860	8533
YAMUNA 49500.00	35629	8531

Table 10.10: Comparison of maximum water level obtained in different cases

Chainage (m) d/s of dam	Bed Level (m)	Maximum discharge (cumec)	
		PMF and dam breach	PMF in virgin condition
		(Table 5.41)	(Table 5.43)
YAMUNA 0.00	635.01	665.65	648.35
YAMUNA 50.00	633.98	664.49	647.22
YAMUNA 1000.00	624.69	648.05	634.47
YAMUNA 2000.00	610.40	639.84	622.86
YAMUNA 3000.00	604.16	631.39	615.63
YAMUNA 4000.00	584.09	612.96	596.12
YAMUNA 4310.00	548.00	608.60	592.49
YAMUNA 4310.00	*	608.60	592.49
YAMUNA 5000.00	579.26	607.24	592.04
YAMUNA 6000.00	*	598.34	581.97
YAMUNA 7000.00	556.90	589.60	572.47
YAMUNA 8000.00	553.24	577.71	563.41
YAMUNA 9000.00	532.10	562.21	545.88
YAMUNA 9545.00	*	556.63	540.68
YAMUNA 10090.00	521.55	550.11	535.28
YAMUNA 11070.00	514.00	532.84	522.49
YAMUNA 11900.00	507.88	527.64	516.73
YAMUNA 12450.00	*	524.13	513.21
YAMUNA 13000.00	500.40	520.26	509.45
YAMUNA 14000.00	493.98	510.23	501.56
YAMUNA 15000.00	482.09	498.89	490.04
YAMUNA 16000.00	475.80	491.92	483.59
YAMUNA 17000.00	471.15	486.02	477.36
YAMUNA 18000.00	466.62	481.28	473.02
YAMUNA 19000.00	461.36	475.37	468.03
YAMUNA 20000.00	457.23	470.01	463.58
YAMUNA 21000.00	455.00	466.92	460.40
YAMUNA 22000.00	450.87	463.29	457.09
YAMUNA 23000.00	*	458.02	452.59
YAMUNA 24000.00	*	452.40	447.65
YAMUNA 25000.00	437.86	447.98	443.28
YAMUNA 26000.00	*	444.97	440.15
YAMUNA 27000.00	430.24	441.31	436.36
YAMUNA 28000.00	427.13	438.70	433.47
YAMUNA 29000.00	424.84	436.36	431.45
YAMUNA 30000.00	422.00	432.30	427.92
YAMUNA 31000.00	*	427.99	424.14
YAMUNA 32000.00	415.42	424.18	420.17
YAMUNA 33000.00	410.06	420.66	416.23
YAMUNA 34000.00	407.00	417.07	412.89

YAMUNA 35000.00	403.45	413.72	409.78
YAMUNA 36000.00	*	410.49	406.41
YAMUNA 37000.00	395.59	407.61	403.40
YAMUNA 38000.00	*	404.98	401.05
YAMUNA 39000.00	391.94	401.89	397.94
YAMUNA 40000.00	388.71	399.76	394.71
YAMUNA 41000.00	*	398.35	392.93
YAMUNA 42000.00	384.34	396.95	390.89
YAMUNA 43000.00	380.53	394.49	388.05
YAMUNA 44000.00	376.65	390.27	384.67
YAMUNA 45000.00	375.00	387.40	382.17
YAMUNA 46000.00	371.27	385.26	379.27
YAMUNA 47000.00	367.04	382.83	376.37
YAMUNA 48000.00	*	381.07	374.15
YAMUNA 49000.00	361.90	380.21	372.84
YAMUNA 50000.00	356.43	379.88	372.31

** cross sections interpolated by MIKE11*

From the **Table 10.43**, it can be concluded that the rise in water level along the river reach in dam breach condition is about 3.94 m to 17.30 m more in comparison to non dam breach condition (col. 3 &4)

The water levels given in **Table 10.44** can be used for the preparation of inundation map. The tables of few cross sections of the River used have been given in **Table 10.45**. The maximum water level at these cross sections due to dam breach flood has also been superimposed over them.

10.1.16 Dam Breach Flood Hydrograph

The dam breach flood hydrograph of **Figure 10.22** has been reproduced in the tabular form and the same are given in **Table 10.46** . The peak of the hydrograph is 61842 cumec.

Table 10.11: Dam breach Flood hydrograph just d/s of dam

Time (Date: hours: minutes: seconds)	Discharge (cumec)
11-08-2019 00:00:00	224
11-08-2019 01:00:00	6901
11-08-2019 02:00:00	6947
11-08-2019 03:00:00	7275
11-08-2019 04:00:00	7712
11-08-2019 05:00:00	6856
11-08-2019 06:00:00	6221
11-08-2019 07:00:00	5581
11-08-2019 08:00:00	3813
11-08-2019 09:00:00	3237
11-08-2019 10:00:00	2813
11-08-2019 11:00:00	2512
11-08-2019 12:00:00	2313
11-08-2019 13:00:00	2197
11-08-2019 14:00:00	2154
11-08-2019 15:00:00	2173
11-08-2019 16:00:00	2248
11-08-2019 17:00:00	2378
11-08-2019 18:00:00	2565
11-08-2019 19:00:00	2815
11-08-2019 20:00:00	3136
11-08-2019 21:00:00	3537

11-08-2019 22:00:00	4036
11-08-2019 23:00:00	5223
12-08-2019 00:00:00	5738
12-08-2019 01:00:00	6002
12-08-2019 02:00:00	6272
12-08-2019 03:00:00	6527
12-08-2019 03:25:59	**61842**
12-08-2019 04:00:00	41833
12-08-2019 05:00:00	25249
12-08-2019 06:00:00	17027
12-08-2019 07:00:00	12612
12-08-2019 08:00:00	10095
12-08-2019 09:00:00	8537
12-08-2019 10:00:00	7474
12-08-2019 11:00:00	6683
12-08-2019 12:00:00	6056
12-08-2019 13:00:00	5534
12-08-2019 14:00:00	5088
12-08-2019 15:00:00	4692
12-08-2019 16:00:00	4331
12-08-2019 17:00:00	4003
12-08-2019 18:00:00	3706
12-08-2019 19:00:00	3432
12-08-2019 20:00:00	3174
12-08-2019 21:00:00	2934
12-08-2019 22:00:00	2717
12-08-2019 23:00:00	2524
13-08-2019 00:00:00	2350
13-08-2019 01:00:00	2189
13-08-2019 02:00:00	2039
13-08-2019 03:00:00	1898
13-08-2019 04:00:00	1769
13-08-2019 05:00:00	1653
13-08-2019 06:00:00	1546
13-08-2019 07:00:00	1446
13-08-2019 08:00:00	1357
13-08-2019 09:00:00	1277
13-08-2019 10:00:00	1200
13-08-2019 11:00:00	1123
13-08-2019 12:00:00	1055
13-08-2019 13:00:00	996
13-08-2019 14:00:00	942
13-08-2019 15:00:00	884
13-08-2019 16:00:00	824
13-08-2019 17:00:00	770
13-08-2019 18:00:00	726
13-08-2019 19:00:00	689
13-08-2019 20:00:00	656
13-08-2019 21:00:00	626
13-08-2019 22:00:00	596
13-08-2019 23:00:00	562
14-08-2019 00:00:00	524
14-08-2019 01:00:00	490
14-08-2019 02:00:00	462
14-08-2019 03:00:00	438
14-08-2019 04:00:00	418
14-08-2019 05:00:00	402

