DESIGN AND DEVELOPMENT OF MICRO HYDRO TURBINE FOR RURAL AREA: CASE STUDY IN ROYAL BELUM

Razak Faculty of Technology and Informatics

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System Components
Turbine Types
Site Analysis
System Design

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Micro-Hydro

- This lecture will cover design considerations as they apply to low head micro-hydro system. The focus will be on core concepts that may be applied to a wide range of hydro applications
- Course instruction will include how to measure elevation differences and water flow rates. Several turbines will be installed and tested as part of the course participation.
- Participants perform preliminary system sizing for mechanical and electrical power generation of 5 to 10-kilowatt capacities. Methods of flow measurement, determining head, analysing and assembling small functioning systems.

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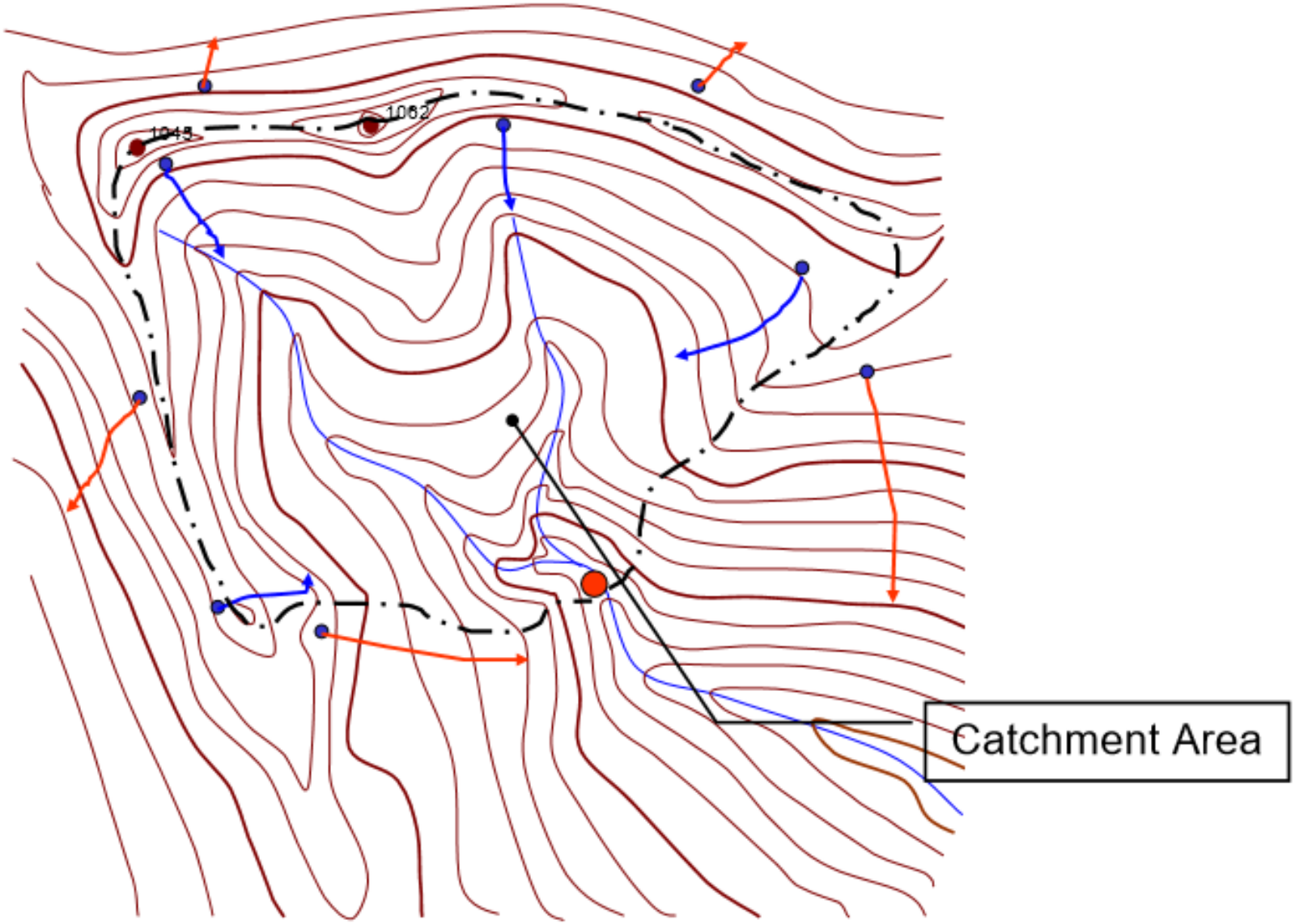
Objective

- Share some experiences of technical staff who have been involved in micro-hydropower development, and
- develop the knowledge of new technical staff who will be engaged in micro-hydropower development in the near future

IDENTIFICATION OF POTENTIAL SITE

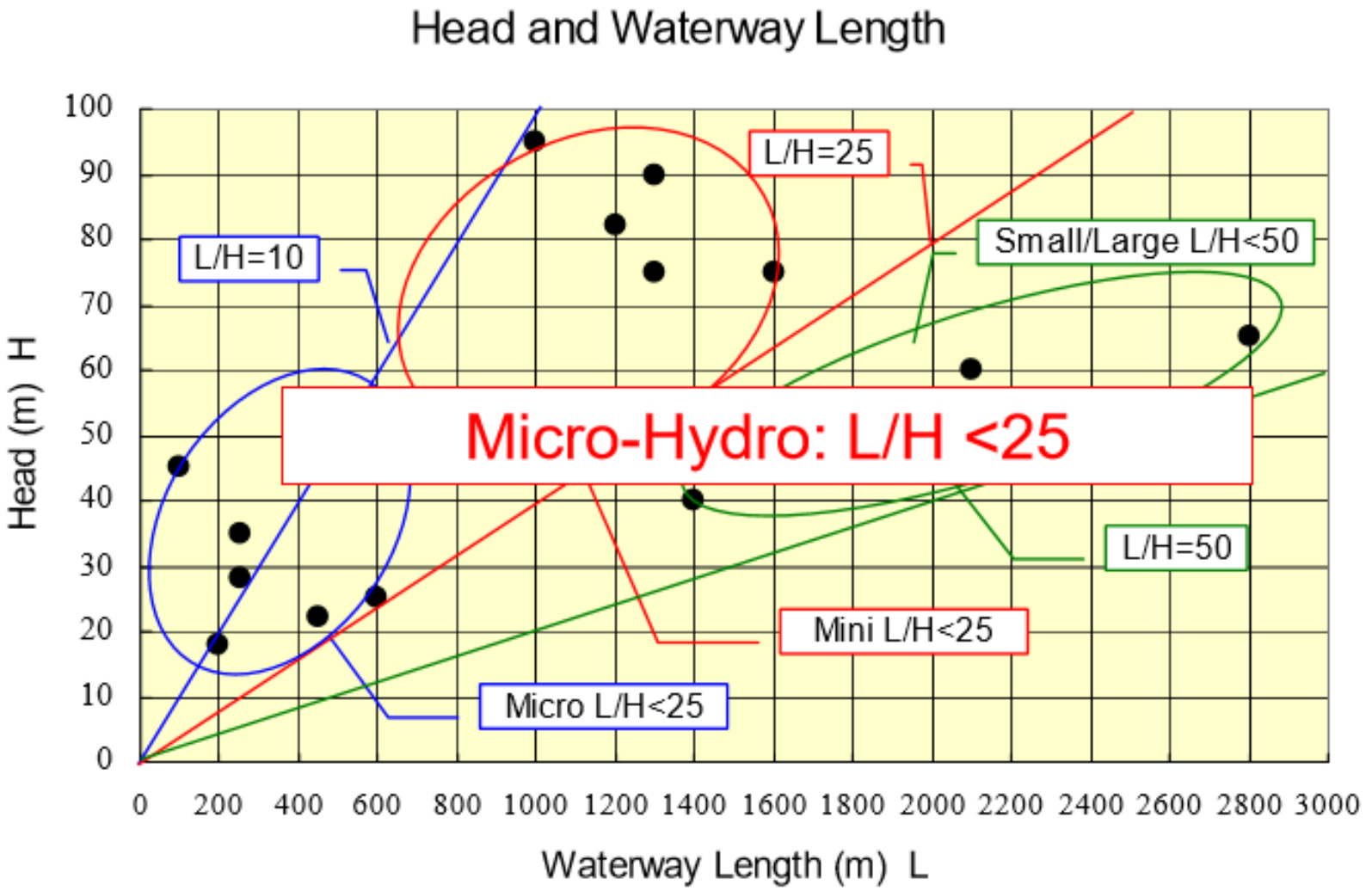
CATCHMENT AREA

- Hydropower depends on Head and Discharge
- Discharge depends on catchment area (for generating power)

