CHAPTER – 8

DAM BREAK ANALYSIS AND DISASTER MANAGEMENT PLAN
8 DAM BREAK ANALYSIS & DISASTER MANAGEMENT PLAN

8.1 DAM BREAK ANALYSIS

The construction of dams in rivers can provide considerable benefits such as the supply of drinking and irrigation water as well as the generation of electric power or the flood protection. However, the consequences, which would result in the event of their failure, could be catastrophic. They vary drastically depending on the extent of the inundation area, the size of the population at risk, and the amount of warning time available.

8.1.1 INTRODUCTION

Dam breach 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 failed structure. A dam break may result in a flood wave up to tens of meters deep traveling along a valley at high speeds. The impact of such a wave on developed areas can be very devastating. Such destructive force causes an inevitable loss of life, if advance warning and evacuation was not possible. Additional features of such extreme flooding include movement of large amounts of sediment (mud) and debris along with the risk of distributing pollutants from any sources such as chemical works or mine workings in the flood risk area.

In spite of great advancements in design methodologies, failures of dams and water retaining structures continue to occur. Dam break is most likely to occur during the monsoons under the occurrence of extremely heavy storms. The dam may breach on account of some structural failure or faulty maintenance. In this condition, the outflow from the dam will be combined with lateral inflows from the areas downstream of the dam. The instances of dam breaks establish that hazard posed by dams, large, and small alike, is catastrophic. As public awareness of these potential hazards grows, and tolerance of catastrophic environmental impact and loss of life reduces, managing and minimizing the risk from individual structures has become an essential requirement, rather than the employment of a simple management option.

The dam break study is based on the guideline used in the United States of America by the Federal Energy Regulatory Commission (FERC) and U.S. Bureau of Reclamation (USBR). The methodology adopted for the dam break analysis and the parameters assumed along with justification for their assumption are discussed in the following paragraphs.

8.1.2 OBJECTIVE OF DAM BREAK MODELLING

The first European Law on dam break was introduced in France in 1968 following the earlier Malpasset Dam failure. Since then many countries have also established requirements and in others, dam owners have established guidelines for assessment.
In India, risk assessment and disaster management plan has been made a mandatory requirement while submitting application for environmental clearance in respect of river valley projects.

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 vis-a-vis conditions assumed for normal river flow modelling and areas will be inundated that are not normally considered. This makes dam break modelling a separate study for the risk management and disaster management plan. The objective of dam break modelling 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:

- Time of first arrival of flood water
- Peak water level – extent of inundation
- Time of peak water level
- Depth and velocity of flood water (allowing estimation of damage potential)
- Duration of flood

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

8.1.3 SCOPE OF PRESENT STUDY

The present study for the New Melling H.E. Project comprises of the hydrodynamic simulations to derive the maximum water level and resulting inundation maps. The following cases are considered:

Case 1: Routing of SPF hydrograph without dam break (all gates open)

Case 2: Routing of SPF hydrograph with dam break (reservoir at FRL El. 2730.0 m, all gates open)

8.1.4 DAM BREAK MODELLING PROCESS

Generally, dam break modelling 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 approximately solves the governing flow equations of continuity and momentum by computer simulation. A flow chart for mathematical modelling is given in Figure 9-1.
Define Dam break Aims & Objectives
(Mapping format & Data requirements)

Data Collection

Breach Formation
Structural failure

Modelling
Base flow
Reservoir Level
Partial

Sensitivity Analysis

Flood Hydrograph

Additional Data Requirements?

Flood Routing

Additional Data Requirements?

Base flow

Modelling
Sensitivity Analysis

Debris & Sediment
Secondary

Mapping & Data Output

Figure 8-1: Flow Chart of Dam Break Mathematic Modelling
Mathematical modelling 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 obtained 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 forecasted.

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. The basic theory for dynamic routing in one dimensional analysis consists of two partial differential equations originally derived by Barre De Saint Venant in 1871. The equations are:

i. **Conservation of mass (continuity) equation**
\[
\frac{\partial Q}{\partial t} + \frac{\partial (A + A_0)}{\partial t} = q
\]

ii. **Conservation of momentum equation**
\[
\frac{\partial Q}{\partial t} + \left\{ \frac{\partial (Q^2/A)}{\partial X} \right\} + g A \left( \frac{\partial h}{\partial X} + S_f + S_c \right) = 0
\]

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.

### 8.1.5 HEC-RAS Model

Selection of an appropriate model to undertake dam break flood modelling is essential to ensure the right balance between modelling accuracy and cost in terms of time spent developing the model setup. In the instant case, **HEC-RAS version 4.1.0** model developed by Hydrologic Engineering Centre of U.S. Army Corps of Engineers has been selected. HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking environment. The system comprises a graphical user interface,
separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities. The model contains advanced features for dam break simulation.

The present version of HEC-RAS system contains two one-dimensional hydraulic components for: i) Steady flow surface profile computations; ii) unsteady flow simulation. The steady/unsteady flow components are capable of modelling subcritical, supercritical, and mixed flow regime water surface profiles. The system can handle a full network of channels, a dendric system, or a single river reach. The basic computational procedure is based on the solution of one-dimensional energy equation. Energy losses are evaluated by friction (Manning’s equation) and contraction/expansion (coefficient multiplied by the velocity head). The momentum equation is utilized in situations where the water surface profile is rapidly varied.

The graphics include X-Y plots of the river system, schematic cross sections, profiles, rating curves, hydrographs, and many other hydraulic variables. Users can select from pre-defined tables or develop their own customized tables. All graphical and tabular output can be displayed on the screen, sent directly to a printer, or passed through the Windows clipboard to other software’s, such as word processor or spread sheet. Reports can be customized taking into account the amount and type of information desired.

8.1.6 MODEL STABILITY DURING UNSTEADY FLOW SIMULATION

HEC-RAS uses an implicit finite difference scheme. The common problem of instability in the case of unsteady flow simulation can be overcome by suitable selection of following:

1. Cross section spacing along the river reach
2. Computational time step
3. Theta weighing factor for numerical solution
4. Solution iterations
5. Solution tolerance
6. Weir and spillway stability factors

8.1.7 CROSS SECTION SPACING

The river cross sections should be placed at representative locations to describe the change in geometry. Additional cross sections should be added at locations where changes occur in discharge, slope, velocity and roughness. Cross sections must also be added at levees, bridges, culverts, and other structures. Additional cross sections should be added at locations where changes occur in discharge, slope, velocity, and roughness to describe the change in geometry. Bed slope plays an important role in
deciding the cross section spacing. Streams having steep slope require cross sections at a closer spacing say 100 m or so. For larger uniform rivers with flat slope the cross section spacing can be kept from 200m to 500m.