Table 10.12: Cross-Sections

1km			2km			3km			4 km			5 km			7km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
0.00	665.91		0.00	701.79		0.00	741.94		0.00	812.16		0.00	715.32		0.00	663.25
27.88	657.45		27.87	689.20		27.87	724.26		27.78	794.93		27.73	703.69		28.96	658.53
55.75	650.38		55.74	677.77		55.74	706.49		55.56	773.54		55.46	682.79		57.91	646.86
83.63	641.30		83.61	661.55		83.61	690.46		83.34	748.59		83.19	658.65		86.87	632.02
111.51	636.01		111.48	642.37		111.48	680.78		111.12	722.84		110.92	640.74		115.83	620.66
139.38	632.63		139.35	628.42		139.35	667.33		138.90	707.63		138.65	624.10		144.79	603.10
167.26	630.96		167.22	619.79		167.22	644.54		166.68	694.70		166.38	609.55		173.74	579.10
195.13	629.85		195.09	611.28		195.09	630.54		194.46	674.93		194.12	600.57		202.70	563.83
223.01	630.00		222.96	610.40		222.96	618.34		222.24	651.64		221.85	597.22		231.66	556.90
250.89	629.87		250.83	612.99		250.83	607.95		250.02	609.25		249.58	592.39		260.61	561.63
278.76	626.01		278.70	616.14		278.70	604.16		277.80	584.83		277.31	583.94		289.57	580.28
306.64	624.69		306.57	628.39		306.57	607.64		305.58	584.09		305.04	579.26		318.53	600.09
334.52	628.16		334.44	644.51		334.44	615.78		333.36	588.91		332.77	581.75		347.49	610.07
362.39	637.61		362.31	662.12		362.31	628.41		361.13	596.74		360.50	588.08		376.44	614.68
390.27	648.37		390.17	681.07		390.18	648.56		388.91	608.77		388.23	596.10		405.40	622.22
418.15	656.31		418.04	701.91		418.05	666.97		416.69	623.51		415.96	601.67		434.36	635.15
446.02	664.60		445.91	721.86		445.92	691.45		444.47	644.92		443.69	607.49		463.31	655.74
473.90	676.93		473.78	743.68		473.79	718.42		472.25	669.18		471.42	614.20		492.27	680.79
501.77	690.59		501.65	769.56		501.66	744.56		500.03	691.40		499.15	625.53			

9km			10.09 km			11.07 km			11.90 km			13 km			14 km			15 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
0.00	643.08		0.00	609.61		0.00	539.74		0.00	536.22		0.00	540.37		0.00	517.44		0.00	488.17
27.69	623.10		26.70	588.18		28.04	534.40		29.08	522.47		29.22	538.65		27.83	511.01		27.78	488.95
55.39	604.79		53.40	572.67		56.08	526.59		58.15	516.84		58.44	537.18		55.67	505.79		55.56	486.95
83.08	592.54		80.10	555.35		84.13	522.05		87.23	513.72		87.66	537.15		83.50	501.93		83.34	485.49

110.77	584.58		106.80	536.65		112.17	518.77		116.31	512.24		116.88	536.19		111.33	499.28		111.13	485.54
138.47	574.65		133.49	521.55		140.21	518.46		145.38	512.91		146.09	532.94		139.17	496.64		138.91	485.10
166.16	564.65		160.19	522.77		168.25	518.41		174.46	514.12		175.31	522.05		167.00	494.42		166.69	485.58
193.85	554.17		186.89	531.68		196.29	517.20		203.54	513.60		204.53	511.42		194.83	494.43		194.47	485.22
221.54	542.67		213.59	545.15		224.33	515.00		232.61	510.58		233.75	503.57		222.67	494.00		222.25	483.98
249.24	533.41		240.29	566.15		252.38	514.00		261.69	508.50		262.97	500.79		250.50	493.98		250.03	483.04
276.93	532.10		266.99	584.69		280.42	514.00		290.77	507.88		292.19	500.40		278.33	497.41		277.81	482.09
304.62	540.29		293.69	601.26		308.46	514.83		319.85	508.40		321.41	502.66		306.16	502.02		305.60	483.14
332.32	548.51					336.50	519.48		348.92	510.09		350.63	501.01		334.00	501.45		333.38	483.85
360.01	565.43					364.54	521.91		378.00	515.51		379.85	503.26		361.83	501.58		361.16	487.01
387.70	590.60					392.59	523.39		407.08	524.72		409.07	507.86		389.66	502.16		388.94	492.23
415.40	615.19					420.63	526.45		436.15	538.39		438.28	513.53		417.50	503.91		416.72	497.49
443.09	630.63					448.67	528.24		465.23	547.37		467.50	517.14		445.33	504.85		444.50	503.36
470.78	644.02					476.71	529.15		494.31	551.52		496.72	518.18		473.16	505.63		472.28	508.22
498.48	672.83					504.75	532.96								501.00	505.23		500.07	511.35
						532.79	539.06												
						560.84	546.10												

16 km			**17 km**			**18 km**			**19 km**			**20 km**			**21 km**			**22 km**	
Distance	**Elevation (m)**		**Distance**	**Elevation (m)**		**Distance**	**Elevation (m)**		**Distance**	**Elevation (m)**		**Distance**	**Elevation (m)**		**Distance**	**Elevation (m)**		**Distance**	**Elevation (m)**
0.00	493.76		0.00	478.00		0.00	470.66		0.00	474.65		0.00	475.26		0.00	520.00		0.00	527.66
27.81	491.11		27.95	477.72		27.89	471.25		27.86	471.06		28.90	473.25		29.15	513.13		29.20	507.66
55.63	485.19		55.91	476.38		55.78	470.94		55.71	467.90		57.80	472.44		58.29	503.16		58.39	489.83
83.44	481.35		83.86	474.78		83.67	470.86		83.57	463.62		86.71	472.00		87.44	490.17		87.59	476.56
111.25	480.12		111.81	473.34		111.56	469.80		111.42	462.02		115.61	470.25		116.58	475.86		116.78	468.23
139.06	478.41		139.77	472.06		139.45	467.72		139.28	461.53		144.51	468.16		145.73	466.99		145.98	462.93
166.88	476.88		167.72	471.85		167.34	467.16		167.13	462.00		173.41	466.77		174.87	461.85		175.17	460.89
194.69	475.80		195.68	471.76		195.23	467.59		194.99	462.00		202.31	466.08		204.02	459.99		204.37	459.78
222.50	476.74		223.63	471.15		223.12	466.98		222.84	461.87		231.22	465.63		233.16	459.80		233.56	461.67
250.31	479.24		251.58	472.01		251.01	466.62		250.70	461.36		260.12	465.08		262.31	460.19		262.76	462.04
278.13	481.20		279.54	472.00		278.90	467.33		278.55	461.46		289.02	462.39		291.45	461.20		291.96	459.53
305.94	482.12		307.49	472.55		306.79	467.57		306.41	462.83		317.92	461.00		320.60	460.81		321.15	458.34
333.75	482.44		335.44	472.33		334.68	467.77		334.27	464.18		346.82	458.71		349.74	460.13		350.35	457.62
361.56	480.93		363.40	472.70		362.56	468.79		362.12	464.46		375.73	457.98		378.89	458.31		379.54	457.80

