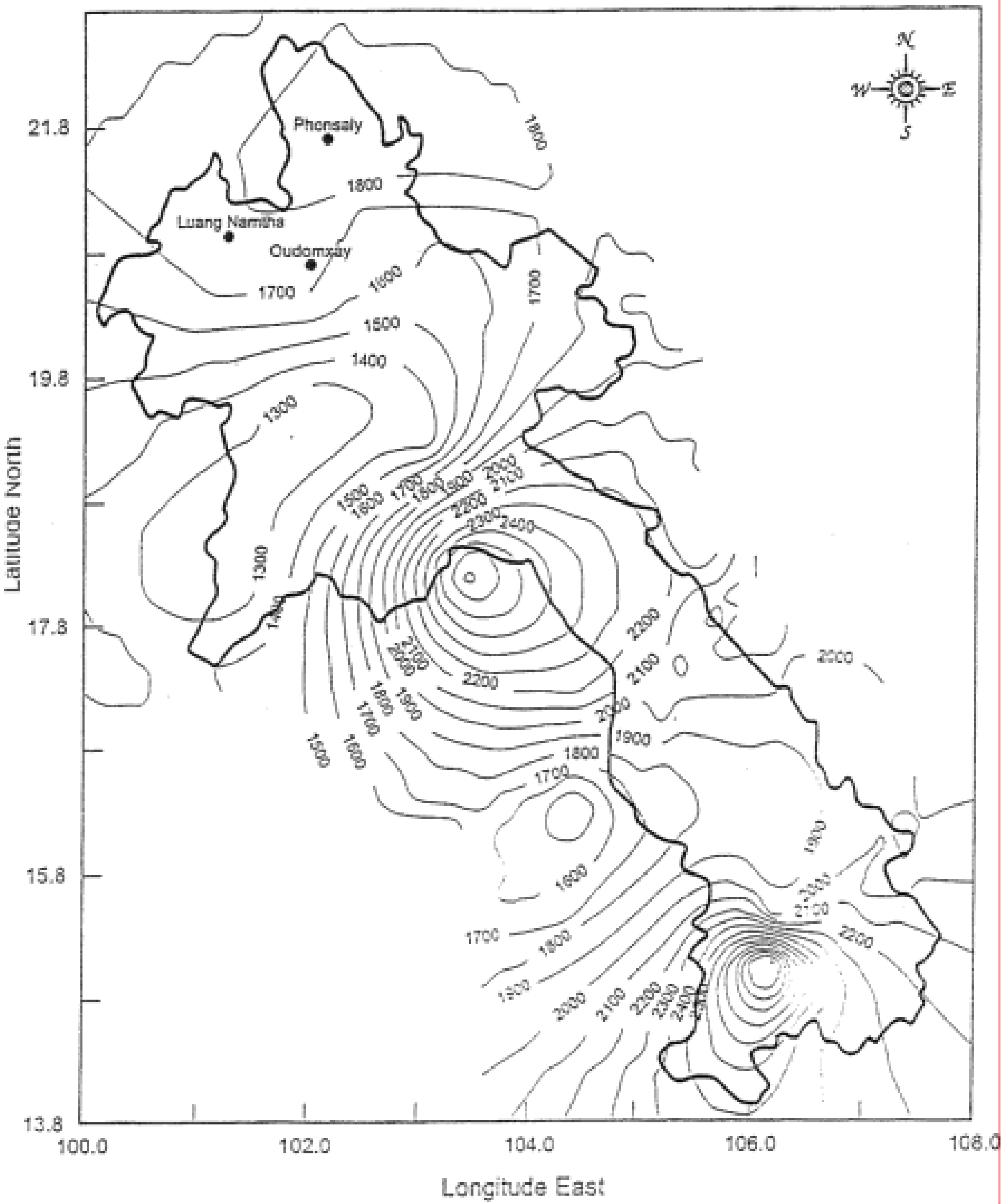
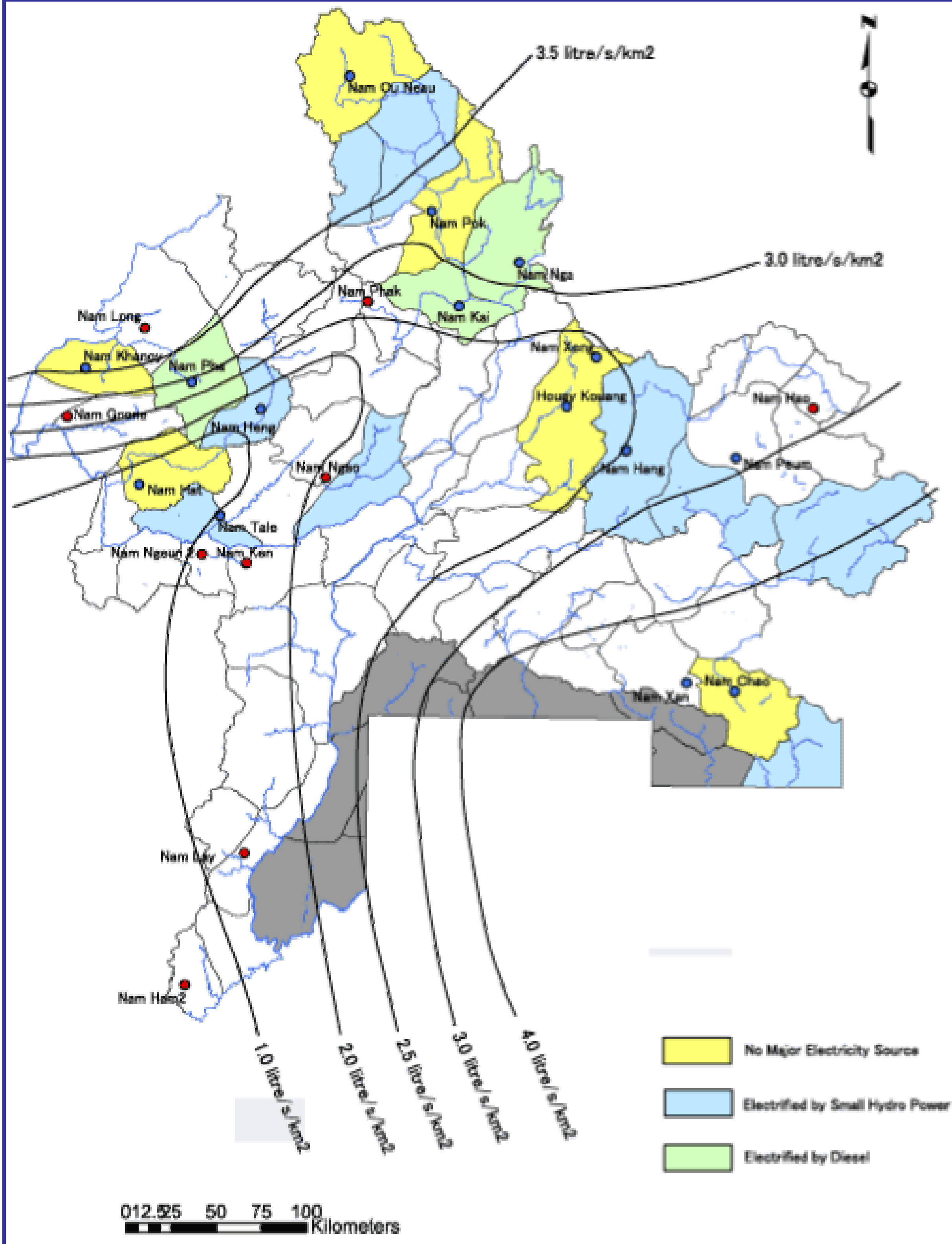
Mean Annual Rainfall Isohyetal Map of Lao PDR