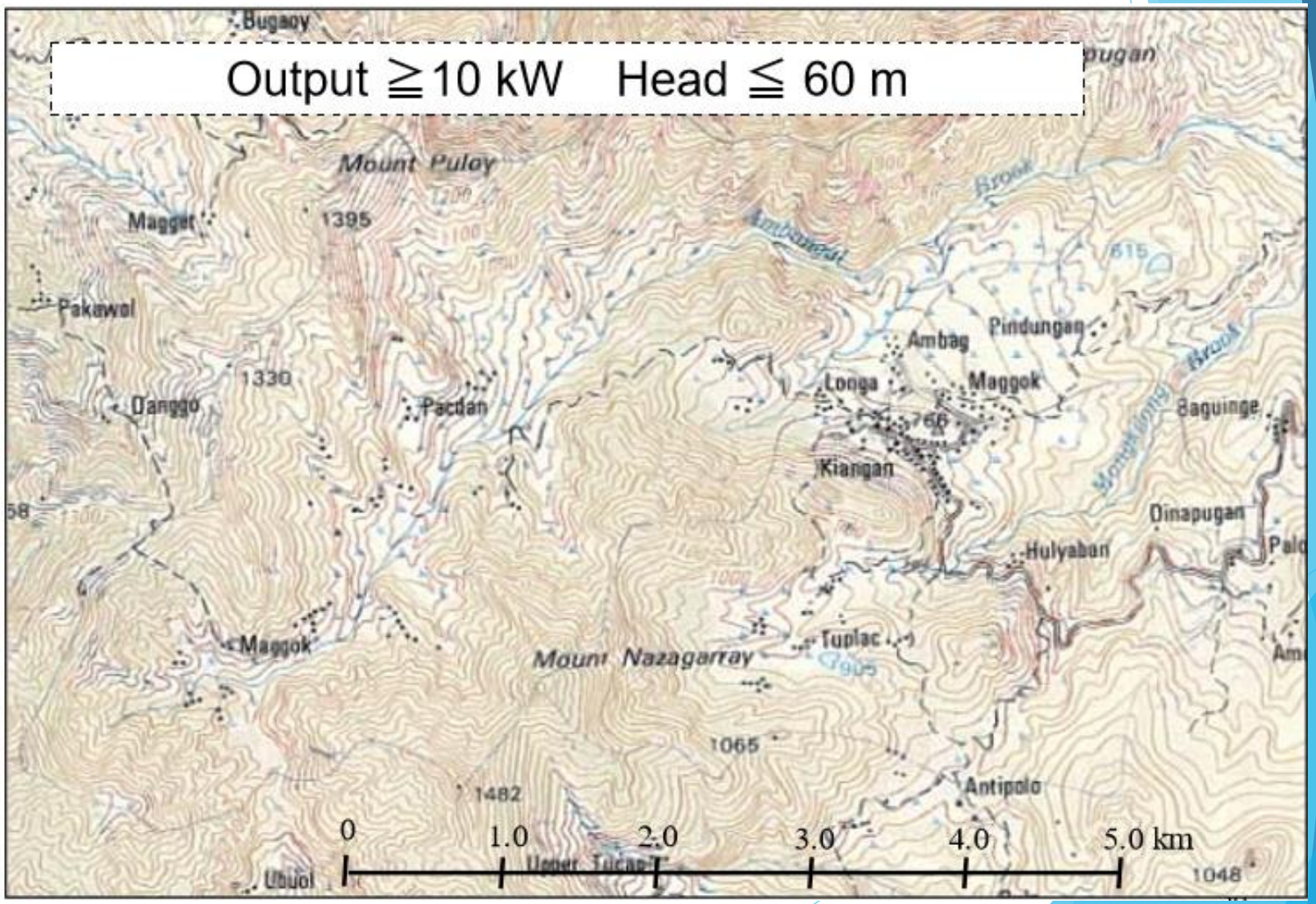


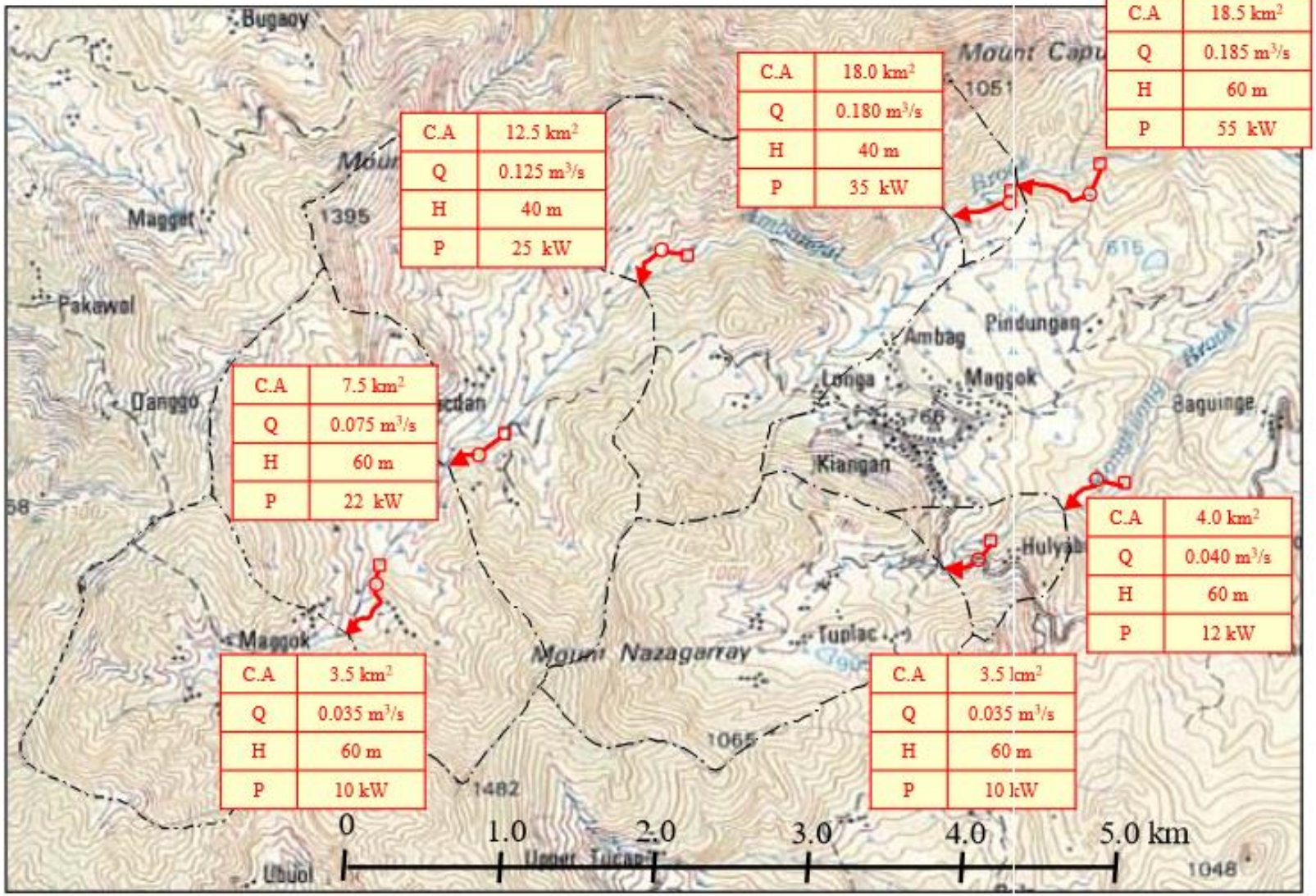
Calculate catchment area

Measurement River Flow at the Site for micro hydro turbine

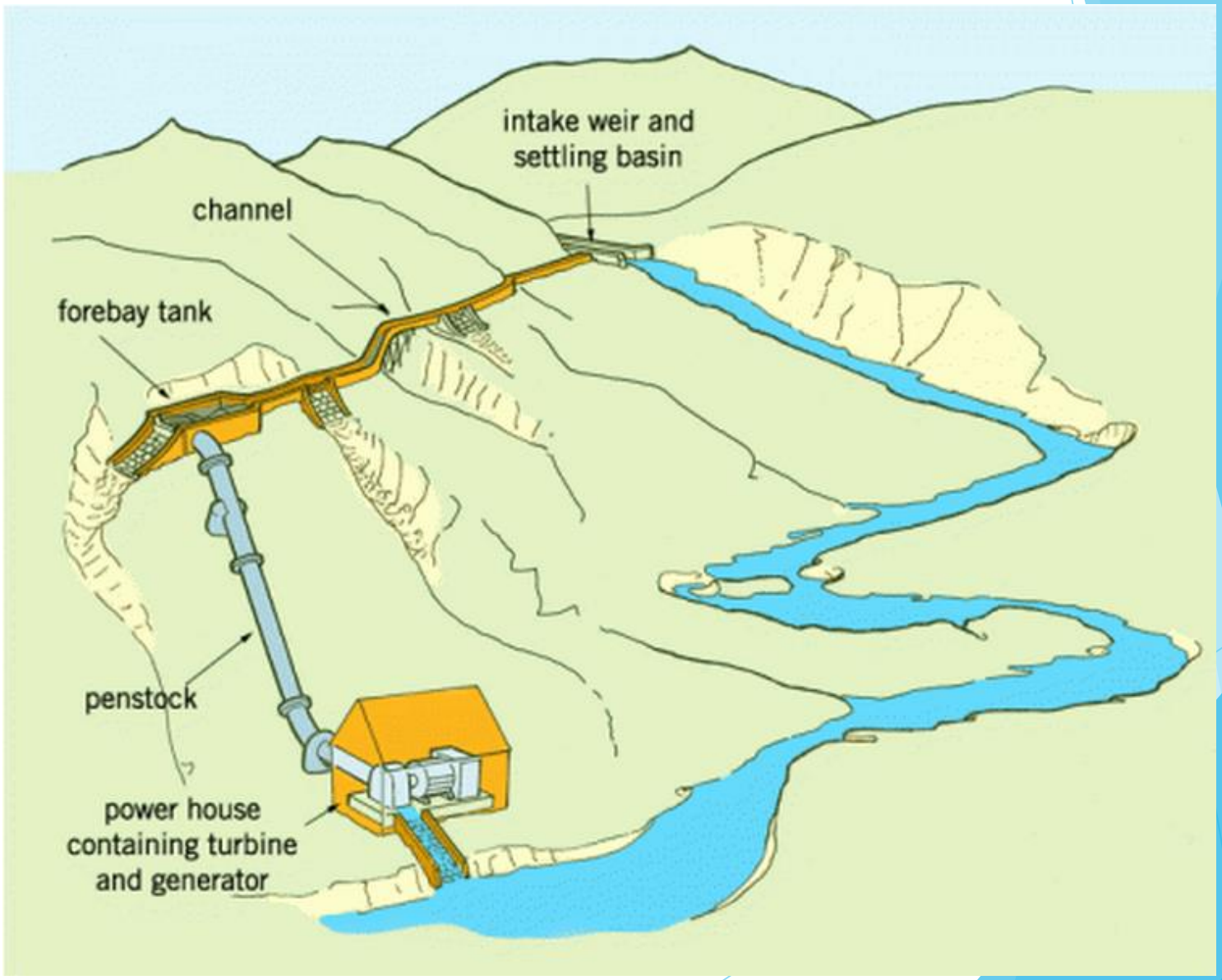


Examples


Output ≧10 kW Head ≦ 60 m
Bugaoy
Mount Pulay
1395
Magget
Pakawol
1330
Danggo
Pacdan
Ambag
Pindungan
Longa
Maggok
766
Kiangan
Baguinge
Dinapugan
Hulyaban
Maggok
Mount Nazagarray
Tuplac
1065
1482
Antipolo
Ubuol
Upper Tucap
1048
0
1.0
2.0
3.0
4.0
5.0 km


Bugaoy
Mount Capu
1051
Magget
1395
Pakawol
Danggo
Ambag
Pindungan
Longa
Maggok
Baguinge
Kiangan
Hulyab
Maggok
Mount Nazagarray
Tuplac
1065
1482
Ubuol
Upper Tucap
1048
C.A 12.5 km²
Q 0.125 m³/s
H 40 m
P 25 kW
C.A 18.0 km²
Q 0.180 m³/s
H 40 m
P 35 kW
C.A 18.5 km²
Q 0.185 m³/s
H 60 m
P 55 kW
C.A 7.5 km²
Q 0.075 m³/s
H 60 m
P 22 kW
C.A 4.0 km²
Q 0.040 m³/s
H 60 m
P 12 kW
C.A 3.5 km²
Q 0.035 m³/s
H 60 m
P 10 kW
C.A 3.5 km²
Q 0.035 m³/s
H 60 m
P 10 kW
0
1.0
2.0
3.0
4.0
5.0 km

Functions of Main Structures



Intake Weir and Intake

- The Intake weir – a barrier built across the river used to divert water through an opening in the riverside (the 'Intake' opening) into a settling basin
- If no Intake Weir-Insufficient Inflow

Settling Basin

- Settling Basin - The settling basin is used to trap sand or suspend the silt from the water before entering the penstock
- Function of Settling Basin - to trap sand or suspend the silt from the water

