Chapter 9

DAM BREAK ANALYSIS AND DISASTER MANAGEMENT PLAN

9.1 Introduction

A hydropower project is laid in river valleys possessing virgin landscape of the natural environment. These projects involve construction of various civil structures like dam, diversion tunnels, headrace tunnel, open channels, shafts, underground/surface powerhouses etc, of all the structures dams are the most critical one which creates a barrier and impounds huge reservoir of water behind and are thus vulnerable to failure because of natural hazards if ill designed. To ensure long and economic life of the project, it requires to be appropriately designed based on the inputs gathered from topographical, hydrological, geological, geotechnical and seismological surveys/investigations of the site selected. The impact of project components on the environment need to be critically and scientifically analyzed, evaluated and a detailed account of disaster be incorporated as a “Disaster Management Plan” (DMP) forming part of EMP. The disaster would occur either because of technical flaw in dam design or because of some natural calamity/catastrophe like earthquakes, incessant rainfall, cloudburst and glacial outburst etc. The principal objective of the Disaster Management Plan is to identify the disaster potential scenario, suggest advance planning and measures to combat any eventuality that the project may experience during the project operation and its life. Thus it is very important to have the dam disaster management plan prepared in advance so that prompt action is taken for rescue operations in case of any eventuality to minimize the damage to nearby settlements, loss of life and property and environment.

9.2. Model for Dam Break Analysis

A number of dam break models are followed to assess failure of dam. However, the choice of a model depends upon the ground prevailing situations. All dam break models are categorized into two groups i.e; the simple empirical models and the sophisticated ones requiring high-level computer skills. Among these National Weather Services

(NWS) dam break (DAMBRK) model has been widely used over and has also been followed in the present study with the help of an empirical method. For purpose of making a decision about as to what exact magnitude of inflow to be adopted for design, a comparison needs to be made between computed synthetic values and record of floods that have occurred in the general area of interest. In the present investigation, such a comparison has been made following the methods outlined here. The input parameters used in these models include reservoir details, failure time interval, terminal size, shape of breach, downstream river cross sections, hydraulic parameters of stream, catchment characteristics, etc.

9.3. Principles of the Dam Break Model

The DAMBRK model simulates the failure of a dam, computes the resultant outflow hydrograph and also simulates movement of the dam break flood wave through the downstream river valley. The model is built around three major capabilities- reservoir routing, breach simulation and river routing. The reservoir routing may be carried out using hydrological routing techniques. DAMBRK model is capable of adopting storage routing or dynamic routing methods for routing floods through reservoirs depending on the nature of flood wave movement in reservoirs at the time of failure. After computing the hydrograph of the reservoir outflow, the time of occurrence of flood in the downstream valley is determined by routing the outflow hydrograph through the valley.

The dynamic wave method based on the complete equations of unsteady flow is the appropriate technique to route the dam break flood hydrograph through the downstream valley. The method is derived from the original equation developed by St. Venant. DAMBRK model uses St. Venant's equations for routing dam break floods in channels.

i) **Reservoir Routing**:

In this model the reservoir routing may be performed either by using storage routing or dynamic routing.

ii) **Storage Routing**:

The storage routing is based on the law of conservation given as:

$$I-Q=ds/dt \qquad (a)$$

Where,

I: Inflow into the reservoir

Q: Outflow from the reservoir

ds/dt: Rate of change of reservoir storage volume with time

The above equation (a) can be expressed in finite difference from as given below:

$$(I+I')/2-(Q+Q')/2= \Delta s/ \Delta t \qquad (b)$$

In which the superscript (') denotes values at the time t-Δt. The term Δs may be expressed as below:

$$\Delta s = (A_s+A'_s)\ (h-h')/2 \qquad (c)$$

Where,

As: Reservoir Surface Area w. r. t. Reservoir Elevation (h)

A's: Reservoir Surface Area w. r. t. Reservoir Elevation (h')

The discharge ‘Q’ in the equation (b) is a function of reservoir storage and is evaluated using Newton-Raphson technique.

iii) **Dynamic Routing**:

The hydrologic storage routing technique, expressed by equation (b) implies that the water surface elevation within the reservoir is horizontal. The routing principle is same as dynamic routing in river reaches and it is calculated by using St. Venant's equation. The movement of the dam break flood wave through the downstream river channel is simulated using the complete unsteady flow equations for one dimensional open channel flow, alternatively known as St. Venant's equations. These equations consist of the continuity equation and the conservation of momentum equation:

$\partial Q/\partial t+\partial (A+A_0)/\partial t=q$ (d)

And the conservation of momentum equation is

$\partial Q/\partial t +\partial (Q^2/A)\, \partial x+g*A(\partial h/\partial x+S_r+S_c+L_c)=0$ (e)

Where,

A= Active cross-sectional flow area

A_0= Inactive (off-channel storage) cross-sectional area

X = Distance along the channel

q=Lateral inflow or outflow per unit distance along the channel

g=Acceleration due to gravity

Q=Discharge

h=Water surface elevation

S_f= Friction Slope

S_C= Expansion-contraction loss slope

L_c= Lateral inflow/outflow momentum effect due to assumed flow, path of inflow being perpendicular to the main flow.

The friction slope and expansion-contraction loss slope are evaluated by the following equation:

$S_f = N^2 * Q^2 / 2.21 * A^2 * R^{3/4}$ and

$S_C = K * \Delta (Q/A)^2 / 2 * g * \Delta x$

Where,

N= Manning's roughness coefficient

R=A/T where T is the top width of the active portion of the channel

K= Expansion-Contraction Coefficient

$\Delta (Q/A)^2$ = Difference in $(Q/A)^2$ for cross sections at their reach end.

* is used to denote multiplication

The non-linear partial differential equations (d) and (e) are represented by a corresponding set of non-linear finite difference algebraic equations and they are solved by the Newton-Raphson method using weighted four point implicit scheme to evaluate 'Q' and 'h'. The initial conditions are given by known steady discharge at the dam, for which steady state non-uniform flow equations are used. The outflow hydrograph from the reservoir is the upstream boundary condition for the channel routing. The model is capable of dealing with fully supercritical or fully sub critical flow or the upstream reach supercritical flow. There is a choice of downstream boundary conditions such as internally calculated loop rating curve, user provided single value rating curve, user provided time dependent water surface elevation, critical depth and the dam which may pass flow via spillways, overtopping and/or breach.

9.4 Methodology

The computation of flood wave resulting from a dam breach basically involves two problems, which can be considered jointly or separately, they are:

i) Outflow hydrograph from the reservoir, and

ii) Routing of the flood wave downstream from the breached dam along the river channel and flow plain.

If breach outflow is independent of downstream conditions, or if their effect can be neglected, the reservoir outflow hydrograph is referred to as free outflow hydrograph. In this case, the computation of the flood characteristics is divided into the following two distinct phases:

i) Determination of outflow hydrograph with or without the routing of the negative wave along the reservoir, and

ii) Routing of flood wave downstream from the dam breach.