8.1.8 COMPUTATIONAL TIME STEP

Stability and accuracy can be achieved by selecting a computational time step that satisfies the courant condition;

\[ Cr = \frac{V_w (\Delta t/\Delta x)}{1.0} \]

Therefore:

\[ \Delta t \leq \frac{\Delta x}{V_w} \]

Where: \( V_w \) = Flood wave speed

\( V \) = Average velocity of flow

\( \Delta x \) = Distance between the cross sections

\( \Delta t \) = Computational time step

For most of the rivers the flood wave speed can be calculated as:

\[ V_w = \frac{dQ}{dA} \]

However, an approximate way of calculating flood wave speed is to multiply the average speed by a factor. Factors for various channel shapes are shown in the table below

<table>
<thead>
<tr>
<th>Channel Shape</th>
<th>Ratio (Vw/V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide rectangular</td>
<td>1.67</td>
</tr>
<tr>
<td>Wide parabolic</td>
<td>1.44</td>
</tr>
<tr>
<td>Triangular</td>
<td>1.33</td>
</tr>
<tr>
<td>Natural Channel</td>
<td>1.5</td>
</tr>
</tbody>
</table>

8.1.9 THETA WEIGHING FACTOR

Theta is a weighing factor applied to the finite difference approximations when solving the unsteady flow equations. Theoretically, Theta can vary from 0.5 to 1.0. Theta of 1.0 provides most stability, while Theta of 0.6 provides most accuracy.

8.1.10 SOLUTION ITERATION

At each time step derivatives are estimated and the equations are solved. All the computational nodes are then checked for numerical error. If the error is greater than the allowable tolerances, the program will iterate. The default number of iterations in HEC-RAS is set to 20. Iteration will improve the solution.
8.1.11 SOLUTION TOLERANCES

Two solution tolerances can be set or changed by the user: i) water surface calculation ii) storage area elevation. Making the tolerance larger can reduce the stability problem. Making them smaller can cause the program to go to the maximum number of iterations every time.

8.1.12 WEIR AND SPILLWAY STABILITY FACTOR

Weirs and spillways can often be a source of instability in the solution. During each time step, the flow over a weir/spillway is assumed to be constant. This can cause oscillations by sending too much flow during a time step. One solution is to reduce the time step.

8.1.13 INPUT DATA AND MODEL SETUP

The dam break analysis required following range of data in general:

1. Spillway rating curve
2. Cross section of the river from dam site and upto location downstream of the dam to which the study is required.
3. Stage-volume relationship for the reservoir.
4. Salient features of all hydraulic structures at the dam site and also in the study reach of the river
5. Design flood hydrograph
6. Stage discharge relationship at the last river cross section of the study area
7. Manning’s roughness coefficient for different reaches of the river under study
8. Rating curve of all the hydraulic structures in the study reach of the river
9. Topographic map of the downstream area at a scale of 1:15000 to 1:25000, with a contour interval of 2 to 5m for preparation of inundation map after dam break studies.
10. Breach Geometry
11. Time taken for Breach formation
12. Reservoir elevation at start of failure and initial water elevation at downstream end of channel
13. Description of d/s flow condition i.e. subcritical and super critical.

8.1.14 RESERVOIR DATA

To predict the flood hydrograph from the reservoir, it is necessary to have either of the following along with details of typical flow through the reservoir and normal retained water level.

a. Have a stage-volume relationship for the reservoir, or
b. Have bathymetric data for the reservoir
Provision of just a stage-area or stage-volume relationship limits the extent of modelling possible to predict flood flow out of the reservoir. Under these conditions only a simple ‘flat pond’ can be modelled, which does not take into consideration the time taken for flow to exit the reservoir. This may be significant, if the reservoir is relatively long and narrow, or has a number of branches.

8.1.15 CATCHMENT HYDROLOGY

Inflow into the reservoir, reservoir condition at the time of failure and base flow conditions in the river valley downstream may combine to have a significant effect on the predicted flood conditions, depending upon the size and nature of the reservoir and dam. Potential reservoir inflow and river base flow data should be collated to allow a sensitivity analysis to be undertaken as part of the dam break analyses. For high-risk sites, it is likely that the flow conditions assumed for the sensitivity analysis would range between normal low flow operating conditions and a probable maximum flood (PMF).

8.1.16 RIVER FLOOD CONDITIONS

When a dam break analysis is undertaken, it is often difficult to clearly communicate the true scale of the potential flooding. To assist in this process it is often beneficial to present a comparison of the magnitude of the predicted flood against lesser extreme events such as, for example, the 50 and 100-year fluvial flood levels. Collation of such data is, therefore, recommended and may also allow a check on the dam break model calibration, for relatively low flow conditions.

8.1.17 STRUCTURE DATA

A minimum of information is required to allow a reasonable prediction of breach size and hence, potential flood flow, in the event of structure failure. Regardless of structure type, it is necessary to provide outline structure dimensions and levels. Details of gates, valves and spillways will be required, if partial failure modes are to be considered, and as part of a sensitivity analysis when considering different reservoir / river water levels and base flow conditions at the time of failure. Techniques for the prediction of breach formation through embankment dams are more advanced than techniques for the prediction of concrete or masonry structure failure. For embankment dams, details of core and layer geometry (including any surface protection) along with respective material sizes will be required. For concrete and masonry structures, the potential failure mechanisms will be based either on maximum potential breach dimensions or failure of single units such as buttresses or spillways. General arrangement drawings for the structure should provide sufficient information to allow such an analysis.
8.1.18 TOPOGRAPHIC DATA

Topographic data representing the whole area potentially liable to flooding is required. The extent of this data should not be underestimated. Floods resulting from dam failure can be significantly larger than natural floods – meaning that flood flow is often through areas considered safe from flooding. Required topographic data will therefore extend widely across floodplains and up valley slopes well above normal flood levels.

Details of major structures that may form an obstruction to flow are also required, such as road and railway embankments and bridges and major river control structures. Contrary to river modelling studies, smaller structures that may be completely inundated and therefore, washed away, may be ignored for dam break modelling purposes.

