3.4 Slope Stability

Foliations of bedrock, being generally steeper than slopes, indicate small possibility of losing stability along foliations. Old land slide deposits cover wide area, but many of then are stable. The slope west of the surge tank and near the paved road, where had become instable in 1944 and accompanies springs, is the area to be careful in terms of slope stability.

Because this slope locally collapsed during a period of about 35 years, after filling the waterway, some suitable repair of the waterway is recommended.

4. SLOPES AROUND THE INTAKE OF POLPITIYA POWER STATION

4.1 Topography and Geology

The slope behind the intake of Polpitiya Power Station had slid to provide the slope materials to the intake. To confirm the slid area and its vicinities, geological mapping was carried out in January and February, 2005.

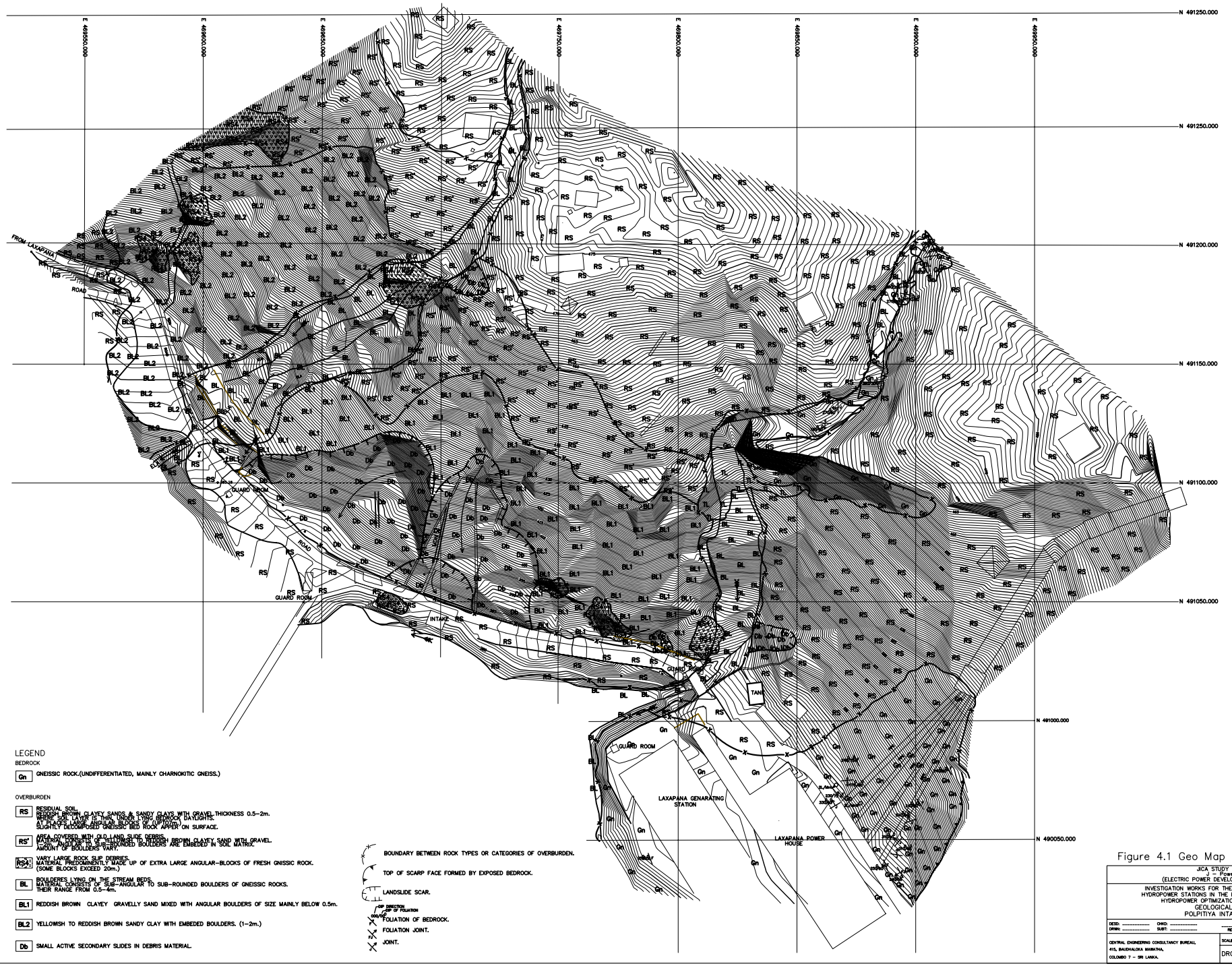
This slope and is vicinities are on the right bank of the Laxapana Dam and incline at 300 in average. The slopes above about 475 m in elevation are gentle, and there are some houses of local people. The slopes below that elevation are steep at about 350 Bedrock is not exposed except near the floor of the stream between Old Laxapana Power Station and the intake.

The geological map around the intake of Polpitiya Power Station is shown in Figure 4.1.

Bedrock is composed of charnockitic gneiss. On the slope behind Old Laxapana Power Station, the dip angle of bedrock foliation is in a wide range of 55 to 75 degrees, steeper than slopes. The dip direction of bedrock foliation falls in the rage of 230-270 degrees, about the same direction of the incline of the slopes. The slopes are covered with residual soils and landslide deposits. Landslide deposits contain boulders. Their thickness are not confirmed and are assumed to be more tan 10 m. At the foot of the slope, 2 landslide areas are observed. They contact each other, 180 m in total length and 50 m high. At the contact of these landslides, just behind the intake, an area of 80 m wide and 15 m high became unstable and a line of steel pipes were driven to decrease the movement. Some concrete drains were constructed on the lower slope.

4.2 Slope Stability

Slopes around the intake are covered by thick landslide deposits. Steep slopes below about 475 m in elevation are formed by collapse of landslide deposits. Though there are no data showing the relation between slope movement and reservoir level, small fluctuations of the reservoir level indicate that the slopes instability is caused by rain. To stabilize the slopes, preventing rain water infiltration into the landslide areas would be effective. Because the topography of the slopes is illustrated by the topographic 1:500 scale map , it would be a good idea to make foot passes for inspection of the slope during heavy rain, and the information would be applied for remedial measures such as suitable drains.



LEGEND

BEDROCK

Gn GNEISSIC ROCK.(UNDIFFERENTIATED, MAINLY CHARNOKITIC GNEISS.)

OVERBURDEN

RS RESIDUAL SOIL.
REDDISH BROWN CLAYEY SANDS & SANDY CLAYS WITH GRAVEL.THICKNESS 0.5–2m.
WHERE SOIL LAYER IS THIN, SHOWS LYING BEDROCK OUTCROPS.
AT PLACES LARGE ANGULAR BLOCKS OF GNEISS.
SLIGHTLY DECOMPOSED GNEISSIC BED ROCK APPEAR ON SURFACE.

RS' AREA COVERED WITH OLD LAND SLIDE DEBRIS.
LOOSE DEPOSITS OF REDDISH BROWN CLAYEY SAND WITH GRAVEL.
LOOSE ANGULAR TO SUB-ROUNDED BOULDERS ARE EMBEDED IN SOIL MATRIX.
AMOUNT OF BOULDERS VARY.

RS2 VARY LARGE ROCK SLIP DEBRIES.
MATERIAL PREDOMINENTLY MADE UP OF EXTRA LARGE ANGULAR-BLOCKS OF FRESH GNISSIC ROCK.
(SOME BLOCKS EXCEED 20m.)

BL BOULDERES LYING ON THE STREAM BEDS.
MATERIAL CONSISTS OF SUB-ANGULAR TO SUB-ROUNDED BOULDERS OF GNEISSIC ROCKS.
THEIR RANGE FROM 0.5–4m.

BL1 REDDISH BROWN CLAYEY GRAVELLY SAND MIXED WITH ANGULAR BOULDERS OF SIZE MAINLY BELOW 0.5m.

BL2 YELLOWISH TO REDDISH BROWN SANDY CLAY WITH EMBEDED BOULDERS. (1–2m.)

Db SMALL ACTIVE SECONDARY SLIDES IN DEBRIS MATERIAL.

BOUNDARY BETWEEN ROCK TYPES OR CATEGORIES OF OVERBURDEN.

TOP OF SCARP FACE FORMED BY EXPOSED BEDROCK.

LANDSLIDE SCAR.

DIP DIRECTION
DIP OF FOLIATION

FOLIATION OF BEDROCK.

FOLIATION JOINT.

JOINT.

Figure 4.1 Geo Map (Polpitiya Intake)

JICA STUDY TEAM
J – Power
(ELECTRIC POWER DEVELOPMENT CO., LTD)

INVESTIGATION WORKS FOR THE FOLLOW-UP STUDY ON HYDROPOWER STATIONS IN THE KELANI RIVER BASIN FOR HYDROPOWER OPTIMIZATION IN SRI LANKA
GEOLOGICAL MAP
POLPITIYA INTAKE AREA

DESD: ..... CHKD: .....
DRWN: ..... SUBT: .....
RECOMMENDED ..... APPROVED DGM (WR) .....

CENTRAL ENGINEERING CONSULTANCY BUREAU,
415, BAUDHALOKA MAWATHA,
COLOMBO 7 – SRI LANKA.

SCALE: 1:500 | DATE: FEBRUARY 2005 | A0
DRG. No. 647/IN/03/04 | REV.

5. SLOPES BEHIND THE POLPITIYA POWER STATION

5.1 Topography and Geology

The penstocks lie on the slope behind the Polpitiya Power Station. Near the foot of that slope, 2 small scale landslides have been known. The geological mapping of the slope behind was carried out in January and February, 2005.

This slopes inclines at an average of 25 degrees. Outcrops of bedrock are limited near the valve house of the penstock at about 315 m in elevation, from the road at about 255 m to about 200 m in elevation, and near the foot of the slope at about 125 m in elevation.