The problem of simulating the failure of a dam is done by computing the free outflow hydrograph from the breached dam using storage routing technique. The routing of this outflow hydrograph along the downstream channel is done by using dynamic routing technique with the aim of reproducing the maximum water level marks reached during the passage of flood wave. The information regarding inflow hydrograph into the reservoir due to the Probable Maximum Flood (PMF) at the time of failure, the structural and the hydraulic characteristic details of the dam, the time of failure, the channel cross sectional details, the maximum water level marks reached in the reservoir at the time of failure and those observed in the downstream reach of the dam due to the passage of flood wave, etc have been considered in this study.

9.5 Project Salient Features and Details

The summary of the project salient features are given in **Table 9.1** and the details are described in the following paras.

iv) The Bursar Project is proposed on River Marusudar which involves construction of straight gravity concrete dam near village Pakal, about 25km downstream of the confluence of Wadwan and Rin rivers. It is proposed to divert a designed discharge of 209.95 cumecs (at Pakal having invert level of the intake structure at EL 2014.69m) through 6.7Km long tunnel of 8.5m diameter to surface powerhouse (at Lopara). A dam toe powerhouse is also planned to utilize 22.90 cumecs of water for power generation as well.

v) Bursar Project is envisaged as a storage project. Based on the Reservoir Elevation-Area-Capacity studies, by utilizing 35 cross sections (at interval varying from 100m to 500m) from the dam axis covering the upstream distance of 22.80km up to tail of the proposed reservoir. Reservoir parameters computed are: surface area 12.48 sq km at FRL (EL 2134m) and the gross storage of reservoir at proposed FRL (EL 2134m) is as 726.30 Mcum. At MDDL (EL 2030m), capacity of reservoir has been as 107.86 Mcum and therefore live storage works out to 618.44 Mcum (0.501MAF). At FRL the reservoir surface area would be of elongated shape.

vi) The proposed dam would be 265m high from river bed level (EL 1872) the dam top would correspond to EL 2137m. The dam top (EL 2137m) shall have a length of 737m, of which non-overflow portion 677m in length and overflow portion 60m in length. The overflow section constitutes spillway portion (total 60m length), to cater the designed flood discharge, which comprises four blocks (each 15m) which has its crest elevation at 2114.50m. Each spillway shall be provided with hydraulically operated radial gates.

vii) Marusudar is a mighty right bank tributary of the river Chenab. The catchment area of the Marusudar River at Dam site is 3060 km^2, comprising 1676 km^2 snow-fed and 1384 km^2 rain-fed.

viii) Design flood analysis has been carried out for the project. The flood/peak discharge in Marusudar River is generally observed during the monsoon period due to heavy rains and snowmelt in its catchment. As the reservoir storage is 726.30 MCUM, the height of the dam being higher than 30m, therefore, as per Central Water Commission criteria and IS-1223-1985, the spillway of the dam is required to negotiate maximum probable flood.

For the estimation of the design flood for the Bursar project the annual flood peaks for the period 1975-2013 have been used in the flood frequency analysis. Thus the series developed in this manner for the period 1975-2013 has been used to perform analysis at the dam site. Since the peak flow can pass at any time other than the observed time of the discharge flow, the annual flood peaks were enhanced by 36% to make it instantaneous flood peaks, as the hourly gauges are not available for the flood period. The data on flood peaks at the dam site for the period from 1975-2013 are given in **Table 9.2** and **Fig 9.1**.

On the basis of the results of the flood frequency analysis Probable Maximum Flood of 4577 cumecs has been recommended and adopted for the Bursar Project. Unit hydrograph studies, for computation of flood inflow to a full reservoir, reveal peak flood discharge of 4419 cumecs which is nearly comparable with the value of 4577 cumecs computed by frequency analysis method. 2-day SPF has been worked out as 2792 cumecs. 100 year return flood value of 2126 cumecs has been adopted. The diversion flood value of 1650 cumecs, based on the available data base, has been recommended for 25 year return period.

HEC-RAS model was run to develop the rating curves at Dam site and at TRT outlet locations on the Marusudar River, and the curves indicate that the discharge of 4750 cumecs correspond to the water level of 1887.66m for the dam axis location while as at the TRT outlet location the discharge of 4750 cumecs correspond to the water level of 1737.65m.

Table 9.1 Salient Features of Bursar Project

S. No	Description	Features
1	River	Marusudar
2	Catchment Area Up to Dam Site	3060 Sq Km
3	Elevation (Origin) of River	5175m
4	Average Annual Rainfall Average Annual Snowfall	757.00mm 467.10mm
5	Design of the Project	Storage
6	River Length Up to Dam Site	133 Km
7	Type of the Dam	Concrete Gravity
8	Dam Top	EL 2137m
9	Bed Elevation at the Dam site	1872m
10	Height of the Dam (from river bed level)	265m
11	Full Reservoir Level (FRL)	2134m
12	Maximum Water Level	2134m
13	Minimum Draw Down Level	2030m
14	Gross Storage At FRL At MDDL Live Storage Reservoir Surface Area at FRL	 726.30 MCUM 107.90 MCUM 618.40 MCUM (0.5 MAF) 12.48 Sq Km
18	Manning's "n"	0.040
19	Design Flood Value (PMF) Adopted GLOF	4577 Cumecs 371 Cumecs
20	Diversion Flood Adopted	1650 Cumecs
21	Annual Peaks Discharges Enhanced by	36%
22	Average Annual Sediment Load (computed)	253.20 Ham
23	Bed Load Sediment (Assumed)	20%
24	Annual Sediment Load (Adopted)	306 Ham
25	Rate of Sediment Inflow	0.1 ham/sq.km/year

Table 9.2 Annual Peak Discharge (cumecs) of the Marusudar River at the Dam Site

S. No	Year	Peak Discharge (Cumecs)	Instantaneous Peak Discharge (Cumecs)
1	1975	1010.1	1373.73
2	1976	1062.6	1445.13
3	1977	1003.2	1364.35
4	1978	1257.4	1710
5	1979	1099.8	1495.72
6	1980	1169.9	1591.06
7	1981	970	1319.2
8	1982	898.9	1222.5
9	1983	1097.7	1492.87
10	1984	1184.1	1610.37
11	1985	936.2	1273.23
12	1986	1417.7	1928.07
13	1987	1407.4	1914.06
14	1988	1476.3	2007.76
15	1989	961.1	1307.09
16	1990	1196.5	1627.24
17	1991	1324.1	1800.77
18	1992	1189.4	1617.58
19	1993	1345.1	1829.33
20	1994	1212.7	1649.27
21	1995	1081	1470.16
22	1996	1162.4	1582.66
23	1997	699.5	951.32
24	1998	1060	1441.6
25	1999	761.1	1035.09
26	2000	571	776.56
27	2001	575.2	782.27
28	2002	735.6	1000.41
29	2003	961.3	1307.36
30	2004	388.7	528.63
31	2005	882.9	1200.74
32	2006	952.1	1294.85
33	2007	1005.4	1367.84
34	2008	1036.9	1410.18
35	2009	854.9	1162.66
36	2010	1031.1	1402.29
37	2011	1021.81	1389.66
38	2012	937.7	1275.27
39	2013	1104.2	1501.71