The accuracy of a dam break study is different to that of a river modelling study. Traditional river modelling simulates natural floods that occur within defined floodplain areas. Our knowledge of typical flow conditions and modelling parameters such as channel and floodplain roughness, for these events is relatively good. Equally, there is likely to be a range of data available with which the model may be calibrated.

For a dam break model the flow conditions typically exceed natural events by a large margin meaning that there is little calibration data and the flooded terrain is outside of the normal floodplain areas making the estimation of channel roughness difficult. Equally, there is uncertainty in prediction of the failure mechanisms leading to the initial flood hydrograph, in understanding 3D flow effects and in predicting the movement and impact of debris and sediment. With this range of uncertainty it is inappropriate to attempt flow modelling to the same level of accuracy as for normal river flow modelling. The accuracy of topographic data collected should also relate to the location within the area at risk.

8.1.19 DAM BREAK MODEL SET UP IN GENERAL

The dam break model set up consists of a single or several channels, reservoirs, dam break structures, and other auxiliary dam structures such as spillways, sluices etc. The river is represented in the model by cross section at appropriate intervals. However, due to the highly unsteady nature of dam break flood propagation, it is advisable that the river course should be described as accurately as possible through the use of closely spaced cross sections, particularly where the cross section is changing rapidly. Further, the cross sections should extend as far as the highest modelled water level, which normally will be in excess of the highest recorded flood level.

The reservoir is normally modelled as a storage area to describe the storage characteristics by the use of storage-volume at different levels. This point will often also be the upstream boundary of the model, where inflow hydrograph may be
specified. However, in case of very long and wide reservoirs the routing of the inflow floods has to be carried out and hence the reservoir itself will also have to be represented by cross sections at regular intervals. The downstream boundary will be either a stage discharge relation or time series water level as in case of tidal waves etc.

8.1.20 DAM BREAK MODEL SET UP FOR NEW MELLING H.E. PROJECT

For dam break model setup and other hydrodynamic model set up as per the scope of work of New Melling H.E. Project, the different components of the project have been represented in the model as follows:

8.1.21 MAGO CHU RIVER

The Mago Chu river for a length of 8449 m from the barrage axis (up to confluence of Nyukcharong Chu and Mago Chu) has been represented in the model by 43 no. of cross sections placed at suitable distance to represent river geometry appropriately with some interpolated sections in between. The upstream end of the Mago Chu river has been connected to a storage area representing the reservoir. As the dam breaches, flood levels far exceed the normal flood level marks and the flood spreads beyond the normal river course, the Manning’s roughness coefficient for the dam break studies should be assumed normally more than the other hydro-dynamic studies. The Manning’s roughness coefficient for this reach of Mago Chu river has been considered as 0.045 considering the bouldery river beds with grassy banks of hilly terrain.

8.1.22 RESERVOIR

The reservoir has been represented in the model by storage area of the graphical editor of the model and its stage-volume relationship has been specified therein. The stage – volume relationship of the reservoir as used in the model set up is given in Table 8-1.

Table 8-1: Stage-Volume Relationship of Reservoir

<table>
<thead>
<tr>
<th>Stage (m)</th>
<th>Cumulative capacity (MCM)</th>
<th>Stage (m)</th>
<th>Cumulative capacity (MCM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2710</td>
<td>0.000</td>
<td>2726.0</td>
<td>0.227</td>
</tr>
<tr>
<td>2712.0</td>
<td>0.00004</td>
<td>2728.0</td>
<td>0.304</td>
</tr>
<tr>
<td>2714.0</td>
<td>0.003</td>
<td>2730.0</td>
<td>0.390</td>
</tr>
<tr>
<td>2716.0</td>
<td>0.012</td>
<td>2732.0</td>
<td>0.485</td>
</tr>
<tr>
<td>2718.0</td>
<td>0.031</td>
<td>2734.0</td>
<td>0.589</td>
</tr>
<tr>
<td>2720.0</td>
<td>0.062</td>
<td>2736.0</td>
<td>0.703</td>
</tr>
<tr>
<td>2722.0</td>
<td>0.105</td>
<td>2738.0</td>
<td>0.825</td>
</tr>
<tr>
<td>2724.0</td>
<td>0.161</td>
<td>2740.0</td>
<td>0.958</td>
</tr>
</tbody>
</table>
8.1.23 BARRAGE AND SPILLWAY

The diversion structure of the project has been represented in the model by its crest length 47.8 m and crest level 2710.50 m at the cross-section just downstream of the reservoir. For the dam break study, the breach plan data has been specified at dam location. The spillway has been represented as a gated inline structure at the barrage location specified by crest level, gate size, and number of gates.

8.1.24 UPSTREAM BOUNDARY

For the dam break model simulation, the Standard Project Flood (SPF) has been considered as the upstream boundary. The SPF hydrograph has been impinged in to the reservoir as a lateral inflow. The details of Inflow Hydrograph (SPF) impinged to reservoir are given below in Table 8-2.

Table 8-2: Inflow Hydrograph Impinged to Reservoir

<table>
<thead>
<tr>
<th>Time (Hr)</th>
<th>SPF (Cumec)</th>
<th>Time (Hr)</th>
<th>SPF (Cumec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61</td>
<td>19</td>
<td>673</td>
</tr>
<tr>
<td>2</td>
<td>62</td>
<td>20</td>
<td>729</td>
</tr>
<tr>
<td>3</td>
<td>66</td>
<td>21</td>
<td>803</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
<td>22</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>82</td>
<td>23</td>
<td>1425</td>
</tr>
<tr>
<td>6</td>
<td>94</td>
<td>24</td>
<td>2071</td>
</tr>
<tr>
<td>7</td>
<td>116</td>
<td>25</td>
<td>2469</td>
</tr>
<tr>
<td>8</td>
<td>132</td>
<td>26</td>
<td>2135</td>
</tr>
<tr>
<td>9</td>
<td>154</td>
<td>27</td>
<td>1518</td>
</tr>
<tr>
<td>10</td>
<td>210</td>
<td>28</td>
<td>974</td>
</tr>
<tr>
<td>11</td>
<td>329</td>
<td>29</td>
<td>623</td>
</tr>
<tr>
<td>12</td>
<td>510</td>
<td>30</td>
<td>430</td>
</tr>
<tr>
<td>13</td>
<td>623</td>
<td>31</td>
<td>295</td>
</tr>
<tr>
<td>14</td>
<td>550</td>
<td>32</td>
<td>197</td>
</tr>
<tr>
<td>15</td>
<td>464</td>
<td>33</td>
<td>127</td>
</tr>
<tr>
<td>16</td>
<td>505</td>
<td>34</td>
<td>83</td>
</tr>
<tr>
<td>17</td>
<td>545</td>
<td>35</td>
<td>66</td>
</tr>
<tr>
<td>18</td>
<td>594</td>
<td>36</td>
<td>61</td>
</tr>
</tbody>
</table>