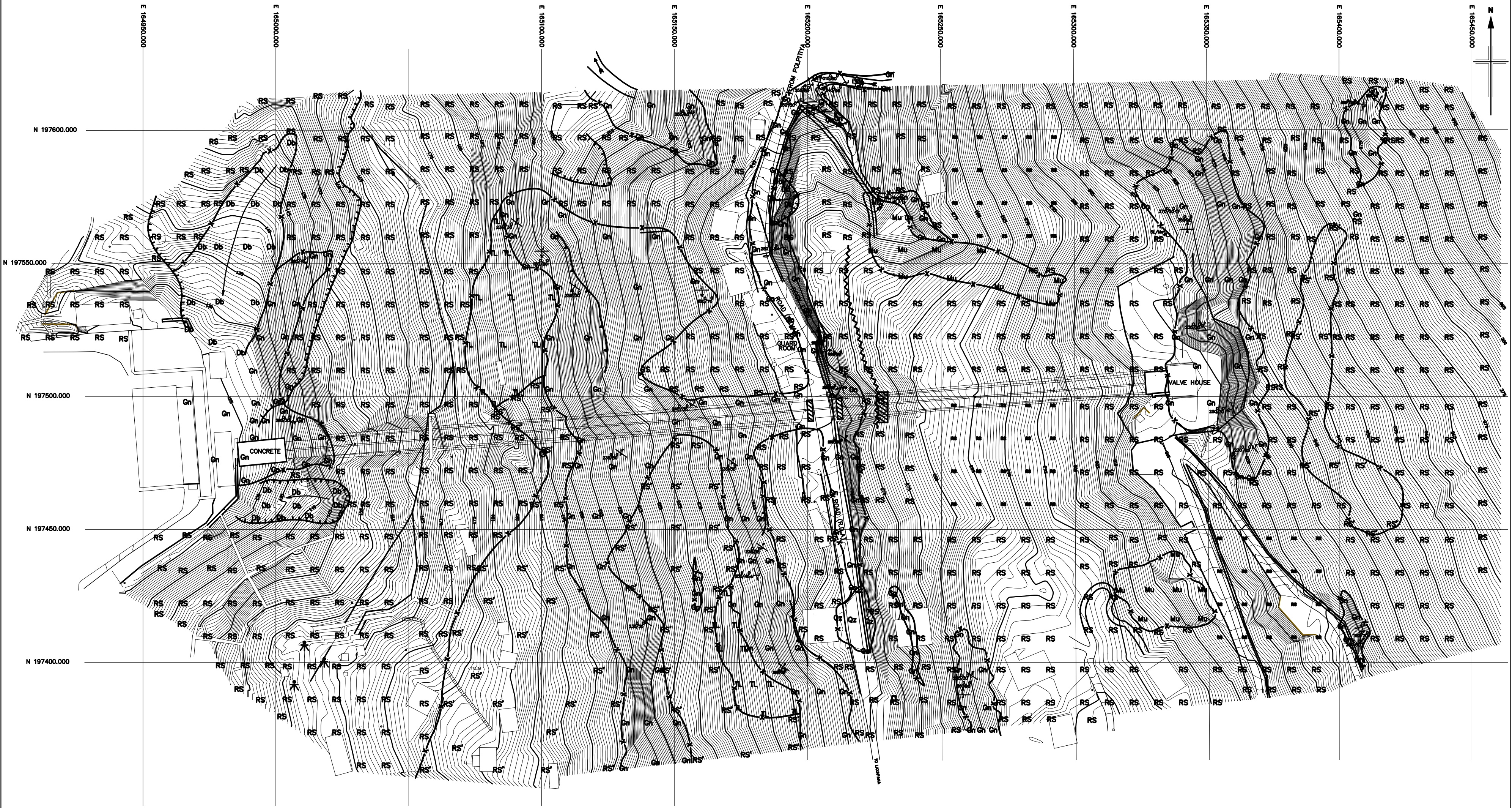
The geological map around the intake of Polpitiya Power Station is shown in Figure 5.1.

Bedrock is composed of charnockitic gneiss, charnockite and quartzite. The dip angle of foliation of bedrock covers a wide range of 25 deg. to 50 deg., about the same or steeper than slopes. The dip direction of bedrock foliation falls in the rage of 230-250 degrees, somewhat oblique to the direction of the incline of the slopes. Joints dipping at 80 deg. toward upstream or at 45 deg. toward the main river are dominant.

The slope is covered with residual soils, talus deposits and landslide deposits. Residual soils cover wide area but are less than 2 m thick. Talus deposits cover limited areas below the steep portion and up to 5 m thick. Landslide deposits cover 2 areas near the foot of the slope with a thickness of less than 5 m. Downstream area is 35 × 57 m, and upstream area is 20 x 40 m. Man-made fill with the muck of the penstock tunnel of Polpitiya Power Station is also distributed over 2 limited areas above the paved road.

5.2 Slope Stability

The foliation and joints of bed rock do not have directions, easily causing slope instability.
To prevent the landslide areas near the foot of the slope from becoming unstable, concrete drains have been constructed upslope of them. The absence of damage in these concrete drains indicates the areas surrounding landslide are stable. However, existing drains cannot stop the water flowing into the landslide areas. It is better to construct additional drains.
A crack on the slope above the paved road and extending parallel to the road was reported in 1989. This crack is at 10 to 40 m upslope of the shoulder of the road cut, where it is covered with residual soils, and is 70 m long and 30 m wide. An effective way to maintain the stability of the surface layer would be filling the crack with clayey materials and constructing drains to intercept the surface runoff .



LEGEND

BEDROCK

Gn	GNEISSIC ROCK. (UNDIFFERENTIATED, MAINLY CHARNOKITIC GNEISS.)
Qz	QUARTZITE.

OVERBURDEN

RS	RESIDUAL SOIL. REDDISH BROWN CLAYEY SANDS & SANDY CLAYS WITH GRAVEL.THICKNESS 0.5–2m. WHERE SOIL LAYER IS THIN UNDER LYING BEDROCK DAYLIGHTS. AT PLACES LARGE ANGULAR BLOCKS OF (2m.) SLIGHTLY DECOMPOSED GNEISSIC BEDROCK APPER ON SURFACE.
RS'	AREA COVERED WITH OLD LAND SLIDE DEBRIS. MATERIAL CONSISTS OF YELLOWISH TO REDDISH BROWN CLAYEY SAND WITH GRAVEL. 1–2m ANGULAR TO SUB–ROUNDED BOULDERS ARE EMBEDED IN SOIL MATRIX. AMOUNT OF BOULDERS VARY.
TL	TALUS ROCK MATERIAL DERIVED FROM ROCKY CLIFF FACE. MATERIAL IS MADE UP OF BOULDERS OF SIZE OF 0.5–1.5m. SOIL FRACTION MADE UP MAINLY OF CLAYEY GRAVEL MATERIAL ABOUT 20/–30/.
Db	DEBRIS OF LANDSLIDES OCCURED IN RESIDUAL SOIL AND WEATHERED ROCK.
Mu	MAN – MADE FILL. MADE UP OF ROCK MATERIAL EXCAVATED FROM TUNNEL AND PENSTOCK ADIT. SIZE OF ROCK FRAGMENTS 0.1–0.5m, MAINLY GNEISSIC ROCK AND SOME CRYSTALLINE LIMESTONE.

BOUNDARY BETWEEN ROCK TYPES OR CATEGORIES OF OVERBURDEN.

TOP OF SCARP FACE FORMED BY EXPOSED BEDROCK.

LANDSLIDE SCAR.

TENSION CRACK ON SOIL

SL/Mnt. SPRING.

DIP DIRECTION

DIP OF FOLIATION

000/00 F FOLIATION OF BEDROCK.

FJ FOLIATION JOINT.

J JOINT.

Figure 5.1 Geo Map (Polpitiya Penstock)

JICA STUDY TEAM
J – Power
(ELECTRIC POWER DEVELOPMENT CO., LTD)

INVESTIGATION WORKS FOR THE FOLLOW–UP STUDY ON HYDROPOWER STATIONS IN THE KELANI RIVER BASIN FOR HYDROPOWER OPTIMIZATION IN SRI LANKA
GEOLOGICAL MAP
POLPITIYA PENSTOCK AREA

DESD: .... CHKD: ....
DRWN: .... SUBT: ....
RECOMMENDED
APPROVED DGM (WR)

CENTRAL ENGINEERING CONSULTANCY BUREAU,
415, BAUDHALOKA MAWATHA,
COLOMBO 7 – SRI LANKA.

SCALE: 1:500 | DATE: FEBRUARY 2005 | A0

DRG. No. 647/IN/03/03 | REV.

APPENDIX A-2
INSPECTION REPORT ON HEADRACE TUNNEL OF WIMALASURENDRA HYDROPOWER PLANT

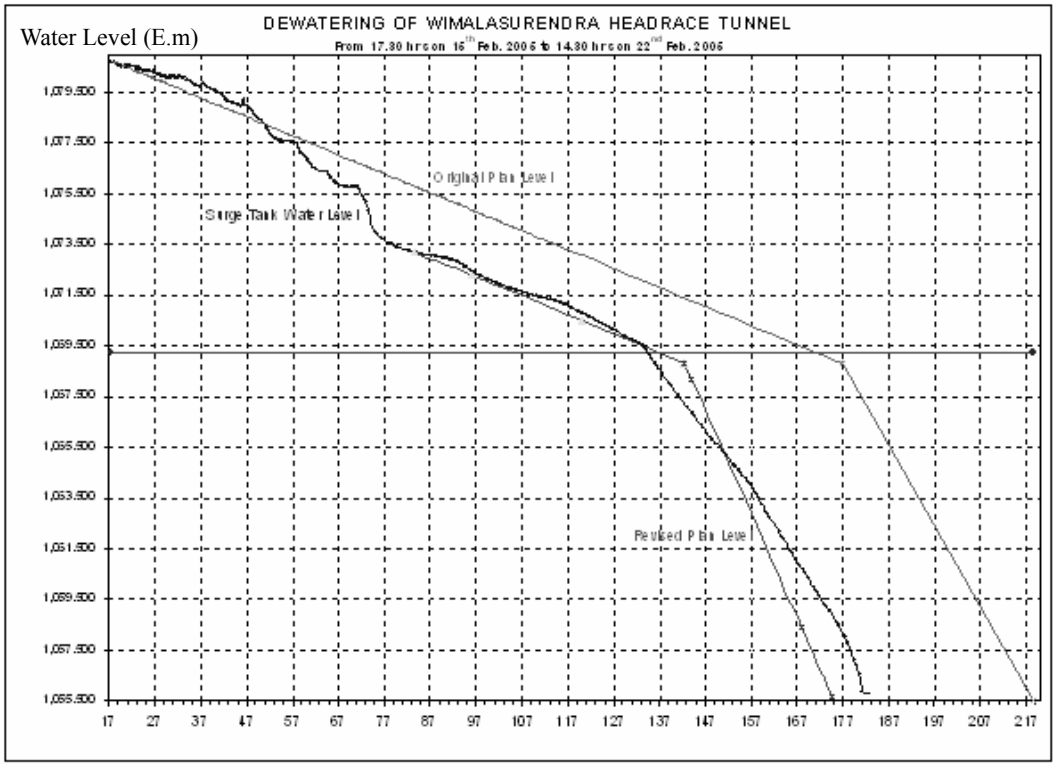
1. GENERAL

It was believed that a collapse has occurred in the pressurized headrace tunnel of Wimalasurendra hydropower plant because of the turbid water discharging at the outlet during the operation in 2001. Therefore, CEB decided to dewater the tunnel for inspection, and committed the dewatering work and its sequential works to CECB in February 2005. Official site inspection of the headrace tunnel, which is approximately 6 km in length and 3.43 m in inner diameter with a concrete lining 15 cm in thickness, of Wimalasurendra hydropower plant was carried out by CEB and CECB on February 25, 2005. The JICA study team joined the official inspection at the same time.