16 km		17 km		18 km		19 km		20 km		21 km		22 km	
Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)
389.38	479.98	391.35	472.03	390.45	468.24	389.98	464.79	404.63	460.62	408.03	456.74	408.74	457.51
417.19	479.32	419.31	471.22	418.34	468.54	417.83	466.09	433.53	462.21	437.18	456.77	437.93	455.92
445.00	479.01	447.26	471.39	446.23	468.16	445.69	466.99	462.43	460.82	466.32	456.61	467.13	454.37
472.81	479.16	475.21	472.35	474.12	468.75	473.54	466.11	491.33	458.05	495.47	456.37	496.33	453.57
500.63	480.30	503.17	473.97	502.01	469.34	501.40	465.10	520.24	457.23	524.61	456.37	525.52	452.95
		531.12	476.88					549.14	458.32	553.76	456.14	554.72	451.81
		559.07	480.09					578.04	459.76	582.90	456.17	583.91	451.26
								606.94	459.16	612.05	455.50	613.11	451.46
								635.84	459.49	641.19	455.00	642.30	452.85
								664.75	460.07	670.34	455.42	671.50	452.85
								693.65	459.64	699.48	455.88	700.69	452.84
								722.55	458.95	728.63	456.58	729.89	451.85
								751.45	458.42	757.77	457.40	759.09	450.87
								780.35	460.41	786.92	458.09	788.28	450.89
								809.26	461.00	816.06	458.73	817.48	452.44
								838.16	460.59	845.21	458.44	846.67	452.45
								867.06	459.23	874.35	457.44	875.87	452.45
								895.96	459.66	903.50	456.45	905.06	452.90
								924.87	460.30	932.64	455.45	934.26	459.03
								953.77	461.75	961.79	455.00	963.45	463.03
								982.67	464.66	990.93	455.00	992.65	460.66
								1011.57	466.68	1020.08	455.00	1021.85	460.08
								1040.47	467.82	1049.22	455.00	1051.04	460.52
								1069.38	468.73	1078.37	455.52	1080.24	461.90
								1098.28	469.15	1107.51	455.65	1109.43	460.06
								1127.18	468.57	1136.66	458.09	1138.63	457.06
								1156.08	467.89	1165.80	462.28	1167.82	457.92
								1184.98	468.85	1194.95	465.12	1197.02	459.88
								1213.89	470.12	1224.09	467.97	1226.22	460.44
								1242.79	470.79	1253.24	471.94	1255.41	460.02
								1271.69	470.65	1282.38	476.25	1284.61	459.07
								1300.59	469.93	1311.53	476.82	1313.80	459.94
								1329.49	467.83	1340.67	474.94	1343.00	462.35
								1358.40	464.74	1369.82	474.09	1372.19	466.72
								1387.30	463.59	1398.96	474.57	1401.39	472.13
								1416.20	462.34	1428.11	476.61	1430.58	472.96
								1445.10	460.19	1457.25	478.62	1459.78	473.47

16 km		17 km		18 km		19 km		20 km		21 km		22 km	
Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)
								1474.00	463.20	1486.40	478.02	1488.98	475.36
								1502.91	466.55	1515.54	474.85	1518.17	475.04
								1531.81	467.80	1544.69	473.07	1547.37	474.08
								1560.71	469.97	1573.83	473.56	1576.56	472.65
								1589.61	476.70	1602.98	474.85	1605.76	472.96
								1618.51	493.04	1632.12	476.11	1634.95	473.91
								1647.42	508.93	1661.27	477.26	1664.15	474.42
								1676.32	518.70	1690.41	478.49	1693.34	475.84
										1719.56	480.66		
										1748.70	480.95		
										1777.85	479.91		
										1806.99	479.00		
										1836.14	478.04		
										1865.28	476.20		
										1894.43	476.29		

25 km		27 km		28 km		29 km		30 km		32 km		33 km	
Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)
0.00	457.38	0.00	443.36	0.00	464.68	0.00	455.92	0.00	455.06	0.00	425.70	0.00	416.60
29.27	452.20	29.25	444.00	29.24	463.82	28.99	454.83	29.15	452.18	29.28	426.26	29.10	416.94
58.55	449.46	58.50	443.99	58.47	463.46	57.98	453.06	58.29	449.51	58.56	427.45	58.21	416.53
87.82	450.07	87.74	443.69	87.71	461.46	86.97	451.09	87.44	446.82	87.84	426.64	87.31	416.60
117.10	448.25	116.99	442.99	116.94	459.36	115.96	449.68	116.58	444.45	117.12	427.27	116.42	417.24
146.37	446.05	146.24	442.93	146.18	454.70	144.95	448.78	145.73	441.66	146.40	427.37	145.52	418.70
175.64	443.76	175.49	442.88	175.41	447.91	173.94	447.38	174.88	442.35	175.68	426.62	174.63	420.00
204.92	441.33	204.74	442.93	204.65	441.85	202.93	445.32	204.02	442.26	204.97	426.15	203.73	419.80
234.19	441.10	233.99	442.97	233.89	436.61	231.93	442.59	233.17	440.13	234.25	425.81	232.83	417.96
263.47	440.79	263.23	442.99	263.12	434.02	260.92	441.19	262.31	438.82	263.53	424.75	261.94	417.57
292.74	440.08	292.48	442.72	292.36	434.00	289.91	441.02	291.46	438.00	292.81	424.13	291.04	418.16
322.02	439.81	321.73	441.99	321.59	432.29	318.90	442.13	320.61	438.00	322.09	424.53	320.15	420.11
351.29	440.59	350.98	441.46	350.83	431.09	347.89	441.91	349.75	437.97	351.37	424.47	349.25	421.44
380.56	439.27	380.23	439.21	380.07	431.00	376.88	441.08	378.90	437.13	380.65	424.20	378.35	420.00
409.84	438.24	409.47	436.23	409.30	431.00	405.87	440.84	408.05	436.34	409.93	424.10	407.46	419.92
439.11	437.86	438.72	433.97	438.54	431.26	434.86	440.97	437.19	436.65	439.21	423.51	436.56	418.44
468.39	438.49	467.97	433.99	467.77	431.02	463.85	439.57	466.34	437.07	468.49	421.31	465.67	417.84
497.66	444.01	497.22	433.99	497.01	430.96	492.84	436.57	495.48	436.38	497.77	420.65	494.77	415.39
526.93	448.63	526.47	434.48	526.24	430.23	521.83	432.37	524.63	436.74	527.05	420.63	523.88	413.01

