

**Inception Report  
For  
Installation of Glacial Lake Outburst Flood  
(GLOF)  
Early Warning System  
In the  
Punakha-Wangdi Valley**



**Prepared for:  
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Ministry of Economic Affairs  
Thimphu, Bhutan**

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#### APPENDIX A – DESIGN DRAWINGS

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# 1. INTRODUCTION

## 1.1 Background

The Kingdom of Bhutan is located in the eastern Himalayas, bordered by China's Tibetan Plateau in the North, the Indian States of Sikkim in the West, West Bengal and Assam in the South, and Arunachal Pradesh in the East. The terrain is rugged and mountainous with elevations ranging from 150 meters to above 7000 meters. Most of Bhutan's rivers are fed by glaciers and glacier lakes and carry a large volume of water during the monsoon season. These lakes and glaciers periodically produce glacier lake outburst floods (GLOF). As glaciers melt and retreat, glacial lakes form behind moraine. A glacier lake outburst flood is created when water dammed by a glacier or a moraine is suddenly released.

In 2001 the International Center for Integrated Mountain Development (ICIMOD) identified 24 of Bhutan's 2674 glacial lakes as potentially dangerous. As indicated in the Site Assessment report for this project eight of these 24 lakes are located in the headwaters of the Pho Chhu River which flows through the Punakha-Wangdi Valley.

The project titled "Reducing Climate Change-Induced Risks and Vulnerabilities from Glacier Lake Outburst Flood in the Punakha-Wangdu and Chamkhar Valleys" was funded by the Global Environment Facility of the United Nations Development Programme (GEF-UNDP) under the LDC funding in an effort to reduce the risk to human life and property caused by these GLOFs. The project has three main components: 1) Lowering the water level of Thorthormi Lake, 2) Installation of Early Warning System along Punatsangchhu Valley and 3) Strengthening of Disaster Management and Community Awareness.

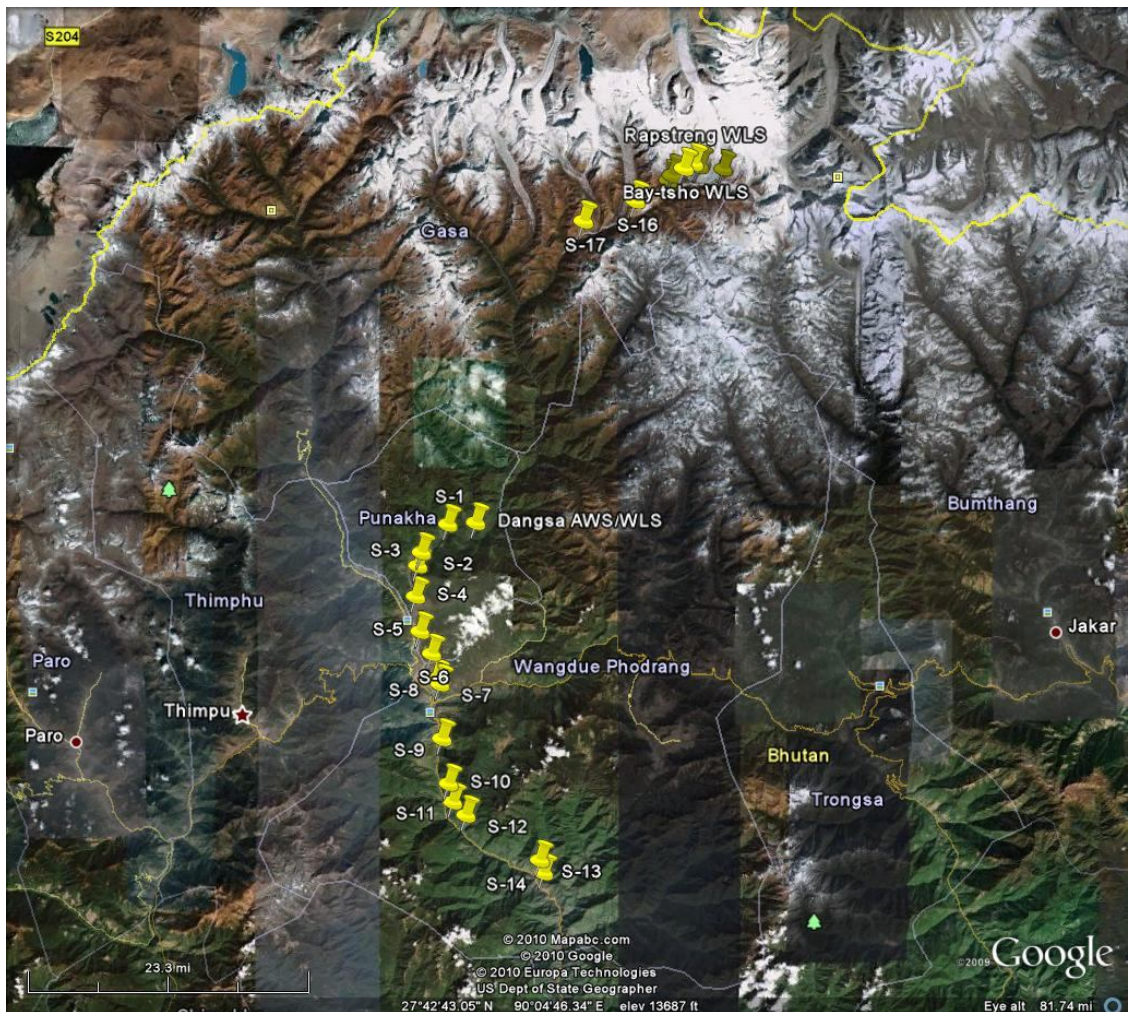
This project titled "Installation of Glacial Lake Outburst Flood Early Warning System in the Punakha-Wangdi Valley" is the second component of the overall project. It is being administered by the Hydromet Services Division of the Department of Energy of the Ministry of Economic Affairs of the Kingdom of Bhutan. The purpose of the project is to provide a real time early warning system to notify the people of approaching floods so that lives may be saved and property damage minimized.

## 1.2 Purpose and Scope

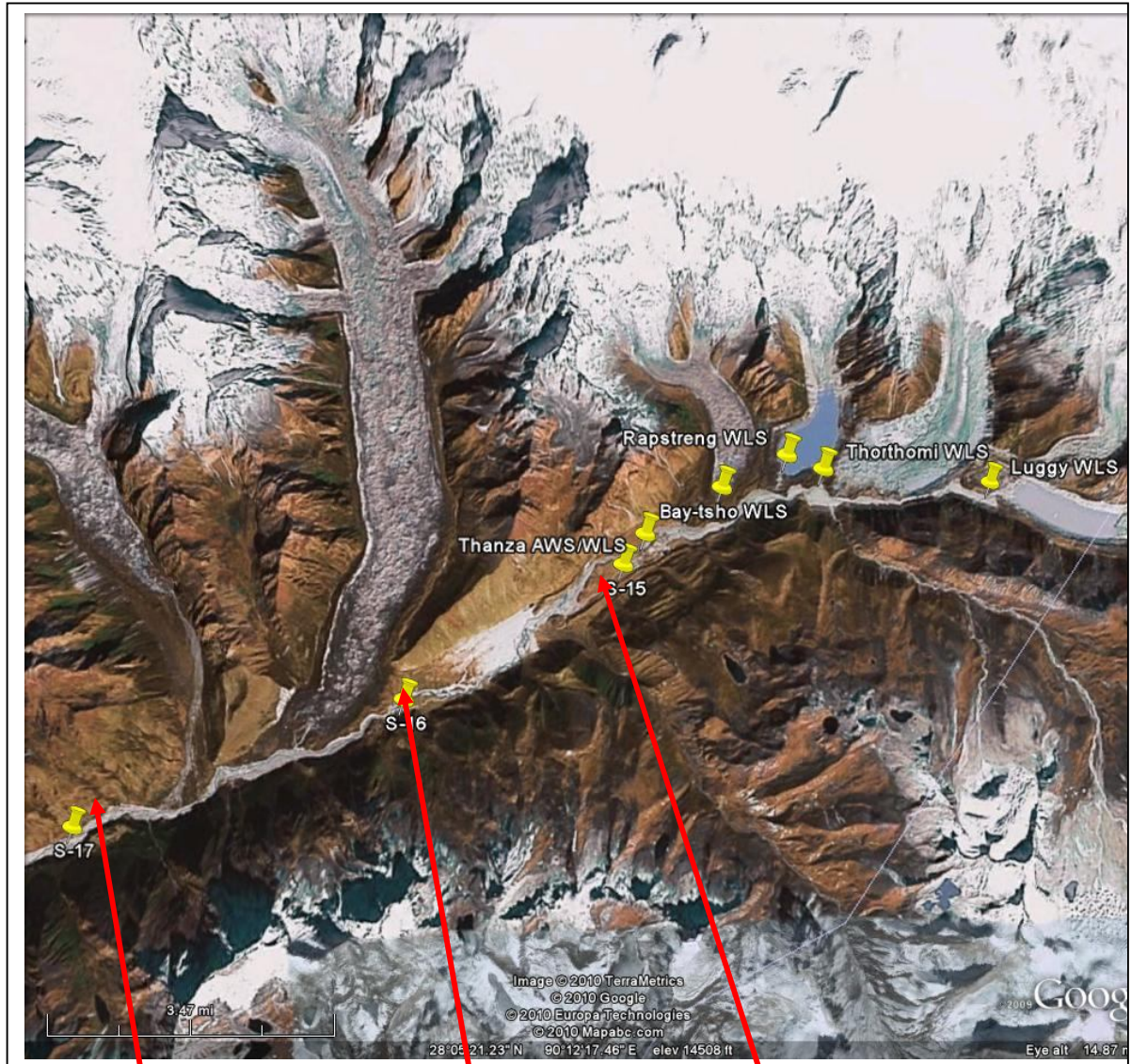
The purpose of this Inception Report is to outline the work plan for the completion of the project. The report provides a more detailed approach to the project than was presented in the proposal. It proposes milestones for the completion of the various components of the project. It provides more detail on the personnel that will be used to complete the project. The report discusses the constraints and potential problems of the project with plans of how to mitigate these. The report identifies information needed from DOE for the completion of the project. Detailed engineering drawings are included in the Appendix A.

