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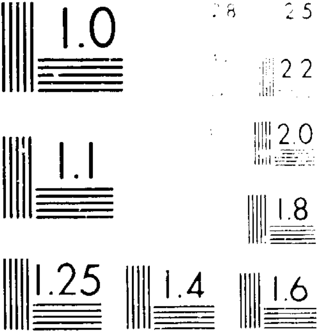
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MINI-HYDRO POWER DEVELOPMENT IN THE PHILIPPINES*

(A Case Study)

by

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and
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This paper is compiled as a case study of the mini-hydro power development project in the Philippines which has been studied during our field survey in 1978 and 1980, with the kind support of the Government of the Philippines through the National Electrification Administration (NEA), the Philippines.

Table of Contents

1. General Description

1-1 The Project (Ref. Fig 1-1)

On a national scale, the Philippine Government set to supply electricity to all barrios by 1984 and to attain total electrification of the country by 1990 in order to make available cheap and dependable power in the rural areas thereby promoting the growth of home industries and raised the low standard of living of the people.

The National Electrification Administration through its ECO-BLISS (Ecology-Bagong Lipunan Sites and Services) Task Force has been identifying potential mini-hydro power, dendro-thermal power and small water impounding project sites all over the country for development as area power sources. To this end the potential mini-hydro power sites in the Bicol Region were allocated to the Japanese-Philippine consultants for survey and evaluation, and to subsequently submit a project evaluation report to the National Electrification Administration which is anticipated to serve as a basis for the detailed engineering development and implementation of the viable mini-hydro power sites in the Bicol Region.

1-2 Summary of Mini-Hydro Power Development Project (Ref. Fig. 1-2)

1-2-1 The Mini-Hydro Power Development Survey in the Bicol Region was conducted two times and as under:

a) October 1978 to February 1979, in the province of Catanduanes
Potential sites: Seven (7) proposed sites were surveyed and among them, 3 viable sites were identified.

b) May 1980 to August 1980, in the Bicol Region
Potential sites: Among the 32 proposed sites in the Bicol Region, 16 sites were selected as highly potential sites.

1-2-2 1) Installed Capacity

The total installed capacity of the selected 19 project sites is estimated at 5,015 kw, from a minimum power capacity of 35 kw to a maximum capacity of 825 kw, average capacity of 264 kw, with a total annual produced energy of 33.2 Gwh. Discharge of power station is from a minimum of 0.2 m^3/s to a maximum of 12.3 m^3/s and the available head is from 168.5 m to 5.2 m.

2) Construction Cost

The construction cost of this project is estimated at 121.65 million and its break-down items are as under:

Items	Estimated Cost	Per Cent
Civil Works	59.56 Million Peso	50
Electro-Mechanical Equipment	20.44 Million Peso	17
Transmission and Distribution Line	21.10 Million Peso	17
Engineering Fee	14.89 Million Peso	12
Interest during Construction Period	5.66 Million Peso	4
Total	121.65 Million Peso	100%

Of the total estimated construction cost, foreign currency will be ₱ 77.41 million and domestic currency ₱ 44.24 million. The unit construction cost is averaged at ₱ 24,258 per kw.

3) Implementation Schedule

Implementation schedule of this Project is divided into 3 phases considering each project's characteristics and transportation of equipment and materials and so on. Each phase requires about 2 years for development and the estimated time table for completion of the whole development program is three (3) years.

1-3 Economic Evaluation

The annual salable energy of this project, taking into account estimated load factor, distribution loss and other relating conditions is about 24.73 Gwh. The annual cost of the project averaged over its service life in ₱ 9.73 million. The power cost is ₱ 0.39 per kwh which is considered competitive compared to prevailing rates of existing coops (₱ 0.39 per kwh ∿ ₱ 0.48 per kwh, except the special high rate of ₱ 1.32 per kwh, as of 1979) in the Bicol Region. For the purpose of comparative study in the economic justification of the project, a standard-type diesel power plant of 500 kw was adopted. The estimated annual benefit is ₱ 19.81 million and the surplus benefit, (B-C) is ₱ 10.07 million with a benefit-cost ratio of 2.04. The economic internal rate of return for this project is 14.3%. This indicates that the Project is economically feasible.