Head-tank (ForebayTank)

- Head-tank - Pond at the top of a penstock or pipeline; serves as final settling basin, maintains the required water level of penstock inlet and prevents foreign debris entering the penstock

Penstock

- Penstock - A close conduit or pressure pipe for supplying water under pressure to a turbine

Water Turbine and Generator

- A water turbine is a machine to directly convert the kinetic energy of the flowing water into a useful rotational energy while a generator is a device used to convert mechanical energy into electrical energy

Appropriate location for Power house

- Gentle River Bank
- The Water Flood Will Have No Great Impact at the River Bank
- Has a Wide Cross Section of the River(Low Flood Water Level)
- Ridge is Better (Geologically Strong and Stable)

Items to be investigated

- Potential capacity of the project site
  - Measurement of river flow
  - Measurement of head
- Topographical and geological condition of the sites for the structure layout
- Accessibility to the site ▫Power demand in the load center
- Distance from the load center to the power house
- Ability of the local people to pay for electricity
- Willingness of the local people for electrification

Measurement River Flow Method:

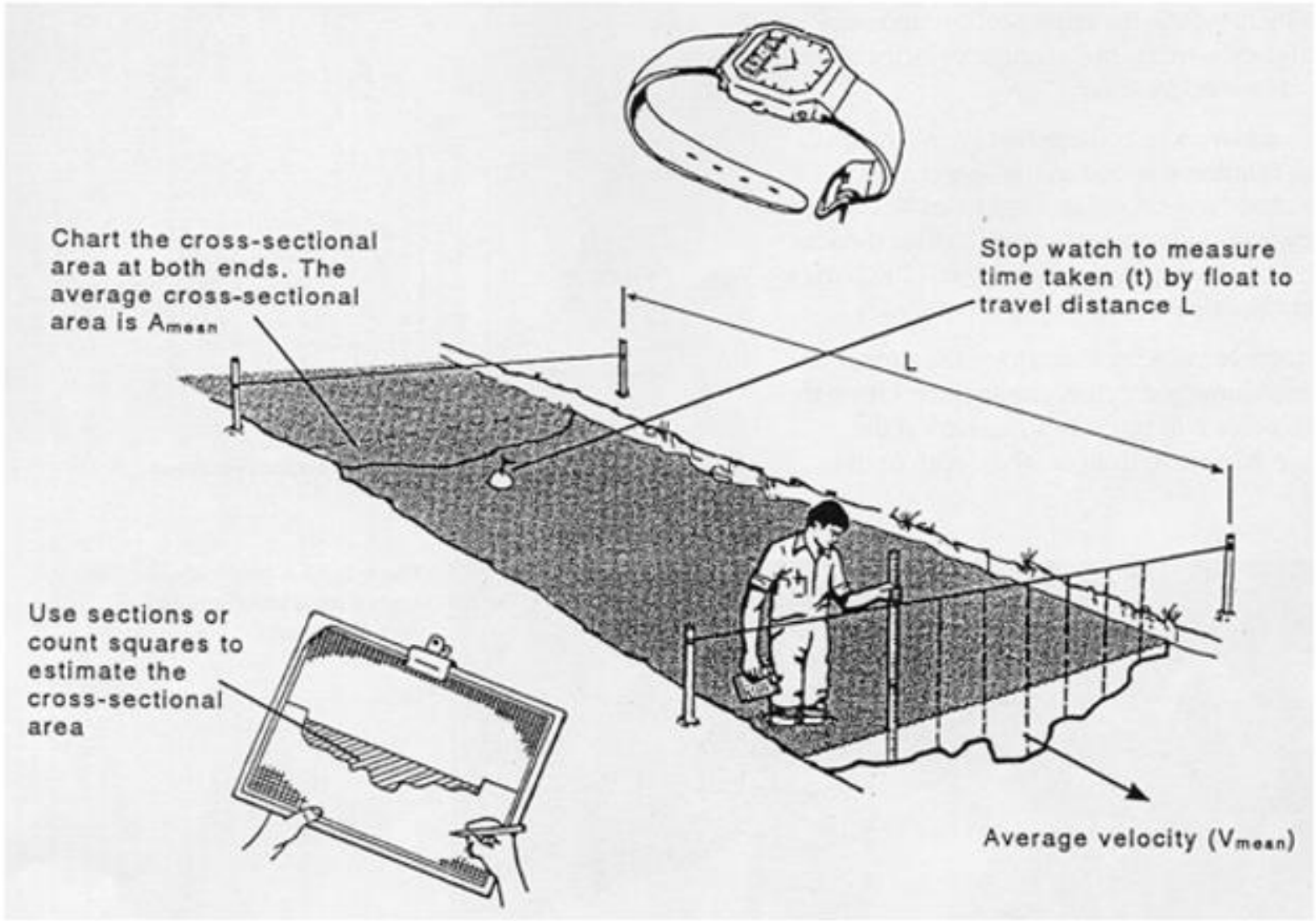
- Current meter method
- Float method
- Bucket method
- Weir measuring method