### 1.3 Station Locations and System Maps

The following system maps show the general locations of the gauging stations and siren stations with reference to the rivers, reservoirs towns and roadways in the area.



The following map shows the general location of the sensor and siren stations in Lunana.

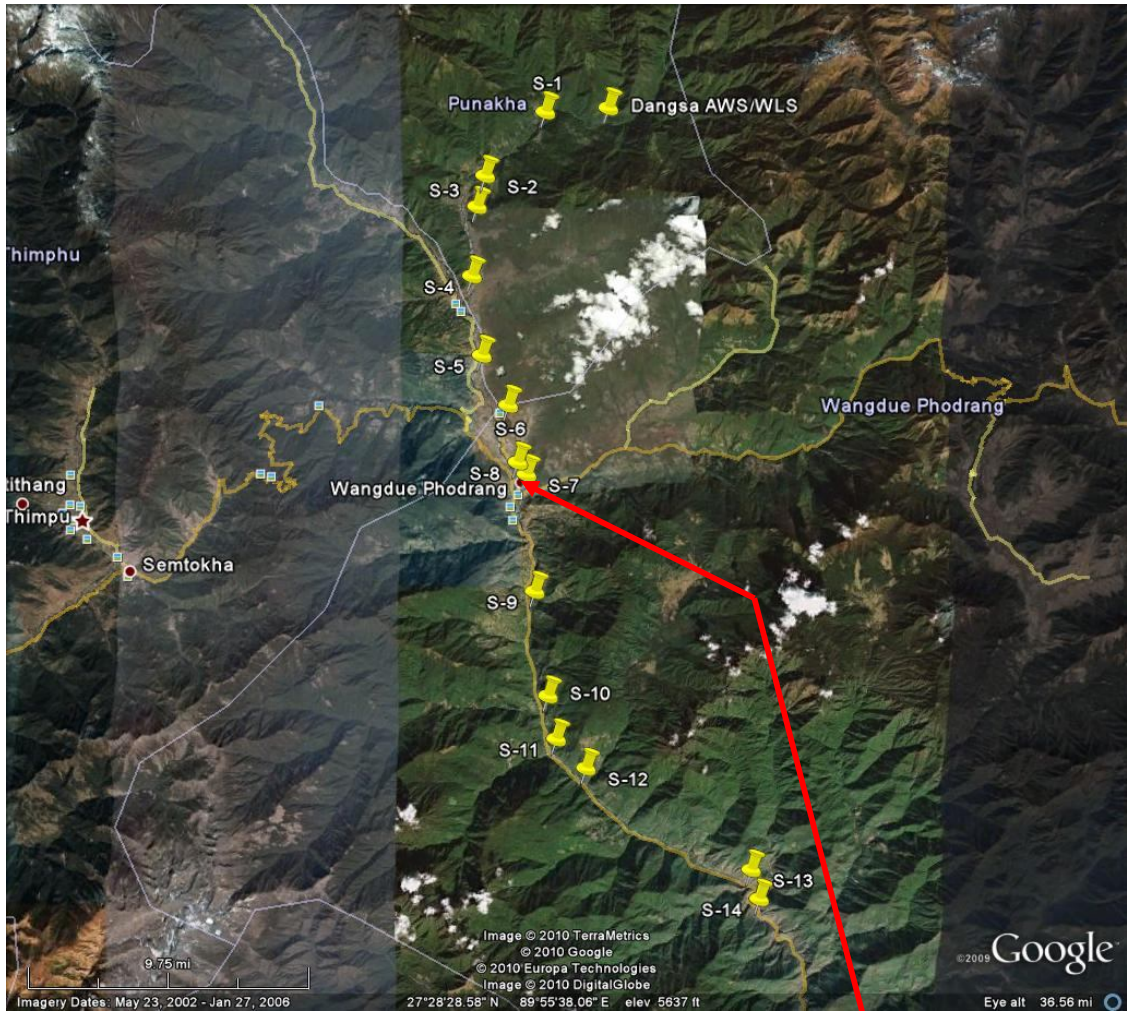


*Siren Station for  
Lhedhi Village*

*Siren Station for  
Tshojo Village*

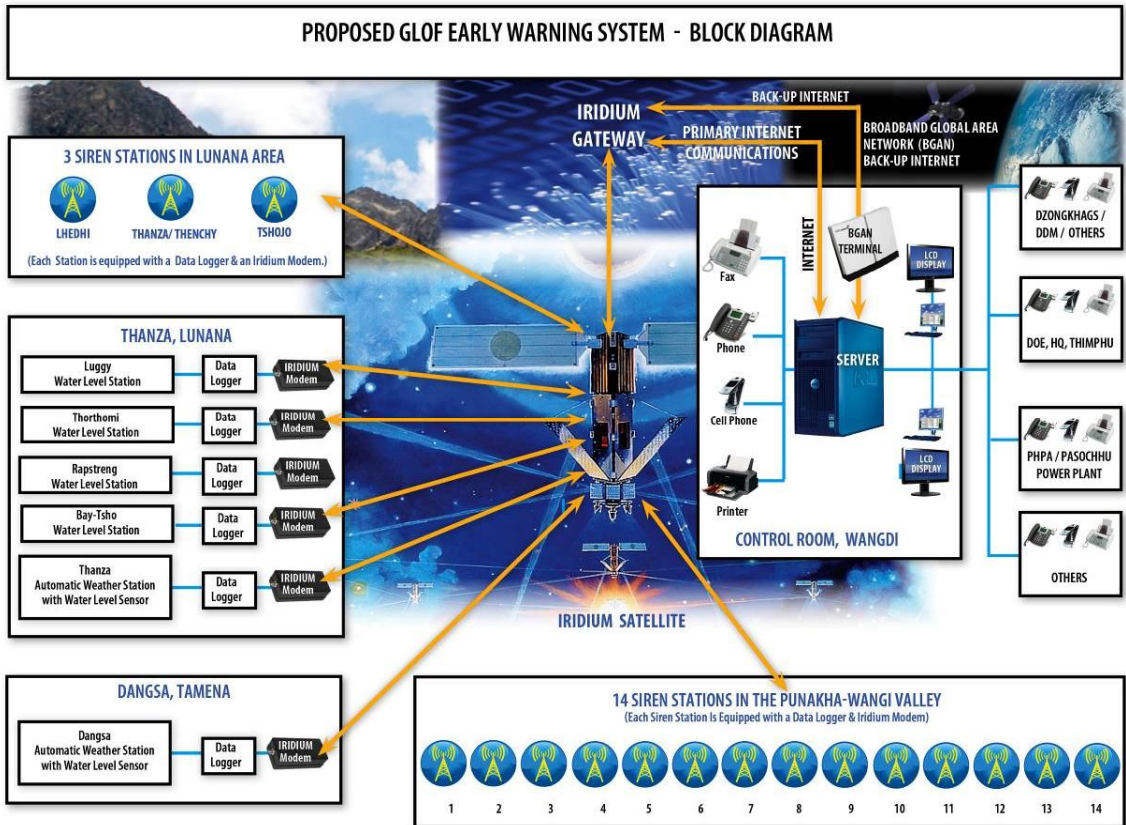
*Siren Station  
for Thanza and  
Tenchey*

The following map shows the general location of the siren stations in the Punakha-Wangdi Valley.



**Central Control  
Station, Wangdi**

The following block diagram illustrates how the sensors, base stations, control stations, sirens and communication systems interact to form the GLOF Early Warning System.