8.1.25 DOWNSTREAM BOUNDARY

Normal depth has been used as the downstream boundary for the dam break model setup. The HEC-RAS model setup for New Melling Barrage is given in Figure 8-1.
Figure 8-2: HEC Model Set Up for the Study
8.1.26 BREACH PARAMETERS AND DAM BREAK SIMULATION

8.1.26.1 SELECTION OF BREACH PARAMETERS FOR DAM BREAK STUDY

For any dam break study it is extremely difficult to predict the chances of failure of a dam, as prediction of the dam breach parameters and timing of the breach are not within the capability of any of the commercially available mathematical models. However, assuming the dam fails, the important aspects to deal with are, time of failure, extent of overtopping before failure, size, shape and time of the breach formation. Estimation of the dam break flood will depend on these parameters.

The breach characteristics that are used as input to the existing dam break models are i) Final bottom width of the breach, ii) Final bottom elevation of the breach, iii) Left and right side slope of the breaching section iv) Full formation time of breach, and v) Reservoir level at time of start of breach. The breach formation mechanism is, to a large extent, dependent on the type of dam and the cause due to which the dam failed.

As per the UK Dam Break Guidelines and U.S. Federal Energy Regulatory Commission (FERC) Guidelines, in case of Earthen, Rock fill dam the breach width should be taken between 1.0 to 5.0 times height of dam and full formation time should be taken of about 1 hours. The final bottom elevation of the breach for sensitivity analysis has been taken corresponding to relative weaker locations in the dam.

Further, the final bottom elevation of the breach should be restricted to the reservoir bed level / natural ground level at the dam location due to nil reservoir storage below this level.

The manner in which the failure is to commence can be specified as one of the following:

- At a specified stage (water surface elevation) of the reservoir and Duration
- At a specified time
- At a specified stage (water surface elevation) of the reservoir

8.1.26.2 CRITICAL CONDITION FOR DAM BREAK STUDY

The critical condition for a dam break study is when the reservoir is at Full Reservoir Level (FRL) and design flood (SPF in present case) hydrograph is impinged. Accordingly, in the present study keeping the initial reservoir level at FRL El. 2730.0 m the reservoir routing has been carried out by impinging the inflow hydrograph (SPF) and keeping all the spillway gates fully open.

8.1.26.3 BREACH PARAMETERS

Considering the criteria for selection of breach parameters and critical condition for the dam break study as discussed above, the breach parameters as given in Table 8-3 have been identified for dam break simulation. The initial breach elevation has been taken...
corresponding to the top of barrage (El 2732 m), and the final bottom elevation corresponding to the river bed elevation (El. 2710 m) at barrage axis.

**Predictive Equation**

A) Froehlich Equation

\[
B = 0.1803 \ K_0 \ V_w^{0.32} h_b^{0.19} \\
T_f = 0.00254 \ V_w^{0.53} h_b^{-0.9}
\]

B) Von Thun Gillete formula (1990)

\[
B = 2.5 h_w + C_b \\
T_f = 0.020 h_w + 0.25
\]

C) Federal Energy Regulatory Commission (FERC) 1987

\[
H_w \leq B \leq 5H_w \\
0.1 \leq T_f \leq 1.0
\]

Where

- \( B \) = Average breach width (m)
- \( T_f \) = time of failure in hours
- \( K_0 = 1.4 \) for Overtopping and 1.0 for piping
- \( V_w \) = Volume of water Stored above Breach Invert level at Failure in \( m^3 \)
- \( H_b \) = Height of breach in m
- \( H_w \) = Height of Water above Breach Invert at failure

Breach bottom width and time of failure have been computed from above equations and finally following breach parameters (Table 8-3) are adopted for dam break analysis. The detailed computations of dam breach parameters are at Appendix 8-1.

**Table 8-3: Breach Parameters Considered for Dam Break Analysis**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Elevations of Breach (m)</th>
<th>Average Breach Width (m)</th>
<th>Side Slope of Breach</th>
<th>Brach Development Time (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2732</td>
<td>2710</td>
<td>56</td>
<td>0.3H:1V</td>
</tr>
</tbody>
</table>
8.1.26.4 Maximum Water Level in Mago Chu due to Occurrence of SPF without Dam Breach

There is a need to assess the water levels at different locations downstream due to occurrence of SPF and without any dam breach, i.e., the design condition. In this case, the SPF hydrograph has been routed through the reservoir assuming initial water level at FRL (El. 2730 m) and keeping the spillway gates fully open. The maximum water level obtained at the different locations along the river downstream of the barrage is given in Table 8-4. The rise in water level above the river bed along the Mago Chu reach varies from 3.3 m minimum to 12.8 m maximum.

Table 8-4: Maximum Water Level in Mago Chu due to Occurrence of SPF without Dam Breach

<table>
<thead>
<tr>
<th>Distance d/s from reservoir (m)</th>
<th>Bed Level (M)</th>
<th>Maximum Flow (cumec)</th>
<th>Water Surface Elevation (M)</th>
<th>Depth of Flow (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2711.25</td>
<td>6719.23</td>
<td>2724.13</td>
<td>12.88</td>
</tr>
<tr>
<td>25</td>
<td>2710.00</td>
<td>6784.07</td>
<td>2722.40</td>
<td>12.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In Struct</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>2709.72</td>
<td>6784.07</td>
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<td>2359.00</td>
<td>3459.42</td>
<td>2365.20</td>
<td>6.20</td>
</tr>
</tbody>
</table>
### 8.1.26.5 Simulation for Worst Possible Condition

The simulation results of Case 2, the worst possible condition, described earlier are given in Table 8.5 and these levels are plotted at different cross-sections are shown below. From the table, the peak discharges at different locations have varied from 6995.5 cumec to 3392 cumec, and the depth from 12.88 m to 3.34 m.