This report presents the status of the headrace tunnel and the recommendation of the remedial works based on the inspection performed by the JICA study team.

2. DEWATERING

Dewatering was commenced on February 15, 2005, and completed on February 22, 2005 as shown in the figure. It took 163.5 hours. Average lowering rate in static water head in the headrace tunnel was around 15 cm/hour.



3. INSPECTION RECORD

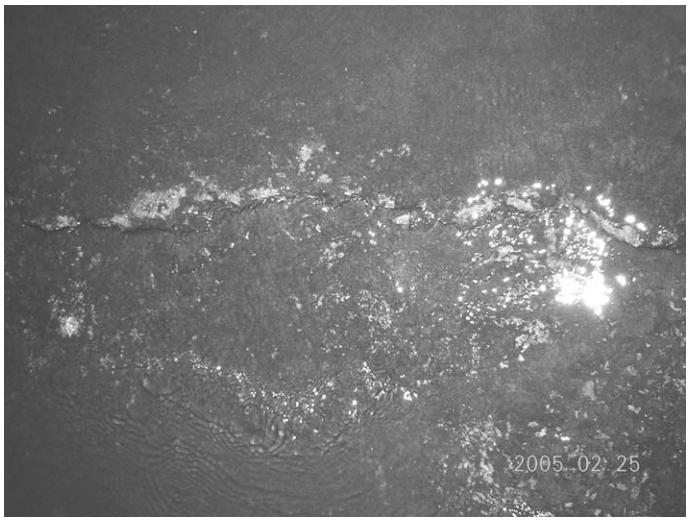
Date & Time:	February 25, 2005 (Friday), from 12:00 to 17:00
Attendant from JICA Study Team:	Mr. Nakahata, Mr. Kaneko, and Mr. Tabata from J-POWER, Mr. Komatsu as JICA expert
Inspected Structure:	Headrace Tunnel of Wimalasurendra Hydropower Plant Length: 6 km Inner diameter: 3.43 m (height) Thickness of concrete lining: 15 cm

4. PRESENT STATUS OF TUNNEL

Major observed aspects are uplift, cavity, seepage, honeycomb and fragment. The details are as follows:

(1) Uplift

Aspect:	There is uplift and a crack approximately 30 m in length in the invert concrete around the tunnel distance of 1,230 ft.
Possible Cause:	External loads such as groundwater pressure, earth pressure, etc.
When it occurred:	It appears that the crack was not developed in the course of the dewatering due to backpressure acting on the concrete lining. The color of the concrete surface in the crack seems to be old.
Countermeasures:	The JICA team does not recommend immediate repair of the uplift and crack in the invert concrete because the tunnel seems to be in stable condition. If CEB wants to repair it, of course the team agrees to repair it.



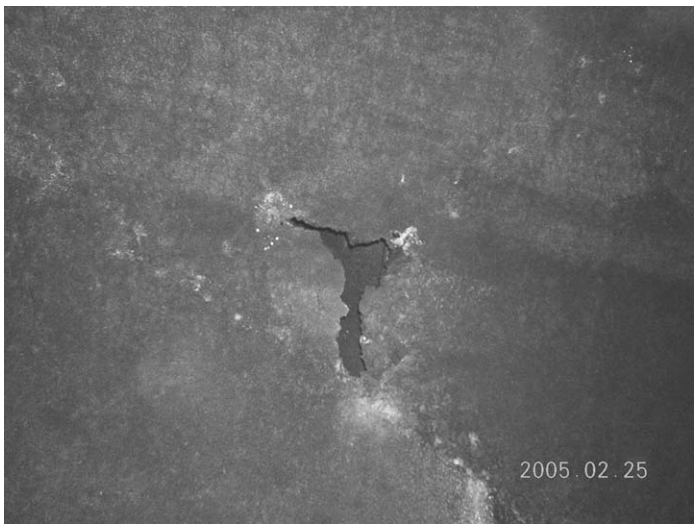
Uplift and Crack

(2) Cavity

Aspect: There are 4 cavities observed in the tunnel. Certain areas of the concrete lining peeled off and the surface of the rock behind the lining appeared at all locations of the cavities. One of them at the tunnel crown at around the tunnel distance of 3,350 ft appears to be deep. This cavity is the most likely cause of the muddy water observed in 2001. Some amount of accumulated mud was found on the invert concrete under the cavity.

Possible Cause: Earth pressure, thin concrete, defect of concrete

Countermeasures: The JICA study team recommends repairing all cavities.



Cavity at TD 3,350 ft.

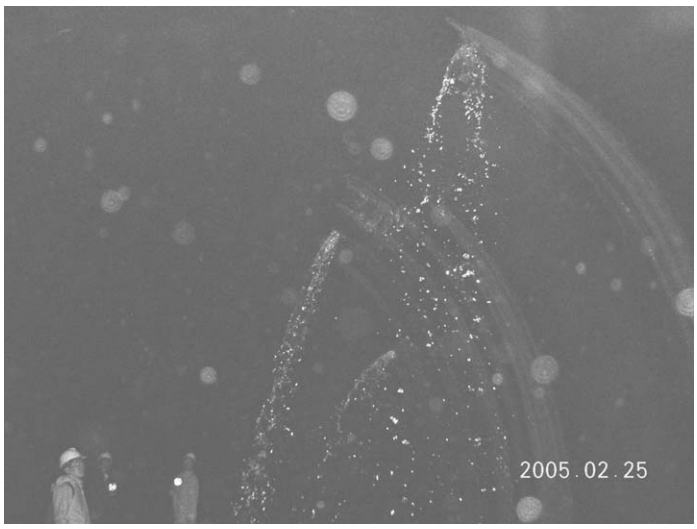
Mud at TD 3,350 ft.

(3) Seepage

Aspect: There are several points of seepage including the seepage from the relief holes in the tunnel. A certain amount of discharge is seen at some of them.

Possible Cause: Groundwater

Countermeasures: The JICA study team recommends not repairing the seepage, subject to the seepage water containing no mud. If the seepage is stopped with repair work, the groundwater level at the tunnel surroundings goes up and sequentially external pressure acts on the lining concrete.
Mud is a sign of erosion behind the concrete.



Seepage

(4) Honeycomb Concrete

Aspect: There are several portions of honeycomb concrete in the tunnel.

Possible Cause: Poor performance of workers who poured the concrete

Countermeasures: The JICA study team recommends repairing them if there is enough time for repairs.

(5) Concrete Fragments

Aspect: There are several concrete fragment found on the invert concrete.

Possible Cause: Earth pressure, thin concrete, defect of concrete

Countermeasures: The fragments shall be removed.

(6) Sedimentation in the Sand Trap

Aspect: There is sedimentation in the sand trap of the surge chamber.

Countermeasures: The JICA study team recommends removing the sedimentation.