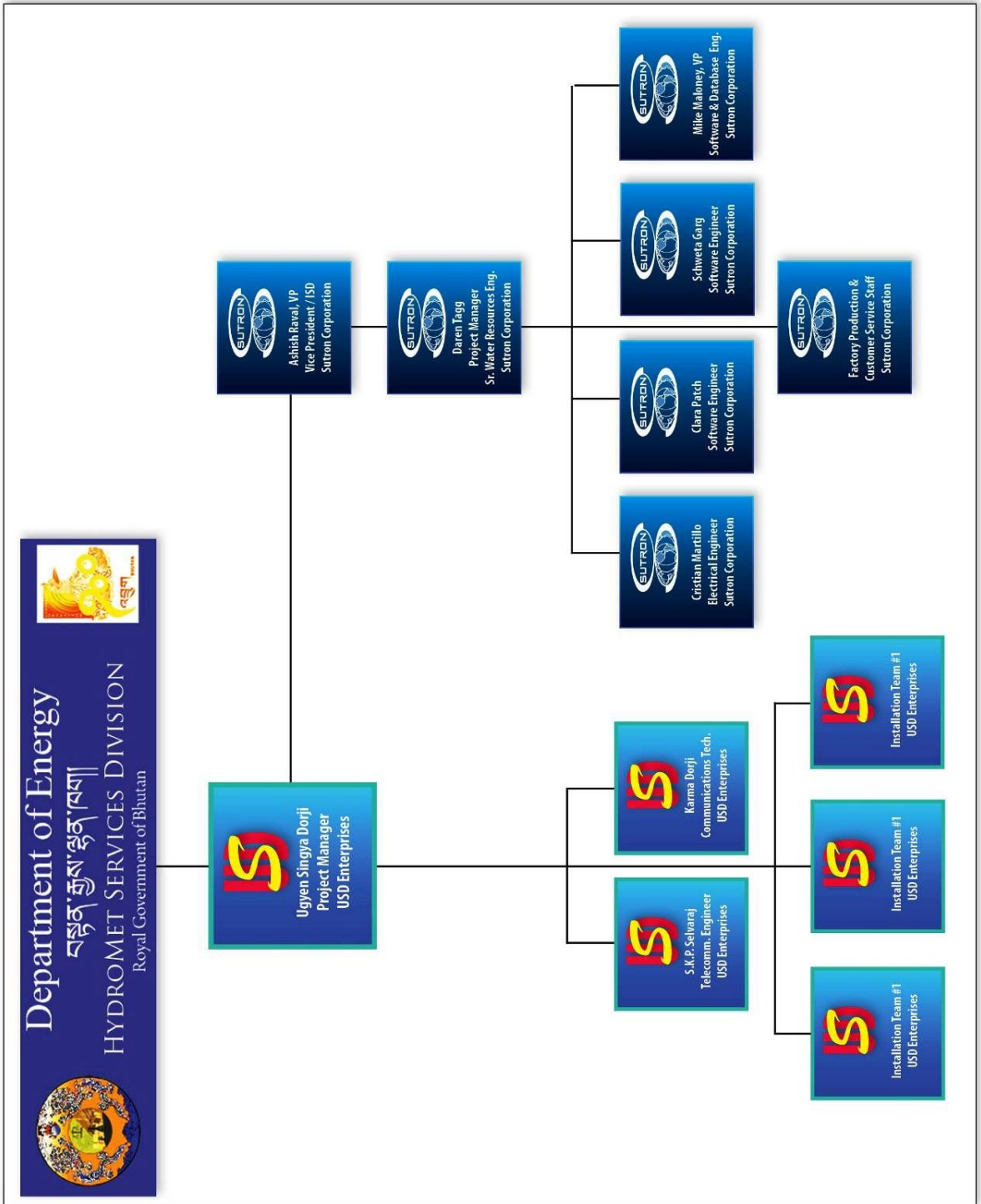
## **2. PROJECT TEAM**

### **2.1 Organizational Chart**

The organizational chart for the project has been refined from what was originally shown in the proposal to accommodate the needs of the Hydromet Services Division better. With the possibility of bad weather effecting the installation of the sites and due to the remoteness of the sites in Lunana, we thought it would be wise to add additional resources to the project. USD Enterprises will hire 20 to 30 laborers and organize them into three installation teams.

These installation teams will be assigned to the three distinct areas of the project; the Lunana area, the Phochhu area and the Punasangchhu area. Since there will be three separate teams, they will be able to work concurrently which will compress the time schedule of the project.

Please refer to the following organizational chart.



## **2.2 USD Enterprises**

USD Enterprises and the Sutron Corporation have formed a joint venture for the execution and completion of this project. USD has been designated as the “partner in charge” of the joint venture. As “partner in charge”, USD will act as the single point of contact for the job with all official communication going through them. USD will be the local Bhutanese contact for the project.

USD will be responsible for the construction of all the civil works for the project. This includes the concrete foundations for the stations, the erection of the towers, the installation of the fence and the trenching and laying of the conduit lines for the bubblers.

To complete these civil works, USD will hire 20 to 30 laborers. These laborers along with the project managers and technicians from USD will be organized into three separate installation teams. This will allow work to progress in three separate areas at the same time. The first team will be located in the Lunana area and will do the installation of the weather station in Thanza, the siren stations at the villages of Lhedhi, Tshojo, and Thanza/Tenchey, and the water level stations at the lakes of Bay-Tsho, Rapstreng, Thorthami and Luggy. The second team will be located in the Phochhu area and will do the installation of the weather station in Dangsa as well as the siren stations S-1 thru S-4. The third team will be located in the Punasangchhu area and will do the installation of siren stations S-5 thru S-14.

Sutron personnel will train USD staff telecommunications engineers and communication technicians to install the hydro meteorological monitoring equipment. These same USD technicians will also perform the maintenance required during the one year warranty period.

USD will also provide the control station hardware and install it at the control station in Wangdi.

## **2.3 Sutron Corporation**

Sutron Corporation will provide the technical expertise in the supply and installation of the real time data collection, telemetry and data management aspects of the project. Sutron will fabricate and integrate the remote station equipment. They will test all the equipment prior to shipping and will also conduct the factory acceptance tests in the presence of the Employer in their facility in Sterling Virginia.

Sutron will provide and develop the control station software according to the parameters listed in the project specifications.

Once the civil works for the sites are complete Sutron will travel to Bhutan to train USD in the installation of the stations. Sutron will install a combined AWS/AWLS station and a siren station. During these installations, Sutron will train the USD and Tshomo Geo-Tech personnel so that they can complete the installations of the remaining stations. The goal is to provide a transfer of technology from Sutron to USD. Additionally the designated DOE staff will participate in the training to receive their “on-the-job” training.

After the stations are installed, Sutron will provide a week long formal classroom training on the field stations. This classroom training will be combined with additional training in the field. Sutron will also provide a week of training on the control station hardware, software as well as the operation of the Flood Warning System.

At the end of the project Sutron will provide the operation and maintenance manuals as well as the final report.

### **3 INITIAL OBSERVATIONS**

Sutron has evaluated the site photos taken as part of the site selection process included in the Site Assessment Report dated September 2008 and the power point presentation of September 16, 2009. We have included some of these photos in this report.

We have also included photos we took the week of May 24, 2010. During the May 24 trip Sutron visited the Dangsa AWS/AWLS site as well as Siren Sites S-1 thru S-14. We have re-numbered the sites to avoid duplicate references and to aid in the fabrication and installation process.

During the month of June 2010, Sutron's local partner USD Enterprises traveled to the Lunana sites with representatives from DOE. Pictures of Siren Sites S-15 to S-17 as well as the Thanza AWS/AWLS and the 4 AWLS stations are included from this trip.

### 3.1 Site Photos

#### Wolathang Community School (S-1)

Description: Wolathang, 100m above the main building of the Wolathang Community School above the Principal's quarters, left bank of Phochhu.

GPS Coordinates: Northing 27° 40' 33.6" N  
Easting 89° 54' 39.6" E  
Elevation 1450 meters