It is confirmed that the Mini-Hydro Power project in the Bicol Region are better alternatives than NPC's grid, even if busbar power costs may be substancially higher than ₱ 0.40 per kwh, due to its inherent foreign exchange savings and estimable economic benefits, not even considering the oil price hikes.

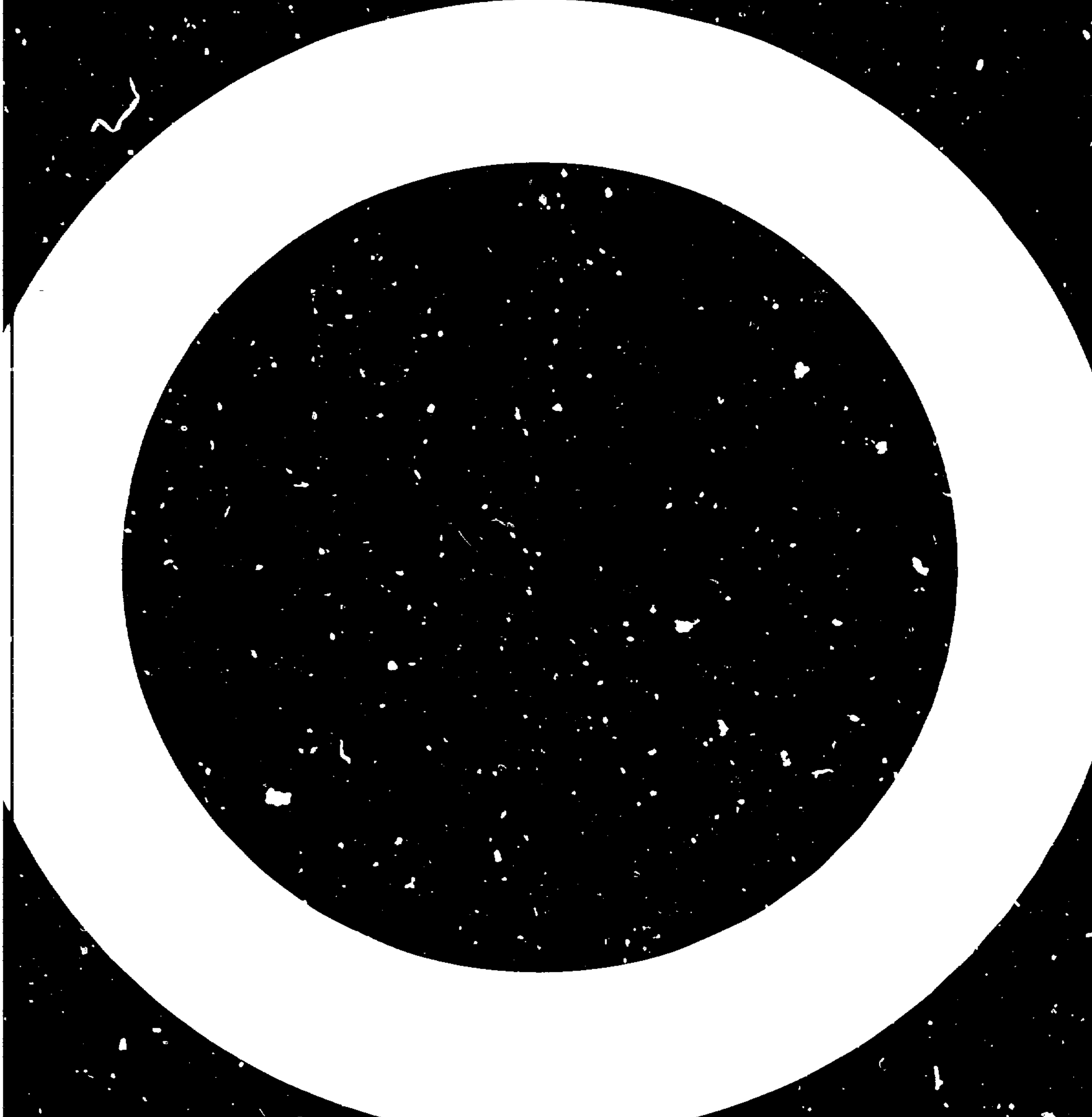
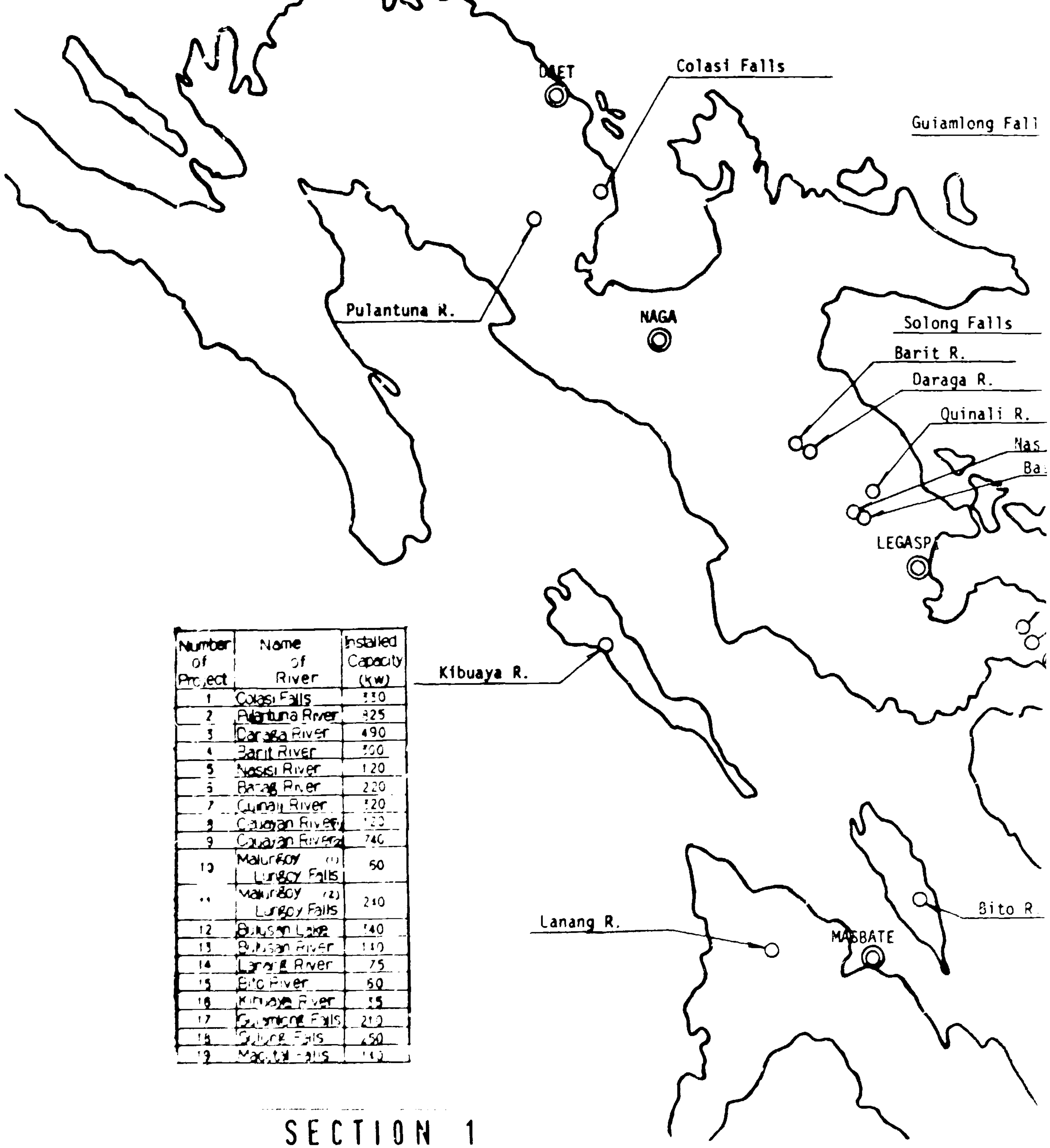