**Table 8.5: Maximum Water Surface Profile of Dam Break Analysis**

<table>
<thead>
<tr>
<th>Distance d/s from reservoir (m)</th>
<th>Bed Level (M)</th>
<th>Maximum Flow (cumec)</th>
<th>Water Surface Elevation (M)</th>
<th>Depth of Flow (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2711.25</td>
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<td>6865.36</td>
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<td>2709.72</td>
<td>6865.36</td>
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<tr>
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<td>2715.62</td>
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<tr>
<td>3768</td>
<td>2519.94</td>
<td>3800.74</td>
<td>2527.41</td>
<td>7.47</td>
</tr>
</tbody>
</table>
### Distance d/s from reservoir (m) | Bed Level (M) | Maximum Flow (cumec) | Water Surface Elevation (M) | Depth of Flow (m)
--- | --- | --- | --- | ---
4299 | 2489.98 | 3687.65 | 2496.37 | 6.39
4822 | 2469.99 | 3636.08 | 2477.84 | 7.85
5113 | 2459.3 | 3592.92 | 2462.79 | 3.49
5323 | 2445.49 | 3556.04 | 2451.62 | 6.13
5523 | 2437 | 3566.61 | 2442.09 | 5.09
5611 | 2430 | 3560.8 | 2439.02 | 9.02
5694 | 2430 | 3554.99 | 2437.11 | 7.11
5820 | 2420 | 3548.89 | 2424.29 | 4.29
6020 | 2391 | 3538.59 | 2397.42 | 6.42
6223 | 2374 | 3523.46 | 2381.76 | 7.76
6425 | 2366 | 3502.67 | 2373.58 | 7.58
6630 | 2359 | 3479.27 | 2365.22 | 6.22
6830 | 2347 | 3477.27 | 2354.06 | 7.06
6944 | 2342 | 3474.8 | 2347.79 | 5.79
7030 | 2337 | 3472.25 | 2342.98 | 5.98
7100 | 2332 | 3470.05 | 2338.68 | 6.68
7238 | 2323 | 3465.09 | 2328.21 | 5.21
7443 | 2309 | 3453.24 | 2315.65 | 6.65
7519 | 2306 | 3447.37 | 2313.37 | 7.37
7584 | 2301 | 3443.31 | 2309.65 | 8.65
7649 | 2298 | 3439.99 | 2303.27 | 5.27
7850 | 2280 | 3426.19 | 2289.26 | 9.26
8051 | 2272 | 3406.27 | 2280.87 | 8.87
8116 | 2270 | 3406.1 | 2277.71 | 7.71
8198 | 2268 | 3404.26 | 2274.65 | 6.65
8249 | 2266 | 3401.74 | 2273.64 | 7.64
8449 | 2260 | 3392.08 | 2267.73 | 7.73

**8.1.26.6 Water Surface profile at downstream Cross-sections for Dam break condition**

The Water Surface profile at Cross-sections of downstream stretches for Dam break condition are attached as Appendix 8-2.

**8.1.27 RESULTS AND DISCUSSION**

**8.1.27.1 Time series of water level**

The plots of time series of maximum water levels and discharges for Case 2 (the worst possible) dam breach condition at different locations of the Mago Chu river downstream of the New Melling Barrage are shown in Figures 8-3 and 8-4. These can be used for estimating the period of inundation corresponding to a particular elevation during the preparation of disaster management plan.
Comparison of maximum water levels in different simulations

i. The rise in water level due to dam breach above the bed level of the river varies from 3.34 m to 12.88 m (maximum).

ii. The rise in water level along the river reach in case of occurrence of SPF with no dam breach condition varies from 3.3 m minimum to 12.8 m (maximum).

Figure 8-3: Water surface elevation variations at various sections d/s of Barrage Axis for Dam Breach condition

Figure 8-4: Discharge Hydrographs at various sections d/s of Barrage Axis for Dam Breach condition
8.1.27.2 Preparation of Inundation Map

From the maximum water levels given in Table 8-4 and 8-5 for different conditions, the inundation map has been prepared for the worst flow condition only, which is of prime interest and importance, shown in Figure 8-4 and corresponding longitudinal section along river is shown in Figure 8-5.

8.1.28 Limitations

The uncertainties associated with the breach parameters, specially breach width, breach depth and breach development time may cause uncertainty in flood peak and arrival times. Further the high velocity flows associated with dam break floods can cause significant scour of channels. This enlargement in channel cross-section is neglected since the equations for sediment transport, sediment continuity, dynamic bed form friction etc. are not included in the governing equations. The narrow channels with minimal flood planes are subject to over-estimation of water elevation due to significant channel degradation. The dam breach floods create a large amount of transported debris, which may accumulate at very narrow cross sections, resulting in water level variation at downstream locations. This aspect has been neglected due to limitations in modelling of such complicated physical process.

Accounting for topography and assumptions made regarding roughness coefficient, flood inflows, dam break parameters, etc., which have been used to develop the inundation maps, the limits of flooding and flood wave travel time, may not reflect the exact situation and shall therefore be used as a guideline to take warning, evacuation, and emergency measures. The actual area of inundation would depend on actual flow condition and failure phenomena and may vary, to some extent, from the limits shown on the actual map.

8.1.29 Conclusions

From the maximum water levels given in Table 8-4 for the worst flow simulation condition, the inundation map has been prepared as shown in Figure 8-5. There are 12 human settlements in the radius of 10 km from the project components. All the settlements are in higher elevation than the maximum water surface elevation that can be reached due to breach of New Melling Barrage. Thus, there will be no such damage in the downstream on human settlement due to breach of New Melling Barrage.
Figure 8-5: Flood Inundation d/s of New Melling Barrage due to breach of Barrage
Figure 8-6: Profile of maximum water surface elevation for breach of New Melling Barrage
8.2 DISASTER MANAGEMENT PLAN

8.2.1 PURPOSE

While the dams constructed over the world have been the prime source for the advancement of human civilization and have enabled harnessing water resources for hydropower, irrigation etc., they also can be a potential hazard, though quite unlikely, in the event of dam failure. A failure of dam may bring in its wake, loss of life and disastrous economic consequences for the basin/valley downstream. The extent of loss is dependent on the extent of population and development in the downstream area. Therefore, it is very essential to regulate and continuously monitor proper supervision and maintenance of dams and take timely corrective measures to prevent any failure. In the unlikely event of failure, the system should be available and be ready for Disaster Management with appropriate plans to mitigate and minimize its effects, which should be visualized in advance and management plans prepared. All actions are therefore aimed at planning for minimum loss of time in taking relief and rehabilitation measures to minimize loss of life and property in the unfortunate event of dam failure. Disaster Management or Emergency Action Plan should therefore aim at identifying in advance the types of emergencies which are likely to occur in such an unlikely event. It is therefore essential for Project authorities to have proper evacuation plans and to ensure maximum protection of vital installations and habitations etc. right from the planning stage.