25 km		27 km		28 km		29 km		30 km		32 km		33 km	
Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)	Distance	Elevation (m)
556.21	452.52	555.71	435.76	555.48	428.85	550.82	426.77	553.78	437.07	556.33	420.52	552.98	413.47
585.48	452.32	584.96	434.52	584.72	428.26	579.81	425.31	582.92	437.59	585.62	419.68	582.08	414.01
614.76	450.68	614.21	432.76	613.95	428.76	608.80	426.13	612.07	438.00	614.90	418.40	611.19	415.00
644.03	448.06	643.46	431.76	643.19	429.00	637.79	427.91	641.21	438.00	644.18	417.07	640.29	415.53
673.31	446.21	672.71	430.77	672.42	429.00	666.79	429.10	670.36	438.00	673.46	417.96	669.40	414.54
702.58	446.29	701.96	430.24	701.66	429.62	695.78	430.15	699.51	437.52	702.74	418.78	698.50	414.08
731.85	446.36	731.20	431.47	730.89	430.39	724.77	431.20	728.65	436.66	732.02	418.72	727.61	414.52
761.13	445.70	760.45	433.47	760.13	430.28	753.76	432.60	757.80	437.31	761.30	419.10	756.71	415.96
790.40	445.76	789.70	435.00	789.37	430.99	782.75	432.59	786.94	438.49	790.58	419.58	785.81	415.42
819.68	445.97	818.95	435.00	818.60	430.61	811.74	431.74	816.09	437.16	819.86	419.71	814.92	414.95
848.95	447.00	848.20	435.00	847.84	431.09	840.73	431.81	845.24	433.53	849.14	418.34	844.02	414.49
878.22	446.91	877.44	435.22	877.07	431.00	869.72	432.51	874.38	429.90	878.42	416.97	873.13	414.03
907.50	444.53	906.69	436.01	906.31	431.00	898.71	433.21	903.53	426.20	907.70	417.42	902.23	414.50
936.77	443.23	935.94	436.02	935.54	431.00	927.70	433.91	932.68	423.42	936.98	417.92	931.34	414.97
966.05	443.24	965.19	435.75	964.78	430.29	956.69	432.91	961.82	422.37	966.27	418.99	960.44	414.57
995.32	441.92	994.44	434.75	994.02	430.26	985.68	432.68	990.97	423.26	995.55	419.34	989.54	413.13
1024.59	439.93	1023.69	433.33	1023.25	430.40	1014.67	432.18	1020.11	423.97	1024.83	420.49	1018.65	412.58
1053.87	438.68	1052.93	431.21	1052.49	429.97	1043.66	432.18	1049.26	423.47	1054.11	421.00	1047.75	412.05
1083.14	439.26	1082.18	432.22	1081.72	429.20	1072.65	431.83	1078.41	424.19	1083.39	421.00	1076.86	411.58
1112.42	439.78	1111.43	433.26	1110.96	429.87	1101.65	431.92	1107.55	424.95	1112.67	420.95	1105.96	410.64
1141.69	440.98	1140.68	433.86	1140.20	431.00	1130.64	431.99	1136.70	425.55	1141.95	421.00	1135.06	410.06
1170.97	440.88	1169.93	432.71	1169.43	430.84	1159.63	431.15	1165.84	425.88	1171.23	421.00	1164.17	411.35
1200.24	440.09	1199.17	431.10	1198.67	430.13	1188.62	428.31	1194.99	425.79	1200.51	420.65	1193.27	412.81
1229.51	441.07	1228.42	431.39	1227.90	429.50	1217.61	425.17	1224.14	424.48	1229.79	419.37	1222.38	413.46
1258.79	442.29	1257.67	433.33	1257.14	427.98	1246.60	424.87	1253.28	422.93	1259.07	417.94	1251.48	413.93
1288.06	442.25	1286.92	435.13	1286.37	427.27	1275.59	424.84	1282.43	424.80	1288.35	416.81	1280.59	414.46
1317.34	441.67	1316.17	435.75	1315.61	428.12	1304.58	425.00	1311.57	424.88	1317.63	416.04	1309.69	413.63
1346.61	440.79	1345.41	434.82	1344.85	429.48	1333.57	425.62	1340.72	423.93	1346.91	416.00	1338.79	413.02
1375.88	439.46	1374.66	434.62	1374.08	430.02	1362.56	426.99	1369.87	423.17	1376.20	416.99	1367.90	412.16
1405.16	439.39	1403.91	437.12	1403.32	429.45	1391.55	427.93	1399.01	422.41	1405.48	418.12	1397.00	412.44
1434.43	439.43	1433.16	437.62	1432.55	428.49	1420.54	427.99	1428.16	422.00	1434.76	418.65	1426.11	413.73
1463.71	439.04	1462.41	436.00	1461.79	427.78	1449.53	427.84	1457.31	422.74	1464.04	417.93	1455.21	414.43
1492.98	439.00	1491.66	436.18	1491.02	427.13	1478.52	428.20	1486.45	425.01	1493.32	417.07	1484.32	414.10
1522.26	438.81	1520.90	437.35	1520.26	428.63	1507.51	428.74	1515.60	426.52	1522.60	416.21	1513.42	414.00
1551.53	439.70	1550.15	438.90	1549.50	430.00	1536.51	427.91	1544.74	427.80	1551.88	416.06	1542.52	414.00
1580.80	439.90	1579.40	438.74	1578.73	429.99	1565.50	428.31	1573.89	427.64	1581.16	416.79	1571.63	412.85
1610.08	441.39	1608.65	438.12	1607.97	429.51	1594.49	428.00	1603.04	426.11	1610.44	417.76	1600.73	411.34
1639.35	443.17	1637.90	438.69	1637.20	429.84	1623.48	430.10	1632.18	425.17	1639.72	418.55	1629.84	411.00
1668.63	444.22	1667.14	439.20	1666.44	431.96	1652.47	431.05	1661.33	425.95	1669.00	417.97	1658.94	411.76
1697.90	444.98	1696.39	442.22	1695.68	433.55	1681.46	432.03	1690.47	426.31	1698.28	417.10	1688.05	414.33

25 km			27 km			28 km			29 km			30 km			32 km			33 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
1727.17	443.94		1725.64	445.38		1724.91	433.82		1710.45	432.78		1719.62	426.00		1727.56	415.42		1717.15	418.93
1756.45	443.00		1754.89	447.81		1754.15	433.02		1739.44	433.84		1748.77	425.26		1756.85	416.00		1746.25	425.93
1785.72	443.06		1784.14	448.31		1783.38	433.72		1768.43	433.70		1777.91	425.60		1786.13	417.03		1775.36	434.27
1815.00	443.80		1813.39	450.21		1812.62	435.51		1797.42	433.98		1807.06	426.41		1815.41	418.51		1804.46	437.22
1844.27	444.40		1842.63	451.87		1841.85	436.39		1826.41	434.78		1836.20	426.88		1844.69	418.06		1833.57	436.40
1873.54	444.15		1871.88	452.19		1871.09	437.10		1855.40	434.70		1865.35	428.03		1873.97	418.47		1862.67	435.67
1902.82	443.96		1901.13	453.89		1900.33	437.37		1884.39	434.18		1894.50	428.72		1903.25	418.18		1891.77	436.25
1932.09	443.14		1930.38	453.84		1929.56	438.52		1913.38	434.18		1923.64	428.61		1932.53	419.49		1920.88	437.94
1961.37	442.39		1959.63	451.99		1958.80	439.46		1942.37	434.58		1952.79	426.82		1961.81	419.26		1949.98	438.91
1990.64	443.00		1988.87	445.46		1988.03	439.62		1971.37	435.00		1981.94	426.17		1991.09	417.68		1979.09	439.07
2019.92	443.33		2018.12	439.21		2017.27	439.99		2000.36	435.00		2011.08	427.59		2020.37	417.04		2008.19	438.38
2049.19	444.04		2047.37	438.00		2046.50	441.00		2029.35	434.33		2040.23	430.21		2049.65	417.71			
2078.46	444.43		2076.62	438.15		2075.74	441.06		2058.34	432.36		2069.37	432.76		2078.93	418.07			
2107.74	442.78		2105.87	439.04		2104.98	442.48		2087.33	430.21		2098.52	432.68		2108.21	418.33			
2137.01	440.74		2135.11	439.45		2134.21	442.45		2116.32	430.00		2127.67	431.78		2137.50	417.97			
2166.29	440.05		2164.36	440.46		2163.45	442.14		2145.31	431.54		2156.81	431.42		2166.78	418.00			
2195.56	440.55		2193.61	441.30		2192.68	442.77		2174.30	434.34		2185.96	430.88		2196.06	417.40			
2224.83	440.61		2222.86	441.02		2221.92	443.56		2203.29	435.75		2215.10	430.01		2225.34	417.70			
2254.11	440.54		2252.11	440.14		2251.16	444.01		2232.28	436.35		2244.25	430.00		2254.62	417.87			
2283.38	443.01		2281.36	440.05		2280.39	444.02		2261.27	435.84		2273.40	429.71		2283.90	418.54			
2312.66	450.17		2310.60	440.46		2309.63	443.61		2290.26	435.19		2302.54	429.53		2313.18	420.20			
2341.93	458.50		2339.85	441.39		2338.86	444.00		2319.25	436.00		2331.69	429.43		2342.46	420.75			
2371.21	461.48		2369.10	442.93		2368.10	444.02		2348.24	438.13		2360.83	430.34		2371.74	420.02			
2400.48	460.05		2398.35	444.03		2397.33	443.78		2377.23	440.93		2389.98	430.98		2401.02	421.19			
2429.75	459.27		2427.60	447.35		2426.57	444.26		2406.23	442.22		2419.13	431.75		2430.30	422.94			
2459.03	463.39		2456.84	452.78		2455.81	444.25		2435.22	442.00		2448.27	432.33		2459.58	424.24			
2488.30	464.30		2486.09	456.83		2485.04	445.57		2464.21	442.00		2477.42	432.99		2488.86	425.41			
			2515.34	459.56		2514.28	446.00		2493.20	441.40		2506.56	432.90		2518.15	426.78			
			2544.59	459.15		2543.51	445.68		2522.19	440.78		2535.71	432.54		2547.43	427.00			
			2573.84	458.94		2572.75	445.00		2551.18	440.27		2564.86	430.89		2576.71	427.57			
			2603.09	459.66		2601.98	445.48		2580.17	440.97		2594.00	429.13		2605.99	428.00			
			2632.33	457.32		2631.22	445.12		2609.16	441.67		2623.15	428.37		2635.27	428.39			
			2661.58	459.17					2638.15	442.30		2652.30	428.71		2664.55	428.52			
			2690.83	466.04					2667.14	442.32		2681.44	428.86		2693.83	427.09			
												2710.59	428.99		2723.11	426.02			
												2739.73	432.87		2752.39	426.00			
												2768.88	434.50		2781.67	426.00			
												2798.03	434.00		2810.95	426.56			
												2827.17	434.02		2840.23	426.33			
												2856.32	434.97		2869.51	425.75			