Electromagnetic Current Meter

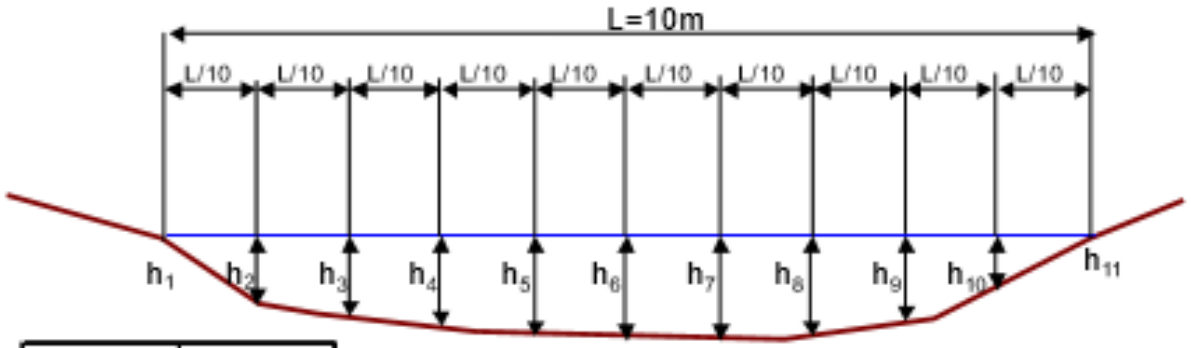
Propeller Current Meter

Actual Measurement

Float Measuring Method



Measurement of Cross Sectional Area



h_1	0.00
h_2	0.45
h_3	0.50
h_4	0.57
h_5	0.60
h_6	0.62
h_7	0.65
h_8	0.60
h_9	0.50
h_{10}	0.35
h_{11}	0.00
Total	4.84
Average	4.84/11=

0.44 m

$A = h_{avarage} \times L = 0.44 \times 10.00$

$= 4.40\ m^2$

Measuring of Cross Sectional Area

Head measurement

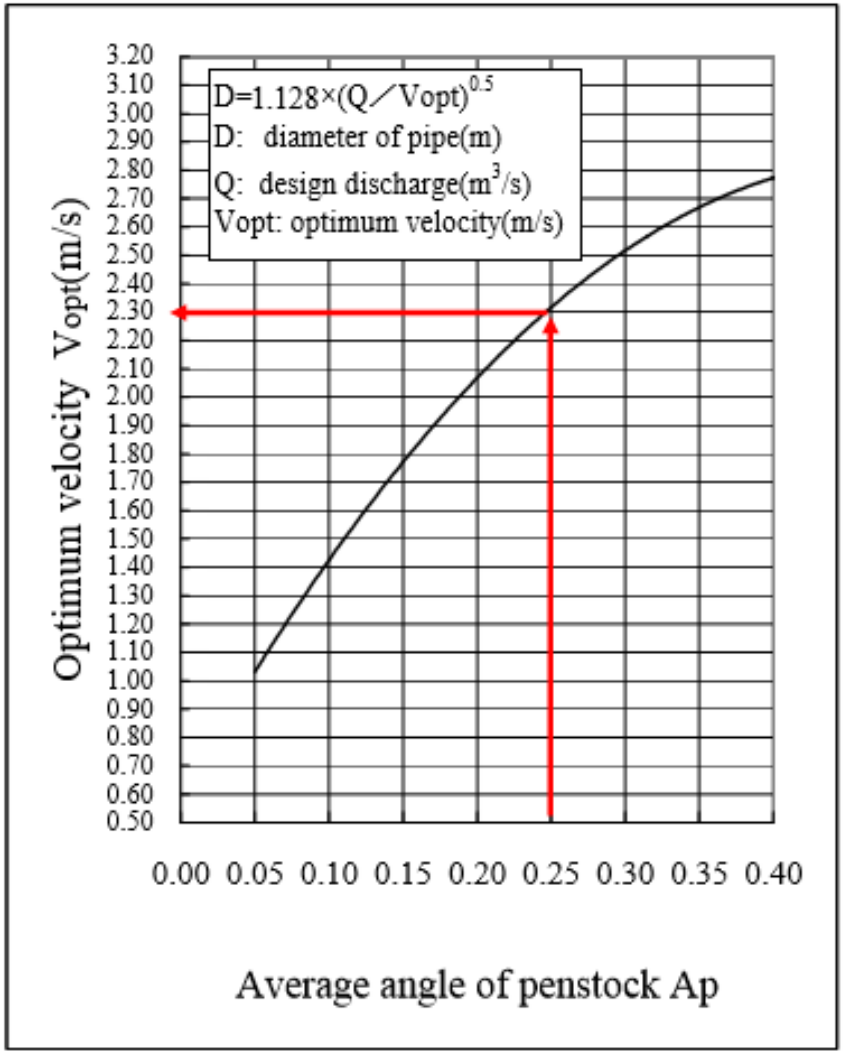
- Water-filled tube method
  - Easy to handle
  - No need for a skilled engineer
  - Relatively accurate

Intake and Settling Basin

- The dimension of the intake should be designed that the velocity of inflow at the intake is 1.0 or less m/s
- The ceiling of the intake should be designed with allowance of 10-15cm from the water surface
- The height and area of the intake should be designed with the minimum size.