This plan presents warning and notification procedures to be followed in case of failure or potential failure of the dam. The purpose is to provide timely warning to the population likely to be affected and alert key people who have to take respective actions in case of an emergency. Disaster preparedness can minimize loss of life and property by proper planning in advance so that appropriate measures are in place to combat the disaster. It is therefore necessary to visualize the challenges in advance and equip the system to fight with it effectively. Such planning envisages:

- Evaluation of the disaster/advance knowledge of the likely occurrence of flood or cyclone
- Identification of the likely effects on property and human beings with a view to assess the damage potential of the disaster.
- Hazard area mapping to identify the likely common area prone to such type of disaster.
- Review of organization and machinery for proper upkeep and maintenance of dams, embankments etc.
- Review of provisions of anti-disaster shelters, adequacy of medical aid facilities and transportation, food etc.
8.2.2 PROJECT PLANNING STAGE

Project implementation envisages that no families are likely to be affected due to the New Melling Hydro Electric Project as the villages are located at very high altitude.

8.2.3 EMERGENCY ACTION PLAN

Once the Emergency is foreseen, the Emergency Action Plan may be put in operation, which may include:

- Areas likely to be evacuated with priorities to be notified.
- Safe routes to be used for evacuation. Such routes have to be identified, discussed and planned sufficiently in advance for proper implementation of the Plan.
- Means of transportation.
- Traffic Control.
- Shelters for evacuees.
- Procedures for evacuation of people from hospitals, public places, prisons etc.
- Procedures for care and security of property from evacuated areas from anti-social elements.
- Instructions regarding assignment of specific functions and responsibilities of various members of evacuation teams

8.2.4 EMERGENCY ACTION COMMITTEE

The information dissemination should cover authorities in Arunachal Pradesh. Deputy Commissioner may be assigned the authority to form Emergency Action Committees. The committee may comprise of:

- Deputy commissioner, Tawang District, Arunachal Pradesh
- Project Manager (New Melling HEP, Maintenance Div.)
- Project Engineer (New Melling HEP, Maintenance Div.)
- Representative of P&T Department
- Representative of State Transport Department
- Representative of State Electricity Board
- Representative of Civil Supplies Department
- District Agricultural Officer
- District Health Officer
- District Commandant of Home Guards
Local Flood Committees may be formed in the towns, villages likely to be threatened by the project in the unlikely event of barrage failure or in the event of heavy floods for assisting in evacuation, maintaining law and order, overseeing entire relief and rehabilitation measures. The composition of the committee could be as under:

<table>
<thead>
<tr>
<th>Additional Deputy Commissioner, Jang</th>
<th>Chairman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaon Buras, GPC, ASM, ZPM of Rho and Yuthembu</td>
<td>Members</td>
</tr>
<tr>
<td>Circle officers, Thingbu, Jang and Lhou</td>
<td>Members</td>
</tr>
<tr>
<td>Local Police Station In-charge</td>
<td>Member</td>
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<tr>
<td>Gram Sevak</td>
<td>Member</td>
</tr>
<tr>
<td>Chairman of Village Farmers' Cooperative Society</td>
<td>Member</td>
</tr>
<tr>
<td>Head Master of Village School</td>
<td>Member</td>
</tr>
<tr>
<td>Nominated representative of barrage Authority</td>
<td>Member</td>
</tr>
</tbody>
</table>

All the above information should be compiled in the Form of ‘Flood Control Order’ for each district and should be distributed to all the concerned authorities well before on set of monsoon season.

8.2.5 FLOOD CONTROL ORDER

Flood Control Order is generally issued by State or Deputy Commissioner every year for their respective area. The State of Arunachal Pradesh also may cover the emergency actions in Arunachal in addition to their other flood control problems of the State/District. The order may contain updated list of names, positions, titles, addresses, office and residence numbers of all officers and authorities connected with implementation of Emergency Action Plan along with Emergency members. Information in respect of alternate officers to be contacted in the event of non-availability of the concerned officers may also be available for easy/early passage of information.

The Flood Control Order may also contain:

- Complete instructions about the emergency and the evacuation procedures in the event of failure of the Barrage.
- Instructions about the order in which key supervisory personnel will be notified/informed and responsibilities fixed.
- List of Names, Addresses, and Office and Residential Telephone numbers of all concerned officers of Irrigation Department, Deputy Commissioner’s offices, MPs, MLAs of area, control room and round the clock emergency telephone numbers during monsoon.

At least one key/nodal person to be designated as responsible for coordination of entire plan from each department who may be available round the clock.

8.2.6 PUBLIC INFORMATION SYSTEM

During a crisis following an accident, the affected people, public and media representatives would like to know about the situation from time to time and the response of the emergency authorities to the crisis. It is important to give timely information to the public in order to prevent panic and rumours. The emergency public information can be carried out in three phases.

(i) Before the crisis

This will include the safety procedure to be followed during an emergency through posters, talks, and mass media in local language. Leaflets containing do’s/ don’ts should be circulated to educate the affected population.

(ii) During the crisis

Dissemination of information about the nature of the incident, actions taken and instructions to the public about protective measures to be taken, evacuation, etc. are the important steps during this phase.

(iii) After the crisis

Attention should be focused on information concerning restoration of essential services, movement / restrictions, etc.

Various tasks of the public information system would include:

- Quick dissemination of emergency instructions to the personnel and public
- To receive all calls from public regarding emergency situations and respond meticulously
- Obtain current information from the Central Control Room.
- Prepare news release
- Brief visitors/ media
- Maintain contact with hospitals and get information about the casualties

8.2.7 EFFICIENT COMMUNICATION SYSTEM

An efficient communication system is essential to achieve a successful Emergency Preparedness Plan and this has to be finalized in consultation with local authorities and administrative setup. More often, the entire communication facility gets disrupted
in a disaster situation. The wireless facility which is comparatively free from general encumbrances of the communication system shall be invariably a part of emergency preparedness plan. The respective department of police, who generally has this facility, must have standing instructions to convey disaster messages effectively in time. In addition, telephone facility should be available at dam site, vulnerable points and population centres. Vehicles equipped with sirens and public address system may also be kept ready for densely populated areas. Warning sirens may also be installed in the likely affected population to save warning time.