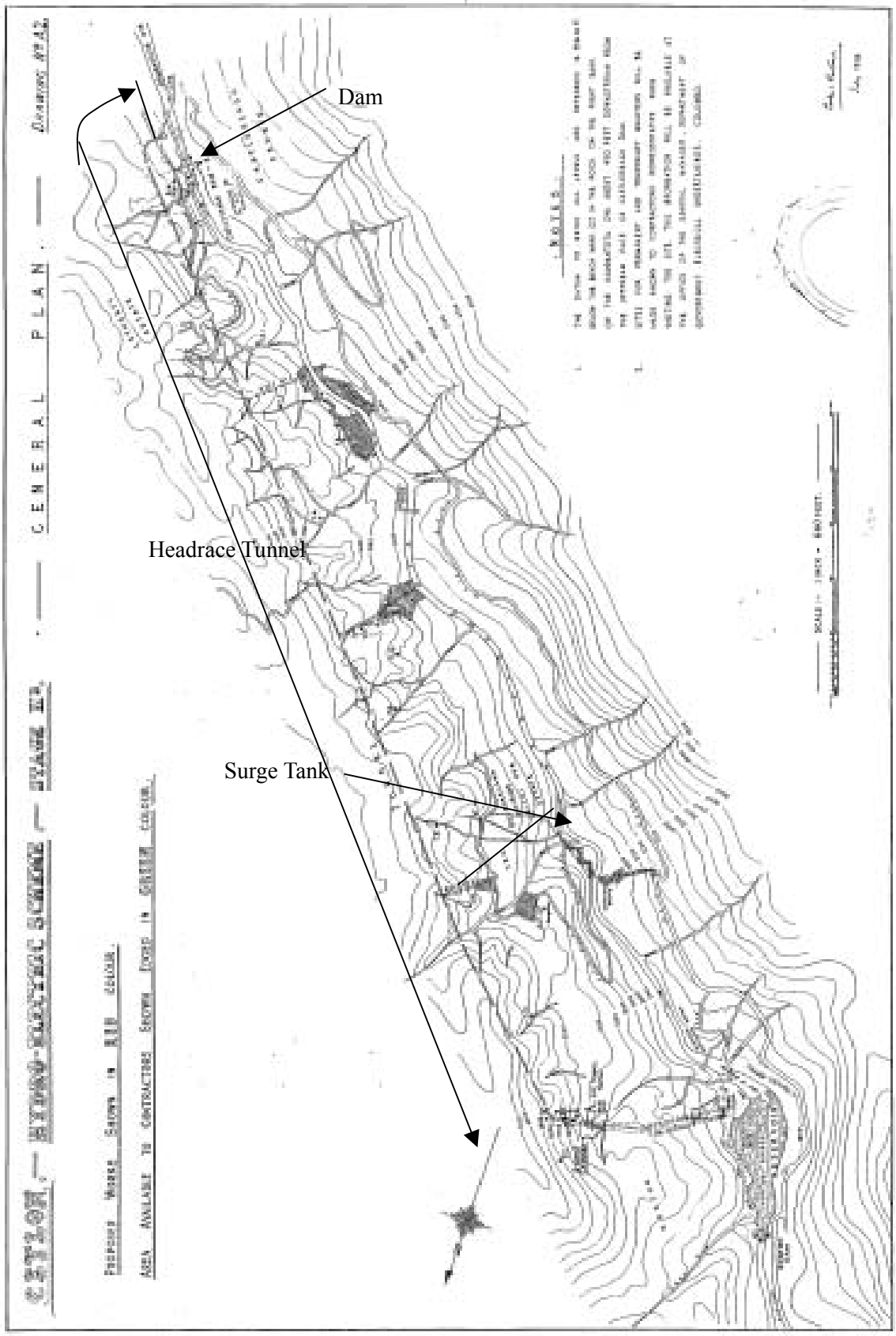
5. RECOMMENDATIONS ON COUNTERMEASURES AGAINST CAVITY AT TD 3,350 FT

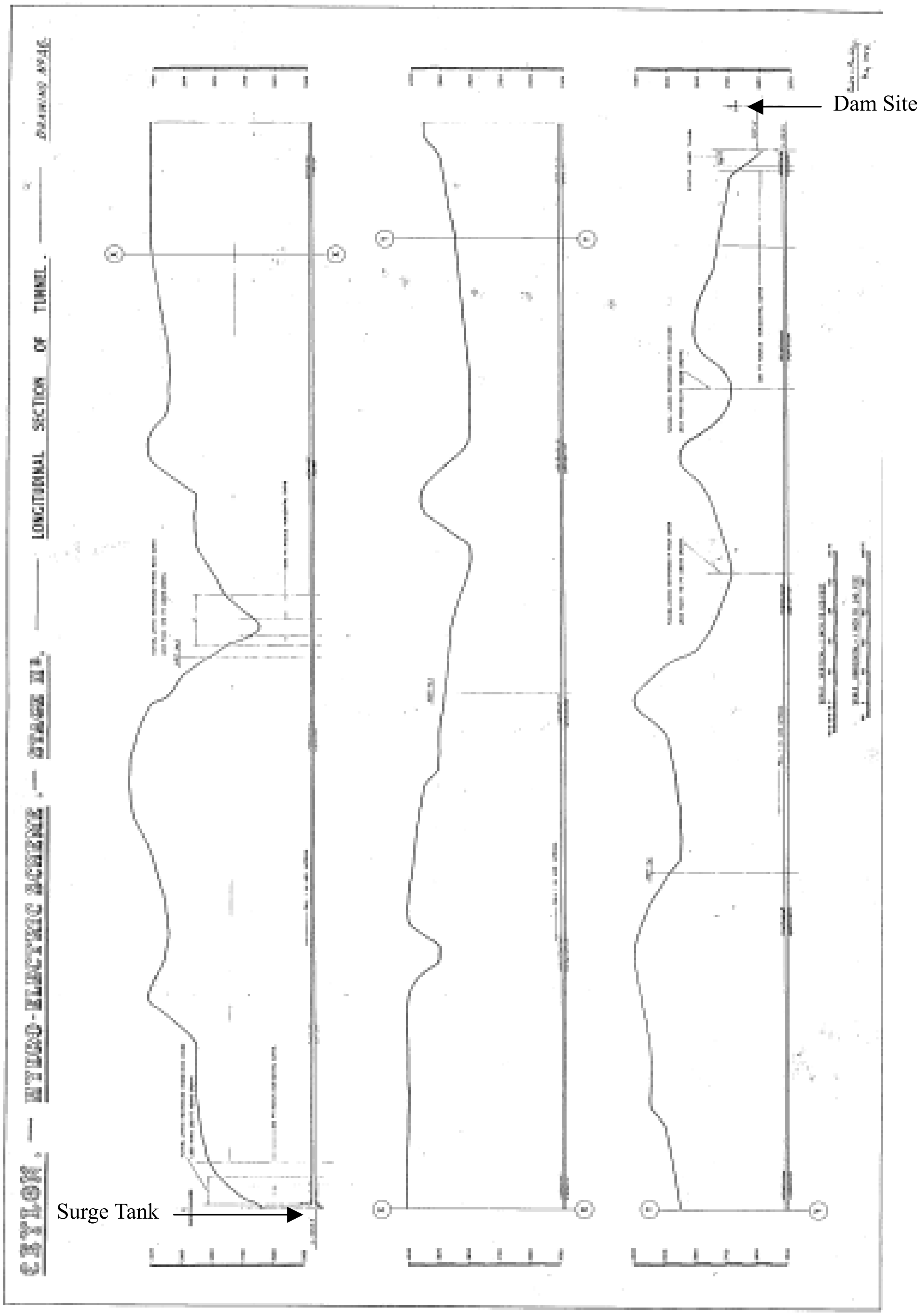
- The extent of the cavity should be checked and measured.
- The cavity shall be filled with some material such as mortar. When the material is injected, low pressure should be applied to the injection site because of the thin concrete lining .
- Some support should be installed for the injection site in order to prevent the concrete lining from collapsing.

6. OTHERS

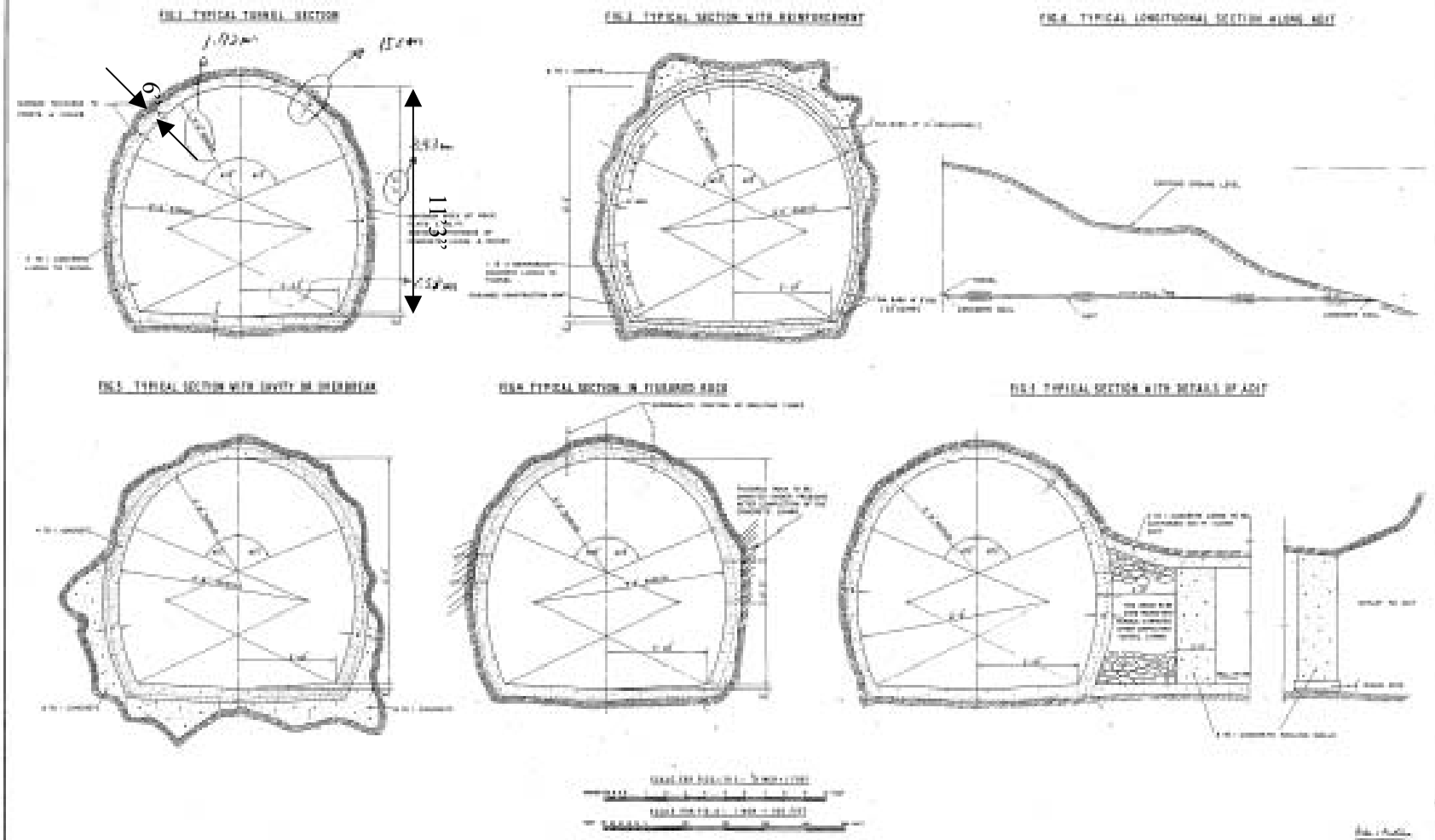
Prior to the dewatering work, the JICA study team provided some information to CEB and CECB concerning dewatering and refilling work so that they can proceed with their work smoothly. The following tables and figures, which are based on the J-POWER's experience, are the provided information.

CEB and CECB have sufficiently prepared the necessary facilities for the dewatering and inspection work during the official inspection held on February 25, 2005.