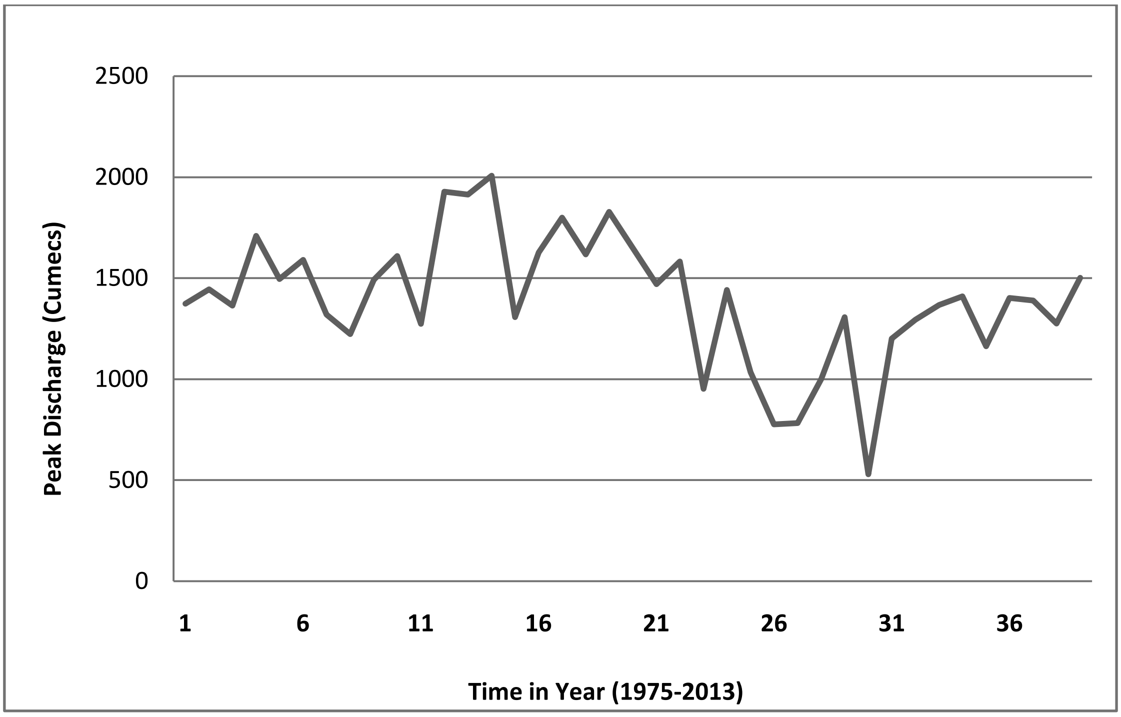

Fig.9.1 Annual Flood Peak Discharge Curve of Marusudar River at the Dam Site

9.6 Data Requirement

The analysis of the dam failure involves the generation of database on catchment which includes soil, drainage, precipitation and topographic characteristics; and hydraulic characteristics, etc. to prepare the following:

i) Inflow hydrograph to the reservoir at the time of failure,
ii) Routing through the reservoir at the time of failure,
iii) Outflow hydrograph at various desired downstream locations, and
iv) Finding the movement of the flood wave downstream to determine travel time, maximum water level reached, inundated areas, etc.

Data on the dam parameters, inflow hydrograph into the reservoir and outflow hydrograph include information on:

v) Reservoir elevation-area-capacity relationship,
vi) Spillway details,
vii) Elevation of top and bottom of the dam,

viii) Elevation of water surface in the reservoir at the beginning of analysis and the time of failure,

ix) Breach description data, and

x) Cross-sections of the river at different locations downstream of the dam site

The data considered for conducting the dam break analysis included data pertaining to dam and river characteristics as given in **Table 9.1**. The breach parameters included time of failure of breach (T), bottom width of breach (b), side slope of breach (z), final elevation of the bottom of breach (hbm), initial elevation of water level in the reservoir (h_i), final elevation of water level when breach (h_f) begins to form and top of dam (h_s)

Concrete gravity dams tend to have partial breach as one or more monolith sections formed during the construction of the dam are forced apart and over turned by the escaping water. The time for breach formation is a matter of a few minutes. It is difficult to predict the number of monoliths, which may be displaced. In the present study, the concrete dam (top 2137m and FRL at 2134m) is having 46 blocks (25 on left bank, 17 on the right bank and 04 spillway blocks). It has been assumed that the four spillway blocks are most critical. Since spillway is in four blocks (each of 15m width), therefore breach widths have been taken 15m, 30m, 45m and 60m. The breach time assumed for all the breach widths are 15 minutes. Since the dam is of concrete type therefore side slope breach has been taken as zero. Bottom breach is at 1872m elevation.

31 cross sections of the river Marusudar downstream of the proposed dam axis, were used 18 of which were furnished by the project authority whereas data of 13 were generated from the available Survey of India Topo Sheets (1: 50,000 Scale and 25,000 Scale). The contraction and expansion coefficients between cross-sections were estimated for all other parameters such as initial size of time step and downstream boundary parameter. The weighting factor the convergence criterion was kept at zero. The routing of the outflow hydrograph through the reservoir to downstream valley was carried out.

The data pertaining to the 31 locations, downstream from the dam, is given in **Table**

9.3. This data includes that of bed levels, water columns in the river channels, flood levels after the dam breach and the lag time.

Table 9.3 Bed Level versus Flood Wave Level at Different Locations Downstream of Dam

Location (D/s from Dam site)	Flood Wave Level (m)	Bed Level (m)	Pre-Flood Water Level (m)	Time Lag (m)
0 km	1982.50	1872.00	1876.42	0
1 km	1962.78	1847.78	1854.54	5.90
2 km	1943.23	1825.73	1828.23	11.80
3 km	1921.00	1803.60	1806.10	17.70
4 km	1885.00	1783.30	1788.08	23.60
5 km	1870.00	1743.90	1750.42	29.50
6 km	1795.00	1717.20	1721.04	35.40
7 km	1740.00	1704.23	1705.73	41.30
8 km	1770.00	1679.66	1680.16	47.20
9 km	1734.50	1669.25	1669.50	53.10
10 km	1732.80	1647.55	1647.80	59.00
11 km	1727.50	1637.62	1637.87	64.90
12 km	1718.50	1622.64	1625.64	70.80
13 km	1736.25	1612.13	1615.13	76.70
14 km	1743.00	1605.75	1608.75	82.60
15 km	1695.00	1597.66	1601.66	88.50
16 km	1673.07	1575.48	1578.48	94.40
17 km	1691.84	1540.90	1542.59	100.30
18 km	1706.40	1520.00	1521.50	106.20
19km	1617.33	1480.00	1482.00	112.10
20km	1624.62	1440.00	1441.48	118.00
21km	1588.75	1400.00	1402.49	123.90
22km	1567.98	1399.00	1401.38	129.80
23km	1482.91	1263.33	1265.83	135.70
24km	1469.69	1185.82	1187.32	141.60
25km	1326.12	1156.05	1158.55	147.50
26km	1401.42	1154.28	1155.78	153.40
27km	1313.35	1154.10	1155.40	159.30
28km	1299.29	1153.50	1154.80	165.20
29km	1213.69	1152.90	1153.90	171.10
30km	1294.32	1152.10	1153.20	177.00
31km	1293.53	1145.25	1146.75	182.90