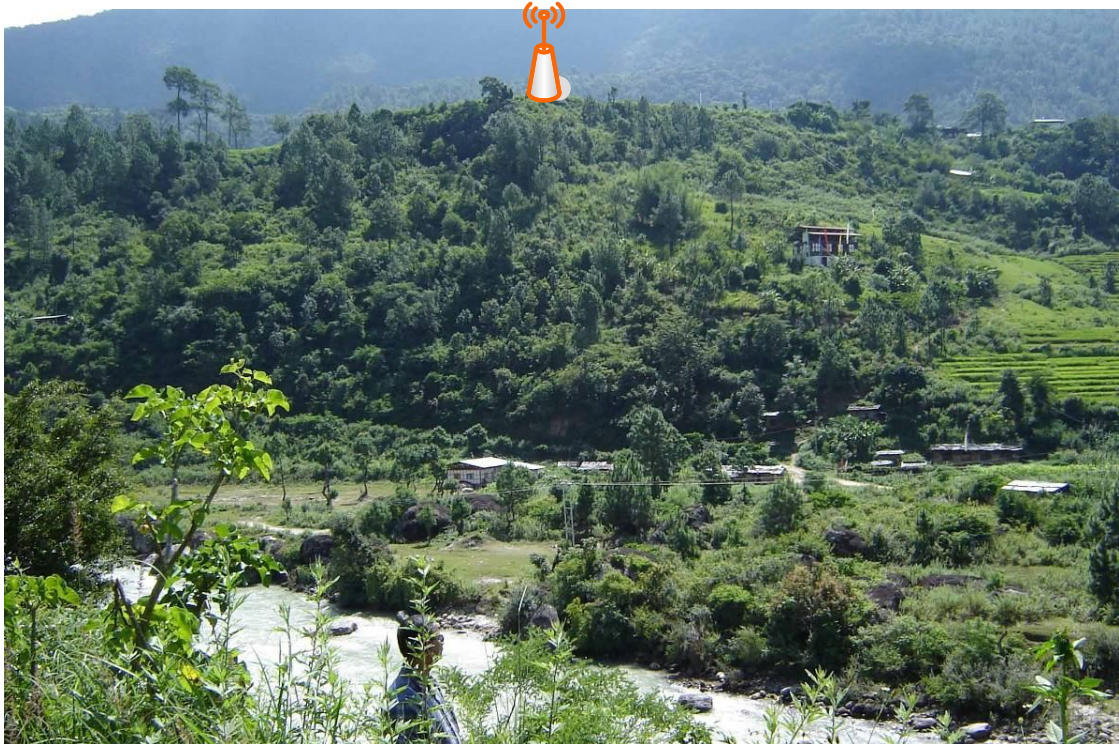


**Siren Site S-1**

### Samdingkha Area (S-2)

Description: Jibjokha hilltop overlooking Samdingkha village below Jibjokha village near Jibjokha Lower Secondary School, left bank of Phochhu.

GPS Coordinates: Northing 27° 38' 31.2" N  
Easting 89° 52' 30.0" E  
Elevation 1430 meters







**View from Siren Site S-2**



**Siren Site S-2**

### **Khawajara Area (S-3)**

Description: Khawajara hillock on the left bank of Phochhu opposite to Khuruthang.

GPS Coordinates: Northing 27° 37' 33.6" N  
Easting 89° 52' 12.0" E  
Elevation 1370 meters





**View from Siren Site S-3**



**Siren Site S-3**

### **Punakha Area (S-4)**

Description: On the hill slope above Punakha Dzong cremation ground.

GPS Coordinates: Northing 27° 35' 20.4" N  
Easting 89° 52' 1.2" E  
Elevation 1340 meters





**View from Siren Site S-4**

### **Kuruthang Area Punakha (S-5)**

Description: Above Kruruthang town near Water Supply Tank.

GPS Coordinates: Northing 27° 32' 59.4" N  
Easting 89° 52' 4.5" E  
Elevation 1321 meters





**Siren Site S-5**



**Siren Site S-5**

### Samthang Area (S-6)

Description: Samthang VTI, above the Wangdi-Samthang road on left bank of Punatsagchhu

GPS Coordinates: Northing 27° 31' 12.0" N  
Easting 89° 53' 20.4" E  
Elevation 1280 meters







**View downstream from Siren Site S-6**



**View upstream from siren site S-6**

### **Flood Warning Office, Wangdi (S-7)**

Description: Flood Warning Office, Wangdi. Siren location is in fenced area in front of the building near the existing rain gauges.

GPS Coordinates: Northing 27° 29' 0.0" N  
Easting 89° 54' 0.0" E  
Elevation 1303 meters





**Siren Site S-7**



**View at rear of Flood Control Office Siren Site S-7**

### Dragon Nest Resort (S-8)

Description: Above Dragon Nest Resort overlooking Bajo, right bank of Punatsangchhu.

GPS Coordinates: Northing 27° 29' 23.0" N  
Easting 89° 53' 41.0" E  
Elevation 1320 meters





**View from Siren Site S-8**



**View from Siren Site S-8**

### **Punatsangchhu-I Project Dam Site (S-9)**

Description: Punatsangchhu Project I Dam Site, right bank of the Punatsangchhu.

Since the dam site is currently under construction, DOE will finalize a location with The Punatsangchhu Hydropower Project Authority (PHPA) that will be most suitable to warn the operators. Current plans are that the siren will be located near the 33/11 KV substation Khempajechhu.

GPS Coordinates: Northing	27° 25' 15.6" N
Easting	89° 54' 18.0" E
Elevation	1280 meters





**Punatsangchhu Dam site under construction**



**View upstream from Siren Site S-9**

### Access Adit between Basochhu and Rurichhu (S-10)

Description: Above Basochhu Hydropower Plant, Rurichhu above viewpoint, right bank of Punatsangchhu.

GPS Coordinates: Northing 27° 21' 54.0" N  
Easting 89° 54' 46.8" E  
Elevation 1100 meters







**Siren Site S-10**

### **Rurichhu Basochhu Power House (S-11)**

Description: Located on the hill on the right bank of the Punatsangchhu above the Basochhu power house's view point above the Wangdi-Tsirang Highway, Rurichhu.

GPS Coordinates: Northing      27° 20' 31.2" N  
   Easting      89° 55' 4.8" E  
   Elevation      1010 meters





**Siren Site S-11**



**View downstream from Siren Site S-11**

### **Punatsangchhu I- Powerhouse (S-12)**

Description: Since the powerhouse site is currently under construction, DOE will finalize a location with The Punatsangchhu Hydropower Project Authority (PHPA) that will be most suitable to warn the operators. Current plans are that the siren will be located near the main access tunnel Dhentri.

GPS Coordinates: Northing      27° 19' 33.6" N  
   Easting      89° 56' 9.6" E  
   Elevation    950 meters



### **Kamichhu Suspension Bridge (S-13)**

Description: Located on top of a ridge on the right bank of the Punatsangchhu above the suspension bridge 50 meters from the Wangdi-Tsirang Highway.

GPS Coordinates: Northing	27° 16' 15.6" N
Easting	90° 2' 9.6" E
Elevation	700 meters



### **Punatsangchhu-II Powerhouse (S-14)**

Description: Proposed powerhouse site of the Punatsangchhu-II project, downstream of Kamichhu above Wangdi-Tsirang Highway.

Since this siren site is to warn the workers and operators of the Hydropower project and the project has not begun, the equipment for this site will be supplied and DOE will construct it in the future. DOE will finalize a location with The Punatsangchhu Hydropower Project Authority (PHPA).

GPS Coordinates: Northing	27° 15' 18.0" N
Easting	90° 2' 27.6" E
Elevation	730 meters



### **Combined Siren Tower for Thanza and Tenchey (S-15)**

Description: On the left bank at Dumbiteng overlooking Thanza and Tenchey villages.

GPS Coordinates: Northing 28° 5' 1.02" N  
Easting 90° 12' 51.72" E  
Elevation 4140 meters



**Siren Site S-15**

### **Siren Tower for Tshojo Village (S-16)**

Description: On the right bank at Neptangsa overlooking Tshojo Village.

GPS Coordinates: Northing	28° 3' 41.22" N
Easting	90° 9' 44.04" E
Elevation	4117 meters



**Siren Site S-16**



### Siren Tower for Lhedhi Village (S-17)

Description: Above Headmaster's Quarters in Lhedhi Community School.

GPS Coordinates: Northing 28° 2' 10.9" N  
Easting 90° 5' 49.0" E  
Elevation 3767 meters



**Siren Site S-17**

### **Luggy Automatic Water Level Station (AWLS - 1)**

Description: Gauge site located about 400 meters downstream of the lake outlet. This location is also the location of the existing gauge site. Station is to be located on the right bank about 65 meters above the water level.

GPS Coordinates: Northing 28° 5' 44.9" N  
Easting 90° 16' 53.85" E  
Elevation 4485 meters