Average Annual Rainfall

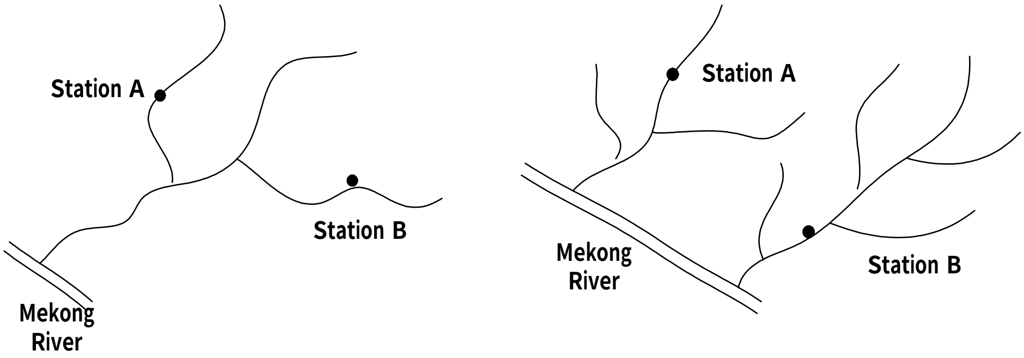
Source: Water Resources Guide Book of Lao P.D.R, Vol.1, Sep.2002, DMH

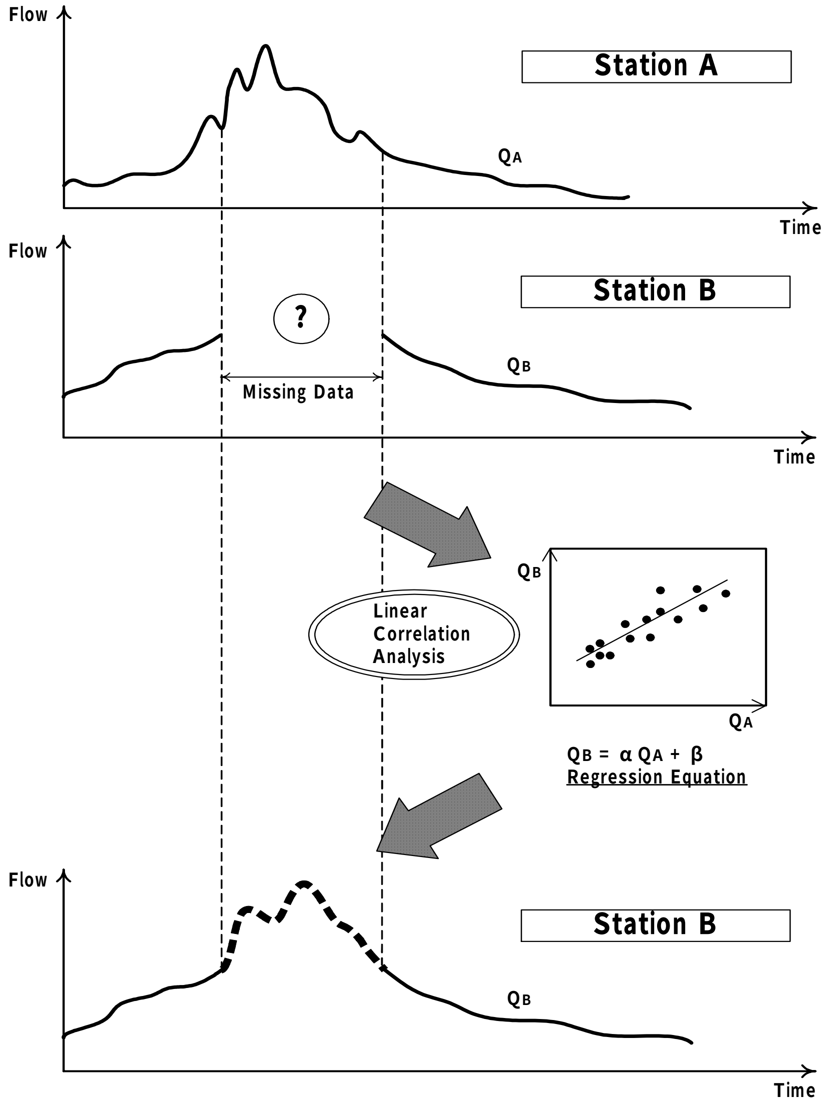
Regional Specific Discharge Map in Northern Laos