9.7 Results and Conclusions

The dam is apparently safe for various upstream and downstream water level cases but a drag force would be exerted on remaining blocks due to assumed breach cases. However, in case of dam break, the maximum water levels of the outflow downstream of dam axis up to 31 km are given in **Table 9.3** and **Fig. 9.2**. The study was conducted on 60m breach width and 15-minute breach period. As per the UK Dam break Guidelines and U.S. Federal Energy Regulatory Commission (FERC) Guidelines the short beach time of 15-minute has been taken because the concrete dam failure is instantaneous. The results of modelling reveal a time lag of about 182.90minutes (about 3h and 04m) to reach 31 km downstream of the dam site. The distribution of time lag v/s flood wave downstream from the dam for 31 km distance is given in **Table 9.3** and the resulting curve is given as **Fig. 9.3 (a & b).** Flood Wave Level versus Different Downstream Locations is shown in **Fig. 9.3 (a);** while as Time Lag Curve of Flood Wave is shown in **Fig. 9.3 (b).**

However, it is seen that the flood wave would terminate near about RD 24875 & EL 1326.12m of the river course i.e; near Simanhine and Kurur located along right and left banks respectively after a time lag of 2h and 45m.

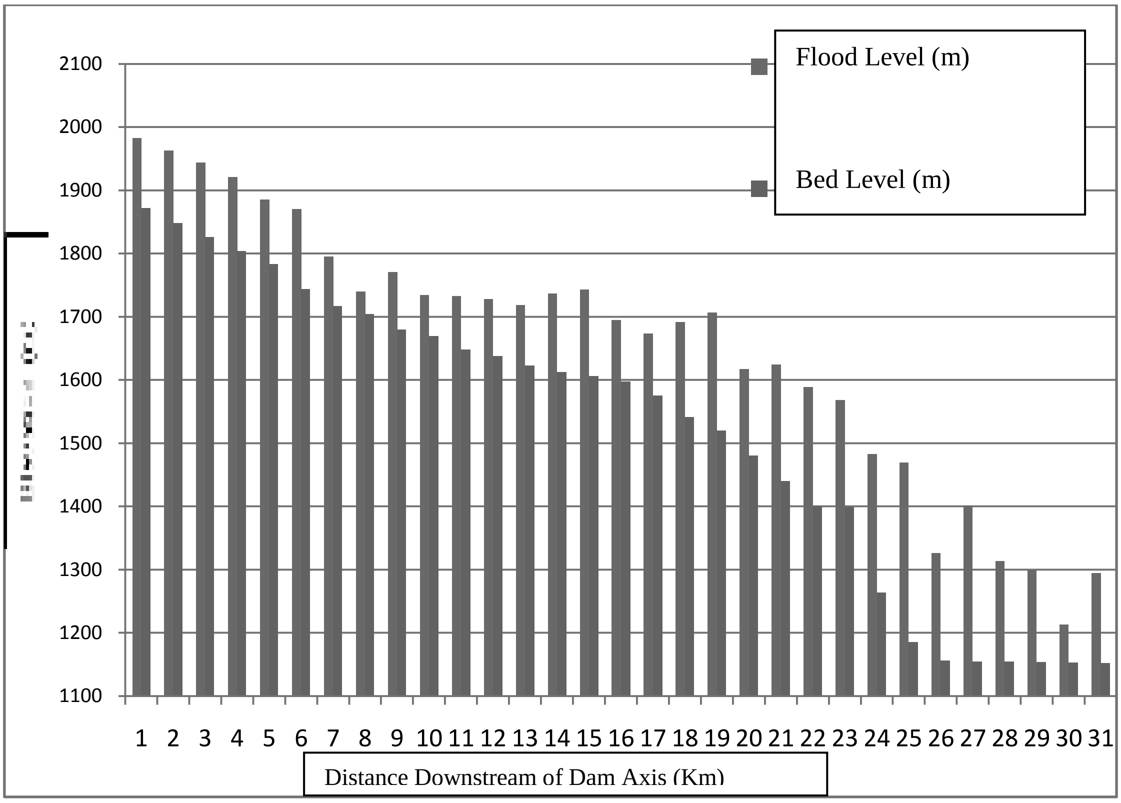

Fig.9.2: Maximum Flood Wave v/s Bed Level at Downstream Locations of Dam

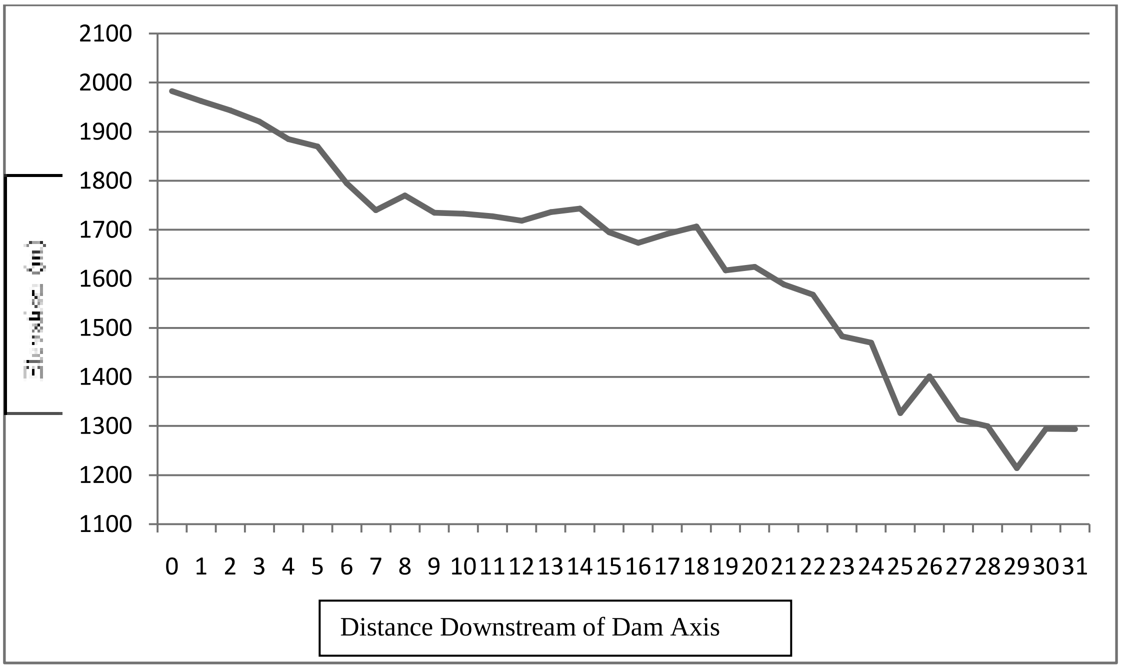

Fig. 9.3 (a) Flood Wave Level versus Different Downstream Locations

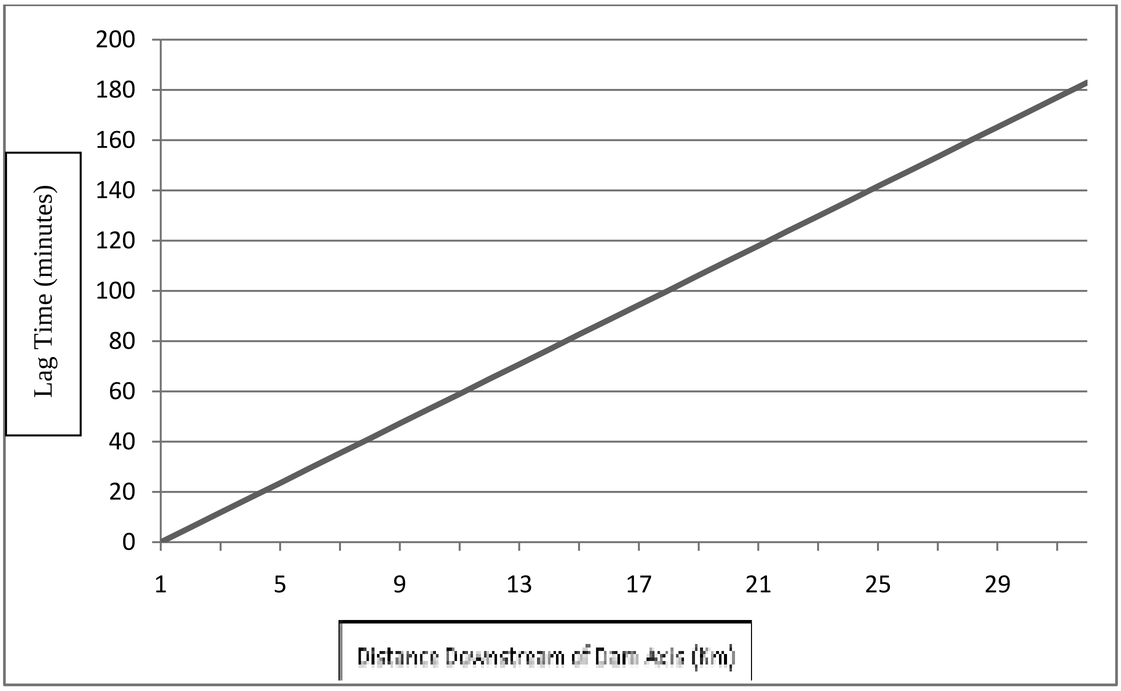

Fig. 9.3 (b) Time Lag Curve of Flood Wave

From the profiles of flood wave crests and flood map downstream of the dam, it seen that the flood wave would inundate the lower portions/fringes of the villages:

- Along right bank- Kaspal Had, Hirar, Tarungai, Bhardu, Lopora, Batpora, Thonsar, Prangas & Tundar, Kraipokhun, Gwan, Bazdiun, Cherabhatson and Simanhine. Amongst all the settlements located in these villages only five (05) houses: one (01) at Bhatpora and three to four (04) at Cherabhatson and Simanhine would get affected.
- Along left bank- Chhichha, Sirshi, Tragbal, Panjdhar, Loharna, Sondar, Tandar, Swarbhati, Drungdhuran, Pinj and Kurur. Amongst all these settlements located in these villages only twenty nine (29) houses: one (01) at Chhichha, three (03) at Chirazbal, one (01) at Loharna, two (02) at Sonder, one (01) at Drangdhuran, six (06) at Pinj, seven (07) at Ikhala and six (06) of Kurur would get affected.