Figure 23.31 showing the unstable outlet east of the Luggy Tsho

**Luggy Tsho**

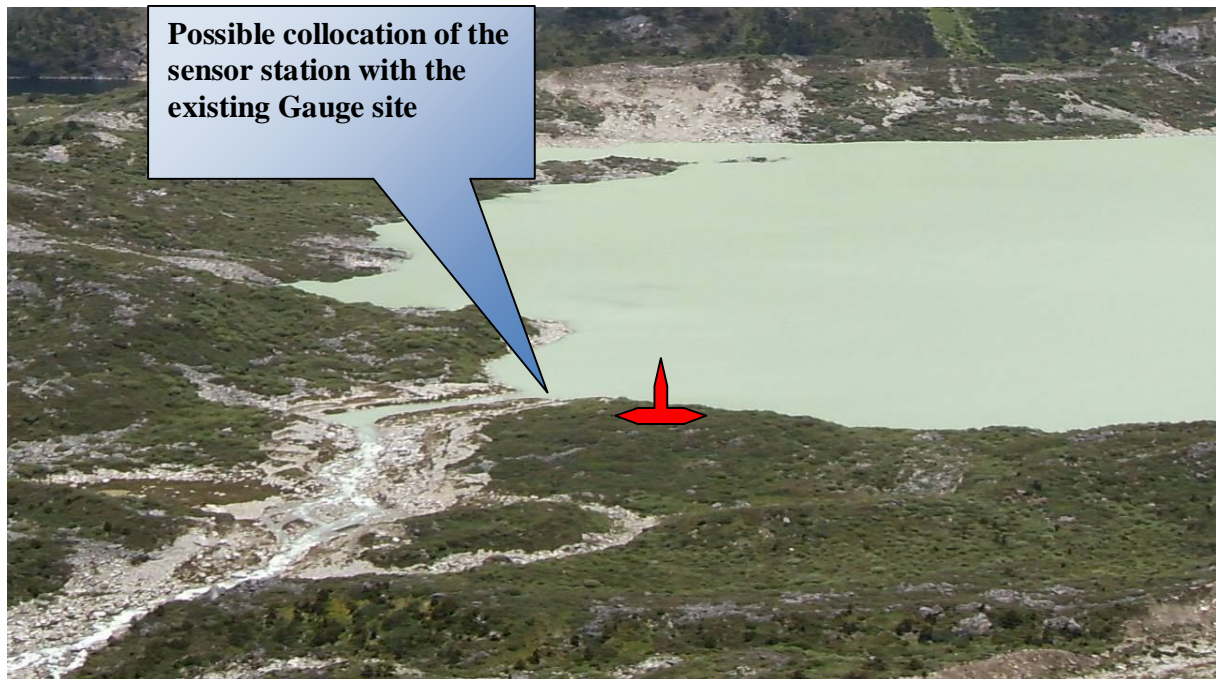
**Lake Outlet**



### **Rapstreng Automatic Water Level Station (AWLS - 3)**

Description: Sensor is to be located on the lake at the existing gauge site about 7 meters from the lake. Station is to be located on the left bank about 35 meters above the water level.

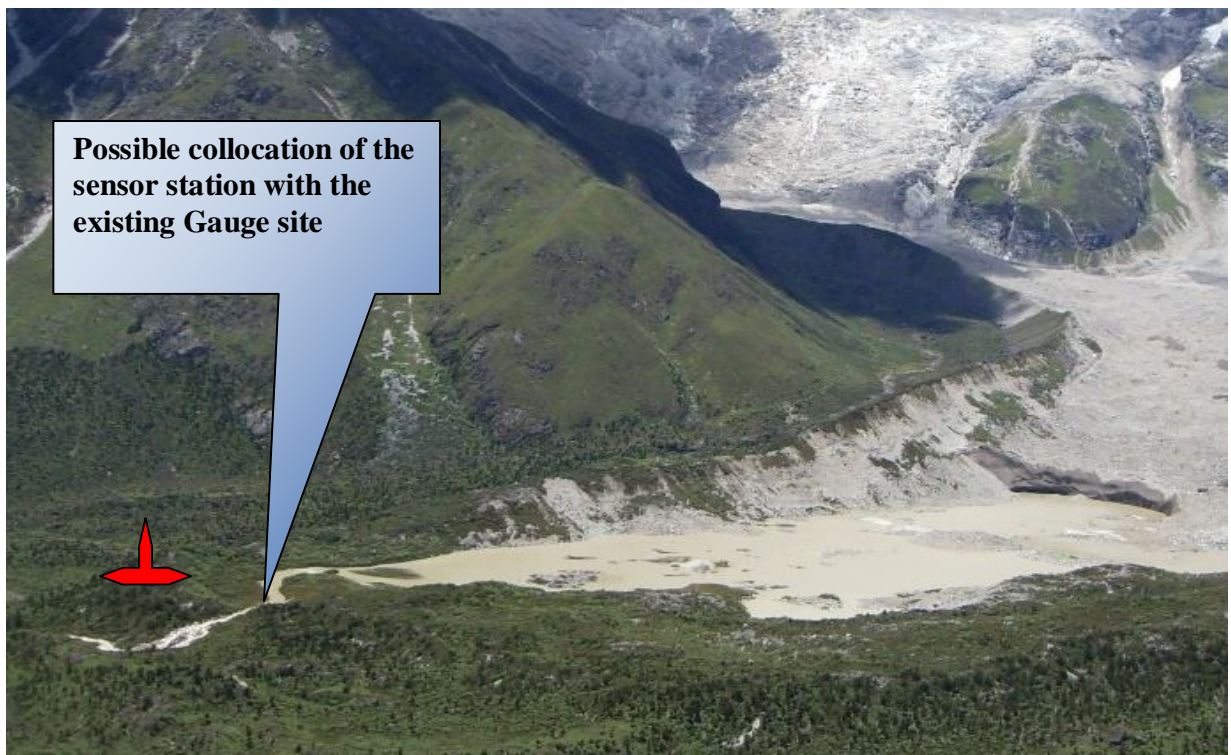
GPS Coordinates: Northing 28° 6' 1.43" N  
Easting 90° 14' 29.46" E  
Elevation 4354 meters



### **Bay-Tsho Automatic Water Level Station (AWLS - 4)**

Description: Sensor is to be located on the lake at the existing gauge site about 8 meters from the lake. Station is to be located on the right bank about 35 meters above the water level.

GPS Coordinates: Northing	28° 5' 41.38" N
Easting	90° 13' 42.83" E
Elevation	4339 meters



### **Dangsa Automatic Weather Station and Water Level Station (AWS/AWLS-1)**

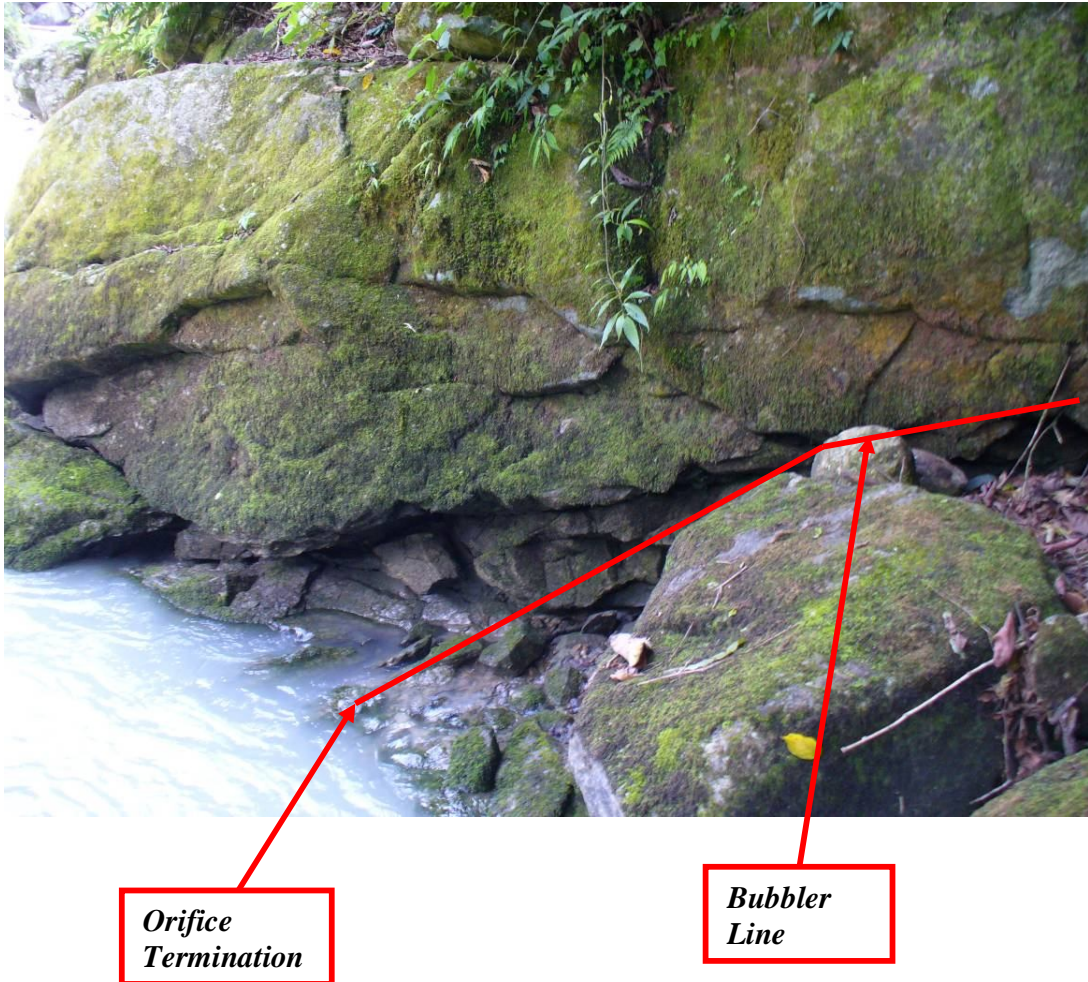
Description: Gauge site is located on the left bank of the Phochhu about 4 or 5 km upstream of the village of Tamena. Tamena is located about 3-4 km upstream of Wolathang.

GPS Coordinates: Northing      27° 40' 41" N  
   Easting      89° 56' 55.7" E  
   Elevation      1450 meters



*Sensor Site  
(Approximately 4-5  
km upstream)*

*Tamena Village  
(Road End)*



The orifice termination is located downstream of a large rock for protection. This location also provides a place that is relatively still and separated from the major currents of the river.