25 km			27 km			28 km			29 km			30 km			32 km			33 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
												2885.46	436.93		2898.80	425.00			
															2928.08	425.00			
															2957.36	426.45			
															2986.64	427.33			

34 km			35 km			37 km			39 km			40 km			42 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
0.00	422.98		0.00	432.55		0.00	409.09		0.00	406.24		0.00	402.51		0.00	391.50
29.27	423.62		29.07	428.85		29.20	405.88		29.07	405.50		29.12	401.10		29.21	390.92
58.55	424.76		58.13	422.06		58.40	406.28		58.14	404.11		58.24	400.35		58.43	391.02
87.82	423.56		87.20	415.39		87.61	404.72		87.20	403.00		87.35	397.32		87.64	392.12
117.09	419.16		116.27	412.03		116.81	403.34		116.27	403.11		116.47	396.74		116.85	393.12
146.36	415.40		145.33	412.76		146.01	402.38		145.34	403.83		145.59	396.23		146.07	393.64
175.64	415.40		174.40	410.05		175.21	402.03		174.41	404.54		174.71	395.53		175.28	393.86
204.91	416.04		203.47	408.15		204.42	402.45		203.47	405.00		203.83	394.98		204.49	396.49
234.18	416.00		232.53	408.06		233.62	403.00		232.54	405.00		232.94	395.08		233.71	401.06
263.45	416.00		261.60	407.49		262.82	403.00		261.61	404.41		262.06	395.00		262.92	403.30
292.73	416.17		290.67	407.00		292.02	402.97		290.68	402.22		291.18	394.99		292.13	402.63
322.00	416.49		319.73	407.24		321.22	402.45		319.75	400.15		320.30	394.99		321.35	400.03
351.27	416.60		348.80	408.03		350.43	403.07		348.81	397.93		349.42	393.07		350.56	395.78
380.54	416.30		377.87	408.89		379.63	404.44		377.88	396.46		378.53	391.28		379.77	392.41
409.82	415.41		406.93	408.10		408.83	405.00		406.95	395.85		407.65	389.90		408.98	390.38
439.09	415.29		436.00	407.97		438.03	405.00		436.02	395.72		436.77	389.40		438.20	388.83
468.36	415.97		465.07	407.74		467.24	404.98		465.08	396.27		465.89	389.62		467.41	387.42
497.64	415.92		494.13	408.36		496.44	404.38		494.15	396.97		495.01	390.00		496.62	386.28
526.91	416.00		523.20	408.38		525.64	403.40		523.22	397.67		524.13	390.57		525.84	388.09
556.18	415.50		552.26	407.99		554.84	402.84		552.29	398.62		553.24	391.20		555.05	390.84
585.45	414.54		581.33	407.47		584.04	403.41		581.35	399.67		582.36	392.35		584.26	389.71
614.73	414.28		610.40	407.01		613.25	403.40		610.42	399.79		611.48	393.71		613.48	387.30
644.00	414.00		639.46	406.51		642.45	402.81		639.49	399.52		640.60	392.72		642.69	387.42
673.27	413.92		668.53	406.01		671.65	401.40		668.56	398.82		669.72	391.88		671.90	388.78
702.54	413.55		697.60	406.84		700.85	400.40		697.63	398.10		698.83	390.17		701.12	390.00
731.82	412.99		726.66	408.92		730.06	398.82		726.69	398.00		727.95	388.71		730.33	389.27
761.09	412.97		755.73	409.00		759.26	397.82		755.76	399.13		757.07	389.03		759.54	389.34
790.36	412.79		784.80	409.00		788.46	396.00		784.83	401.24		786.19	391.40		788.76	390.43