- From the above it is also seen that in all 32 (thirty two) households besides some ropeways, mills and wooden bridges may also get affected.

Based on this likely anticipated disaster that may occur at the time of dam breach a comprehensive Disaster Management Plan with tentative costs has been formulated to deal with the situation and is discussed in the paras that follow.

9.8 Disaster Management Plan

Preparation of "Disaster Management Plan" for any hydroelectric project is a prerequisite, as catastrophic situation, which is highly unpredictable, may occur any time in the life span of project. To tackle the catastrophic situation development of an effective "DMP" is imperative to establish co-ordination between District Administration and Project Authority. Line/Assisting agencies from district administration side are Fire Services, Police Department, Medical Services, Consumer Affairs and Public Distribution Department, Transport Department, Communication Department, Meterology Department, Irrigation and Flood Control Department, Civil Defence Forces and Voluntary Organizations. Coordination and close cooperation among all the agencies involved is essential for the timely and successful implementation of "DMP" to provide relief to the affected at the time of need.

Well defined role and responsibilities of assisting agencies in "DMP" is required, so that proper planning, according to the intensity of disaster could be made by agencies. Identification of the event and its intensity in the affected area is assessed by the Chief Co-ordinator. He should be authorized to declare "disastrous situation" based on detailed information available, so that assisting agencies swing in action to mobilize their resources in affected area. Based on the intensity of disaster in project a proper relief programme may be implemented by District Administration with the help of assisting/line agencies.

9.8.1. Preparation of Inundation Map

The downstream areas vulnerable to inundation by dam break flood are shown in the inundation map prepared for the area is placed as **Fig.9.4.** In the dam break models maximum flood elevation at each original or interpolated cross section is computed. The selected dam break flood for this purpose corresponds to the extreme conditions that yield maximum possible flow storage at the downstream locations. The extreme condition is estimated from various parameters like breach width, minimum time of