**Phochhu upstream of the orifice termination**



**Phochhu downstream of the orifice termination**





*AWS/AWLS station location 10 to 15 meters above floodplain on top of a small hill*

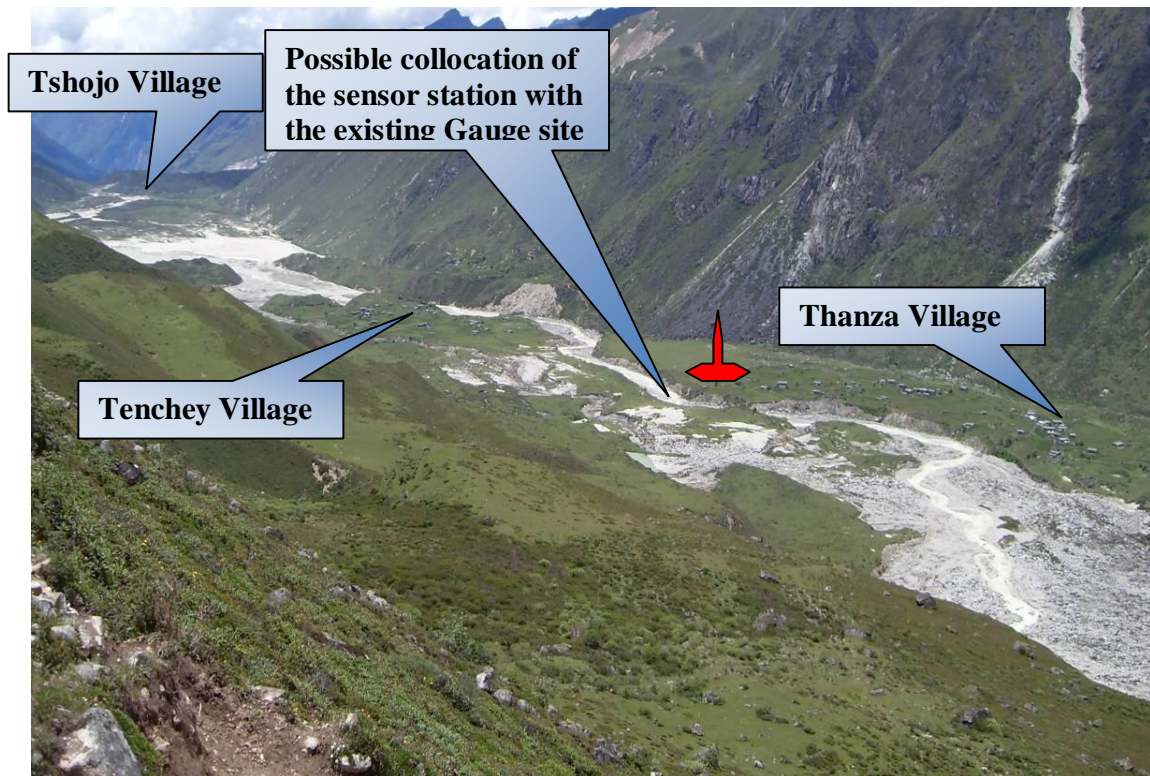


**Weather Station and Water Level Station Location**

### Thanza Automatic Weather Station and Water Level Station (AWS/AWLS-2)

Description: Sensor is to be located at the existing gauge site near the temporary footbridge connecting Thanza and Tenchey village. Station is to be located on right bank about 35 meters above the water level.

GPS Coordinates: Northing      28° 5' 12.05" N  
   Easting      90° 12' 47.6" E  
   Elevation    4120 meters



## **3.2 Comments and Observations**

### **Siren Stations**

In reviewing the previous studies and in particular the “Site Assessment Report” dated September 2008 it appears that great care was taken to place the siren stations in areas that had the most need to warn residents as well as workers. When we visited siren sites S-1 thru S-14 during the week of May 24, 2010 it was evident that most if not all of the significant population centers in the Punakha-Wangdi Valley have a siren located within them. These sirens have been placed high above the population centers where the sound will be able to carry the best.

Based on conversations with members of the Hydromet Services Division, the travel time from the glacial lakes in Lunana to Dangsa is approximately 5 hours, and to Punakha is approximately 7 hours. This will give the residents and workers in the Punakha-Wangdi valley plenty of time to hear the warning sirens and make the necessary preparations to move to higher ground in the event of a GLOF. This will also give government officials time to warn the people by other means in case they do not respond to the sirens.

In reviewing the power point presentation of September 16, 2009 it appears that the three siren sites in Lunana were added to warn the four villages located near the glacial lakes. When Sutron’s local partner USD Enterprises visited these three siren sites, their locations were finalized on elevated ground and in close proximity to the villages. Due to the small size of the villages of Thanza, Tenchey, Tshojo, and Lhedhi, the placement of the sirens and with the lack of large vegetation in the area, these residents should have no problem hearing the sirens. Based on conversations with members of the Hydromet Services Division, the travel time from the glacial lakes to these villages in Lunana varies from approximately 20 minutes to 60 minutes. Although the time available for warning is significantly less than for the Punakha-Wangdi valley due to the short distance downstream, it will still be a useful warning for the residents of these villages.

The Bidding Document for the project did not have detailed specifications regarding the sound requirements for the sirens. Since this is a flood warning project and lives are at stake, we selected a high quality warning siren. The Whelen OA-1 produces a sound pressure of 60 dB at a distance of 2800 feet (0.85 km). We assume that most of the residents of the towns and villages will be within this 0.85 km radius. If there are significant populations outside this range, other warning methods will need to be employed which are beyond the scope of this current project. If, in the future, it is determined that a particular siren needs to be heard at a greater distance, the siren station could be upgraded with a second speaker. The Whelen sirens are modular and can be easily upgraded. The Whelen OA-2 produces a sound pressure of 60 dB at a distance of 4400 feet (1.34 km).

## **Automatic Water Level Stations**

From the pictures and descriptions available we were able to understand the general location of these 4 stations at the lakes (Luggy, Thorthomi, Rapstreng, and Bay-Tsho). From the site visit by our local partner USD Enterprises in June of 2010, we were able to understand the final location of these stations.

The sensors at Luggy and Thorthomi are located on the river downstream of the lakes. They are also located at the existing gauge sites. This is a good idea to locate the sensors where the existing gauges are in order to extend the period of record of the existing gauges. The station locations for these two sites are located on an elevated area well above the flood stage.

The sensors at Rapstreng and Bay-Tsho will measure the water level in the lakes. They are also located at the existing gauge sites. Both station locations are located on an elevated area well above the flood stage.

These four stations are located at the critical points in the high elevation portion of the project. The two lake stations will detect any sudden drop in water level in the lake due to a GLOF. The two stream stations will detect and sudden rise in water level due to a GLOF.

The station containing the DCP, solar panel, telemetry and bubbler should be located above the expected flood stage. This is for the safety and protection of the station in the event of a flood. The end of the bubbler line (orifice termination) should be located in the stream at a place where it will be protected from debris. The orifice termination will be encased in concrete for stability. The bubbler line has a maximum length of 150 meters and must be installed at a continuous downhill slope from the bubbler to the orifice termination. These parameters will determine the final location of these water level stations.

## **Automatic Weather Stations with AWLS**

During our trip of the week of May 24, 2010, we visited the **Dangsa** site to finalize the location of the orifice termination and the combined weather and water level station. The Dangsa AWS/AWLS is located approximately 4 to 5 kilometers upstream of the village of Tamena. This site is remote since the road ends at Tamena and it takes a couple of hours to walk to the site. Because the site is remote we feel that there will be very few problems with vandalism.

The orifice termination will be located on the downstream side of very large boulder. This boulder will offer protection from debris that may come down the river in a large event. It will also provide an area where the water is more still than most of the river since it is separated from the major currents of the river. Both orifice lines should terminate in this protected area and should be separated by at least 4 or 5 meters. This site is an excellent location for an orifice termination.

During the site visit we evaluated a flat area about 10 to 15 meters above the river as a potential location for the station. This area was not considered to be the best site since we found evidence of flood waters reaching this elevation and since the weather station sensors would not be as accurate located in this low lying and heavily treed area.

The final location of the station was decided to be on a small hill 10 to 15 meters above the floodplain. After a few trees are cleared on the top of this hill, the site will offer an excellent location for a weather station. Since it is located 20 to 30 meters above the river, it will be protected from the flood waters of the river. Horizontally the site is approximately 30 or 40 meters from the river and well within the preferable range of 150 meters for the orifice lines. Care needs to be taken to ensure that the orifice lines have a continuous downhill slope from the sensor to the orifice termination.

The **Thanza** AWS/AWLS is located in an ideal place to measure weather parameters. The whole surrounding area is free from tall vegetation which could potentially affect the readings from the sensors.

The combining of the AWS/AWLS and the existing gauge site is a good idea since the stage of the river has been measured here in the past and the new sensor will merely automate the measurement and continue to add to the period of record for the site.