Continuous monitoring of the Water levels and Rainfall is proposed to be carried out using automated recorders and transmission of data through V-sat. Two Water level monitoring stations and three Rainfall monitoring stations and V-Sat are proposed to be established in the upstream reaches and Barrage site of the New Melling HEP. It is proposed to monitor the Rainfall & Water levels and any disaster symptoms closely during rainy season and data collection are continuous throughout the year.

An amount of **Rs. 103 lakhs** (As detailed in **Table 8-6**) has been provided in the EMP for this monitoring. Provision in the EMP estimate has been made to have public information / address system, Emergency shelters etc. for providing information to the affected people in case of accident and crises.

Table 8-6: Installation and maintenance of Efficient Communication System

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Particulars</th>
<th>Amount (Rs. Lakhs)</th>
</tr>
</thead>
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<td>1.</td>
<td>Water level monitoring station</td>
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</tr>
<tr>
<td>2.</td>
<td>Snow Gauge in the CA at 4500m level</td>
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</tr>
<tr>
<td>3.</td>
<td>Rain gauge station</td>
<td>1.00</td>
</tr>
<tr>
<td>4.</td>
<td>V-sats for communicating the data</td>
<td>8.00</td>
</tr>
<tr>
<td>5.</td>
<td>AMC for the equipment at 10% cost for 5 years</td>
<td>13.00</td>
</tr>
<tr>
<td>6.</td>
<td>Monitoring of data transmission with 3 persons during monsoon season for 6 months (@ Rs. 25,000/- per month) for 10 years including computers, printers etc.</td>
<td>45.00</td>
</tr>
<tr>
<td>7.</td>
<td>Drawing of committee meetings twice in monsoon for 10 years</td>
<td>10.00</td>
</tr>
<tr>
<td>8.</td>
<td>Construction of Emergency shelters</td>
<td>5.00</td>
</tr>
<tr>
<td>9.</td>
<td>Public information / addressing system</td>
<td>4.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>103.00</strong></td>
</tr>
</tbody>
</table>

### 8.2.8 SPARE EQUIPMENT/ MATERIAL/ LABOUR

The spare equipment/material, labour etc. should be available at pre-decided locations and this information should be available in Flood Control Order. The quantities of such equipment & places/locations should be reasonable & decided by Flood Control Authorities considering overall district requirement.
8.2.9 RESPONSIBILITIES OF VARIOUS AUTHORITIES

Each person of flood control room in the notification flow chart has the responsibility to notify the next persons or groups as indicated.

Project Engineer in-charge of the New Melling HEP shall have the responsibility to operate the facilities in accordance with approved reservoir operation procedures to be made for the purpose before barrage is completed, regularly observe and report flood conditions to the Division ‘Flood Control Cell’ and take preventive actions at the dam site in emergency or potential emergency condition. It is expected that during high flood event, the Project Engineer in charge of the dam shall also be present at the dam site to guide the others. It is also expected that the Project Manager is kept informed of the situation and in emergency, the situation is monitored by Project Manager, and all other concerned authorities are kept informed. In this case, proper and timely information will also be required to be sent to counterparts in Arunachal Pradesh.

Project Manager in-charge of the New Melling HEP shall be the main coordinator of Emergency Action Plan (EAP) activities. Moreover, he/she has the authority to direct the activities of the flood control room at the dam site.

District Collector, who is the Civil Administrator for the district, shall be responsible for ordering, coordinating and controlling evacuation and relief measures.

Consequently, MPs, MLAs, Panchayat representatives in the disaster prone areas and all responsible persons of the locality shall be invited/associated in the Emergency Action Plan. The services of voluntary organizations like Red Cross and other Agencies, who may be active in the area shall be utilized. To chalk out the plan of Action and fixing responsibilities, a meeting shall be held by the District Collector before onset of the flood season every year to define the respective duties in the event of disaster flood occurrence. An awareness drill/programme shall also be arranged. A mock exercise to test the level of preparedness without creating panic in the public should be encouraged to understand strength/weaknesses and take corrective steps.

8.2.10 SPECIAL PREPAREDNESS BEFORE FIRST FILLING OF RESERVOIRS

Many failures of dams have reportedly occurred at the time of first filling of reservoirs. The period of first filling is a critical period in the life of Barrage. Hence special vigilance and precautionary steps are necessary at the time of first filling of the Barrage in order to avoid failure of the Barrage. It is, therefore, necessary to inspect the performance of the Barrage carefully during this period. The preparedness shall be carried out for the first filling of reservoir as indicated below:

- Before starting the first filling of reservoir, the EAP of the project should be completed and implemented as far as possible.
- The installation of Spillway gates including hoisting arrangement, emergency
power supply etc. should be completed and trial operation of gates must be made before it becomes actually operational.

- Project Engineer of the New Melling HEP along with his senior officials shall visit the Barrage before onset of the monsoon and submit their inspection report to senior officials. The routes to Barrage site shall be inspected and any deficiencies should be removed. Alternate routes should also be identified.

- Project Engineer of the New Melling HEP should prepare the schedule for first filling of the reservoir and get the same approved from Project Manager before the start of monsoon. The Barrage should be filled up in stages during the first filling of reservoir.

- The copy of the first filling schedule shall be sent to the District Administration, and State Dam Safety Organization, if any.

- Proper lighting facilities on and nearby the Barrage area are to be provided before the onset of monsoon to facilitate close vigilance of the Barrage behaviour during the night time also. A generator and flood light should also be provided for emergency purpose.

- The control room of the Barrage is to be connected with the office and residence of officers-in-charge of the dam by telephone or by wireless set. The wireless/telephone stations and telephone lines should be completely out of the flood zone.

- Sufficient amount of materials such as sand, shingle, rubble etc. should be stock piled at convenient locations near the Barrage sites. Sufficient number of filled sand bags should also be kept ready for emergency purposes. Machineries like tippers, trucks, excavators etc. along with sufficient number of labour are to be kept ready on both the flanks of Barrage to start remedial measures within a very short notice. Access roads along the downstream of the Barrage as well as on the top of the Barrage should be established for proper movement of the machines and vehicles.