SPECIFIC DISCHARGE IN DRY SEASON AT NORTHERN LAOS

Infilling of Missing Runoff Data





Infilling of Missing Data by Regression Method

Creager's Curve for Design Floods

Creager's Equation

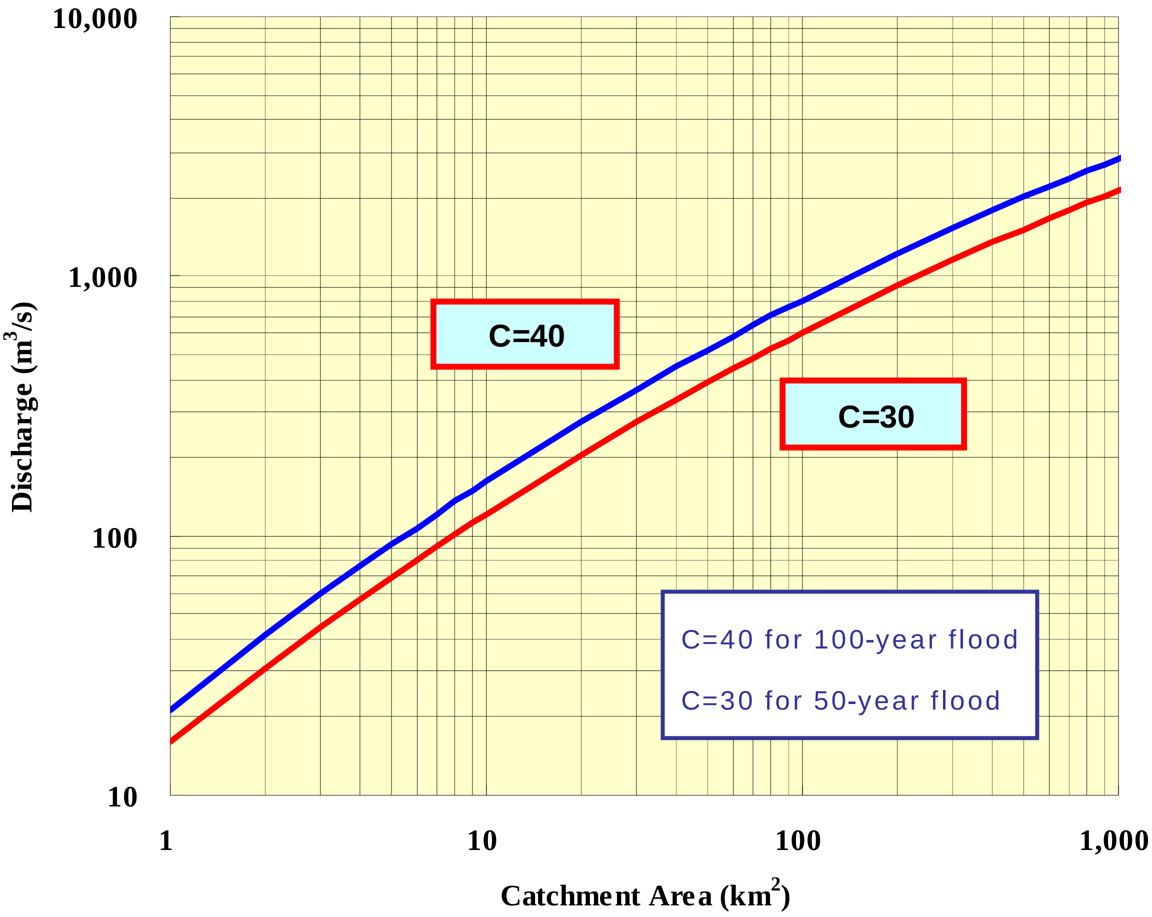
$$Q = (46 \times 0.02832) \times C \times (0.3861 \times A)^{a-1}$$

$$a = 0.894 \times (0.3861 \times A)^{-0.048}$$

where, Q : Peak Discharge (m^3/sec)

C : Creager's Coefficient

A : Catchment Area (km^2)



Creager's Curves

Design Floods in Laos

The Lao Electric Power Technical Standards was established by MIH/DOE on February 12, 2004 under the technical cooperation between the Governments of Lao PDR and Japan. This Standards prescribes the fundamental requirements for power facilities and technical contents that should satisfy the fundamental requirements.

Article 17 of the Standards provides the Inflow Design Flood for dams as quoted below

Article 17 Inflow Design Flood

1. Inflow design flood shall be set as follows, according to the dam classification specified in Paragraph 2.

Table: Inflow design flood

Dam Classification	Inflow design flood
High	Probable maximum flood (PMF)
Significant	Between PMF and annual exceedance probability 1/1,000
Low	Between PMF and annual exceedance probability 1/100

2. Each dam shall be classified in terms of the reasonably foreseeable consequences of failure. Consideration of potential damage shall not be confirmed to conditions existing at the time of construction. Probable future development in the downstream flood plain shall be evaluated in estimating damages and hazards to human life that would result from failure of the dam.

Table: Dam classification

Dam Classification	Loss of life	Impact on economy, society and environment
High	Large increase in loss expected	Excessive increase in economic, social and/or environmental impact
Significant	Some increase in loss expected	Substantial increase in economic, social and/or environmental impact
Low	No increase in loss expected	Low increase in economic, social and/or environmental impact

An Example of Site Reconnaissance Memo (1/5)

SITE RECON MEMO

Project	**Nam Gnone**	Code	
River	Nam Gnone (Nam Gnone Basin)	CA	121 km^2

Province	Bokeo	District	Houaysay	Load Center	Grid connection
Village at I/T			Village at P/H	B. Namkat	

Recon Date	Dec. 03, 2004
Recon Members	JICA S/T: Kataoka, Ohuchi, Mochizuki, Nishimaki Yamamura, ; DOE: Sanhya, Vithounlabandith; PDIH: Thongdy, Kim

General Condition (Access, Electrification Status, etc)

Access to B. Namkat

- From Houaysay to the crossroad is 45 min on paved road. From crossroad to B. Phouxai is 20 min on dirt road.

Electrification Status of B. Namkat

- B. Namkat is electrified by pico hydro but not so much.