34 km			35 km			37 km			39 km			40 km			42 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
819.63	412.69		813.86	409.45		817.66	395.59		813.90	403.32		815.31	392.32		817.97	390.77
848.91	412.58		842.93	408.37		846.86	395.59		842.96	402.94		844.42	392.31		847.18	390.06
878.18	413.07		872.00	406.31		876.07	396.58		872.03	400.91		873.54	392.33		876.40	388.74
907.45	414.55		901.06	405.22		905.27	396.59		901.10	399.64		902.66	393.00		905.61	388.08
936.73	414.50		930.13	404.29		934.47	397.16		930.17	399.43		931.78	393.00		934.82	388.62
966.00	413.11		959.20	404.63		963.67	398.56		959.24	399.24		960.90	391.98		964.04	387.04
995.27	413.01		988.26	403.45		992.88	399.97		988.30	398.72		990.01	390.77		993.25	384.34
1024.54	412.80		1017.33	404.76		1022.08	400.00		1017.37	398.12		1019.13	391.23		1022.46	384.41
1053.82	412.15		1046.40	406.11		1051.28	400.40		1046.44	397.42		1048.25	391.52		1051.68	384.74
1083.09	410.90		1075.46	405.53		1080.48	400.41		1075.51	397.00		1077.37	391.00		1080.89	385.09
1112.36	409.38		1104.53	404.75		1109.68	400.98		1104.57	396.31		1106.49	391.65		1110.10	386.00
1141.63	409.37		1133.60	405.21		1138.89	401.00		1133.64	394.78		1135.60	393.50		1139.32	387.45
1170.91	408.77		1162.66	406.39		1168.09	402.12		1162.71	394.74		1164.72	394.46		1168.53	389.56
1200.18	408.07		1191.73	406.88		1197.29	401.61		1191.78	395.19		1193.84	395.97		1197.74	388.67
1229.45	408.37		1220.80	406.41		1226.49	400.64		1220.84	394.09		1222.96	397.99		1226.95	387.95
1258.72	409.02		1249.86	406.87		1255.70	401.53		1249.91	392.79		1252.08	398.83		1256.17	387.33
1288.00	409.00		1278.93	408.10		1284.90	401.03		1278.98	392.09		1281.19	397.70		1285.38	386.92
1317.27	408.63		1308.00	408.54		1314.10	401.00		1308.05	391.94		1310.31	395.55		1314.59	387.00
1346.54	407.24		1337.06	408.41		1343.30	400.06		1337.12	393.32		1339.43	394.21		1343.81	386.83
1375.82	407.78		1366.13	409.88		1372.50	400.39		1366.18	394.00		1368.55	392.37		1373.02	386.93
1405.09	409.90		1395.20	410.37		1401.71	402.27		1395.25	394.00		1397.67	391.03		1402.23	386.17
1434.36	411.44		1424.26	411.72		1430.91	403.88		1424.32	394.41		1426.79	391.73		1431.45	384.95
1463.63	411.00		1453.33	411.42		1460.11	403.62		1453.39	394.52		1455.90	391.97		1460.66	384.97
1492.91	408.87		1482.40	409.74		1489.31	403.43		1482.45	395.94		1485.02	391.08		1489.87	385.83
1522.18	407.00		1511.46	408.68		1518.52	403.03		1511.52	397.33		1514.14	390.08		1519.09	388.42
1551.45	407.44		1540.53	408.18		1547.72	403.00		1540.59	397.27		1543.26	390.45		1548.30	390.29
1580.72	410.47		1569.59	408.12		1576.92	403.38		1569.66	395.87		1572.38	390.37		1577.51	392.64
1610.00	412.49		1598.66	408.23		1606.12	402.88		1598.73	395.72		1601.49	390.40		1606.73	397.01
1639.27	411.56		1627.73	408.63		1635.32	402.45		1627.79	396.46		1630.61	391.61		1635.94	399.07
1668.54	410.51		1656.79	408.20		1664.53	402.94		1656.86	397.30		1659.73	393.35		1665.15	404.94
1697.81	410.00		1685.86	408.00		1693.73	404.79		1685.93	397.27		1688.85	393.29		1694.37	405.58
1727.09	409.93		1714.93	407.52		1722.93	405.89		1715.00	396.57		1717.97	392.61		1723.58	405.07
1756.36	409.19		1743.99	407.87		1752.13	405.11		1744.06	395.64		1747.08	392.00		1752.79	405.39
1785.63	408.30		1773.06	409.20		1781.34	404.48		1773.13	395.84		1776.20	392.00		1782.01	406.71
1814.91	408.05		1802.13	410.06		1810.54	404.41		1802.20	396.54		1805.32	391.94		1811.22	406.49
1844.18	408.15		1831.19	410.92		1839.74	402.81		1831.27	396.84		1834.44	391.72		1840.43	406.11

34 km			35 km			37 km			39 km			40 km			42 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
1873.45	409.69		1860.26	411.78		1868.94	402.22		1860.33	397.88		1863.56	391.10		1869.65	406.00
1902.72	410.13		1889.33	412.00		1898.14	402.17		1889.40	397.36		1892.67	391.60		1898.86	406.76
1932.00	412.02		1918.39	411.63		1927.35	401.66		1918.47	396.03		1921.79	392.09		1928.07	407.69
1961.27	412.49		1947.46	411.89		1956.55	401.08		1947.54	395.03		1950.91	392.41		1957.29	408.65
1990.54	412.55		1976.53	413.20		1985.75	402.37		1976.61	394.97		1980.03	393.18		1986.50	410.69
2019.81	411.67		2005.59	414.35		2014.95	403.80		2005.67	394.84		2009.15	395.03		2015.71	412.88
2049.09	411.06		2034.66	414.70		2044.16	403.50		2034.74	394.87		2038.26	397.14		2044.92	416.43
2078.36	412.94		2063.73	415.08		2073.36	405.12		2063.81	395.70		2067.38	397.78		2074.14	418.96
2107.63	414.23		2092.79	414.05		2102.56	408.11		2092.88	396.00		2096.50	397.04		2103.35	419.37
2136.90	418.78		2121.86	413.14		2131.76	410.78		2121.94	396.25		2125.62	396.49		2132.56	418.55
2166.18	429.50		2150.93	411.91		2160.96	414.20		2151.01	397.19		2154.74	395.47			
2195.45	434.34		2179.99	410.54		2190.17	418.12		2180.08	398.68		2183.85	396.09			
2224.72	435.00		2209.06	410.89		2219.37	420.29		2209.15	398.72		2212.97	397.65			
2254.00	435.00		2238.13	410.61		2248.57	421.76		2238.22	399.46		2242.09	398.30			
2283.27	434.67		2267.19	409.82		2277.77	422.83		2267.28	399.97		2271.21	399.53			
2312.54	434.77		2296.26	409.10		2306.98	423.97		2296.35	399.14		2300.33	400.70			
2341.81	433.91		2325.33	409.63		2336.18	423.83		2325.42	399.00		2329.44	400.82			
2371.09	433.05		2354.39	410.53		2365.38	423.42		2354.49	399.08		2358.56	400.43			
			2383.46	411.42					2383.55	399.00		2387.68	401.49			
			2412.53	412.78					2412.62	399.00		2416.80	404.38			
			2441.59	413.84					2441.69	399.04		2445.92	406.92			
			2470.66	413.35					2470.76	403.03		2475.04	407.81			
			2499.73	413.10					2499.82	403.15		2504.15	409.29			
									2528.89	403.08		2533.27	409.48			
									2557.96	403.66		2562.39	410.18			
									2587.03	402.48		2591.51	410.89			
									2616.10	400.51		2620.63	411.65			
									2645.16	398.82		2649.74	411.71			
									2674.23	399.14		2678.86	411.55			
									2703.30	400.41		2707.98	413.20			
									2732.37	400.99		2737.10	415.71			
									2761.43	401.67		2766.22	417.65			
												2795.33	418.35			
												2824.45	417.97			
												2853.57	417.98			
												2882.69	419.81			

34 km			35 km			37 km			39 km			40 km			42 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
												2911.81	421.95			
												2940.92	424.06			
												2970.04	425.60			