### 8.2.11 VIGILANCE DURING THE FIRST YEAR OF FILLING OF A RESERVOIR

During the first year of filling of Barrage, careful vigilance needs to be kept at the Barrage site and in the deepest riverbed portion. The Barrage should be inspected by the Project Engineer of the Barrage in three phases. The first phase inspection is to be carried out just before the onset of first heavy rain. The second phase of the inspection will be conducted after the filling of the reservoir to half the height of the Barrage. After the second inspection, if no untoward behaviour of the Barrage is observed, third inspection will be made when the reservoir would be filled up to FRL. When the spillway starts working, the Project Manager should inspect the Barrage periodically during the entire period of overflowing. If any sweat, excessive settlement, leakage,
cracking or sloughing of slopes is noticed, it should be brought to the attention of the higher authorities immediately. Daily reports about stage of reservoir filling, condition and behaviour of the Barrage must be submitted by the Engineer responsible to his immediate superior as a part of the continuous vigilance of the Barrage.

8.2.12 ACTIONS FOLLOWING DISCOVERY OF PROBLEMS

A close vigilance of the Barrage by a competent person is the basic requirement for the Emergency Action Plan. When some distress in the Barrage is noticed, the nature and potentialities of the problems are required to be identified immediately by the person in charge of Barrage. Immediately, he may take initiative for remedial measures and further activities for involving the operation of Emergency Action Plan.

The information of any unusual development on the Barrage should be immediately flashed/ conveyed by the person in charge of the Barrage to the higher officials in the Department by means of the fastest available communication facilities such as wireless message/ telephone. In the event of likely failure of Barrage, the man with highest stature present at the Barrage site should initiate the actions as described in notification procedure and possible construction repairs depending on the seriousness of the development. Therefore, it is necessary that the staff posted on the vigilance and maintenance of the Barrage be adequately trained/ experienced to handle various emergent situations. An inexperienced person on such a duty could be a liability. If any potential failure of the Barrage is observed, action should be taken immediately to lower the water levels in the Barrage.

8.2.13 NOTIFICATION PROCEDURES

The name of the responsible persons, positions, office and residential telephone numbers and alternate contacts and means of communication shall be clearly written in the `Notification Flow Chart’. Flood control room shall be manned by two or more persons round the clock, so that alternative person is available for notification at all times during flood season. Communication by wireless shall be the primary method of communication. Phones are for back-up wherever possible. When not available, communication shall have to be established by messenger service.

Flood control room/important sites shall be tuned into the same wireless channel. Thus, communication from one place to another is heard at all the places. The populations of villages/ towns, which are likely to come under inundation, are also to be notified prior to the release of water from the dam under different conditions. People of the downstream area shall be warned in advance of onset of disaster flood to enable timely evacuation including livestock. In this case, time available for advance warning may be limited but is very important. Hence, effective warning systems shall have to be adopted like:
Using multiple warning channels (police, radio, television, telephone, sirens, loudspeakers, mobiles etc.)

Using official sources for warning (city civil officials, police, fire fighting etc.)

Repeat warnings

Ensuring that warnings are consistent and accurate

Giving specific instructions about what actions should and should not be taken by people of the area to protect themselves.

Conveying to the affected persons, possible extent of duration of flood/danger and urgency. However, this should not be overplayed to cause panic.

All departments, which are charged with the emergency preparedness, shall be identified and nodal officer in each department shall be identified from each department in advance. Such officers shall be provided residential telephone/cell phone in addition to their office telephones during the flood season. It is evident that the emergency preparedness plan is an integrated matter requiring technical expertise, specific administrative skill and spontaneous public participation (if is required) to be practical, pragmatic and successful.

8.2.14 FUNCTIONS OF CONTROL ROOM

- To receive flood warnings and other related information.
- To submit flood situation reports to the concerned authorities everyday/as often as required.
- To convey flood situation reports and orders relating to flood control measures.
- To issue necessary flood situation information-emergency situation, if any, and necessary directions for evacuation etc.
- To arrange necessary temporary shelters, food articles and other relief supplies.
- To maintain liaison with likely flood affected areas.
- To mobilize necessary fleet for vehicles needed for mobilizing staff, relief materials and shifting.
- To maintain logbook of messages received, messages dispatched, directions received and follow up actions taken.

8.2.15 FUNCTIONS OF OFFICER-IN-CHARGE OF RELIEF CAMP

The officer-in-charge of relief camp shall assist in the process of timely evacuation and rehabilitation of the persons likely to be affected, cattle and property. He shall also maintain record of persons/families in the camp and make arrangements for essential items of daily use and ensure reasonable health, sanitation, water supply and street lighting facilities. A daily situation report shall be sent to the control room.
8.2.16 PREVENTIVE ACTIONS

The Barrage and appurtenant works shall be inspected twice daily during the monsoon season; once during the day and once during the night. Whenever sinkholes, boils, increased leakage, rapid rise or fall of the reservoir level, reservoir rise beyond maximum working level, or wave overrun on the Barrage crest are observed, the person in-charge of patrolling shall immediately inform the Project Engineer or Official In-Charge of ‘Flood Control Cell’ in his absence. The Project Engineer shall decide action to be taken at the site and will immediately notify the flood cell Arunachal Pradesh. If the Barrage is seriously distressed or is in imminent danger of failing or if a potential emergency condition (failure) is developing, he shall initiate the EAP by notifying the nearest authority and the division flood cell in Tawang as per Emergency Action Plan. Similar information with likely available time for flood submergence will be flashed to Authorities in Arunachal Pradesh.

Equipment and materials shall be made available at and near the Barrage site. These may comprise about 1000-2000 sandbags at around five locations on the Barrage, one tractor, one motor-boat, lanterns, ropes and logs (to hold the sandbags).

8.2.17 AWARENESS PROGRAMME ORGANIZED BY SEW FOR THE PROJECT AFFECTED VILLAGERS

A site visit to the following Hydro Projects in Sikkim was organised by SEW from 4th to 9th January for the local people (representatives of impacted villages):

- Teesta Low Dam Project Stage III (in Operation)
- Teesta Stage IV Project (under construction)

About 30 people attended the site visit. The visit created awareness and helped the representatives of Rho, Jangda & Yuthembu villages in better understanding of the operations, safety features and benefits of hydro projects.
During the visit, the local people had an opportunity to interact with the project development authority as well as with the impacted villagers. They interacted with the impacted villagers about the benefits they received from the project development authority during construction and during operation. They also discussed with the project developers about the operation of turbines, opening of gate and safety measures.