Access to Power Station Site

- There is a foot path to area of the P/H site, which cross a tributary of Nam Gnone. This footpath is used to go to paddy fields along Nam Gnone and to go to see Nam Gnone Falls. It seems difficult to cross the tributary during rainy season.
- The time taken from B. Namkat to wate fallws at downstream end is 3 minutes on foot.

Access to Intake Site

- The same footpath which leads to water falls extends to the I/T with crossing the Nam Gnone by a log bridge. The condition of the footpath near I/T is covered with bamboo grove and not the same as to the P/H.
- The time taken from Powerhouse site to the I/T is approx. 1.0 hours.

Access to Staff Gauge

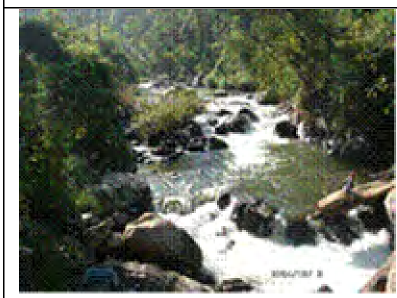
- Staff gauge is installed at B. Namkat.

Photos

B. Namkat.

Water fall located just upstream of powerhouse site

Intake canal constructed for previous piko hydropower, which stopped to operate now.



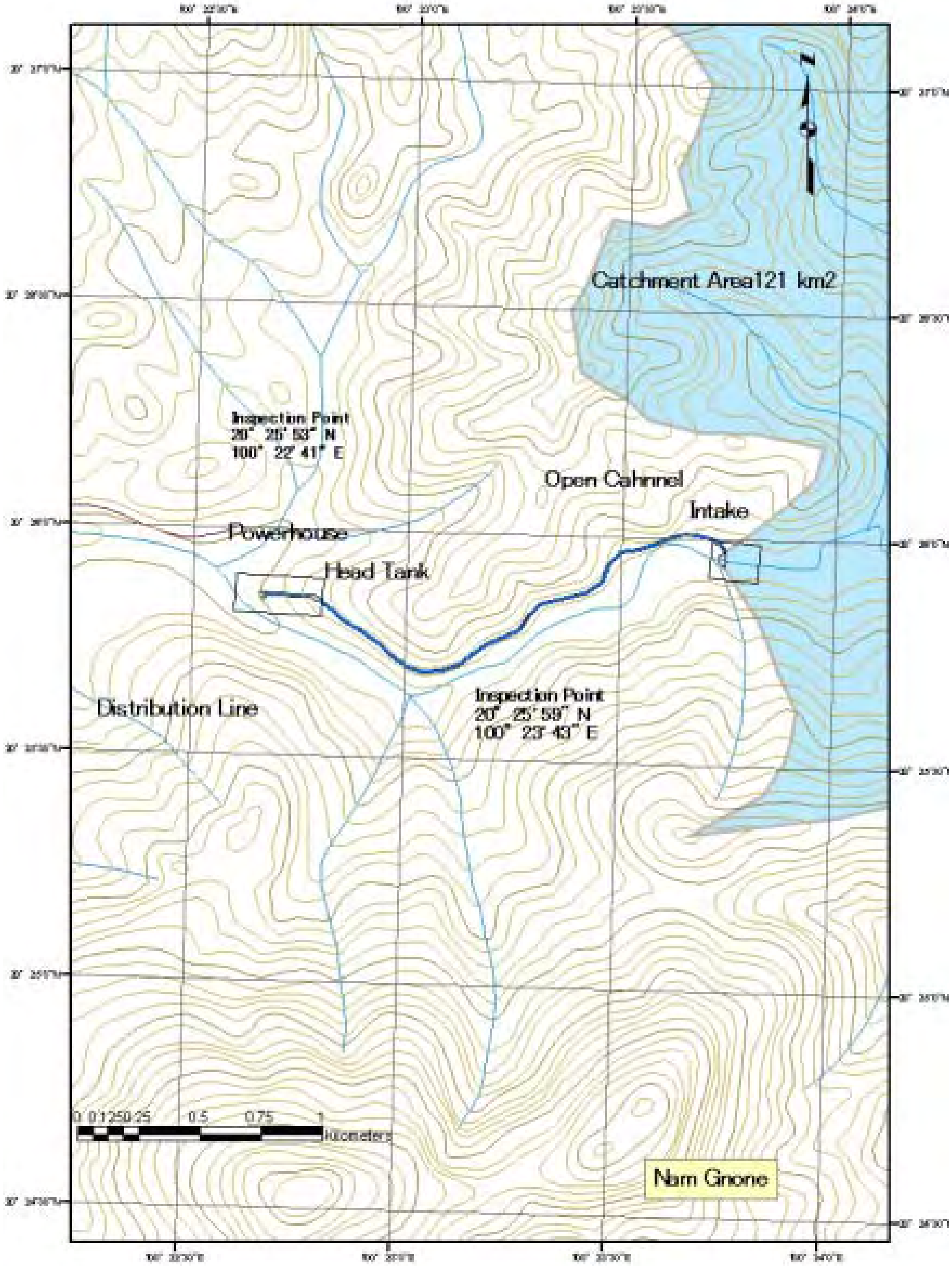
Rapid continue toward upstream.

Irrigation intake and canal for irrigation at paddy field located downstream area

Paddy field taking water from canal during rainy and dry seasons

An Example of Site Reconnaissance Memo (2/5)

Location Map



An Example of Site Reconnaissance Memo (3/5)

Intake Facilities (Weir/Dam, Intake, Desilting Basin)

Condition of the Intake Site

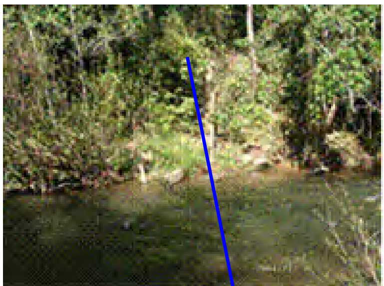
- The intake site proposed through the map study seems to be adequate, but a left bank is flat with paddy field. Right bank has steep slope covered with bamboo grove. At downstream of proposed intake dam site, a steep rapid starts. Further upstream area is very flat and a new village locates near the river on right bank. Access road exists on right bank which lead to new village. Coordinates at center of dam axis is N20°25’58.68”, E100°23’43.45 and elevation is EL.413m.
- There is alternative dam site at downstream of proposed dam site mentioned above. This dam site is little wider than original dam site. This site locates at middle way of steep rapid portion of this river, which has lower elevation than original dam site by 17m. Coordinates at center of dam axis is N20°25’41.16”, E100°23’16.6 and elevation is EL.396m. The condition of access is same as original dam site.
- It is judged that the original axis is more adequate, because it can have higher head as mentioned above.