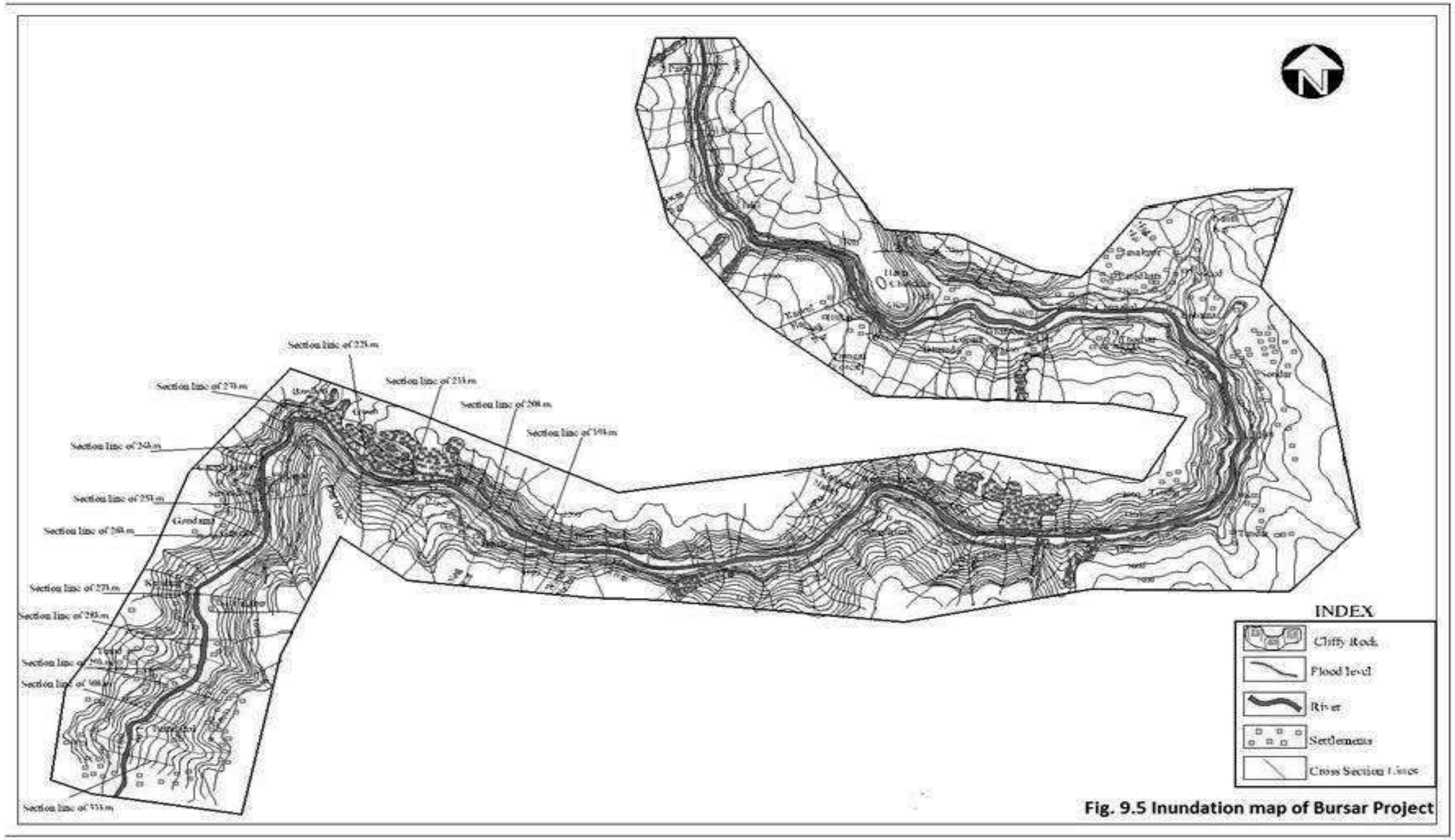

Fig. 9.5 Inundation map of Bursar Project

Fig. 9.4 Inundation map of Bursar Project

failure and Manning's coefficient. The inundation map has been prepared with the help of water surface elevation profile, which has been computed for maximum flood discharge elevation and at various downstream locations.

Given the topographic characteristics the flood will be confined generally within the narrow valley sections barring low lying areas of Kaspal Had, Hirar, Tarungai, Bhardu, Lopora, Batpora, Thonsar, Prangas & Tundar, Kraipokhun, Gwan, Bazdiun, Cherabhatson and Simanhine along the right bank; and Chhichha, Sirshi, Tragbal, Panjdhar, Loharna, Sondar, Tandar & Swarbhati, Drungdhuran, Pinj and Kurur. However, thirty two household owners of these villages shall get affected. The details of these are: Five (05) houses: one (01) at Bhatpora and three to four (04) at Cherabhatson and Simanhine along the right bank would get affected; and Twenty nine (29) houses: one (01) at Chhichha, three (03) at Chirazbal, one (01) at Loharna, two (02) at Sonder, one (01) at Drangdhuran, six (06) at Pinj, seven (07) at Ikhala and six (06) of Kurur along left bank would get affected. Besides some ropeways, mills and wooden bridges may also get affected.

The map thus prepared, would serve as a guide for working out details of these vulnerable areas. The inundation map would be displayed at all the downstream flood prone locations depicting maximum water level that would be attained. The elevations together with other geographical details could be marked on ground of the downstream areas **(fig. 9.5).**

On the basis of the dam break analysis the flood wave is expected to inundate some low lying areas in the first twenty five km downstream of the dam site approximately in 02 hour and 45 minutes. This means that very little time would be available for execution of any rescue and/or evacuation plan. Therefore, the Disaster Management Plan has been devised mostly for preventive measures. As a first measure of the management plan it is suggested that surveillance and monitoring schemes be implemented simultaneously with the design and detailed engineering stage of the project. It should continue during the construction phase through impoundment of reservoir, early operation period, and operation and maintenance phases during the life of the dam. On