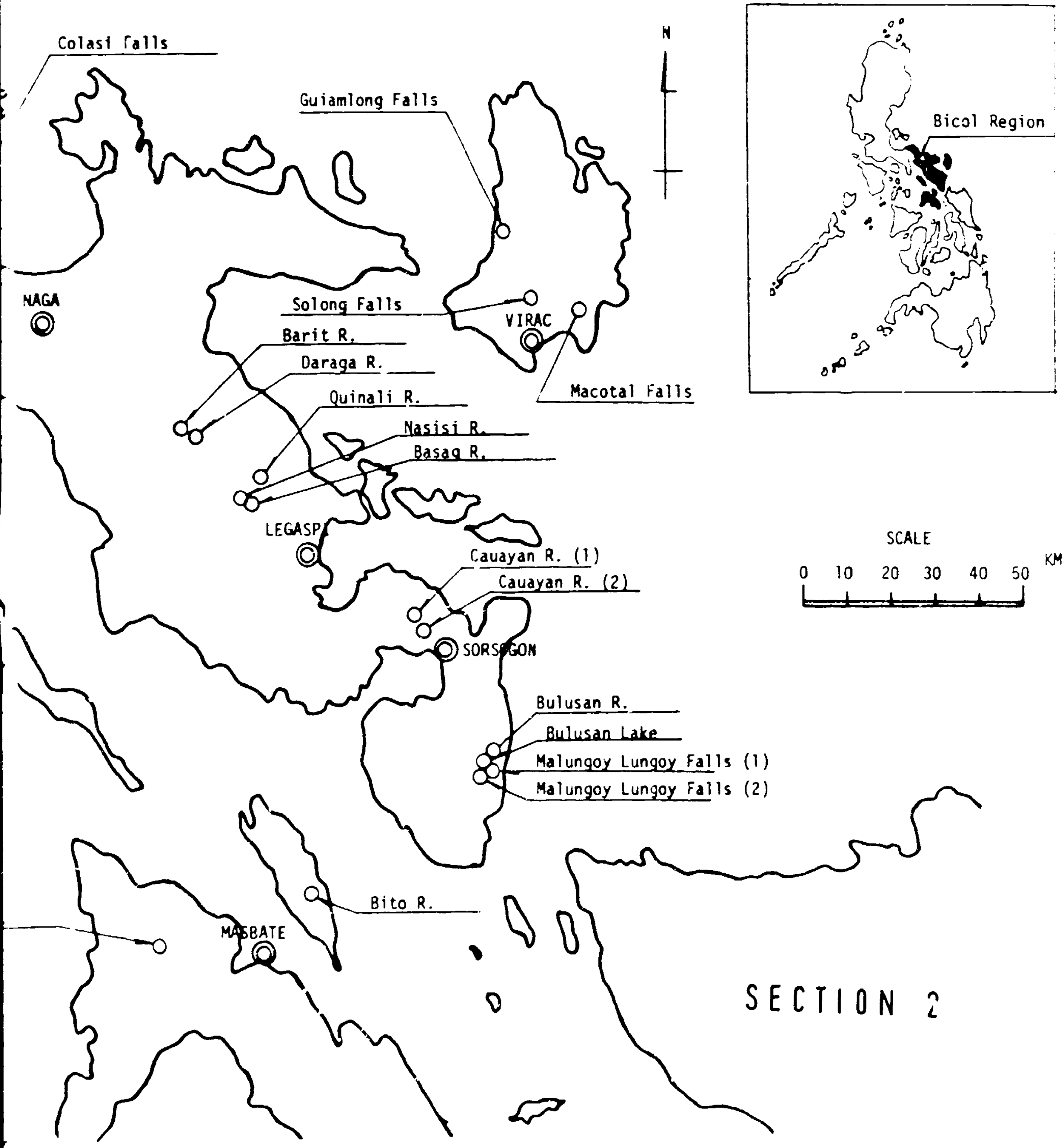
Fig. 1-1 LOCATION MAP OF THE PROJECT SITES