Dam
Headrace Tunnel
Surge Tank


CEYLON. — HYDRO-ELECTRIC SCHEME.
LONGITUDINAL SECTION OF TUNNEL.
Dam Site
Surge Tank

CEYLON — HYDRO-ELECTRIC SCHEME — STAGE II. — TUNNEL CROSS SECTIONS AND DETAILS OF ADITS — Drawing No. A7



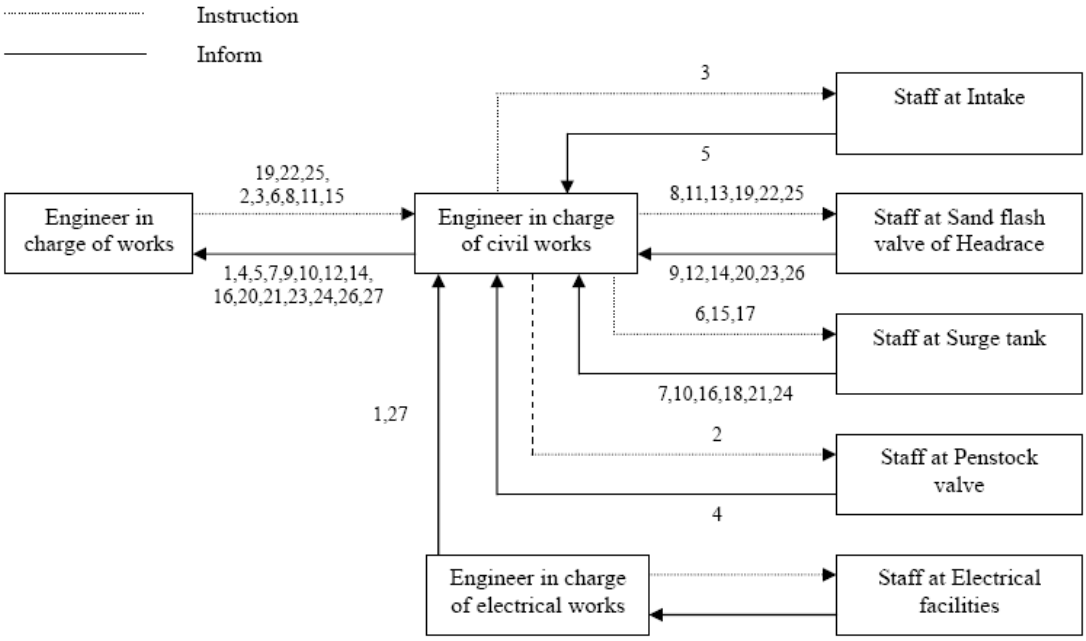
Inspection Device List for Dewatering Work for Headrace

Name	Specification	Unit	Quantity	Point	Note
Hammer	0.9kg		as required	Headrace	
Ladder	Length 40m		as required	ditto	
Oxygen inhaler	K-6AG		1	ditto	
Oxygen analyzer			1	ditto	
Illumination system	Flashlight (Spare battery)		same as the number of staff to enter tunnel	ditto	
Camera			1	ditto	
Rubber boots			same as the number of staff to enter tunnel	ditto	
Measurement device for interior inspection					
Development map of headrace			1	Headrace	
Tape measure	100 m		1	ditto	
Convex rule	5 m		1	ditto	
Field note	Water proof		1	ditto	
Pole			1	ditto	
Measurement device for leakage					
Graduated cylinder	1 litter		1	Headrace	
Stop watch			1	ditto	
Waste cloth	1 kg		1	ditto	
Float for flow measurement	Piece of wood		1	ditto	

Spare Part List for Dewatering Work for Headrace

Name	Specification	Quantity	Facility to be applied	Note
Sealing material for manhole	Exterior diameter 514×414(mm), Width 32(mm), Thickness 10(mm)	7	No.7,23,31,48,55pipe, Valve house	
Bolt and Nut for manhole	Width 1/4" ×H35×2 pieces	ditto	ditto	

Organization Chart and Communication for Dewatering Work for Headrace



Ref.	Item to be communicated	Work to be done by staff
1	Confirmation of suspension of the generator	To confirm suspension and lock of the generator
2	Instruction of closure of the penstock valve	To close the penstock valve fully
3	Instruction of closure of the intake gate	To close the intake gate fully
4	Completion of closure of the penstock valve	
5	Completion of closure of the intake gate	
6	Instruction of measurement of water level in the surge tank	To measure water level in the surge tank
7	Measurement result of water level in the surge tank	
8	Instruction of opening the sand flash valve of the headrace	To open the sand flash valve of the headrace
9	Completion of opening the sand flash valve of the headrace	
10	Measurement result of water level in the surge tank	To measure water level of the surge tank at 5 to 10 minutes intervals, and inform of the results
11	Instruction of adjustment of opening the sand flash valve of the	To adjust opening the sand flash valve of the
12	Adjustment of opening of the sand flash valve of the headrace	
13	Instruction of suspension of the dewatering the headrace	To close the sand flash valve of the headrace for measuring amount of leakage
14	Completion of closure of the sand flash valve of the headrace	
15	Instruction of measuring amount of leakage in the headrace	To measure water level variation and water color
16	Measurement result of leakage in the headrace	
17	Instruction of measuring water level in the surge tank	To measure water level in the surge tank
18	Measurement result of water level in the surge tank	
19	Instruction of resume of dewatering the headrace	To open the sand flash valve of the headrace
20	Completion of opening the sand flash valve of the headrace	
21	Measurement result of water level in the surge tank	To measure water level of the surge tank at 5 to 10 minutes intervals, and inform of the results
22	Instruction of adjustment of opening the sand flash valve of the	To adjust opening the sand flash valve of the
23	Adjustment of opening the sand flash valve of the headrace	
24	Completion of dewatering the headrace	
25	Instruction of opening the sand flash valve of the headrace	To open the sand flash valve of the headrace
26	Completion of opening the sand flash valve of the headrace	
27	Completion of dewatering the headrace	

Organization for Dewatering Work for Headrace

Location	Work	Number of staff	Note
Intake gate	Operation, Supervision	2	To close the gate
Outlet of sandflash of headrace	Operation, Supervision (to check water color and amount of water)	2	To open the valve
Surge tank	Measurement of water level	2	
Penstock valve	Operation, Supervision	2	To close the valve
Office	Record the dewatering	1	To control gate operation judging from the record

Time Table for Dewatering Work for Headrace (Example)

Work item	Schedule (hour) 10 20 30 40 50 60 70 80	Duration (hour)	Note
Preparation		1	
Closure of intake gate		2.5	
Closure of penstock valve		1	
Operation of sand flash valve of headrace		82	To start measurement of leakage when difference of water level between dam and surge tank becomes 5m in height
Measurement of water level in the surge tank		82	
Opening of sand flash valve		0.5	

Record Format

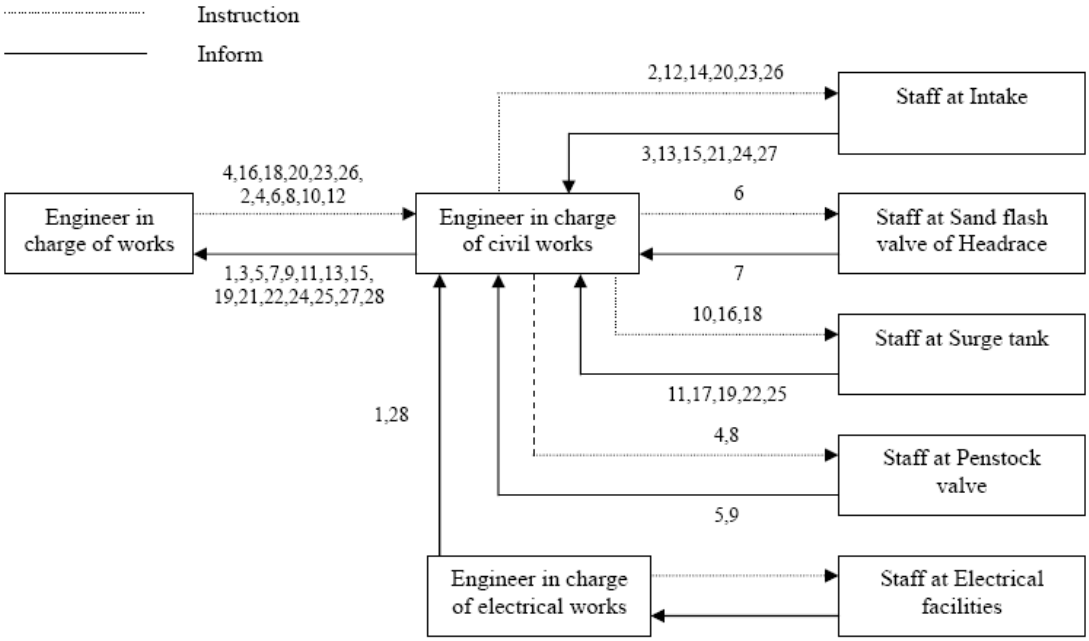
No. _____

Record Format for Dewatering/Refilling Headrace

Month: Date: Year:

Month/Date		Time		Water Level		Opening		Note

Organization Chart and Communication for Refilling Work for Headrace



Ref.	Item to be communicated	Work to be done by staff
1	Confirmation of commencement of refilling	
2	Confirmation of closure of the intake gate	To confirm closure of the inteke gate
3	Report of closure of the intake gate	
4	Instruction of closure of the penstock valve	To close the penstock valve
5	Report of closure of the penstock valve	
6	Instruction of closure of the sand flash valve of headrace	To close the sand flash valve of headrace
7	Report of closure of the sand flash valve of headrace	
8	Instruction of opening the bypass valve of intake	To open the bypass valve of intake
9	Report of opening the bypass valve of intake	
10	Instruction of measurement of water level in the surge tank	To measure water level in the surge tank
11	Measurement result of water level in the surge tank	To measure water level of the surge tank at 5 to 10 minutes intervals, and inform of the results
12	Adjustment of opening the bypass valve of intake	To adjust opening the bypass valve of intake
13	Report of adjustment of opening the bypass valve of intake	
14	Instruction of suspension of the refilling the headrace	To close the bypass valve of intake for leakage investigation
15	Report of closure of the bypass valve of intake	
16	Instruction of measurement of water level in the surge tank	To measure water level in the surge tank and check water color
17	Report of measurement result of water level in the surge tank	
18	Confirmation of measurement of water level in the surge tank	To measure water level in the surge tank
19	Report of measurement result of water level in the surge tank	
20	Instruction of resumption of the refilling the headrace	To open the bypass valve of intake
21	Report of completion of opening the bypass valve of intake	
22	Measurement result of water level in the surge tank	To measure water level of the surge tank at 5 to 10 minutes intervals, and inform of the results
23	Adjustment of opening the bypass valve of intake	To adjust opening the bypass valve of intake
24	Report of adjustment of opening the bypass valve of intake	
25	Report of refilling headrace	
26	Instruction of closure of the bypass valve of intake	To close the bypass valve of intake
27	Instruction of opening the intake gate	To open the intake gate
28	Report of completion of refilling headrace	