Penstock

Penstock



Example

Q : Discharge 0.220 m^3/s

Lp: Total length of penstock

80.0m

Hp: Head from Head-tank to C/T

20.0m

Ap=Hp/Lp=0.25

Vopt= 2.3 m/s

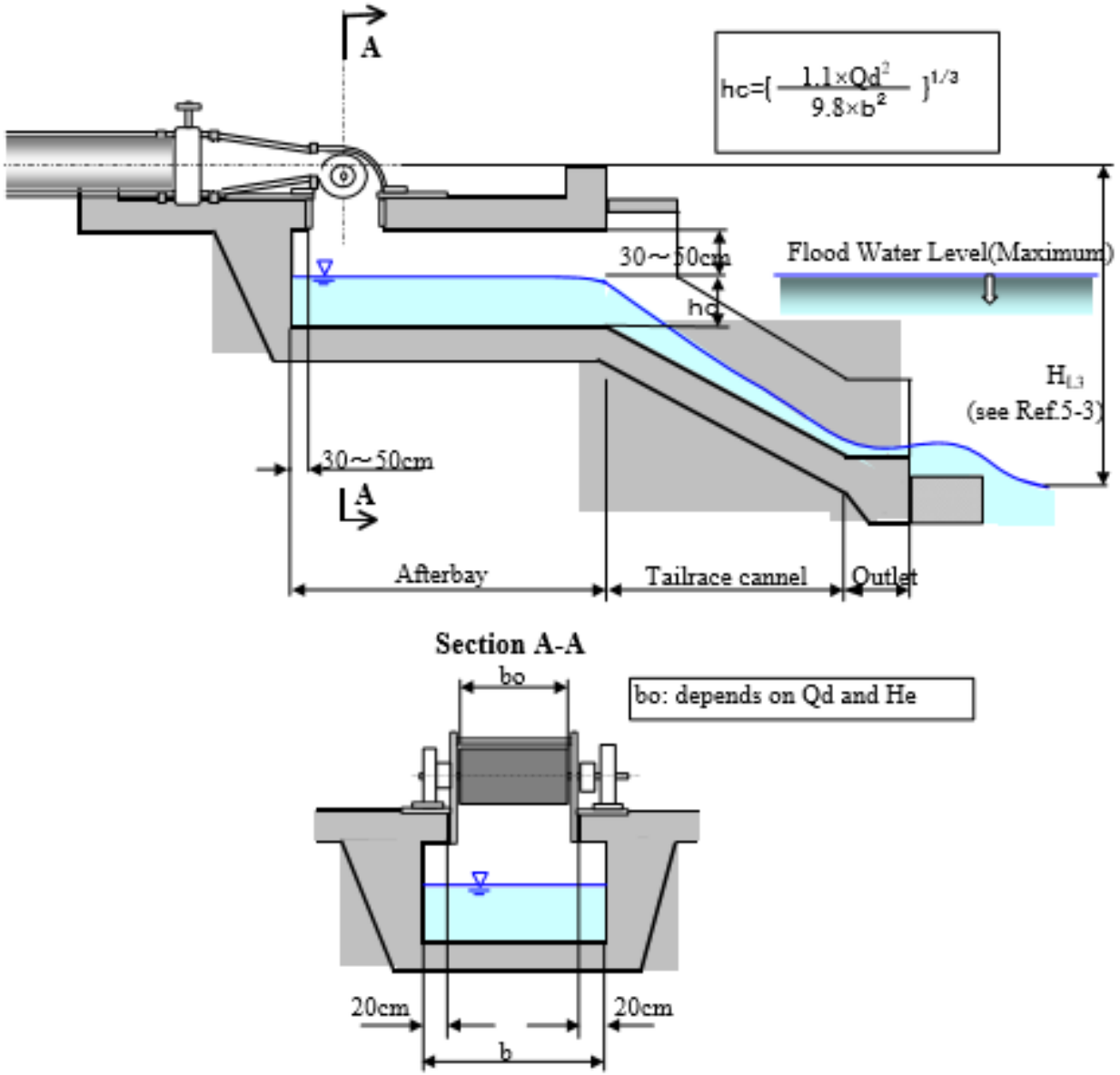
$D=1.128 \times (Q/Vopt)^{0.5}$

$=1.128 \times (0.22/ 2.3)^{0.5}$

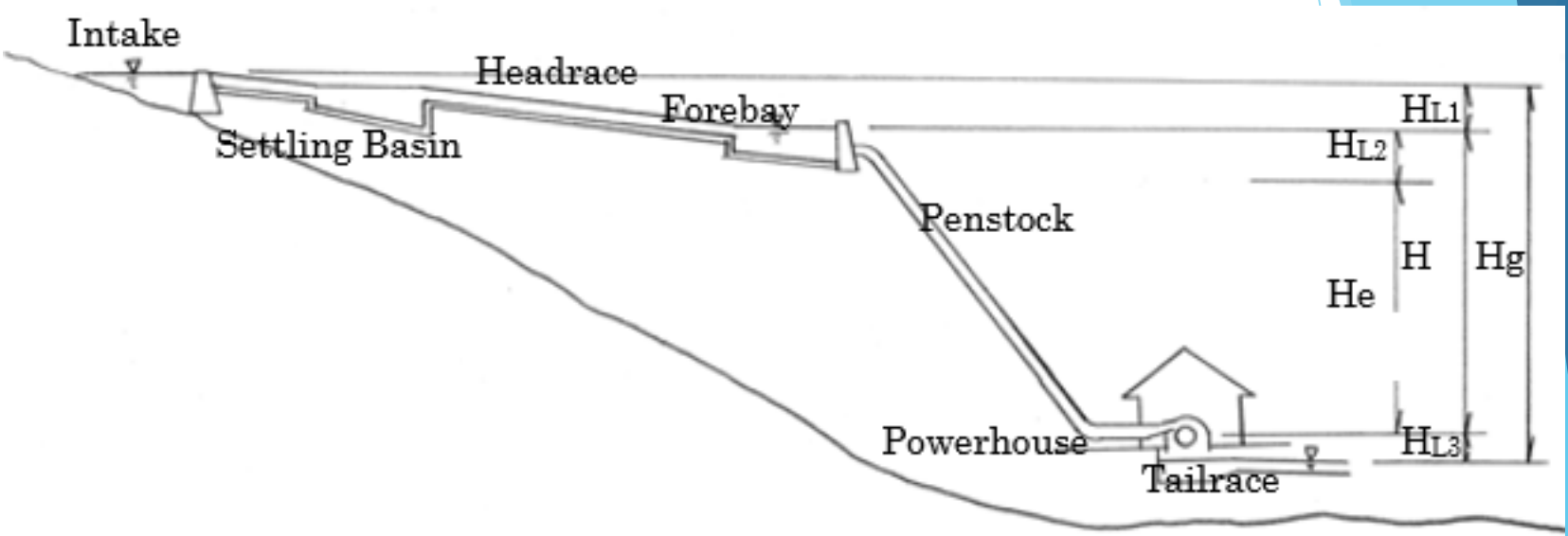
$=0.348 \rightarrow 0.350$ m

Powerhouse

Powerhouse (for impulse turbine)



Calculation of Head Loss



$$He = Hg - (H_{L1} + H_{L2} + H_{L3})$$

Where:

He	- Effective Head
Hg	- Gross Head
H_{L1}	- Loss from intake to head-tank (fore-bay)
H_{L2}	- Loss at penstock
H_{L3}	- Installation head and Loss at tailrace

Types of turbine

- Impulse turbine:

  The runner rotates by impulsive force of water jet with the velocity head, which has been converted from the pressure head at the time of jetting from the nozzle

  - Pelton turbine
  - Crossflow turbine
  - Turgo-impulse

- Reaction turbine

  The runner rotates by reactive force of water with the pressure head

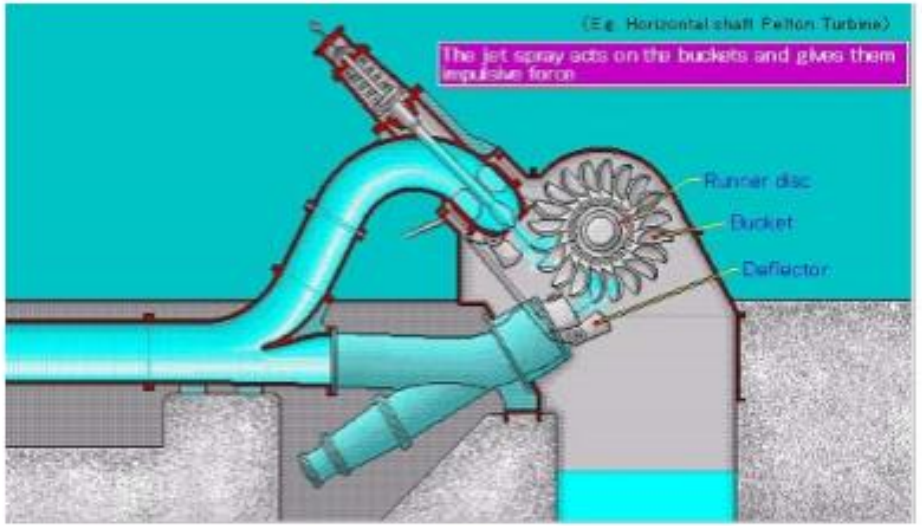
  - Propeller turbine (Kaplan, Bulb, Tubular, etc.)
  - Francis turbine

Pelton turbine

- Water jet from the nozzles acts on the buckets, and the runner is rotated by the impulsive force
- Horizontal-shaft Pelton turbine can be applied to micro/small hydropower project
- Suitable for run-of-river project, especially with high-head and less head change

Applicable range

- Output: 100 – 5,000 kW
- Discharge: 0.2 – 3 m^3/s
- Head: 75 – 400 m



Crossflow turbine

- Arc shape runner blades are welded on the both side of iron plate discs
- Simple structure, easy O&M, and reasonable price
- Suitable for rural electrification project using micro hydropower plant

Applicable range

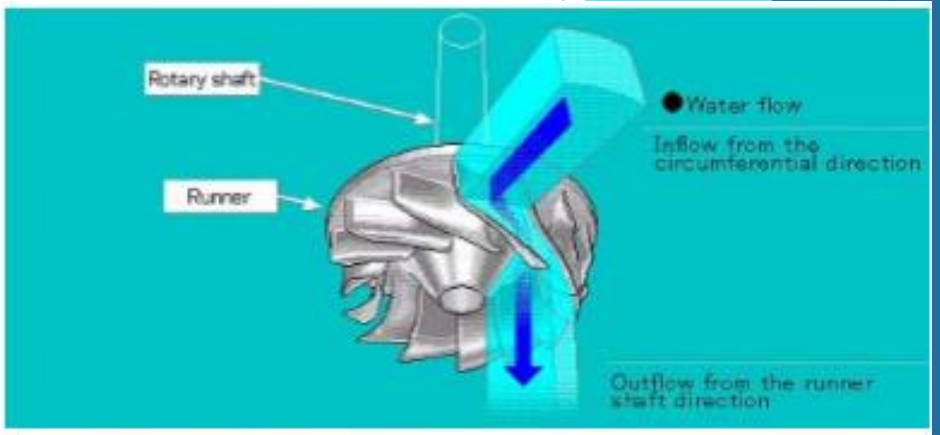
- Output: 50 – 1,000 kW
- Discharge: 0.1 – 10 m^3/s
- Head: 5 – 100 m

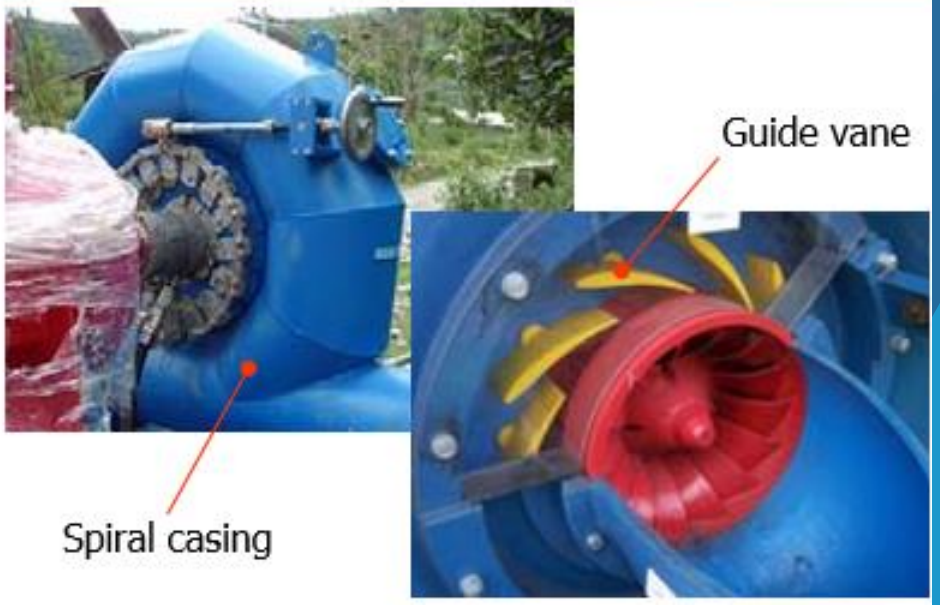
Francis turbine

- Water flow brought from the penstock flows into the runner through casing and guide vane
- Wide applicable range of head and discharge
- Horizontal-shaft Francis turbine can be applied to micro/small hydropower project