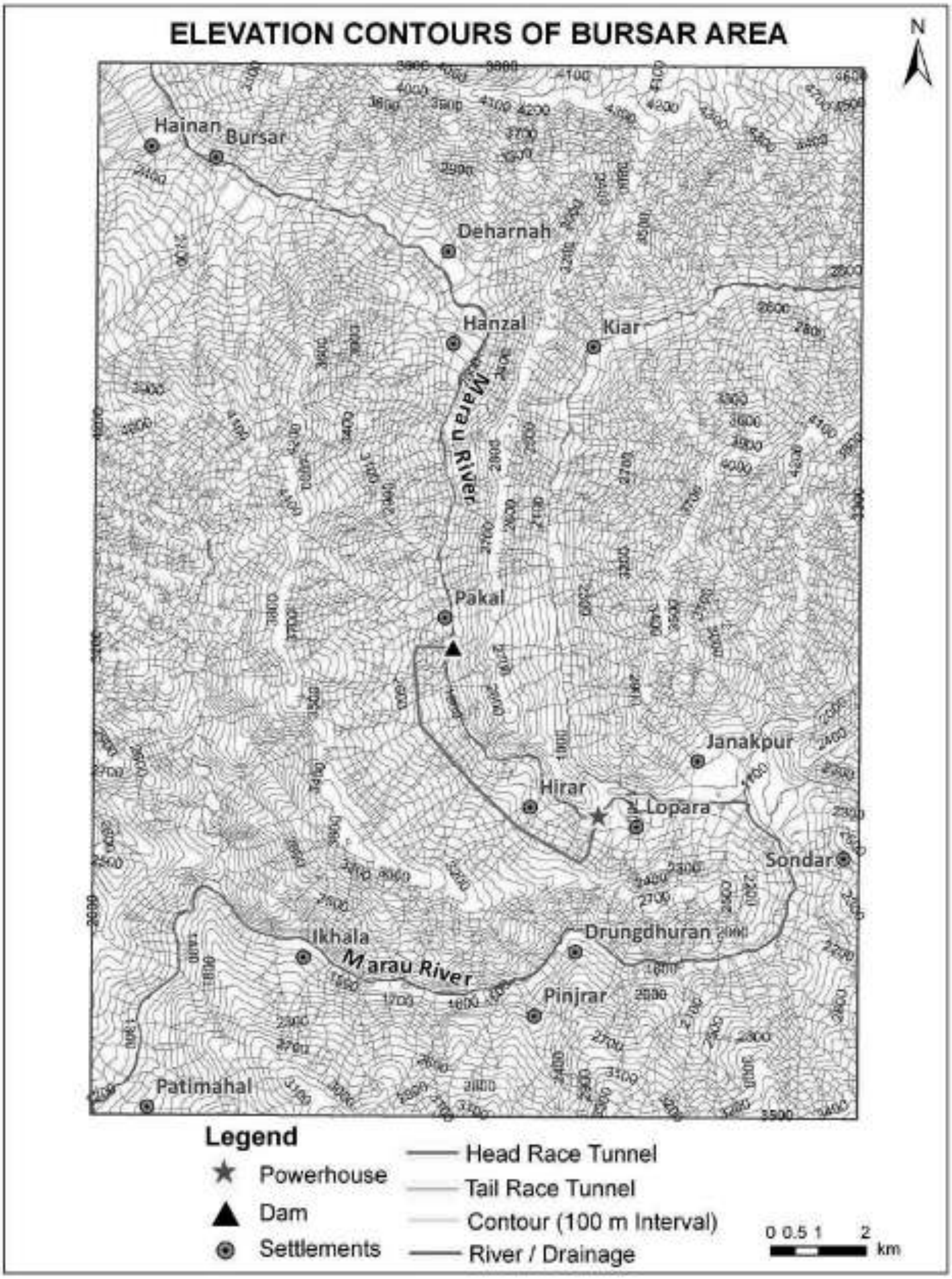

Fig. 9.5 Elevation contours of Bursar project area

the onset of high discharge period on all dates the electricity, public announcement system, power generator backups etc; should be thoroughly checked.

In the event of dam break the following flood conditions have been considered for different levels of alertness.

Table 9.4 Flood conditions for different levels of alertness

Sl. No.	Water Level	Status
1	Below FRL (2134m) (20% of the PMF)	Normal Flood
2	Rises above FRL	Level-1 Emergency
3	Top of Dam (2137) and keeps on rising	Level-2 Emergency
4	Top of dam and continues to rise and breach start	Disastrous Level

The following precautionary and preventive measures need to be taken up at the different levels of emergency:

Level-1 Emergency: At the Level-1 Emergency all gates should be kept fully operational. All concerned officials should reach at the dam site to take suitable preventive measures. All warning systems should be kept on alert. The local monitoring officials should be kept abreast of the situation. A flood warning should be issued to the people at risk for taking up of life saving measures.

Level-2 Emergency: At this point only a few minutes would be available for taking any action. All the staff from the dam site would be alerted and advised to move to a safe place. The District Administration and NHPC authorities should be informed about the possibility of dam failure. All the communication systems and safety measures should be put into operation immediately. Public announcement system and/or centralized siren system should be used.

Disastrous Level: Under the disastrous conditions only life saving measures should be given priority and the administration and project authorities should be intimated immediately.

9.8.2. Mitigation Measures/ Dam Safety Measures

The following measures should be taken to avoid loss of lives and property.

a. Monitoring

As the dam safety plan is most important, the project authorities (NHPC) should prepare detailed effective dam safety surveillance and monitoring scheme, which should include rapid analysis and interpretation of instrumentation and different observation data along with periodic inspection, safety reviews and their evaluation.

The Dam Safety Plan is implemented during the following the following five phases covering the life of the dam.

(i) Design and investigation phase
(ii) Construction Phase
(iii) First reservoir impoundment
(iv) Early operation period, and
(v) Operation and maintenance phase

b. Strengthening of river banks downstream of dam

The slopes of the low lying areas of the Kaspal Had, Hirar, Tarungai, Bhardu, Lopora, Batpora, Thonsar, Prangas & Tundar, Cherabhatson and Simanhine along the right bank; and Chhichha, Sirshi, Tragbal, Panjdhar, Loharna, Sondar, Tandar & Swarbhati, Chirazbal, Drangdhuran, Pinj, and Kurur along the left bank shall get inundated thus be provided with protection measures viz; construction of gabions/wire mesh crates. These structures may be raised up to the level of danger mark.

c. Emergency action plan

The formulation of an emergency action plan would depend upon the expected levels of emergency. The specific safety plans for different levels of emergency would have to be prepared for tackling the dam break situation and chalk out appropriate warning procedures to be followed in case of failure and/or potential failure of the dam. The main emphasis should be an issuing timely warning to the people at risk and alert the officials responsible for taking action in case of an emergency.

d. Administrative setup

The administrative and procedural aspects of an Emergency Action Plan consist of a flow chart depicting the names and addresses of the designated officials appointed for the purpose. In case the failure is imminent or the failure has occurred or a potential emergency condition is developing, the observer at the site should report to the Engineer-in-Charge through a wireless system or by any fastest available communication system. The Engineer-in-Charge would in turn be responsible for informing the Civil Administration, viz; District Magistrate about the developing situation.

For implementation of "Disaster Management Plan" at the time of emergency, setting of a control room as nodal point to monitor the ground situation is essential. Control room should be located in close vicinity of the project and equipped with the following:

i. Copy of Disaster Management Plan
ii. Resource Plan prepared by the District Administration
iii. Map indicating evacuation points for affected population at the time of emergency and their shelter areas etc
iv. Area map showing topographic, demographic and infrastructure details, i.e; hospitals, roads, helipads, school etc.
v. Telephone directory to contact various assisting agencies and communication system such as telephones, VHF sets etc.

Each person should be made aware of his/her responsibilities/duties and the importance of work assigned under the Emergency Action Plan. All villages falling under the flood prone zone or on margins should be connected through wireless communication system with a back-up of standby telephone lines. A centralized siren alert system should be installed at all the village “Panchayat Ghars” so that in the event of a warning all villagers can be alerted through sirens.

e. Maintenance measures

The personnel responsible for preventive measures would identify equipments that need repairs and the materials needed for the purpose, labour and expertise for use during an emergency. The amount and type of material required for emergency. The amount and type of material required for emergency repairs should be determined for the dam, depending upon its characteristics and design. Sufficient and suitable construction materials should be stockpiled near the dam site. The anticipated need of equipment should be evaluated and if these were not available at the dam site, the exact location and availability of this equipment should be determined and specified. The sources/agencies be provided with necessary information/instruction or assistance in case of emergency situations.