Organization for Refilling Work for Headrace

Location	Work	Number of staff	Note
Intake gate / Bypass valve	Operation, Supervision	2	To operate the gate
Outlet of sandflash of headrace	Operation, Supervision	2	To close the valve
Surge tank	Measurement of water level	2	
Penstock valve	Operation, Supervision	2	To close the valve
Office	Record the refilling	1	To control gate operation judging from the record

Time Table for Refilling Work for Headrace (Example)

Work item	Schedule (hour) 10 20 30 40	Duration (hour)	Note
Preparation		1	
Closure of penstock valve		1	
Operation of sand flash valve of headrace		0.5	
Operation of bypass gate of intake		33	To refill headrace with water
Measurement of water level in the surge tank		33	
Opening intake gate			

Check List of Inspection Works

Works			Tools and Instruments
Before entering the tunnel			
	Examining of existing data		
		As-build drawings, existing record of tunnel	
	Confirmation of water level in the tunnel		
		Followings are the causes of delay in water level lowering	
		Leakage at intake gates	
		Inflow of groundwater	
		Inflow of surface water through adits	
	Groundwater level around the tunnel		
		Measurement of water level in drillholes around tunnel route.	
	Ventilation	Measurement of oxygen concentration	oxygen concentration meter
	Inspection Plan		
		Formation of inspection	
		Formation of communication between outside and inside of the tunnel	
		Power house-Intake gate-Entrance-Inspection team-Outlet	wireless, mobilephone, person of communication
		Schedule and route of inspection	
	Equipment	Safety tools and wears, light	Head light, long boots,
		(22℃:Temperature of water in the tunnel)	Helmet, Rope, (life jacket), (safety belt)
		Tools and instrument for inspection	hammer
			survey rod, recording tools, (tape recorder)
	Survey	Survey to mark the distance on tunnel surface at every 50m	
		(In case distance plats are not found)	
Inspection			
	Entering into the tunnel		
		door, ladder, manhole	
	Confirming of location		
		Looking for plate showing tunnel distance	
		When tunnel surfaces are coated with weed, brush is necessary for cleaning.	Brush with long rod is useful as a survey rod.
			Measure of 50m
	Damage of concrete		
		Erosion, cracks、cavity, collapse, deterioration of concrete	
	Damage of rock mass		
		Erosion, cracks、cavity, collapse,	
	Water inflow	Volume of inflow	
	Sand trap	state of filling	
		filled material	small shovel
	Entrance of leakage		
		Approximate location would be assumed by the relation of lowering water level and volume of springs on nearby slope	
		By observation of water movement and pouring of water.	small bucket
		Dye test	
		To be conducted after the observation net on the slope is prepared	(Salt+electrical conductivity meter, dye such as fluoressen soda)
	Recording	Photographs (remember the location)]	
		Sketch (log)	Waterproof paper
	Marking	Showing the place or area of repairing and/or danger	Stick nails on tunnel surface and attach tags.
			(Spray would be no use on wet surface.)
	Getting out of tunnel		
		Manhole, ladder, door	
Attention needed during works in tunnel			
		large profile of tunnel floor	
		slippy	
		smell	
		small animals (worms, insects, etc.)	
		entrance of penstock	

APPENDIX A-3
INSPECTION MANUAL
FOR HYDROPOWER PLANT
CIVIL VERSION

INSPECTION MANUAL
FOR HYDROPOWER PLANT
CIVIL VERSION

Established on February 2005
Revised on _____

LAXAPANA COMPLEX
CEYLON ELECTRICITY BOARD

CONTENTS

1. GENERAL

1.1 Purpose

This inspection manual specifies the details of the patrol, inspection, measurements and investigation for the structures of the Laxapana Complex in order to maintain the function of the structures, to prevent incidents that could affect the structures and to perform operations effectively.

1.2 Scope of the Inspection Manual

The inspection manual shall be applied to the structures, which include civil structures and some hydromechanical facilities, and their surroundings.

1.3 Inspection Manual for Each Hydropower Plant

An engineer in charge shall specify the details of the patrol, the inspection, the measurements and the investigations for each hydropower plant so that a staff member of the Laxapana complex can patrol, inspect, measure or investigate the structures and their surroundings.

2. PATROL AND INSPECTION

2.1 Patrol Items and Frequency

The patrol and inspection items and frequency are specified and described in Table-1.

2.2 Patrol Procedure

The patrol shall be carried out by utilizing the five senses of the inspector to detect any unusual condition of the structures. If an inspector finds something wrong in the structures during the patrol, he should repair it roughly depending on circumstances. Table-2 shows the details of the patrol procedure.

2.3 Regular Inspection Procedure

2.3.1 Exterior Inspection

The exterior inspection shall be carried out with measurement tools and utilizing the five senses of the inspector to detect any unusual condition of the structures and to confirm the operation of the structures. If an inspector finds something wrong in the structures during the inspection, he should repair it roughly depending on circumstances. Table-3 shows the details of the inspection procedure.

2.3.2 Interior Inspection

The interior inspection, performed after the waterway is dewatered, shall be carried out with measurement tools and utilizing the five senses of the inspector to understand the state of the structures. If an inspector finds something wrong in the structures during the inspection, he should repair it roughly depending on circumstances. Table-3 shows the details of the inspection procedure.

- As for the dewatering to be done prior to the interior inspection, the following items should be confirmed, and the procedures should be determined taking the items into account .
- Operation manual of the facilities to be used for dewatering (example: gate operation manual)
- Monitoring items (example: monitoring point, staff allocation, communication tools)

- ♦ Measuring devices and other equipment (example: measuring tape, oxygen analyzer, illumination system, drain pump)

- ♦ Spare parts (example: sealing material)

2.4 Special Inspection Procedure

2.4.1 Special Inspection

If necessary, the special inspection shall be done before and after a flood, heavy rain or an earthquake. If an inspector finds something wrong in the structures during the inspection, he should repair it roughly depending on circumstances. Table-4 shows the details of the inspection procedure.

2.4.2 Special Detailed Inspection

If necessary, the special detailed inspection shall be done with an appropriate procedure taking into account the results of the patrol, the exterior inspection, the interior inspection and the special inspection.

2.5 Patrol and Inspection Records

The format for the patrol and the inspection records shall be in accordance with the attached formats. If necessary, the detailed information should be attached.

2.5.1 Patrol

The format for the patrol record is shown in the Appendix-2.

2.5.2 Inspection

(1) Exterior Inspection

The format for the exterior inspection record is shown in the Appendix-3.

(2) Interior Inspection

The format for the interior inspection record is shown in the Appendix-3.

(3) Special Inspection

The format for the special inspection record is shown in Appendix-4.1 and 4.2.

(4) Special Detailed Inspection

The format for the special inspection record is not specified. Information shall be reported using any format depending on the record to be reported.

3. MEASUREMENTS

3.1 Reservoir and Pond

3.1.1 Sedimentation Survey

The sedimentation survey shall be done annually after rainy season finishes, if necessary.

3.1.2 Others

If necessary, a water quality test, a geological survey especially for landslides, and so on shall also be carried out.

3.2 Dam

3.2.1 Measurements of Dam

Measurement items and frequency are as shown in Table-5, in principle. However, if there is a direction specified in a law or regulation or in any related law, the measurements shall be done in accordance with those directions.

3.2.2 Measurements with Instrument

Measurements with embedded instruments for a dam shall be done subject to the specified period, and frequency based on the purpose of the measurement.

If a measurement target is achieved without any particular phenomenon or the measurements cannot be continued effectively due to deterioration of the instruments, it is necessary for the related parties to discuss how to deal with it.

3.2.3 Other Measurements

Measurements for scours, surrounding areas and so on shall be done if necessary.

3.3 Measurement of Waterways

3.3.1 Measurement of Thickness of Penstock Steel Pipe

The frequency of the thickness measurement shall be once every 6 years for the penstock steel pipes, if the pipes have been exposed for more than 20 years.

However, if the conditions are regarded as safe judging from the results of the measurement, the frequency of the thickness measurement could be reduced up to once every 10 years.

3.3.2 Other Measurements

Measurements with embedded instruments for the waterway, measurements for the surrounding area shall be done if necessary.

3.4 Other Structures

Measurements for other structures shall be done if necessary.

3.5 Record

Measurement results shall be tabulated or illustrated as a diagram so that the people concerned in the Laxapana complex can easily understand the data.

4. INVESTIGATION

If it is necessary to carry out an investigation as a result of the measurement, it shall be done after a proper investigation method is established, which should be based on the design report, construction record, measurement record and other related data.

Table 1 Patrol and Inspection Items and Frequency

	Patrol	Inspection			
		Periodic inspection		Special inspection	
		Exterior inspection	Interior inspection	Special inspection	Special detailed inspection
Definition	The patrol shall be done utilizing the five senses of the inspector to detect any unusual condition of the structures. If an inspector finds something wrong in the structures during the patrol, he should repair it roughly depending on circumstances.	The exterior inspection shall be done with measurement tools and utilizing the five senses of the inspector to detect any unusual condition of the structures, and to confirm the operation of the structures. If an inspector finds something wrong in the structures during the inspection, he should repair it roughly depending on circumstances.	The interior inspection, after the waterway is dewatered, shall be done with measurement tools and utilizing the five senses of the inspector to understand the condition of the structures. If an inspector finds something wrong in the structures during the inspection, he should repair it roughly depending on circumstances.	If necessary, a special inspection shall be done before and after a flood, heavy rain or an earthquake. If an inspector finds something wrong in the structures during the inspection, he should repair it roughly depending on circumstances.	If necessary, a special detailed inspection shall be done with an appropriate procedure taking into account the results of the patrol, the exterior inspection, the interior inspection and the special inspection.
1. Reservoir/ Pond	Once /month	Once /year	-		
2. Dam	Once /month	Once /year	-		
3. Waterway	Once /month	Once /year	Once /3years	As required	As required
4. Other structures	Once /month	Once /year	-		

Note 1) Inspection
If it is impossible to carry out an inspection due to inaccessibility caused by a natural disaster, the inspection will be postponed where it does not affect the public safety.