43 km			44 km			45 km			46 km			47 km			49 km			50 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
0.00	402.71		0.00	395.83		0.00	396.59		0.00	426.12		0.00	449.19		0.00	373.19		0.00	379.22
28.57	402.65		29.18	394.40		29.14	392.39		29.01	410.65		28.83	450.18		28.58	373.00		29.27	378.44
57.14	401.50		58.36	392.11		58.28	387.81		58.03	398.12		57.66	437.54		57.15	373.03		58.53	378.04
85.71	400.03		87.55	389.89		87.42	385.35		87.04	388.96		86.50	413.38		85.73	373.10		87.80	377.23
114.29	398.87		116.73	388.08		116.56	383.86		116.05	382.45		115.33	392.53		114.30	372.05		117.06	374.82
142.86	398.15		145.91	385.70		145.71	382.15		145.06	379.00		144.16	381.81		142.88	370.36		146.33	374.81
171.43	397.00		175.09	385.36		174.85	380.38		174.08	376.98		172.99	376.26		171.45	369.41		175.59	376.98
200.00	396.60		204.27	382.46		203.99	380.53		203.09	373.60		201.82	373.56		200.03	369.20		204.86	376.79
228.57	394.73		233.46	381.30		233.13	382.37		232.10	372.61		230.65	373.88		228.60	369.00		234.13	376.06
257.14	392.93		262.64	381.27		262.27	384.62		261.12	372.00		259.49	374.57		257.18	368.03		263.39	374.88
285.71	389.50		291.82	380.91		291.41	384.25		290.13	371.27		288.32	374.81		285.75	367.24		292.66	373.99
314.29	386.11		321.00	379.91		320.55	382.03		319.14	371.42		317.15	373.74		314.33	367.02		321.92	373.35
342.86	382.81		350.18	378.80		349.69	379.77		348.16	374.69		345.98	373.45		342.90	367.00		351.19	372.54
371.43	380.53		379.37	376.74		378.83	379.76		377.17	376.34		374.81	372.94		371.48	365.42		380.46	371.36
400.00	380.56		408.55	378.30		407.98	380.26		406.18	377.00		403.65	372.32		400.05	364.18		409.72	370.93
428.57	381.53		437.73	378.17		437.12	380.95		435.19	376.68		432.48	370.68		428.63	362.50		438.99	371.32
457.14	381.99		466.91	376.65		466.26	381.19		464.21	376.31		461.31	369.88		457.20	361.90		468.25	372.01
485.71	382.00		496.09	377.30		495.40	379.73		493.22	377.89		490.14	367.95		485.78	361.96		497.52	371.52
514.28	382.99		525.28	377.34		524.54	378.00		522.23	380.29		518.97	367.04		514.36	363.50		526.78	370.25
542.86	383.06		554.46	378.13		553.68	377.15		551.25	380.72		547.81	368.32		542.93	365.21		556.05	368.28
571.43	382.60		583.64	380.41		582.82	378.22		580.26	379.46		576.64	372.29		571.51	366.71		585.32	366.98
600.00	383.39		612.82	382.43		611.96	378.99		609.27	378.00		605.47	372.04		600.08	367.72		614.58	366.31
628.57	383.53		642.00	385.08		641.10	378.78		638.29	378.00		634.30	374.90		628.66	368.55		643.85	365.57
657.14	383.53		671.19	386.70		670.25	377.63		667.30	377.76		663.13	373.10		657.23	368.85		673.11	365.03
685.71	383.53		700.37	386.73		699.39	375.81		696.31	376.77		691.96	372.76		685.81	368.86		702.38	365.93
714.28	383.53		729.55	387.41		728.53	375.00		725.32	375.78		720.80	372.74		714.38	368.78		731.65	365.84
742.86	384.21		758.73	387.73		757.67	375.00		754.34	374.79		749.63	372.07		742.96	368.81		760.91	365.23
771.43	386.91		787.92	388.76		786.81	375.85		783.35	373.80		778.46	371.34		771.53	369.85		790.18	363.92
800.00	388.93		817.10	391.07		815.95	377.44		812.36	373.38		807.29	372.58		800.11	370.87		819.44	363.49

43 km			44 km			45 km			46 km			47 km			49 km			50 km	
Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)		Distance	Elevation (m)
828.57	388.40		846.28	394.30		845.09	378.22		841.38	375.00		836.12	374.27		828.68	371.00		848.71	364.60
857.14	387.54		875.46	394.29		874.23	378.65		870.39	375.51		864.96	372.62		857.26	371.85		877.97	365.61
885.71	387.94		904.64	393.69		903.38	379.15		899.40	378.16		893.79	372.44		885.83	372.89		907.24	367.44
914.28	388.34		933.83	392.29		932.52	379.05		928.42	379.15		922.62	376.10		914.41	372.49		936.51	369.64
942.86	390.08		963.01	390.00		961.66	379.63		957.43	380.00		951.45	380.74		942.98	371.89		965.77	370.58
971.43	392.53		992.19	391.40		990.80	379.92		986.44	380.00		980.28	385.99		971.56	372.25		995.04	370.06
1000.00	394.45					1019.94	380.25		1015.45	380.24					1000.13	373.26		1024.30	369.21
1028.57	396.36					1049.08	381.33		1044.47	382.11								1053.57	369.02
						1078.22	381.31		1073.48	382.80								1082.84	367.76
						1107.36	380.54		1102.49	381.00								1112.10	366.66
						1136.50	381.75		1131.51	381.08								1141.37	366.74
						1165.65	383.64		1160.52	382.07								1170.63	367.00
						1194.79	381.92		1189.53	383.00								1199.90	366.38
						1223.93	379.04		1218.55	383.05								1229.16	365.71
						1253.07	378.00		1247.56	384.04								1258.43	363.01
						1282.21	377.88		1276.57	384.97								1287.70	356.43
						1311.35	376.65		1305.58	383.95								1316.96	358.88
						1340.49	377.61		1334.60	382.00								1346.23	364.26
						1369.63	380.28		1363.61	382.00								1375.49	368.67
						1398.77	380.71		1392.62	382.00								1404.76	369.71
						1427.92	384.25		1421.64	382.98								1434.03	369.79
						1457.06	390.78		1450.65	383.00								1463.29	369.66
						1486.20	400.82		1479.66	381.07								1492.56	369.02
						1515.34	408.34		1508.68	380.04								1521.82	369.51
						1544.48	416.54		1537.69	380.00								1551.09	371.83
									1566.70	382.81									
									1595.71	383.00									
									1624.73	387.58									
									1653.74	391.63									
									1682.75	393.79									

10.1.17 Preparation of Inundation Map

An inundation map (**Figure 10.23**) is a map depicting the d/s areas vulnerable to inundation by the Dam break flood. The MIKE11 model computes maximum flood elevation at each original or interpolated cross-section. In present case, the cross-sections are available up to 50,000 m d/s of Dam. The profile of water levels below the Dam at all cross-sections (original and interpolated) is given as **Table 10.47**. From this profile, at locations below the Dam & their subsequent markings on the topographic maps, it can be seen which areas are likely to be submerged in case of Dam break.