Environmental Impact

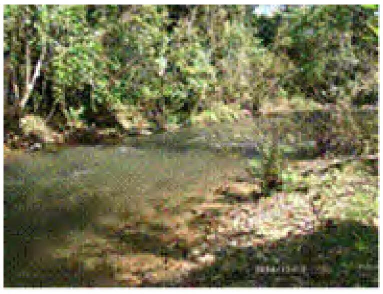
- The weir height needs to be kept low in order not to inundate the paddy fields which extend on left bank.
- There in no serious problem on Fishing activities.
- There is an existing irrigation intake weir and canals which take water and invite it to paddy fields. The water is taken from June to October in rainy season and December to April in dry season. The area of existing paddy fields is 30ha and there is plan to expand the area to 50 ha in rainy season only. According to head of former, the one forth of river water is taken to irrigation canal at driest season. It seems that the water taking for hydropower at upstream of irrigation intake considering the requirement of irrigation water will not affect to irrigation even though the dry season. This water usage for irrigation should be considered in duration curve of river flow.

Photos

Proposed Intake Weir site. Photo taken from upstream. There are steep slope in right bank and flat slope and paddy field in left bank.



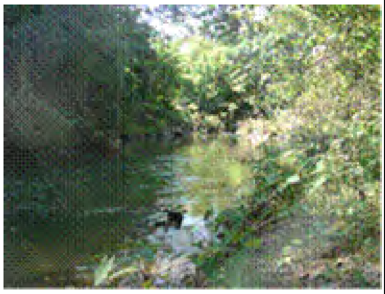
At bottom of weir axis on right bank, a rock is exposed. Upper area of right bank is covered with bamboo grove. (adopted)



Upstream river has relatively flat slope.

Alternative Intake Weir site. Upstream view. Total head become about 30 m.

Alternative Intake Weir site. Marking for weir axis. (not adopted)



Alternative Intake Weir site. Downstream view.

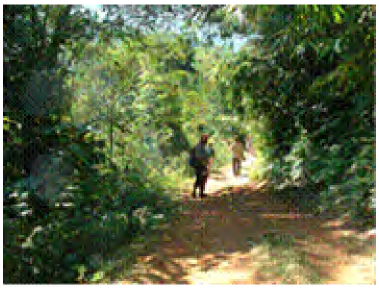
An Example of Site Reconnaissance Memo (4/5)

Waterway (Canal/Tunnel, Head Tank/Surge Tank, Penstock)

Conditions along Waterway

- The open channel will be constructed on the R/B. The waterway was not directly investigated, but observed from the existing access road on R/B.
- The waterway may be as long as 2 km, but the mountain slope seem to be adequate for construction.
- At the design stage, it should be careful that the excavation for water way should not affect to stability of exsiting accessr road on right bank.
- For discharge Q = 3.8 m^3/s flowing at v = 1 m/s, the channel dimension will be in the order of 2.0 m x 2.0 m.
- The necessity of concrete cover of open canal should be considered site by site.

Photos



There is an access road to village on right bank, which pass through the upper part of Intake Weir Site and Powerhouse site.

Open channel will locate along the access road at lower elevation.

Between Intake Weir site and Powerhouse site, there is irrigation intake and canal on left bank. Same type of wet masonry canal will be adopted for open channel for hydropower.

Powerhouse (Power Station, Tailrace, Outdoor Switchyard)

Conditions of Powerhouse Site

- The riverbed coordinates below the proposed P/H site is N20°25’51.31”, E100°22’43.01”, WL 364 (Trimble GPS Geo explorer CE Series).
- The location is D/S of the lowest water falls, where locates beside water pool.
- The annual FWL is high at approx. 2m above the present WL. In order to lower the P/H as much as possible and to prevent the P/H from the flood, the pond mouth and downstream area of river should be reshaped to have bigger flow capacity.

Alternative Powerhouse Site

- There is alternative powerhouse site at downstream of original powerhouse site. However, this site locates at flat area with paddy field on left bank. In the case of this alternative, the water way should be designed on left bank and the penstock will locates in the paddy fields and became very long. Totally, the water way layout is very difficult. It seems not to be adequate.
- Alternative P/H site is N20°25’57.77”, E100°22’16.03”, WL 350.

Discharge Measurement

- Discharge measurement was conducted on Dec. 03, 2004 at the gauging station.
- Q = XXXX m^3/s (current meter)

Installed Capacity

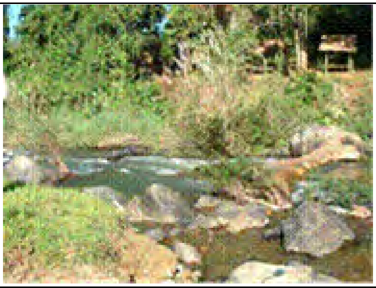
- The approximate net head H = 413 - 364 - (2000x(1.5/1000) = 46 m. Assuming Q = 3.8 m^3/s , and ηcomb = 70%, installed capacity P = 1200 kW.

Environmental Impact

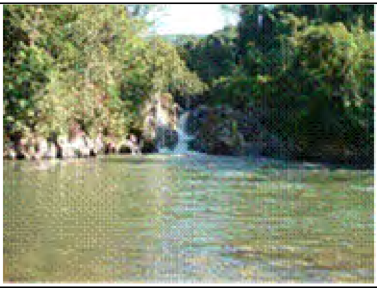
- Due to usage of river water for hydropower, the water which flow down through water falls will be reduced and the appeal strength as the sight seen location will be decreased in dry season especially. However, during rainy season, there will no serious problem on sight seen.