Note 2) Exterior Inspection (Dam)
For a period of 2 months after the water level reaches the full supply level at the initial commissioning period ----- Once/week
Until the time that it is recognized that the dam is stable ----- Once/2 months

Note 3) Interior Inspection
If it is concluded that it does not affect the public safety judging from past inspection records, and the geology and topography reports, the frequency of the inspection can be reduced taking into account the characteristics of each power plant.

Table 2 Patrol Procedure

Structure	Objective	Check Point	Note
1. Reservoir / Pondage	Reservoir area	• State of reservoir • State of backwater area	
	Surrounding area	• Collapse • Landslide • Scour	
2. Dam			
(1) Dam	Concrete type	• Damage to surface of concrete • Leakage	
	Fill type	• State of surface of riprap • State of surfacing structure • Leakage	
	Surroundings	• Leakage • Crack • Collapse • Landslide	
(2) Discharging structure	Spillway gate Sand flash gate Discharge valve Others Channel Maintenance flow Irrigation flow Fishway	• Power supply • State of lock function of machinery • State of maintenance of machinery • Leakage • Other unusual state	Refer to Inspection Manual of Hydromechanical version
(3) Machinery	Emergency generator	• State of working • Cooling facility • Fuel stock	Refer to Inspection Manual of Hydromechanical version
	Gate control system	• Power supply • Monitoring panel • State of machinery	Refer to Inspection Manual of Hydromechanical version
	Centralized control system for gate operation	• Power supply • Monitoring panel • State of machinery • State of subsidiary equipment	Refer to Inspection Manual of Hydromechanical version
	Warning system for discharge	• Power supply • Monitoring panel • State of machinery	Refer to Inspection Manual of Hydromechanical version

Structure	Objective	Check Point	Note
	Drain valve	• State of performance • Unusual state	Refer to Inspection Manual of Hydromechanical version
Surrounding structures	Apron Concrete wall for spillway Bridge Retaining wall Riverbed protection Others	• Damage to concrete • Unusual state	
Other structures	Water level gauge Water level staff Floating pier Log boom Boat garage Boat Protection fence Measurement device Illumination light Others	• Damage to concrete • Loss • Unusual state	
3. Waterway			
(1) Intake	Intake	• Damage • Unusual state	
	Screen	• Damage • Unusual state • Garbage • Sedimentation	Refer to Inspection Manual of Hydromechanical version
	Gate	• Power supply • State of lock function of machinery • State of maintenance of machinery	Refer to Inspection Manual of Hydromechanical version
	Intake with selective level function	• Damage • Unusual state • Garbage • Power supply • State of lock function of machinery • State of maintenance of machinery	Refer to Inspection Manual of Hydromechanical version
	Log boom and Trash raking machine	• Garbage • Unusual state	Refer to Inspection Manual of Hydromechanical version

Structure	Objective	Check Point	Note
(2) Settling basin	Settling basin	• State of inner basin • Unusual state	
	Sand flash	• Damage • Unusual state	
(3) Headrace	Aqueduct	• Damage • Deformation • Leakage • Unusual state	Refer to Inspection Manual of Hydromechanical version
	Sand flash	• Damage • Unusual state	
	Other structures	• Damage • Leakage • Unusual state	
	Surrounding area	• Collapse • Landslide • Seepage • Unusual state	
(4) Surge tank	Surge tank	• Damage • Unusual state	
	Combined tank	• Damage • Unusual state	
	Sand flash facility	• Damage • Unusual state	
	Surrounding area	• Collapse • Landslide • Seepage • Unusual state	
(5) Penstock	Supporting structures	• Damage • Deformation • Settlement • Unusual state	
	Steel pipe and Mechanical structures	• Damage • Deformation • Unusual state of pipe and supporting equipment	Refer to Inspection Manual of Hydromechanical version

Structure	Objective	Check Point	Note
	Pipe for wasteway	• Damage • Deformation • Unusual state of pipe and supporting equipment	Refer to Inspection Manual of Hydromechanical version
	Surrounding area	• Collapse • Landslide • Seepage • Unusual state	
(6) Powerhouse	Basement	• Deformation • Crack • Seepage • Unusual state	
	Surrounding structures	• Deformation • Crack • Seepage • Unusual state	
	Surrounding area	• Deformation • Crack • Seepage • Unusual state	
(7) Tailrace	Gate	• Power supply • State of lock function of machinery • Unusual state	Refer to Inspection Manual of Hydromechanical version
	Surrounding structures	• Deformation • Crack • Seepage • Unusual state	
(8) Outlet	Surrounding structure	• Damage • Unusual state	
	Gate	• Power supply • State of lock function of machinery • Unusual state	Refer to Inspection Manual of Hydromechanical version
	Surrounding structures	• Deformation • Crack • Seepage • Unusual state	

Structure	Objective	Check Point	Note
(9) Diversion structures	Intake dam Intake Screen Gate Settling basin Waterway Other structures	• Refer to the items for the dam, intake and headrace part as shown above	Refer to Inspection Manual of Hydromechanical version
4. Other structures	Warning system for discharge	• Damage • Unusual state	Including siren
	Warning signboard for discharge	• Damage • Deformation • Loss • Unusual state	
	Meteorological station	• Damage • Loss • Unusual state	
	Gauging station	• Damage • Loss • Unusual state	
	Disposal area	• Collapse • Landslide • Seepage • Unusual state • Growth of greenery	
	Access road	• Depression • Unusual state • Retaining wall • Bridge • Unusual state	
	Other structures	• Damage • Leakage • Unusual state	

Table-3 Inspection Procedure

Structure	Objective	Check Point	Note
1. Reservoir/ Pondage	Reservoir area	• Driftwood • Water quality (Turbidity, Red tide) • Backwater area	
	Surrounding area	• Collapse • Landslide • Scour • Settlement of retaining wall • Crack • Bulge • Indication board for sedimentation survey	
2. Dam			
(1) Dam	Concrete dam	• Damage • Wear • Crack • Location, Volume and Turbidity of Leakage	
	Fill dam	• Collapse • Hollow • Weathering • Crack, Bulge, Weathering and Deterioration of surfacing structure • Location, Volume and Turbidity of Leakage	
	Surrounding area	• Leakage • Crack • Collapse • Landslide	
(2) Spillway structures	Spillway gate	• Damage, Deformation, Wear and Leakage in guide frame and fixed parts	Refer to Inspection Manual of Hydromechanical version
	Sand flash gate	• Damage, Deformation, Wear of gate leaf and winch machine • Deterioration of painting	Refer to Inspection Manual of Hydromechanical version
	Discharging valve Other discharging structures Channel Irrigation flow Fishway Others	• Loosened part of control board • Unusual state of Wiring • Relay switch and insulator • Unusual state of panel, switch, monitor of operation board	Refer to Inspection Manual of Hydromechanical version

Structure	Objective	Check Point	Note
(3) Machinery	Emergency generator	• Loosebolts, Oil leak, Wear, Deformation, Overheating, Noise, Smell, Lower oil pressure, Imperfect combustion • Lower voltage in starter equipment, Defect in battery charger, Problem with cooling water tank, Unusual state • Alarm lamp of cubicle, Unusual state	Refer to Inspection Manual of Hydromechanical version
	Gate control system	• Test for each part, Remote control test, Running test	Refer to Inspection Manual of Hydromechanical version
	Centralized control system for gate operation	• Test for each part, Remote control test, Running test • Test for subsidiary equipment	Refer to Inspection Manual of Hydromechanical version
	Warning system for discharge	• Confirmation test for transmission, Confirmation test for siren, Confirmation test for operation	Refer to Inspection Manual of Hydromechanical version
	Drain system in dam gallery	• Performance, Noise, Vibration	Refer to Inspection Manual of Hydromechanical version
(4) Surrounding structures	Apron Guide wall Bridge Others	• Wear, Scour, Crack	
(5) Others	Water level measuring system Staff gauge for water level Log boom Measuring devices Others	• Damage, Loss, Rust	
3. Waterway			
(1) Intake	Intake	• Damage, Deformation, Crack, Wear, Scour	

Structure	Objective	Check Point	Note
	Screen	• Damage, Deformation, Loosebolts, Deterioration of paint	Refer to Inspection Manual of Hydromechanical version
	Gate	• Damage to gate leaf, Deformation • Damage to gate leaf and winch, Deformation and wear of gate leaf and winch, Deterioration of paint • Looseness in operation board and wiring system, Response of relay in electromagnetic circuit breaker, Unusual state in isolation resistance • Unusual state of indicator, switch and lamp	Refer to Inspection Manual of Hydromechanical version
	Selective intake	• Damage to gate leaf, Deformation • Damage to gate leaf and winch, Deformation and wear of gate leaf and winch, Refilling of lubricant, Deterioration of paint • Looseness in operation board and wiring system, Response of relay in electromagnetic circuit breaker, Unusual state in isolation resistance • Unusual state of indicator, switch and lamp	Refer to Inspection Manual of Hydromechanical version
	Log boom	• Damage to and corrosion in anchor, wire, pier	Refer to Inspection manual of Hydromechanical version
	Trash rack	• Damage to rake, traveling system and conveyor, Unusual state of rake, traveling system and conveyor, Corrosion and rust	Refer to Inspection Manual of Hydromechanical version
(2) Settling basin	Settling basin	• Accumulated sediment • Unusual state	
	Sand flash	• Damage to sand flash	
(3) Headrace	Inside	• Leakage, Seepage, Scour, Flaking off, Deformation, Sediment, Deterioration of paint	Steel liner to be included
	Aqueduct	• Damage, Deformation, Leakage	Refer to Inspection Manual of Hydromechanical version