This station is located well above the flood stage and within the preferable range of 150 meters for the orifice lines. Care needs to be taken to ensure that the orifice lines have continuous downhill slope from the sensor to the orifice termination.

## **4. WORK PLAN**

We have prepared a detailed work plan for the completion of this project. It is contained in a Gantt chart located in Appendix C. The following paragraphs give more detail on some of the parts of the work plan as well as the thinking behind it.

### **4.1 Procurement, Fabrication and Assembly Plan**

The fabrication and assembly of the DCPs for the siren stations, the water level stations and the weather stations will be performed by Sutron. Some of the parts will be fabricated in our manufacturing facility and some of the parts will be purchased from our normal suppliers here in the United States. Once the manufactured parts have been manufactured and the purchased parts have been received we will begin the process of assembly and integration in our Integrated Systems Division (ISD) lab. After the stations have been assembled, they will undergo a three week period of testing of the hardware as well as integration with the software.

The 17 siren poles will be fabricated in Bhutan and provided and installed by USD Enterprises.

### **4.2 Control Station Software Plan**

Sutron will provide software for the server located at the Wangdi Control Station for the control and monitoring of each station's XLite Datalogger, each station's Power System, Communications System, Water Level Sensors, AWS Met Sensors and Sirens which comprise the GLOF Early Warning System.

Below is a list of the functionality requirements of the control station software.

- ▶ A digital map will be produced which shows the location of each water level sensor, each AWS and each siren station.
- ▶ Control Station and System Software will be customized to display the most recent GLOF data using icons on the digital map.
- ▶ Data will be collected by the dataloggers every 15 minutes and transmitted to the Control Station every hour.
- ▶ Historical data for each parameter will be displayed in graphical and tabular form using map icons.
- ▶ The software will automatically activate the Sirens when water levels reach pre-determined levels.
- ▶ Sirens can be activated individually or in groups either automatically and/or manually.
- ▶ On-demand (manual) activation and de-activation (turned off) of Sirens will apply individually or in groups.

- ▶ In addition to the hydrological and meteorological information provided by the sensors, the battery status of each station will be reported and monitored as well as the status (on/off) of each sensor.
- ▶ From the Control Station in Wangdi the Employer will have the ability to communicate with the XLite Dataloggers in order to change the timing of the sirens and data collection intervals of the sensors.
- ▶ Control Station Software will also provide the ability to check the quality and accuracy of the data being reported by the stations.
- ▶ Data collected at the control station will be stored on the server in Wangdi which will have the capacity to store over 12 months of data. Data will be able to be exported into Micro Soft Excel format.
- ▶ Data will be able to be transmitted via the internet to the Weather Forecasting Center in Thimphu or any other user selected by the operator of the Control Station.
- ▶ Data will also be able to be retrieved through dialing in through the internet in a password protected environment.

During the development of the software, Sutron will send to DOE screen shots or if practical, functioning prototypes for their review. Sutron will address the comments made by DOE.

When DOE comes to Virginia for the Factory Acceptance Tests (FAT), Sutron will have a version of the software that will be available for demonstration. We will incorporate any feedback that is presented into the final version of the software.

### **4.3 Civil Works Plan**

Key to the successful and on time completion of the project is the Civil Works plan. Since the biggest unknown or constraint is the weather we decided to use three separate teams to do the civil works instead of just one. By doing this we can make progress in three different areas at the same time.

The intent of the schedule shown in the Gantt chart is to finish all the civil works before the weather gets bad in late September or early October. This will allow the installation of the stations in the Punakha-Wangdi valley to proceed first (in the November timeframe), and the installation of the Lunana stations to proceed as soon as the weather gets good in the spring. Installing the lower stations first will allow a better situation for training of USD staff in the installation of the stations since the areas are not remote. Once USD has completed all the lower stations, they will be able to quickly finish the Lunana stations in the spring. We feel like pushing hard to

get the civil works done by October will ensure that the project will be completed within the 15 month period.

USD will add 20 to 30 laborers to ensure that the civil works will be completed on time. They will also add project managers and technicians to guide and direct the work of the laborers. Each team (Lunana, Phochhu, and Punatsangchhu) will work on more than one site at a time. Please refer to the Gantt chart in Appendix C for further details.

#### **4.4 Shipping Plan**

The assembled DCPs, sensors, weather station towers, mounting hardware, solar panels and batteries will be shipped from Virginia to Paro either by air freight through Bangkok or by air freight to Calcutta and then by truck to Paro.

If the shipment comes into Paro by air freight, there are many restrictions and constraints. Drukair has a restriction on freight dimensions of 2.25m x 0.8m x 0.8m and a weight restriction of 50 kg for each piece. What this means is that the equipment will be packed by Sutron employees and shipped on pallets to Bangkok. Due to these restrictions, the pallets will then be broken down into smaller pieces when they arrive in Bangkok. These smaller pieces will then be flown into Paro. Even though all pieces will be packed separately at Sutron with packing slips and labels, there is a good chance for something to get lost in the transition.

If the shipment is flown to Calcutta, there are no unusual restrictions in the dimensions or weights of the pieces. The shipment can be packed in the normal manner at Sutron on pallets and loaded into trucks when they arrive in Calcutta. The shipment will then be trucked to Paro.

Based on our experience in these two routes we will likely use the Calcutta route. The Calcutta route only takes a few days longer but has less of a chance for pieces to get lost and does not have the restrictions in package size or weight that the Bangkok air route does.

Once the shipment has arrived in Paro, DOE will assist USD in clearing the shipment through customs.

#### **4.5 Storage and Warehousing Plan**

Once the shipment has cleared customs, USD will transport it via truck to a rented warehouse in Punakha. USD will be responsible for the safety of the equipment while it is in storage. Although DOE could inspect the equipment at the warehouse it may be better to inspect it at the sites as the equipment is unpacked. Retaining the original packaging will help protect the equipment during the transportation within the country.



## 4.6 In Country Transportation Plan

There are two distinct types of transportation that will be used to take the equipment from the warehouse to the sites. All of the equipment for the Punakha-Wangdi valley can be transported by truck. The equipment for the stations in Lunana will go from the warehouse to a staging area at the head of the road. From that point the equipment will be arranged and packed on mule for transportation to the remote sites.

For the Lunana sites we have approximated the total weight of the equipment and the materials needed for the civil works to be 6000 kg. Most of the individual pieces are less than 50 kg. The siren poles will be the heaviest item and will be broken down into three pieces for transport. USD has already begun making the arrangements for this transportation by mule.

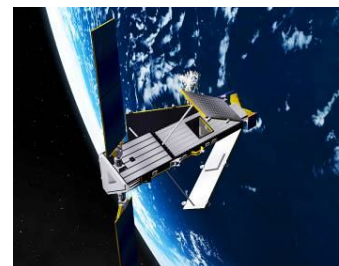
At the request of HSD we have looked into the possibility of using helicopters to transport some or all of the equipment to Lunana. We found that the closest available helicopters would come from Nepal. The B3 helicopter has a capacity of 700kg and would require 9 trips. The MI-17 helicopter has a capacity of 4,000kg and would require only 2 trips. We are currently evaluating the costs, benefits, and budget impacts of this mode of transportation.

## 4.7 Iridium Communications Plan

Sutron proposes using the Iridium Satellite System as the back-bone of communications for the GLOF Early Warning System Project. The Iridium constellation has more satellites than any other commercial constellation. The 66 Iridium Satellites are in a near-polar orbit at an altitude of 485 miles (780 km). They fly in formation in six orbital planes, each comprising 11 satellites, evenly spaced around the planet. Each Iridium Satellite completely circles the Earth once every 100 minutes, traveling at 16,832 miles per hour, and traveling from horizon to horizon across the sky in about ten minutes.

When an Iridium customer sends data from a device, that device connects to the Iridium Satellite that happens to be overhead. The traffic is routed among Iridium Satellites around the globe to reach the satellite above the Earth gateway, which downlinks the data to the Internet so that it reaches the recipient. Because the Iridium constellation comprises Low Earth Orbit (LEO) satellites, data delays are typically so minimal they are virtually unnoticeable.

Sutron recommends the Iridium System as the most economical, reliable and best suited system for Bhutan's remote and rugged terrain and extreme climate conditions. Other communications systems were ruled out for the following reasons:



- ▶ INSAT was not adequate because its communications are only one-way.
- ▶ VSAT was ruled out because it was not economical.
- ▶ HF Radio communications were ruled out due to reliability issues.
- ▶ Line-of-sight (LOS) radio was ruled out due to the requirements to construct several repeater stations across remote and rugged terrain and their associated costs in both time and money.

Recognizing the possibility that regular internet service may be disrupted or unavailable at times, and also recognizing the importance of immediate activation of the sirens in an emergency, we have proposed to use a BGAN terminal as a back up for the internet. BGAN stands for Broadband Global Area Network and is a Satellite Internet Network. The I4 Asia Pacific geostationary satellite provides coverage for Bhutan. The BGAN terminal would be connected directly to the server via Ethernet connection. The BGAN terminal could be configured to be used only if the regular internet connection went down or as a completely redundant form of communication depending on the budget that DOE will be working with.