An Example of Site Reconnaissance Memo (5/5)

Photos

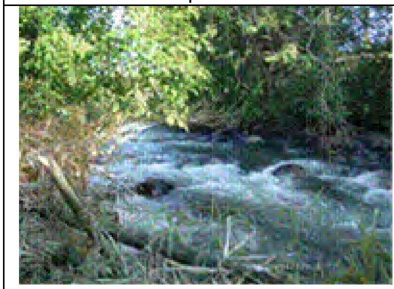


Proposed powerhouse located the flat area of 4 m higher than water surface of pond. Tailrace water will be invited to downstream of pond.

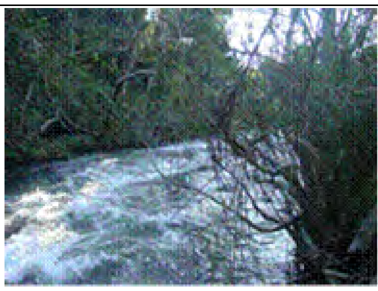


The last water fall flow into pond and spill out to further downstream area.

Proposed powerhouse site is flat area beside the last water fall. There is some huts and steps to go down to see pond at water fall side.



Alternative Powerhouse Site: Upstream view



Alternative Powerhouse Site: Downstream view

Alternative Powerhouse Site: River Bottom conditions

Distribution Line and Temporary Facilities (D/L, Spoil Bank, Construction Materials, Access Road)

Conditions of Distribution Line Route

- From the proposed P/H site, D/L can easily be constructed to B. Namgnon-Mai along the existing road, which locates near to junction of Nm Gnone and Nam Mekon.
- The nearest villages to the P/H are B. Namkat, and they can easily be reached.
- There is existing T/L which is delivering the electricity imported from Thailand to Tonpheung. The capacity of this T/L should be checked to study the possibility of connection of new T/L from P/H into existing T/L.

Access Road

- Access road can easily constructed along the existing road to the village on right bank.

Construction Materials and Spoil Bank

- Boulders are mostly available from the river.
- There are enough spoil bank area near the I/T.
- The excavated much from the diversion channel of the river will be used to construct a levy along the diversion channel.

Evaluation and Remarks

- As a alternate dam site and powerhouse site, two numbers of sites for both structure were planned and each site was investigated. As the result of total evaluation, the upper dam site and upper powerhouse site were selected for the layout in Pre-F/S.
- According to DOE, there is information that the generator with 60m head is available in order to save the construction cost.
- If this hydropower plant will be constructed with 1.2MW installed capacity, the huge electricity imported from Thailand will be reduced.

Others

- The existing irrigation system was constructed in 2000 by IFAT. The construction period was 1 year. According to the former team, they feel no problem with construction of hydropower project.
- The other private company was investigating this same hydropower scheme on same day. They are making cross section survey. It seems that their layout has the downstream site for intake dam and downstream site for powerhouse also.

River Flow Measurement Survey

A) Current Meter Method

i) 2-point method $V_m = 1/2 \times (V_{0.2} + V_{0.8})$ for depth > 1 m

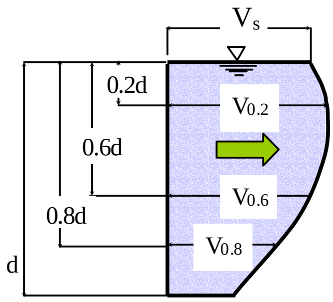
ii) 1-point method $V_m = V_{0.6}$ for depth < 1 m

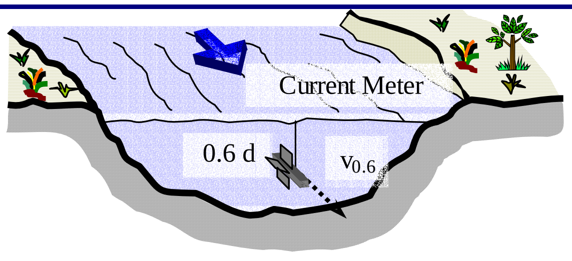
where, V_m : mean velocity

$V_{0.2}$: velocity at 20% depth from surface

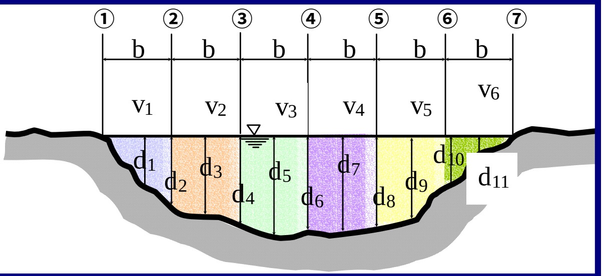
$V_{0.6}$: velocity at 60% depth from surface

$V_{0.8}$: velocity at 80% depth from surface





Velocity Measurement by Current Meter



Measurement of Sectional Area & Velocity

The river discharge can be derived using the following equation:

$$Q = V \times A$$

where, Q : Discharge (m^3/s)

V : Mean Velocity (m/s)

A : Cross Sectional Area (m^2)

Field Discharge Measurement

Field reconnaissance of the small hydropower sites was carried out from November 17 to December 11, 2004. The reconnaissance aimed at confirmation of the site conditions such as accessibility, river course, river flow, geography, geology, water withdrawal for the local irrigation and so on. Under the site reconnaissance, discharge measurement was conducted jointly by staff of DOE and PDIH.

Photos below show the discharge measurement on site in the Nam Pha River, Vieng Phoukha, Luangnamtha. The measured river discharge was 1.8 m^3/sec on November 25, 2004.