Structure	Objective	Check Point	Note
	Sand flash	• Damage	
	Others	• Leakage, Crack	
	Surrounding areas	• Collapse, Landslide, Seepage	
(4) Surge tank	Surge tank	• Damage, Deformation, Crack, Wear, Scour	
	Combined tank	• Damage, Deformation, Crack, Wear, Scour	
	Sand flash	• Damage	
	Surrounding areas	• Collapse, Landslide, Seepage	
(5) Penstock	Supporting structures	• Damage, Deformation, Settlement	
	Steel pipe and Mechanical structures (for outside)	• Damage to steel pipe and supporting system • Deformation and vibration of steel pipe and supporting system • Leakage • Deterioration of paint	Refer to Inspection Manual of Hydromechanical version
	Steel pipe and Mechanical structures (for inside)	• Damage to steel pipe • Deformation of pipe • Deterioration of paint • Unusual state	Refer to Inspection Manual of Hydromechanical version
	Pipe for wasteway (for outside)	• Damage to steel pipe and supporting system • Deformation and vibration of steel pipe and supporting system • Leakage • Deterioration of paint	Refer to Inspection Manual of Hydromechanical version
	Pipe for wasteway (for inside)	• Damage to steel pipe • Deformation of pipe • Deterioration of paint • Unusual state	Refer to Inspection Manual of Hydromechanical version
	Surrounding areas	• Collapse, Landslide, Seepage	

Structure	Objective	Check Point	Note
(6) Powerhouse	Basement	• Deformation, Crack, Seepage	
	Surrounding structures	• Deformation, Crack, Seepage	
	Surrounding areas	• Collapse, Landslide, Seepage	
(7) Tailrace	Gate	• Damage to gate leaf • Deformation of gate leaf • Damage to gate leaf and winch • Deformation of gate leaf and winch • Wear of gate leaf • Refilling of lubricant for winch • Deterioration of paint • Looseness in operation board • Unusual state of wiring • Response of relay in electromagnetic circuit breaker • Unusual state in isolation resistance • Unusual state in indicator, switch and lamp	Refer to Inspection Manual of Hydromechanical version
(8) Outlet	Inside	• Leakage, Seepage, Scour, Flaking off, Deformation, Sediment, Deterioration of paint	
	Surrounding structures	• Deformation, Crack, Seepage	
	Main unit	• Damage, Deformation, Crack, Wear, Scour	
	Gate	• Damage to gate leaf • Deformation of gate leaf • Damage to gate leaf and winch • Deformation of gate leaf and winch • Wear of gate leaf • Refilling of lubricant for winch • Deterioration of paint • Looseness in operation board • Unusual state in wiring • Response of relay in electromagnetic circuit breaker • Unusual state in isolation resistance • Unusual state in indicators, switches and lamps	Refer to Inspection Manual of Hydromechanical version

Structure	Objective	Check Point	Note
	Surrounding structures	• Deformation, Crack, Seepage	
(9) Diversion structures	Intake dam Intake Screen Gate Settling basin Diversion tunnel Other structures	• Refer to the items for the dam, intake and headrace part as shown above	
4. Other structures	Shed for siren station of warning system	• Damage	
	Warning board for discharge	• Damage, Deformation, Loss	
	Meteorological station	• Damage, Loss	
	Gauging station	• Damage, Loss, Unusual state	
	Others	• Deformation, Crack, Seepage	

Table-4 Special Inspection Procedure

Incident	Before or After Incident	Occasion	Check point
Earthquake	Before incident	Issuance of earthquake warning	• Check on dam, spillway, intake and other major structures • Check on emergency generator • Check on fuel of emergency generator • Trial run with emergency generator • Safety measures for ongoing operations • Transportation and Communication system
	After incident	Occurrence of earthquake measuring not less than one third of the designed seismic coefficient	• Inspection of damage to structures and their surroundings • Measurement of leakage, deformation, crack, movement, survey
Flood or Heavy rain	Before incident	Flood expected	• Check on spillway gate and other machinery • Check on emergency generator • Check on fuel of emergency generator • Trial run with emergency generator • Check on dam, reservoir and their surroundings • Transportation and Communication system
	After incident	Flood or heavy rain with a volume greater than the specified one Other occasions if inspection is required	• Inspection of damage to structures and their surroundings (cracks, collapse, landslides.) • Other check points as required
Others		Other occasions if inspection is required	• Following the above check points

Table-5 Measurement Items and Frequency

Measurement Item	Leakage	Uplift	Deformation				Seepage line
Definition of measurement item	The term "Measurement of leakage" means measurement of amount, temperature and turbidity of leakage.	The term "Measurement of uplift" means measurement of uplift at the base of the dam.	The term "Measurement of deformation" means measurement of deflection for a concrete dam or measurement of vertical and horizontal movement for a fill dam.				The term "Measure-ment of seepage line" means measure-ment of seepage line at the typical section.
Dam type to be measured	• Gravity type • Hollow gravity type • Arch type with the height not less than 30m	All types	• Gravity type with a height not less than 100m • Hollow gravity type • Arch type with a height not less than 30m	Concrete dam except the types shown in the left column	Fill dam with a height not less than 70m	Fill dam with a height less than 70m	Homogene-ous type of fill dam
Frequency of measurement for stable period of dam	Twice /month	Once /3month	Once /month	Once /3month	Once /3month	Once /6month	Once /3month
Frequency of measurement for dam not more than one year past the first achievement with full water level	Once/day	-	-	-	-	-	-
Frequency of measurement for dam more than one year and not more than 3 years past the first achievement with full water level	Once/week	-	-	-	-	-	-

Measurement Item	Leakage	Uplift	Deformation				Seepage line
Frequency of measurement for dam not more than 2 month past the achievement with full water level		Once/week	Once/day	Once/week	Once/week	Once/week	Once/week
Frequency of measurement for dam more than 2 month past the achievement with full water level			Once/week	Once/month	Once/month	Once/month	Once/month
	* Frequency of measurement of uplift, deformation and seepage line can be reduced or stopped if it is concluded that a dam is safe judging from the obtained measurement results.						

The measurement has to be continued until the time that the dam is regarded as being stable judging from the obtained measurement results.

APPENDIXES

Appendix-1 Format for the summary of the patrol and inspection record

Appendix-2 Format for the patrol record

Appendix-3 Format for the exterior inspection record

Appendix-4.1 Format for the special inspection record (before incident)

Appendix-4.2 Format for the special inspection record (after incident)

Appendix-1

Summary of Patrol and Inspection Record

(XXXXX Hydropower Plant)

Structure	Unusual state	Measures	Beginning time for remedial work	Rough estimate

Appendix-2

Patrol Record of XXXXX Hydropower Plant

Month: Date: Year:

(Result: Satisfactory .....○ ,Be careful..... Δ ,Unusual ..... ×)

Structure			Check Point	Result	Note
Reservoir/ Pondage		Reservoir Area	• State of reservoir • State of the end of backwater area		
		Surrounding Area	• Collapse on slope • Landslide • Scour		
Dam	Dam	Concrete type Fill type	• Damage to concrete at the surface • Leakage • State of riprap • State of facing • Leakage		
		Surrounding area	• Leakage • Crack • Collapse • Landslide		
	Discharge facility	Spillway gate Sand flash gate Discharge valve Discharge channel Maintenance flow Irrigation flow Fishway Others	• Power supply • State of lock function with machinery • State of maintenance of machinery • Leakage • Other unusual state		
	Machinery	Emergency generator	• State of performance • Cooling facility • Stock of fuel		
		Gate control system	• Power supply • Indicator • State of machinery		

To be continued as shown on Table-2

Appendix-3

Exterior Inspection Record of XXXXX Hydropower Plant

Month: Date: Year:

(Result: Satisfactory .....○ ,Be careful..... Δ ,Unusual ..... ×)

Structure			Check Point	Result	Note
Reservoir/ Pondage		Reservoir Area	• Driftwood • Water quality (Turbidity, Red tide)		
		Surrounding Area	• Collapse • Landslide • Scour • Settlement of retaining wall • Crack • Bulge • Indication board for sedimentation survey		
Dam	Dam	Concrete type	• Damage • Wear • Crack • Location. Volume and Turbidity of leakage		
		Fill type	• Collapse • Hollow • Weathering • Crack, Bulge, Weathering and Deterioration of surfacing structure • Location. Volume and Turbidity of leakage		
		Surrounding Area	• Leakage • Crack • Collapse • Landslide		
	Discharge facility	Spillway gate Sand flash gate Discharge valve Discharge channel Maintenance flow Irrigation flow	• Damage, Deformation, Wear and Leakage in guide frame and fixed parts • Damage, Deformation, Wear of gate leaf and winch machine • Deterioration of painting • Loosened part of control board • Unusual state of Wiring • Relay switch and insulator • Unusual state of panel, switch, monitor of operation board		

To be continued as shown on Table-3

Appendix-4.1

Special Inspection Record (before incident) of XXXXX Hydropower Plant

Month: Date: Year:

(Result: Satisfactory ○ ,Be careful Δ ,Unusual ×)

Structure			Check Point	Result	Note
Reservoir/ Pondage		Reservoir Area	• Driftwood • Water quality (Turbidity, Red tide)		
		Surrounding Area	• Collapse, Landslide and Scour		
Dam	Dam	Concrete type	• Damage • Leakage •		
		Fill type	• Unusual state of riprap • Leakage		
		Surrounding area	• Leakage, Crack, Collapse, Landslide		
	Discharge facility	Spillway gate Discharge valve	• Power supply • State of lock function with machinery • State of maintenance of machinery • Indication panel, Switch, Lamp		
	Machinery	Emergency generator	• State of working • Cooling facility		
		Gate control system Centralized control system for gate operation Warning system for discharge	• Power supply • Indication panel		

To be continued as shown on Table-4

［Present state of works and Measures to be taken ］

［Note］

Special Inspection Record (before incident) of XXXXX Hydropower Plant

Month: Date: Year:

(Result: Satisfactory ○ ,Be careful Δ ,Unusual ×)

Structure			Check Point	Result	Note
Reservoir/ Pondage		Reservoir Area	• Driftwood • Water quality (Turbidity, Red tide)		
		Surrounding Area	• Collapse, Landslide and Scour		
Dam	Dam	Concrete type	• Damage to Crest, Surface, Gallery • Crack in Crest, Surface, Gallery • Leakage, Tendency change in amount of leakage		
		Fill type	• Change of appearance of crest, surfacing structure, riprap • Leakage, Tendency change in amount of leakage		
		Surrounding area	• Leakage, Crack, Collapse, Landslide		
	Discharge facility	Spillway gate Discharge valve	• Damage, Deformation, Leakage		
	Machinery	Emergency generator	• State of working • Cooling facility • Stock of fuel		
		Gate control system Centralized control system for gate operation Warning system for discharge	• Power supply • Indication panel		
	Surrounding structures	Apron Guide wall Slope protection	• Damage • Unusual state		

To be continued as shown on Table-4