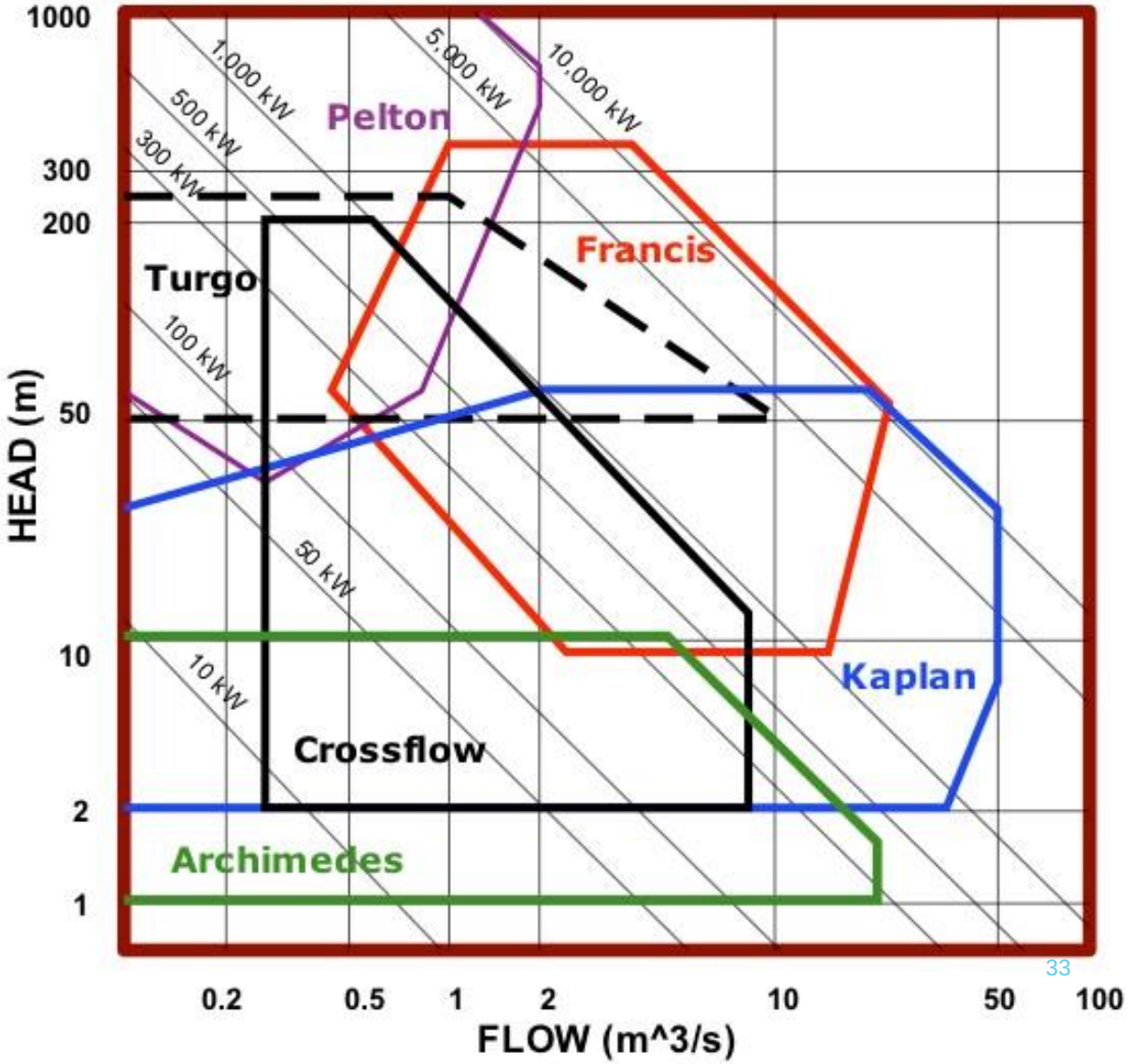
Applicable range

- Output: 200 – 5,000 kW
- Discharge: 0.4 – 20 m^3/s
- Head: 15 – 300 m



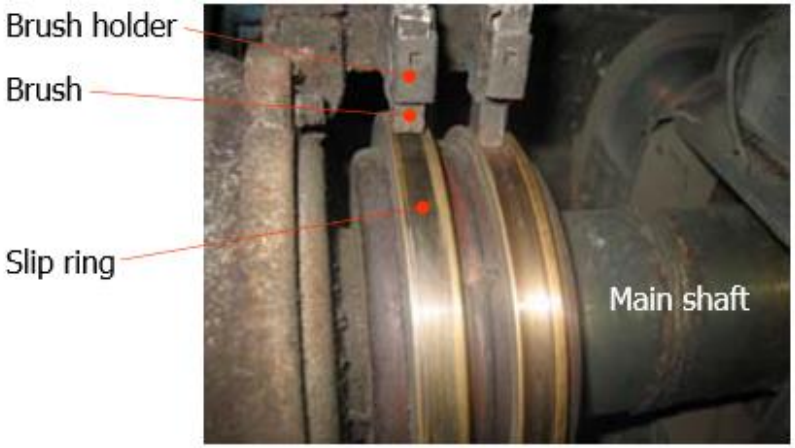


Turbine selection chart



Generator Structure

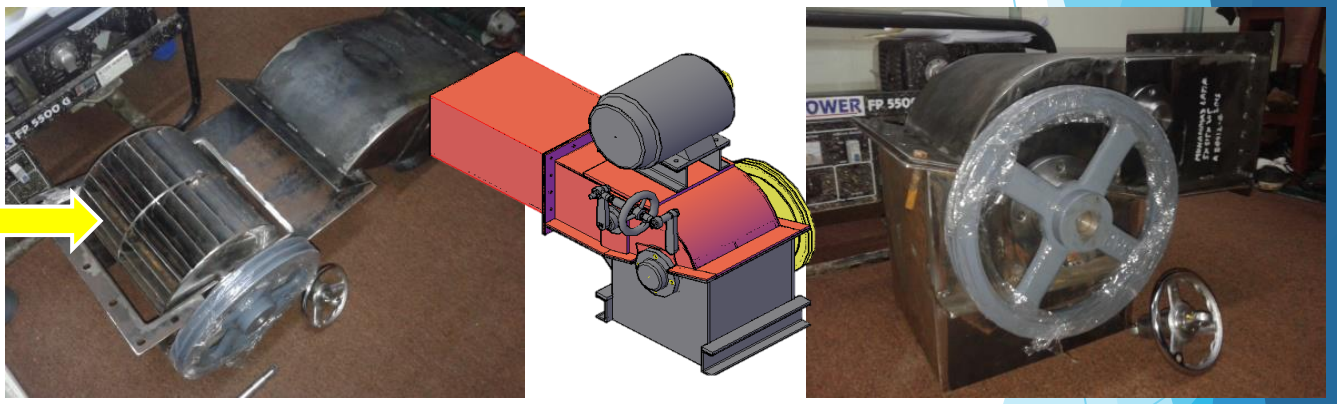
Appearance of ST series generator



Basic Design of Electro Basic Design of Electro-mechanical Equipment

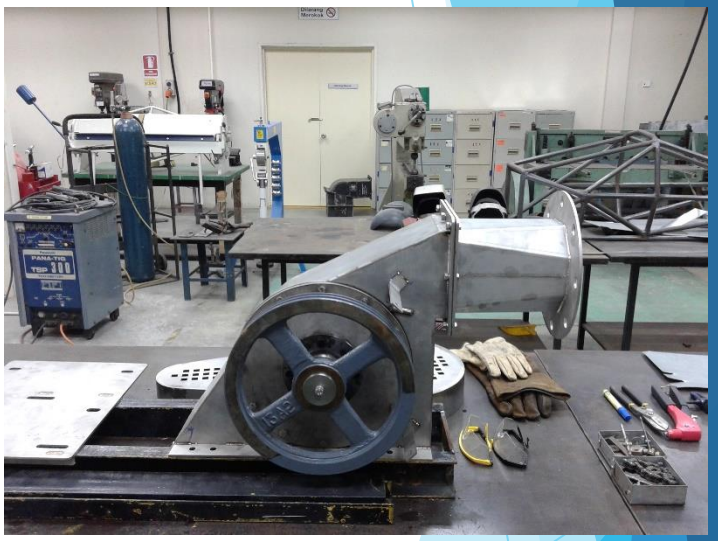
1st Prototype of Micro Hydro Turbine

Sustainable micro hydro turbine



2nd Prototype of Micro Hydro Turbine

Sustainable micro hydro turbine



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PUSAT TRANSFORMASI LUAR BANDAR

Royal Belum Expedition

First visit: **8-17 Sept 2015**
Location: Kg. Ulu Kejar dan Kem Sg Kejar

Second visit: **10-12 May 2016**
Location: Kg. Ulu Kejar dan Kg. Sg. Tiang (Royal Belum)

Third visit: **03-07 Okt 2016**
Location: Kg. Ulu Kejar dan Kg. Sg. Tiang (Royal Belum)