Dry mock runs, drills and exercises should be conducted from time to time simulating the emergency situations in order to evaluate and assess the effectiveness of various preventive actions that should be framed to tackle emergency situations. A plan for regular inspection of the dam should be drawn. The overflow and non-overflow sections be properly illuminated. Whenever sinkholes, boils increase in leakage, movement of soil, gate failure, rapid rise or fall of the level in the reservoir or wave overrun of the dam crest are observed, the personnel on patrol should immediately inform the Engineer-in-Charge. He should inform local administration authority about the situation. The downstream population should be warned about the imminent danger using siren or other warning systems available.

f. Communication system

An efficient downstream warning and communication system is essential for the success of Emergency Preparedness Plan. The population living downstream should be educated about the difference between a high flood and dam break situation. In case of emergency situations telecommunication plays a critical and crucial role in mitigating the problems faced by people during and after calamity. Any efficient communication system in disaster management should have the following characteristics:

i. Reliability
ii. Ease of maintenance
iii. Quick deployment
iv. High tolerance to extreme adverse conditions
v. Compatibility on alternative power sources, and
vi. Fast transportability and easy deployment

The traditional communication facilities such as telephones, microwave links, telex services, mobile phones, etc. should be installed simultaneous with project initiation. Besides, the project authority should install a modern suitable communication system in the project impact area.

g. Communication Components

The communication system, in general consists: (a) Strong Mobile network with dedicated towers for efficient network availability in the entire project earlier, (b) a Transmitter; (c) a Receiver, and (d) a network management system. A single communication unit may have both transmitter and a receiver on a single platform. In addition, there has to be a medium for messages and data to travel. Keeping various factors in mind, the basic medium would be radio waves as other mediums such as copper or fibre optic cable are likely to be distorted during disaster. In the far flung areas such terrestrial links are either not existing or are extremely expensive and time consuming. The foremost requirement of a communication system is to support voice, fax and data services so as to enable transmission of any type of data from one site to other.

h. Evacuation Plan

The Emergency Action Plan also includes evacuation of people at risk and procedures for implementation are based on the local needs. Generally the following procedure forms the basis of the plan:

- i) Demarcation and prioritization of areas to be evacuated
- ii) Notification procedures and evacuation instructions
- iii) Safe routes, transport and traffic control
- iv) Safe areas and shelters, and
- v) Functions and responsibilities of members of the evacuation team

The flood prone zone identified from the dam break studies should be delineated and the entire zone should be assigned adequate factor of safety. As the flood wave would take about two hours and forty five minutes up to 25 Km, the people living in downstream areas namely Kaspal Had, Hirar, Tarungai, Bhardu, Lopora, Batpora, Thonsar, Prangas & Tundar, Cherabhatson and Simanhine along the right bank; and Chhichha, Sirshi, Tragbal, Panjdhar, Loharna, Sondar, Tandar & Swarbhati, Chirazbal, Drangdhuran, Pinj, and Kurur along the left bank should be informed well in time through wireless, alerted through sirens, etc. The flood zone should be marked at all the inhabitated areas downstream.

i. Notification

Notification procedure forms an integral part of any Emergency Action Plan. Different procedures are suggested to establish for different situations in the process of dam break. Two types of notifications should be issued. The first one should include communication of an alert situation indicating that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. The second type of notification should include an alert situation followed by a warning situation. A warning situation should indicate that flooding is imminent due to expected dam failure. It should normally include an order for evacuation of delineated inundation areas.

The copies of the Emergency Action Plan also include the above described inundation map. This map should be made available to the persons responsible for execution of the plan. Besides, the copies of the map should be displayed at prominent locations and in the offices of the authorities concerned. Inundation maps should be displayed in the Village Panchayat Ghars in the project impact area. For a regular watch on the flood level situation, two or more people should man the flood cells so that an alternative person is available for notification round the clock.

For speedy and efficient communication, a wireless system would be a preferable mode of communication. Telephones and mobile phones should also be used as and when required. All the critical points in the project impact area including dam component should be provided with the wireless/cordless communication systems.

The guidelines to be observed by the inhabitants in the event of dam break, formulated under the public awareness for disaster mitigation in the Disaster Management Plan are:

i) Listen to the radio/TV for advance information and advice,
ii) Disconnect all electrical appliances and move all valuable personal and household belongings out of reach of flood impact area,
iii) Move vehicles, farm animals and movable goods to the nearby safer places,
iv) Prevent dangerous pollution by moving all insecticides out of reach of water,
v) Turn off electricity and gas,
vi) Lock all outside doors and windows in case of evacuation, and
vii) Do not enter floodwater

9.9. Public Awareness Programme

The people living around the project area can play a vital role in the event of disaster due to dam break. For this purpose Public Awareness Programs should be conducted regularly to make the general public aware about potential hazards likely to occur in the project area. Emphasis may be given to the following aspects:

- Pamphlets and booklets containing details about the hazards associated with hydropower project may be prepared and distributed among general public,
- Permanent notice boards may be fixed at all the suitable places in the area displaying information related to assisting agencies, their telephone numbers, etc;
- Help from local youth organizations, voluntary organizations, educational institutions may be sought to conduct educational sessions to make people aware about the safety measures and rescue operations in the event of the disaster, and
- Teachers in these areas can educate the students about the preparedness in the event of any eventuality in case of dam break.

A monitoring committee should be constituted in consultation with the District Administration to ensure preparedness for implementation of the "Disaster Management Plan". The committee shall review the effectiveness of plan at regular intervals and call for mock-rill as per requirement in the project area. The committee may also suggest improvement in the action plan as may be deemed fit by it on the basis of its observations through time.

9.10. Setting up of the Seismic Observatory

The area fall in the seismic Zone –IV, as per the Seismic Zonation Map of India prepared by India Meteorological Department (IMD), all the characteristics related to seismicity, tectonics, seismotectonics and associated aspects have been dealt in detail in the Geology Chapter of the EIA Report. Therefore, a plan of seismic surveillance of the area by establishing a seismic monitoring station is recommended. Setting of seismic observatory and installation of the equipment should coincide with the commencement of project execution in order to gather micro details and refine the already collected data: (i) with regard to neo-tectonic activity prevailing if any in the area, and (ii) to judge the effect of reservoir impoundment on the seismic status of the area.

9.11. Cost Estimates

The disaster management plan and related activities would incur some expenditure on construction of gabions/wiremesh crates, rehabilitation costs of affected household owners etc; and setting up of the seismological and communication networks, preparation of different plans related to the warning system, administrative jobs, training programmes, public awareness programmes, setting of seismic observatory etc. For this purpose budgetary provision of **Rs. 750.00 Lakhs** has been kept in the Disaster Management Plan the details of which are given in **Table 9.5.**

Table 9.5 Cost Estimates for Implementation of Disaster Management Plan

S. No	Particulars (Item of Work)	Amount (Rs in Lakhs)
1	Construction of Gabbions/Wire mesh Crates, etc	200.00
2	Rehabilitation and relief measures of the affected household owners	224.00
3	Installation of alert systems, setting up of control room etc	50.00
5	Setting of Communication System	30.00
5	Notification and publication procedures, miscellaneous, etc	10.00
6	Setting Up of Seismological Observatories	200.00
7	Costs on account of future detailed studies	36.00
	Total	**750.00**