Nam Pha River

Looking for the best discharge measurement point

Straining a measurement tape across the river

Measuring the river water depth at 1 m intervals

Measuring the river flow velocity by a current meter at 1 m intervals

DOE Form of Discharge Measurement

JICA-DOE Study Team (Field Notebook of Discharge Observation)

FIELD WORKS										HOME WORKS						
		Depth of Water. (m)			Velocity Mesurement (Flow speed)					Velocity		Area of cross section				Disch-arge
No. of measure-ment	Distance from bank (m)	First (on way)	Second (return)	Average	Depth of observation(m)	Count of current meter	Mesu. Velocity 1st	2th	Average	Mesu. Veloc. at point(m/s)	Mean meas. Veloc.in vert(m/s)	Average depth(m)	Width of section(m)	Area of Section(m^2)	Total Area(m^2)	(m^3/s)
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																

Station No.			
Observation Date		Year:	Mon: Date:
Observer Name	Mesure		
	Wrote	***Sanhya***	
Weather	Weather	:clear, :fine, :cloudy :rain	
	Wind blows	from Down/s, Up/s, Left, Right	
	Wind power	0:None, 1:light, 2:windy, 3:strong, 4:very strong	
Mesurement Time (Hour, min)	Start		
	End		
	Average		
Water Level at gauging station (m)		Initial Point	No.1 Point
	Start		
	End		
	Average		
Current meter	Type of current meter	Digital	
	Table/formula	V =	
	Useing method	lods・wire・weight	
		by boat / bridge / walk	
Calculator	Calculator		
	Checker		
Result	Total Discharge (m^3/s)		
	Total area cross section(m^2)		
	Average Velocity (m/s)		

Notes

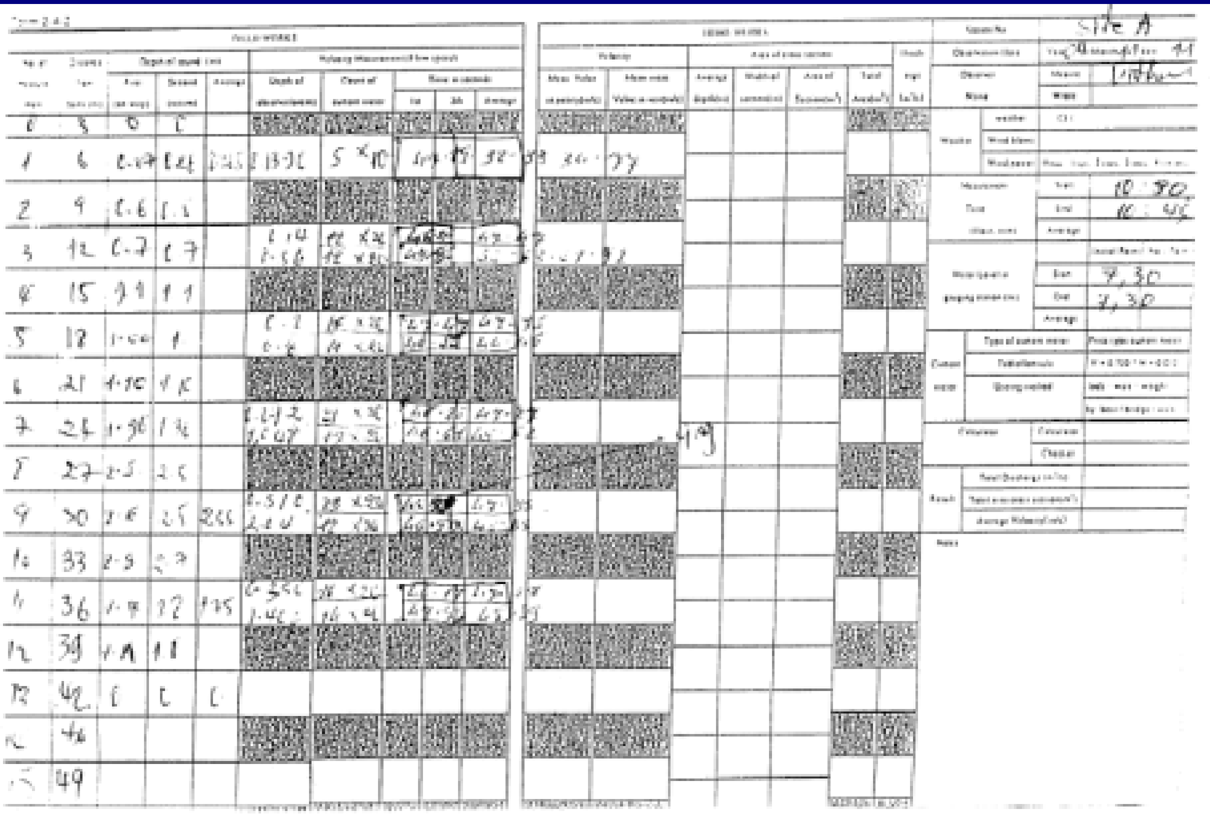
Catchment Area (km^2)=

Discharge (m^3/s)=

Specific Discharge ($m^3/s*100km^2$)=

Remark:

An Example of Record of Field Discharge Measurement



River Flow Measurement Survey

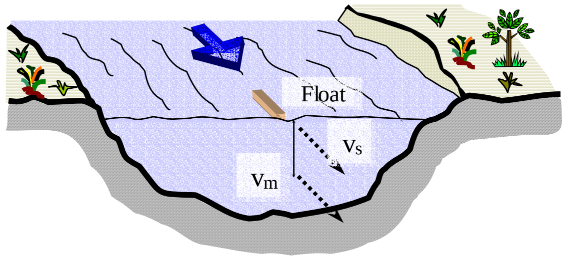
B) Float Method

$$Q = c \times V \times A$$

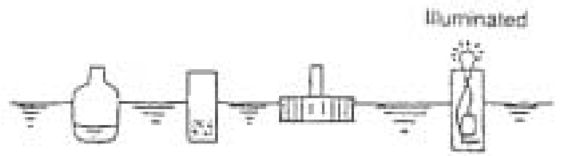
where, c = 0.85 for Concrete Channel

0.80 for Smooth Stream

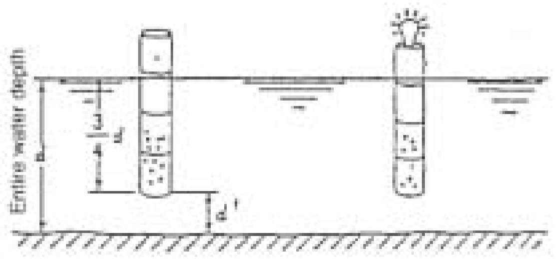
0.65 for Shallow Stream



Measurement by Float



Surface Float



Bar Float

River Flow Measurement Survey

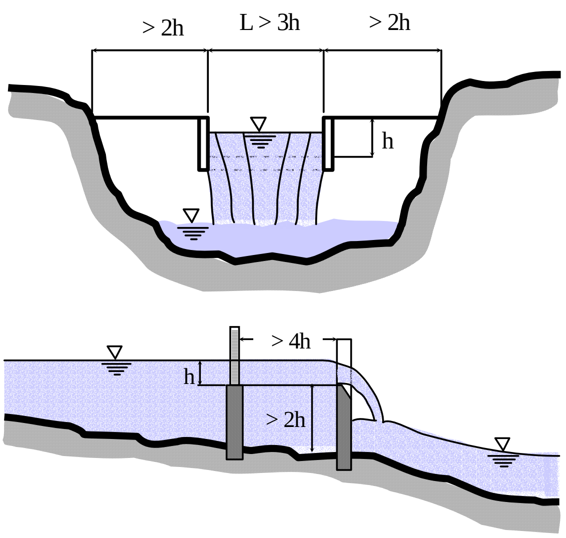
C) Weir Method

$$Q = 1.84 \quad (L \quad 0.2 \quad h) \quad h^{1.5}$$

where, Q : Discharge (m^3/s)

L : Length of Weir (m)

h : Overflow Depth (m)



Discharge Rating Curve

To Measure the River Flows (Flow Velocity & Flow Area) Frequently is Difficult.

Discharge Rating Curve is Drawn to Estimate the River Flow from the Measure Water Level based on:

- Discharge Measurement more than 10 Times in Range Required to Establish a Stage-Discharge Rating Curve
- Water Level Gauge Reading Using Staff Gauge
- The Curve shall be Developed Based on the Actual Discharge Measurement in the Dry Season

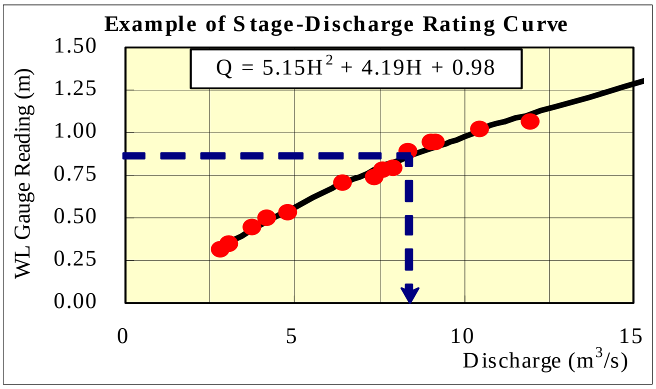
When the discharge rating curve is already developed, the daily discharge shall be obtained by reading the staff gauge.

$$Q = a + bH + cH^2$$

Q : River Flow (m^3/sec)

H : Water Level (m)

a, b, c : Constants



Water Head Measurement

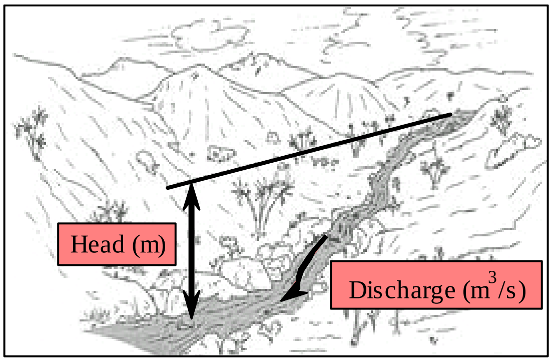


Figure Measurement of Discharge and Head

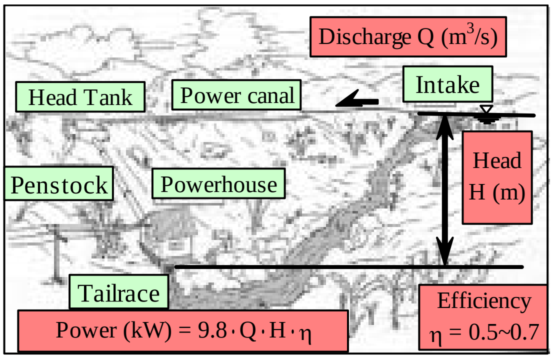


Figure Preliminary Planning of Layout Based on Q & H

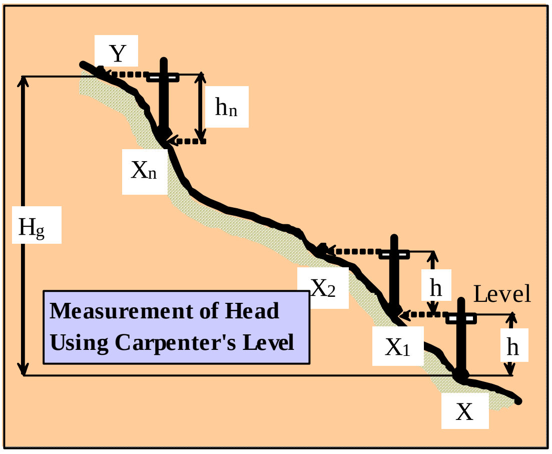


Figure Measurement of Head Using Carpenter's Level

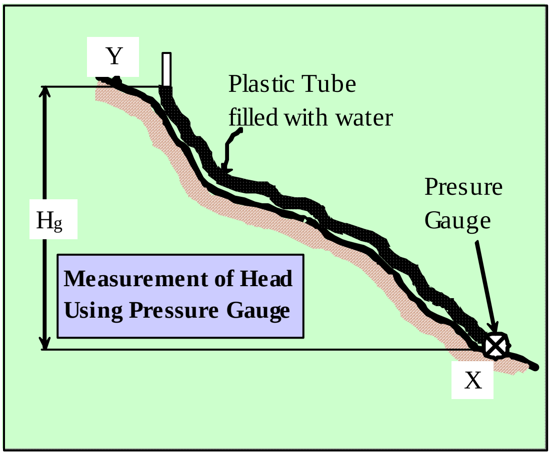


Figure Measurement of Head Using Pressure Gauge

GPS to measure coordinates & altitude

Distance Meter

Clinometer

Portable Compass

Tools for Measurement of Head