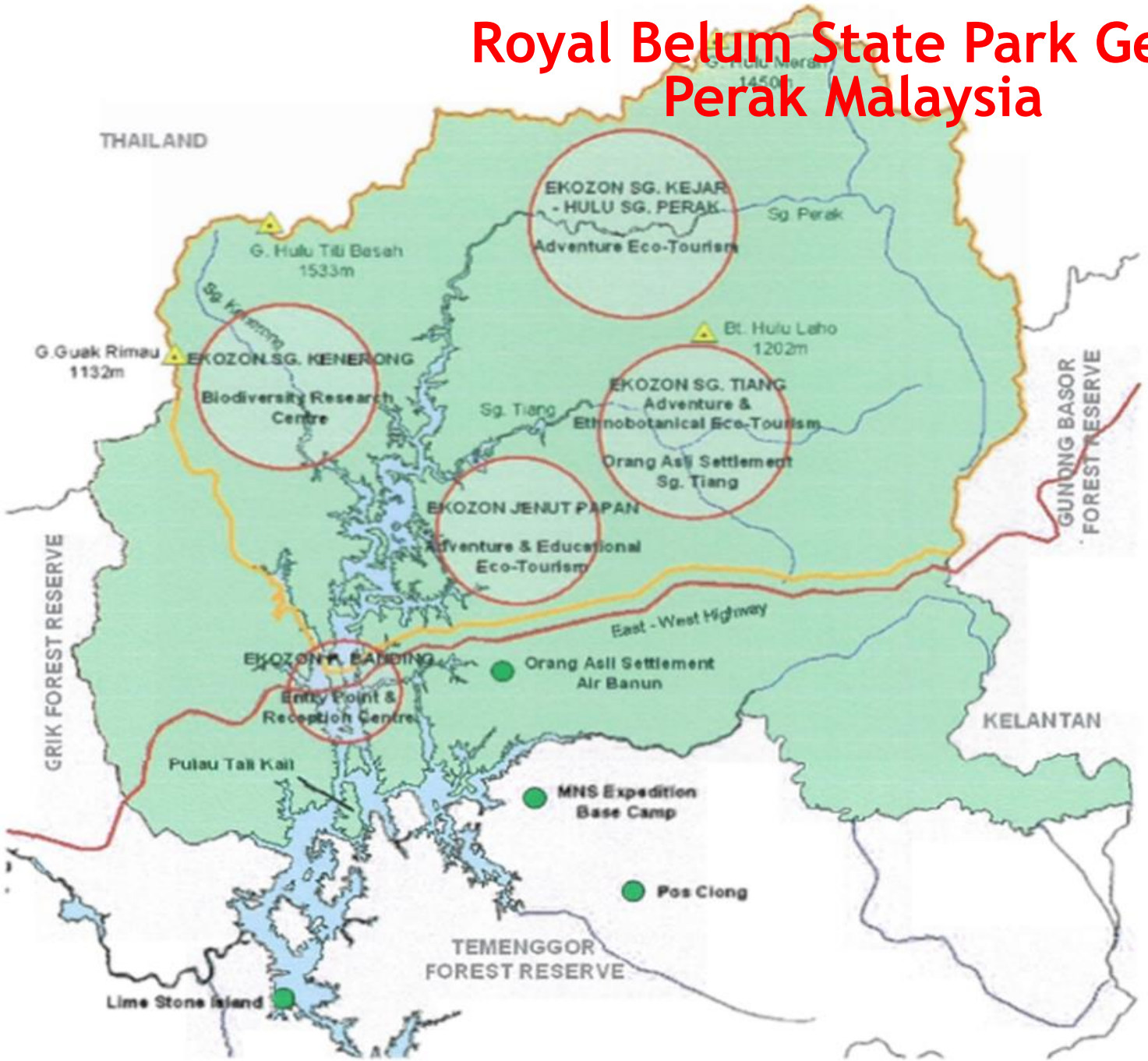
Forth visit: **17-19 Jan 2017**
Location: Kg. Ulu Kejar dan Kg. Sg. Tiang (Royal Belum) – Turbine installation

Fifth visit: **03-08 April 2017**
Location: Kg. Ulu Kejar dan Kg. Sg. Tiang (Royal Belum) – piping installation

Six visit: **17-18 May 2017**
Location: Kg. Ulu Kejar dan Kg. Sg. Tiang (Royal Belum) – maintenance visit

Seven visit: **14-16 Aug 2017**
Location: Kg. Ulu Kejar dan Kg. Sg. Tiang (Royal Belum) – training to the comunity

Royal Belum State Park Gerik Perak Malaysia



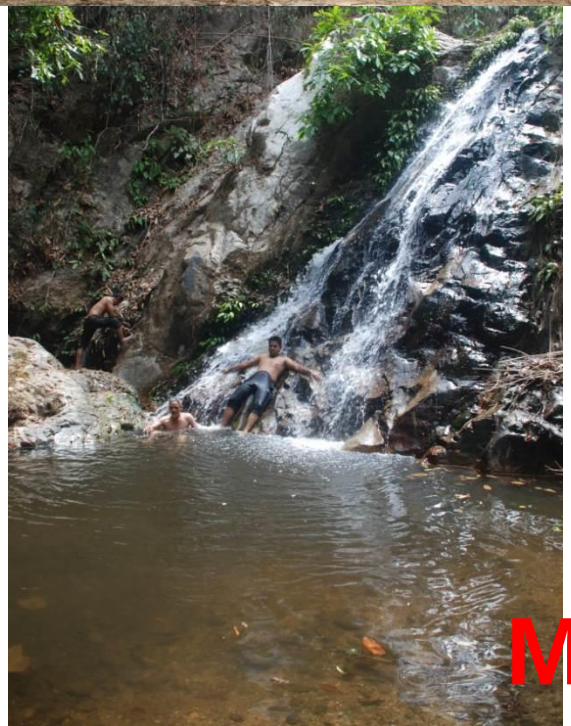
Royal Belum State Park Gerik Perak Malaysia

1st Expedition- Data collection

Flow measurement

Interview with Orang Asli

2nd Expedition – Micro hydro site visit



MES WATERFALL

3rd Expedition- Powerhouse development

- Team from UTM Razak School went to Royal Belum on 03 Oktober – 07 Oktober 2016

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PUSAT TRANSFORMASI LUAR BANDAR

RESULTS OF THE PROJECT

Before

Current

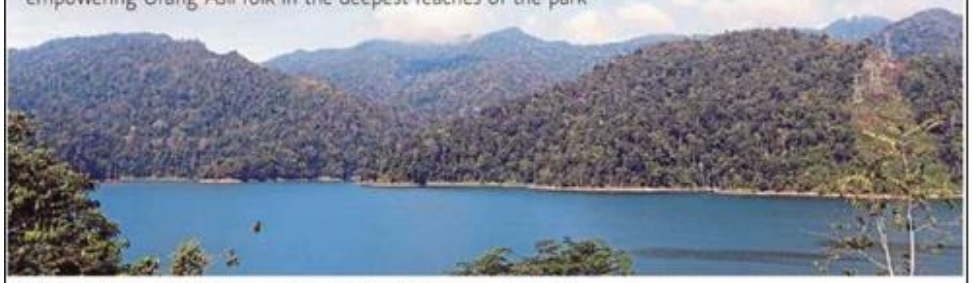
After

NST Paper cutting 12 Jun 2016

NEWS

Royal Belum Park community gets power

DEVELOPMENT: Laili Ismail finds out how one UTM team is empowering Orang Asli folk in the deepest reaches of the park



THE Orang Asli community of Kampung Sungai Kejar in the Royal Belum State Park never needed constant electric to go about their daily l they saw how the outsid world developed an prospered with a constar power source, they to felt the need to bette their lives.

Compared with othe Orang Asli communitie in the forest reserve, th particular settlement's lo cation, furthest in the park's interior, makes it a challenge to get to. The village is only accessible via a 2½-hour boat ride (one hour on speedboat) from the Pulau Banding jetty, a 40-minute drive from Grik.

Universiti Teknologi Malaysia's (UTM) Razak School of Engineering and Advanced Technology lecturer Shamsul Sarip said the community, led by Tok Batin Rudi, had made ends meet by hunting, fishing and harvesting whatever they could from the forest.

"Back in the day, these communities dared not cut a tree in the jungle so as to protect the greenery but since coming into contact with outsiders, they were provided portable diesel generators, which [illegible]sustainable and not an environmentally-conscious option.

Shamsul Sarip

"They were given a 5kW portable fuel generator but it was damaged and the health of the river ecosystem will directly affect the community's traditional lifestyle. In line with this concern, my team and I decided to provide free electricity through a micro-hydropower plant for this community," he told the *New Sunday Times*.

Shamsul was involved in the fourth Royal Belum scientific expedition with a group of researchers and scientists last year and their findings had led them to the decision that this form of electrical generation was the most suitable for the community due to its topography.

"The village is close to a waterfall at a river called Sungai Mes, meaning there is high water pressure. We also conducted a survey by distributing questionnaires to the 11 households in the village and found that hydropower was the preferred renewable energy source.