The communications system Sutron proposes is reliable simple and fast. Water level and meteorological sensors will communicate with their site's datalogger via cables. Each station's datalogger using an Iridium Modem will then transmit their data via the Iridium Constellation to the Iridium Gateway, where the data will be immediately transmitted by Iridium/internet to the server in the Control Station in Wangdi. In the event an alarm is required, the server (automatically) or authorities (manually) will activate the appropriate Siren Stations. The signals from the Server to the Siren Stations will also be sent via Iridium and the internet.

Sutron is an authorized value added reseller (VAR) for Iridium. Sutron will set up the Iridium system and pay for the communication charges until the time of system acceptance. At that point DOE will establish their own Iridium account.

We have done some preliminary estimates of the Iridium communication costs for each station type. They are based on an hourly transmission of data collected every 15 minutes from the stations. For the AWS/AWLS we expect the monthly cost to be about \$91. For the AWLS stations we expect the monthly cost to be about \$39. For the Siren stations we expect the monthly cost to be about \$22. The total monthly cost for the system of 2 AWS/AWLS stations, 4 AWLS stations, and 17 Siren stations is estimated to be \$712. Please keep in mind that this does not include an estimate for configuration messages or other non-periodic messages. There is also a one time activation fee of \$40.00 per station.

For the BGAN terminal we have preliminarily estimated that the monthly usage fee will be \$132. This assumes hourly transmission of 15 minute data to be a completely redundant form of communication.

## **4.8 Testing and Acceptance Plan**

There are three types of testing and acceptance that will be done on this project.

- Factory Acceptance Testing (FAT)
- Site Acceptance Testing (SAT)
- Final System Testing and Acceptance

The Factory Acceptance Testing (FAT) is done at our manufacturing facility in Virginia. Representatives from DOE will come to Virginia for a week of training on the equipment and to observe the testing of the equipment before it ships to Bhutan. This testing is to ensure that everything is working properly before it leaves the factory.

Site Acceptance Testing (SAT) is performed at each individual remote site after the equipment has been installed. Each individual component is tested to ensure it is fully operational. DOE will observe this testing and will sign off on each site as it is finished and tested. At this point ownership of the station and the site is transferred to DOE.

Final System Acceptance and Testing is performed after all the remote sites have been accepted by DOE. The Final System Testing is performed at the control center and will ensure that data is being received from all the remote stations, that the sirens can be activated manually and automatically, and that all the required information is displayed properly. Once the system has been fully demonstrated and is functioning properly DOE will formally accept the system as a whole.

## **4.9 Training Plan**

In addition to the week of training that DOE will receive at the FAT in Virginia, Sutron will provide training in Bhutan. In-country training for the project will take place in three distinct phases.

- Phase 1 – On-the-job training
- Phase 2 – Field stations
- Phase 3 – Control Center

The on-the-job training will take place during the installation phase of the project. DOE personnel will observe the installation of the civil works as performed by USD and TGT. Sutron personnel will do the on the job training for the installation of the equipment. This training will be informal but will be extremely valuable.

For the training on the field stations, Sutron will provide both field instruction and classroom instruction. This training will be for a group of 4 students and will be one week in duration. This training will cover all aspects of datalogger setup, operations and maintenance. It will also cover sensor calibration, maintenance and installation. It will also cover the field aspects of the Iridium telemetry system.

For the control room training, Sutron will provide instruction to a group of 4 students for a duration of one week. This will cover hardware and software as well as the operation of the Flood Warning System. This training will cover a review of datalogger and sensor setup, operation and maintenance. It will cover the data processing hardware and software. It will cover the operation of the Iridium and BGAN terminal usage, as well as the use of the Tempest data monitoring and control software.

## 5. DATES AND MILESTONES

A detailed Gantt chart has been prepared for the project and is found in Appendix C. The following is a list of the major milestones and the planned dates associated with them.

Notice to Proceed	March 29, 2010
Engineering Design	March 29 to June 11, 2010
Inception Report	May 24 to May 28, 2010
Order Parts and Equipment	June 14 to July 23, 2010
Assemble Stations	July 26 to August 13, 2010
Testing	August 18 to September 17, 2010
Factory Acceptance Test	September 20 to September 24, 2010
Ship Equipment	October 4 to October 15, 2010
Clear Customs	October 18 to October 22, 2010
DOE Inspection of Equipment	October 25 to October 29, 2010
Civil Works Lunana	July 5 to August 23, 2010
Civil Works Phochhu	June 7 to July 28, 2010
Civil Works Punatsangchhu	June 7 to September 14, 2010
Installation Lunana	April 18 to May 13, 2011
Installation Phochhu/Punatsangchhu	November 1 to November 23, 2010
Site Acceptance Testing Lunana	May 5 to May 16, 2011
Site Acceptance Testing P/W Valley	November 15 to November 26, 2010
Training	May 16 to May 27, 2011
Final System Testing and Acceptance	May 27, 2011

This is a very aggressive schedule and will require cooperation from all parties involved. The contractual deadline for the project is 15 months from notice to proceed which would be June 29 2011.

## **6. CONSTRAINTS AND POTENTIAL PROBLEMS**

As we have assessed and evaluated this project we have identified a few constraints and potential problems that could effect the timely completion of the project. As we have planned out the project we have take these into consideration in order to minimize or eliminate the issue. At the beginning of a project it is not possible to foresee all the potential problems, but the following have been identified at this point in time.

Bad weather will definitely effect the construction of the civil works and the installation of the remote stations. The way we plan to minimize the problem of bad weather is to mobilize enough manpower to work on multiple stations at the same time and start the construction as early as possible.

To complete the civil works, USD will hire 20 to 30 laborers. These laborers along with the project managers and technicians from USD will be organized into three separate installation teams. This will allow work to progress in three separate areas at the same time. The first team will be located in the Lunana area, the second team will be located in the Phochhu area, and the third team will be located in the Punasangchhu area.

We have started the civil works this past June in an effort to complete them before the bad weather sets in. By starting the civil works as soon as DOE turned over the sites to us we have maximized the time of working in good weather.

The remoteness of the sites and the difficulty of transportation to the sites in Lunana is a constraint to the project. Recognizing that there are no roads to bring construction materials and equipment to this area, we are in the process of securing transportation by mule and also looking into helicopter transportation. We will ensure that the equipment is as light weight as possible for either method. USD will also look into the possibility of utilizing local labor for the Lunana sites.

Availability and reliability of the internet at the control station may be an issue. To eliminate this issue we are proposing a BGAN terminal (Satellite Internet Service) to be used as back up in case the internet is down.

Availability and stability of the AC power is also a concern for the control station. We will provide a UPS which will provide back up power for 2 hours.

## **7. NEEDED ITEMS FROM DOE**

There are many things which will be needed from DOE in order to complete the project successfully. The following list is by no means a complete list, but will be a good one to get started with.

1. Either purchase the sites or provide permission to use the sites prior to the commencement of construction of the sites.
2. Assistance in obtaining any permits required for construction.
3. Reliable AC power at the control station.
4. Reliable internet access at the control station.
5. Assistance in clearing the shipment through customs.
6. Input on the software.
7. Input on desired siren operation.
8. Hydraulic and Hydrologic information to determine the three threshold levels for the Water Level Stations.
9. Input on the Inception Report
10. Overall Cooperation

## **8. CONCLUSION**

This Inception Report was written to provide an initial work plan for the successful completion of the project. We have installed many similar systems all over the world and are confident that the system we are providing will meet the needs of DOE in providing early warning of GLOF events.

We have been very aggressive with the schedule in order to complete the civil works before the weather gets bad in early October. This will allow us some flexibility in training our local partner in the installation of the equipment and the proper testing of the system in the lower areas of the project before we go to the remote area of Lunana. The project will be completed within the 15 months required by the contract. In order to meet this schedule we will need the cooperation of all parties involved in the project.

We have benefited greatly from the input that DOE has provided on the earlier draft of this Inception Report and from their cooperation and discussions when we were in Bhutan. We look forward to the FAT in September where we will provide a week of training to DOE representatives and where they can see the equipment first hand. We look forward to the successful completion of this project to provide a state-of –the-art flood warning system for GLOF events.



# **APPENDIX A**

## **DESIGN DRAWINGS**

- Typical AWS/AWLS 10 Meter Tower Station
- Typical AWLS 3 Meter Tower Station
- Typical Siren Tower Station
- Dangsa Fence Detail
- Thanza Fence Detail
- Siren Fence Detail, Punakha Wangdi Valley
- Lunana AWLS & Siren Fence Detail
- Typical Bubbler Conduit and Orifice Termination
- Typical AWS/AWLS Station Enclosure
- Typical AWLS Station Enclosure
- Typical Siren Station Enclosure

# **APPENDIX B**

## **SURVEY PROCEDURES**

# **APPENDIX C**

## **GANTT CHART**