It is clear from the inundation map that in case of Dam break, following villages are likely to be affected :

1	Ahirpur	25	Kadarpur
2	Amargarh	26	Kala Patthar
3	Ambwala Singhpura	27	Kandriyan
4	Badrinagar	28	Kawagi
5	Badripur	29	Khodri
6	Bahral	30	Kishanpur
7	Bain Kuan	31	Kulhal
8	Barotiwala	32	Kundian
9	Baruwala	33	Luhari
10	Bata Mandi	34	Majri
11	Bhagwanpur	35	Manpur
12	Bhatanwali	36	Manpur Devra
13	Bhuppur	37	Parma Nand
14	Byasi	38	Puruwala
15	Dakpathar	39	Santokhgarh
16	Devinagar	40	Sati
17	Devthala	41	Satiwala
18	Dhalipur	42	Shamsherpur
19	Ganguwala	43	Sindhpurwala
20	Guruwela	44	Singhpura
21	Haronwala	45	Siphon
22	Hothiari	46	Stlon
23	Jaklu	47	Surajpur
24	Jamunwala		

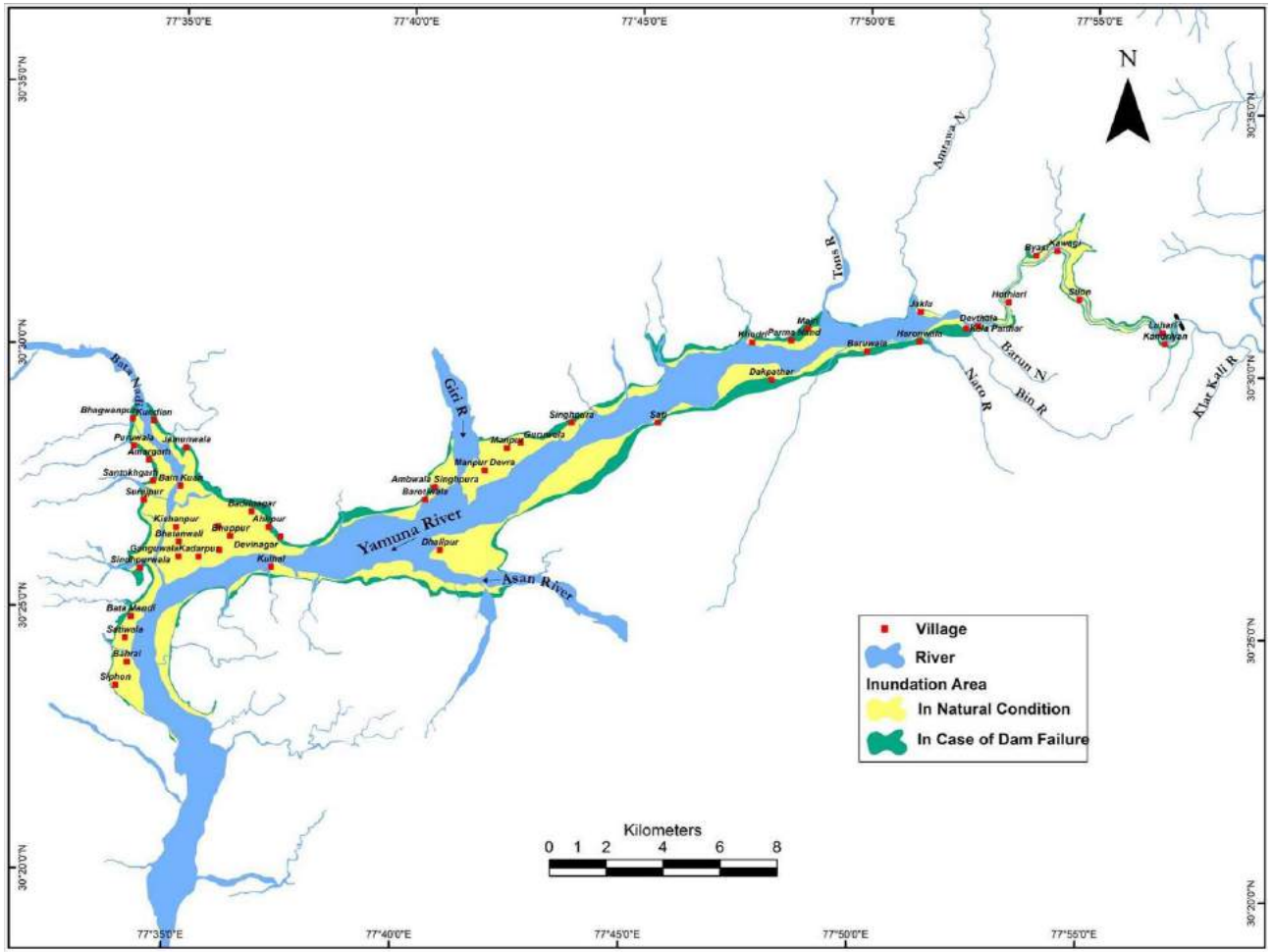


Figure 10.5: Inundation Map

10.1.18 Disaster Management Plan

Emergency action plan: Emergency identification and evaluation during construction stage

The emergency action plan includes emergency identification and evaluation matrix containing following items:

i. Listing of the conditions or events which could lead to or indicate an existing or potential emergency during construction stage of the project;

ii. Brief description of the means by which potential emergencies identified, including the data and information collection system, monitoring arrangements; and

iii. Designation of persons responsible for identifying and evaluating emergency.

Accordingly, emergency identification and response level matrix would need to be prepared for the construction stage of the project and be included in disaster management plan as proposed subsequently.

10.1.18.1 Vulnerability Assessment

From the result of Dam Break Modeling it is evident that up to about 50,000 m d/s of the Dam, time required in reaching the flood wave elevation to the maximum is about three hour. Since the time available is very short, the Disaster Management Plan should concentrate on preventive actions. Also as evident from the inundation map, that in case of design flood plus Dam break scenario, few villages are likely to be affected, Disaster Management Plan is more of a precautionary measure.

10.1.18.2 Surveillance & Monitoring

The surveillance and monitoring programs are required to be implemented during design and investigation, construction, early operation period and operation and maintenance phases of the life cycle of the Dam. An effective flood forecasting system is required by establishing hourly gauge reading at suitable upstream locations with real time communication at the top. An effective Dam safety surveillance, monitoring and observation along with periodic inspection, safety reviews and evaluation must be put in place. These programs will be implemented in five phases in the life cycle of Dam/embankment *viz*.,

i) Design and investigation phase,
ii) Construction phase,
iii) First reservoir filling,
iv) Early operation period, and
v) Operation and maintenance phase.

Surveillance and monitoring programmes are required to be implemented during design and investigation, construction, first reservoir filling, early operation period and operation & maintenance phases of the life cycle of Dam/embankment.

10.1.18.3 Disaster Management Plan (DMP) for Project

A Disaster Management Plan essentially consists of Disaster Response Plan, Contingency Plans and Standard Operating Procedures (SOPs). A well-coordinated Disaster Response Plan, which makes best use of the organisation's combined expertise and resources, is essential for efficient and successful disaster response. During an actual emergency, rapid and effective action is required. For this to happen, disaster response and contingency plans must be in place before a disaster strikes along with the necessary resources. If appropriate action is not taken or if the response is delayed, lives may be needlessly lost.

A detailed comprehensive Disaster Management Plan including emergency action plan for construction stage would need to be prepared which would need to be dove tailed with the state disaster management plan for which adequate provision has been kept in cost estimates. In addition to components of emergency action plan during construction stage, broadly it should consist of following:

- Disaster Response Plan
- Contingency Plan
- Awareness and Emergency Preparedness
- Emergency Action Plan (EAP)
- Communication System
- Emergency Alert System
- Emergency Warning and Control System
- Health & Medical Response System
- Training
- Mock Drills & Exercises
- Public Information System
- Information Dissemination and Safety Procedures & Plan
- Safety Procedures & Plan
- Evacuation Plans
- Notifications

10.1.19 Cost Estimates for Disaster Management

The estimated total cost of execution of disaster management plan including the equipment would be **Rs. 200.00 lakh** and the breakup of the same is given at **Table 10.48**.

Table 10.13: Estimated cost disaster management plan

S. No.	Particulars	Amount Rs. in Lakh
1	Preparation of compressive Disaster Management Plan	**100.00**
2	Setting up of communication system	**50.00**
3	Public Information System	**25.00**
4	Training & Miscellaneous	**25.00**
	Grand Total A+B	**200.00**