"Following this study, we drew up a plan to install a micro-hydro plant that takes advantage of the streams and small rivers at Royal Belum," he said, adding that the one-year project commenced in April after receiving sufficient funding.

While drawing up the construction plan, Shamsul had one aim in mind, which was to create a fuss-free and environmentally-friendly system.

"Micro-hydro power is a simple and cheap run-of-river project that has minimal environmental impact. It does not need large construction works and the piping system will not affect the trees," he said.

The villagers, Shamsul said, would also be involved in the construction of the system to ensure that they understood how it worked and how to maintain it.

He said a cross-flow turbine would be used to convert kinetic energy into electric power, which would then produce up to 10kW of electricity, enough to provide power to the 11 houses and the village's library.

"We decided to help provide them free power on one condition, which was that they also get their hands dirty in the process and be involved in the upkeep. Hence, they will be trained to carry out these tasks.

"The project was funded by the Higher Education Ministry and UTM's Centre for Community and Industrial Network (CCIN).

"With the funding, I designed the turbine, which was built by UTM students, and the villagers were tasked with building the powerhouse by bringing cement to the hill as well as completing the piping system."

On the social impact the facility would have on the community, Shamsul said it would make their lives more organised.

"Every house will be provided with one socket and one plug, which are enough for a television, a radio and up to three fluorescent lamps. Before this, they had only gas lamps to light their houses at night.

"Eventually, electrical appliances, such as kettles, rice cookers and even satellite television may come into play. Considering that the community is only accessible by boat, the village folk are eager to make their lives easier with consistent electricity."

Despite the empowerment model (involving the Orang Asli in the construction and maintenance) that the project adopted, it would still face some challenges.

"Training them will be quite a feat as they lack basic knowledge. Not only that, some of the older folk are illiterate, so it will be difficult for them to understand how the system works, much less maintain it.

"A critical part of the system is the trash rack, which can accumulate rubbish and get clogged, meaning it needs weekly maintenance. Meanwhile, the alternator will wear out and needs to be changed every five years," Shamsul said.

"It is important not to let the community be left behind in terms of development.

Keeping track of the reserve's flora and fauna

THE Belum Forest Reserve, believed to be older than the Amazon rainforest in South America, is a vast reservoir of natural resources. Thus, there is a great need to protect it.

In line with this, 217 participants, including 125 scientists of various specialisations, got their feet dirty in September last year for a 10-day recce programme to see what the virgin jungle has to offer.

Organised by the Pulau Banding Foundation and Perak State Parks Corporation, the fourth scientific expedition in the Royal Belum Forest Complex was followed by the fourth Royal Belum Scientific Symposium held on May 23.

The three-day event saw hundreds of researchers presenting their findings during the expedition and 33 papers were presented at the Royal Belum Rainforest Resort.

Natural Resources and Environment Minister Datuk Seri Dr Wan Junaidi Tuanku Jaafar said these efforts were in line with the government's aspirations to conserve biodiversity and manage the country's natural resources in a sustainable manner.

"Scientific expeditions such as this will help the ministry in identifying and establishing data and preparing a more effective action plan.

"This is also in line with the Aichi Biodiversity Targets 2011-2020, which aims to boost awareness on biodiversity-related science and technology to minimise the extinction of endangered or protected species," he said in a speech read by the ministry's Biodiversity and Forestry Management Division Undersecretary Dr Megat Sany Megat Ahmad Suplan.

In the march to become a developed country, Wan Junaidi said, it was necessary to balance conservation and development.

"It is hoped that future developments take into account the aspect of environment preservation," he said.

Pulau Banding Foundation chief executive officer Datuk Abdul Rashid Ab-Malik said the participants camped in the 117,500ha forest for 10 days at two operation centres near Sungai Kejar and Sungai Tiang.

"The participants carried out an inventory of flora and fauna as well as research projects on hydrology, soil and eco-tourism.

"I was told that there were two new species of thrips (insects) and 14 new ferns and lycophytes recorded during this expedition."

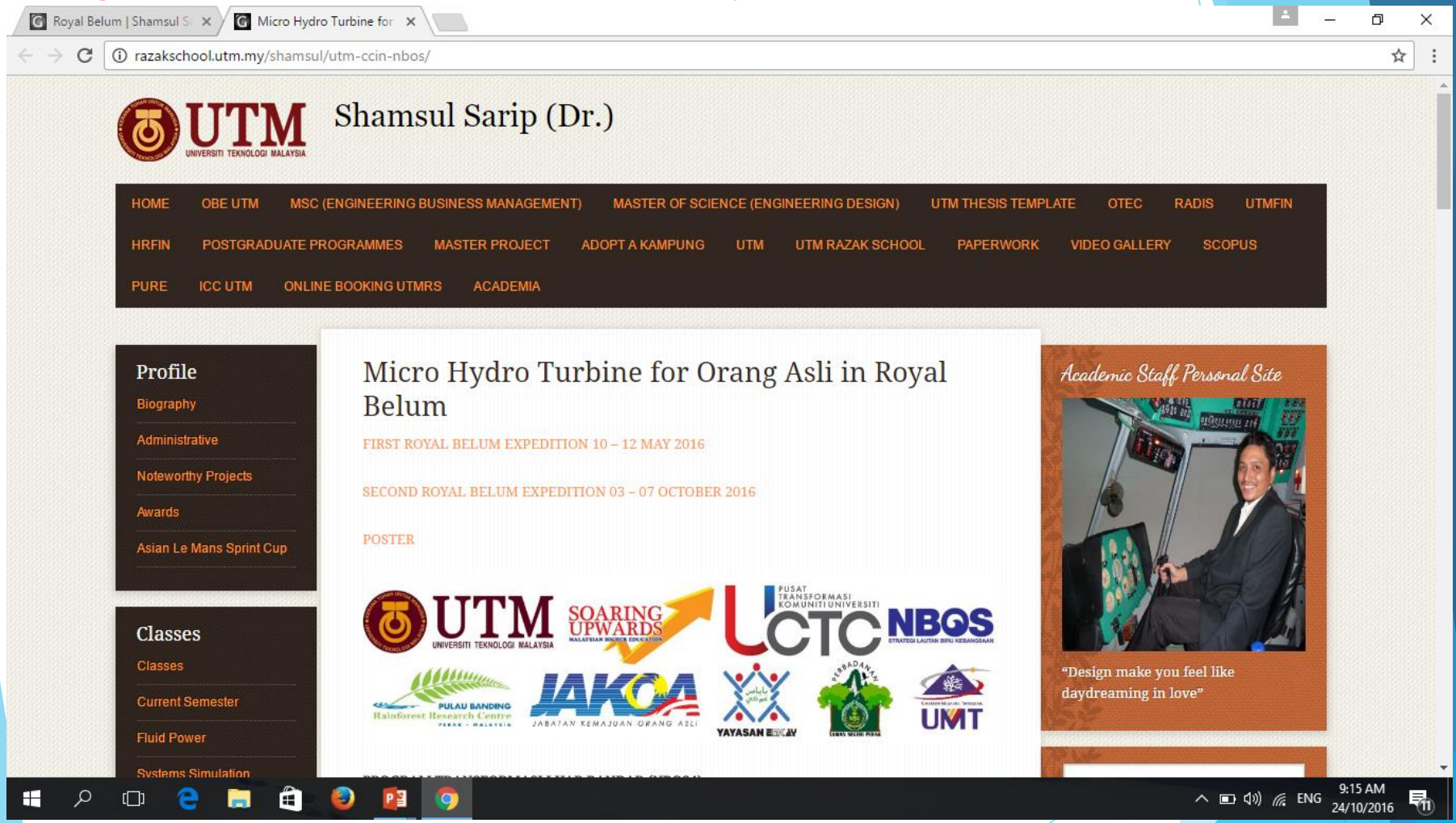
Pix 1-7: Lush greenery covering Belum Forest Reserve. ***Numerous waterfalls and rivers*** *in the forest make the area suitable for the implementation of* ***hydropower projects, much to the benefit of Orang Asli communities.***

"That is why we chose micro-hydro instead of solar photovoltaic technology. This is supported by the fact that in the biggest Orang Asli settlement in Sungai Tiang, the solar power facility failed as the community lacked the skills to maintain it."

Empowering the community means creating awareness and educating the Orang Asli, Shamsul said, which will be key in keeping the system up and running.

TURBINE PROJECT WEBSITE

http://razakschool.utm.my/shamsul/utm-ccin-nbos/



Lifestyle@UTM KL

VIDEO POWERHOUSE DEVELOPMENT ROYAL BELUM

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PUSAT TRANSFORMASI LUAR BANDAR

12:40PM

astro AWANI BM ENG

Misi bina sistem janakuasa untuk manfaat penempatan Orang Asli

Diterbitkan pada: April 9, 2017 08:16 (MYT) | **Durasi:** 2 min, 54 saat

36 peserta dari Universiti Teknologi Malaysia (UTM) Razak School Of Engineering And Advance Technology akan memulakan misi membina turbin hidro mikro di Sungai Kejar, Royal

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THANK YOU

ARUS TEKNOLOGI GLOBAL
A RENEWABLE ENERGY FOR UNIVERSAL SUSTAINABILITY

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