Number of Project	Name of River	Installed Capacity (kw)
1	Colasi Falls	330
2	Pulantuna River	825
3	Daraga River	490
4	Barit River	300
5	Nasisi River	120
6	Barag River	220
7	Quinali River	320
8	Cawayan River(1)	[illegible]
9	Cawayan River(2)	740
10	Malungboy (1) Lungboy Falls	50
11	Malungboy (2) Lungboy Falls	210
12	Bulusan Lake	340
13	Bulusan River	110
14	Lanang River	75
15	Bito River	50
16	Kibuaya River	55
17	Guiamlong Falls	210
18	Solong Falls	450
19	[illegible] Falls	[illegible]

SECTION 1

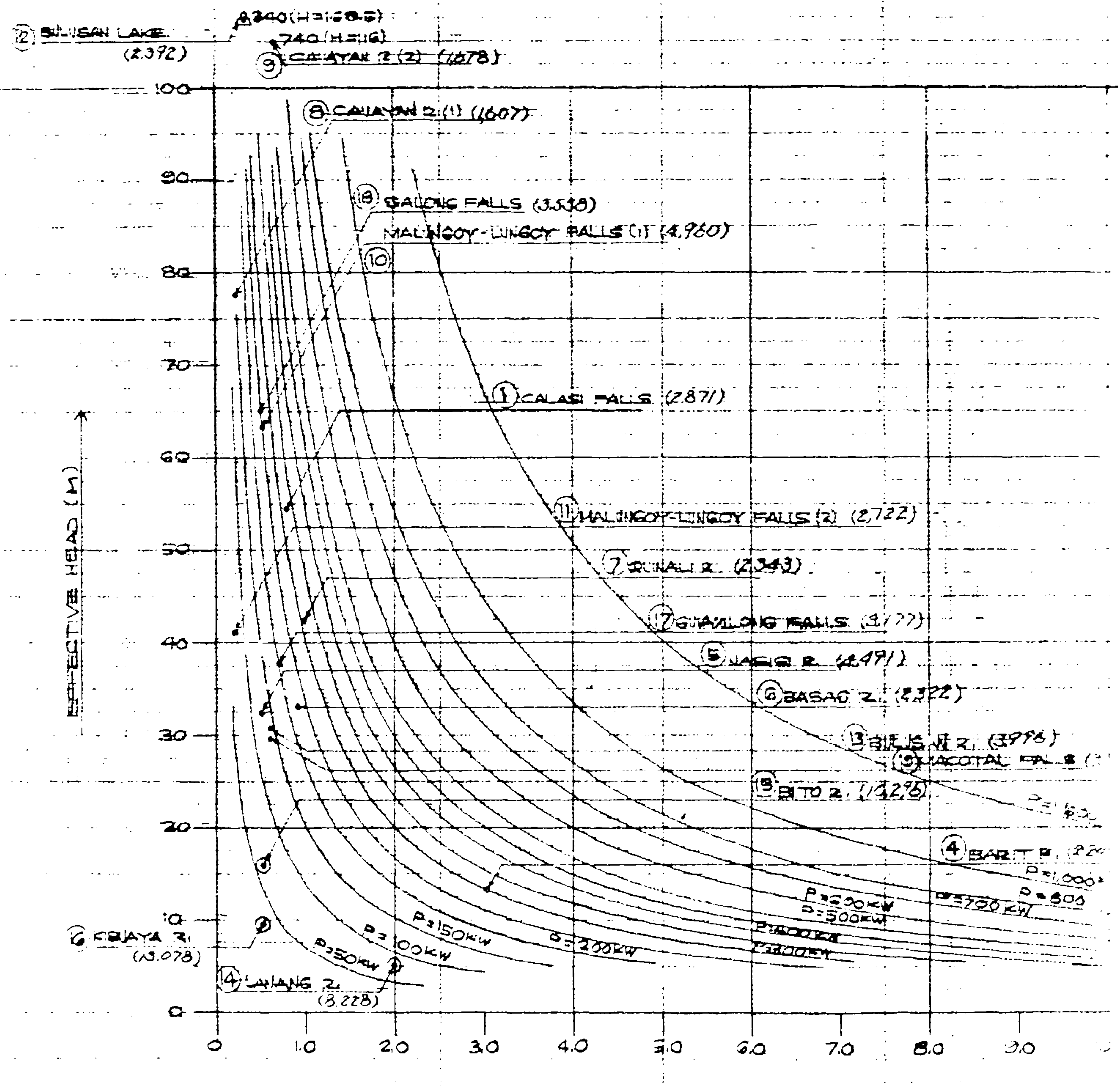
ig. 1-1 LOCATION MAP OF THE PROJECT SITES



SECTION 2

FIG. 1-2

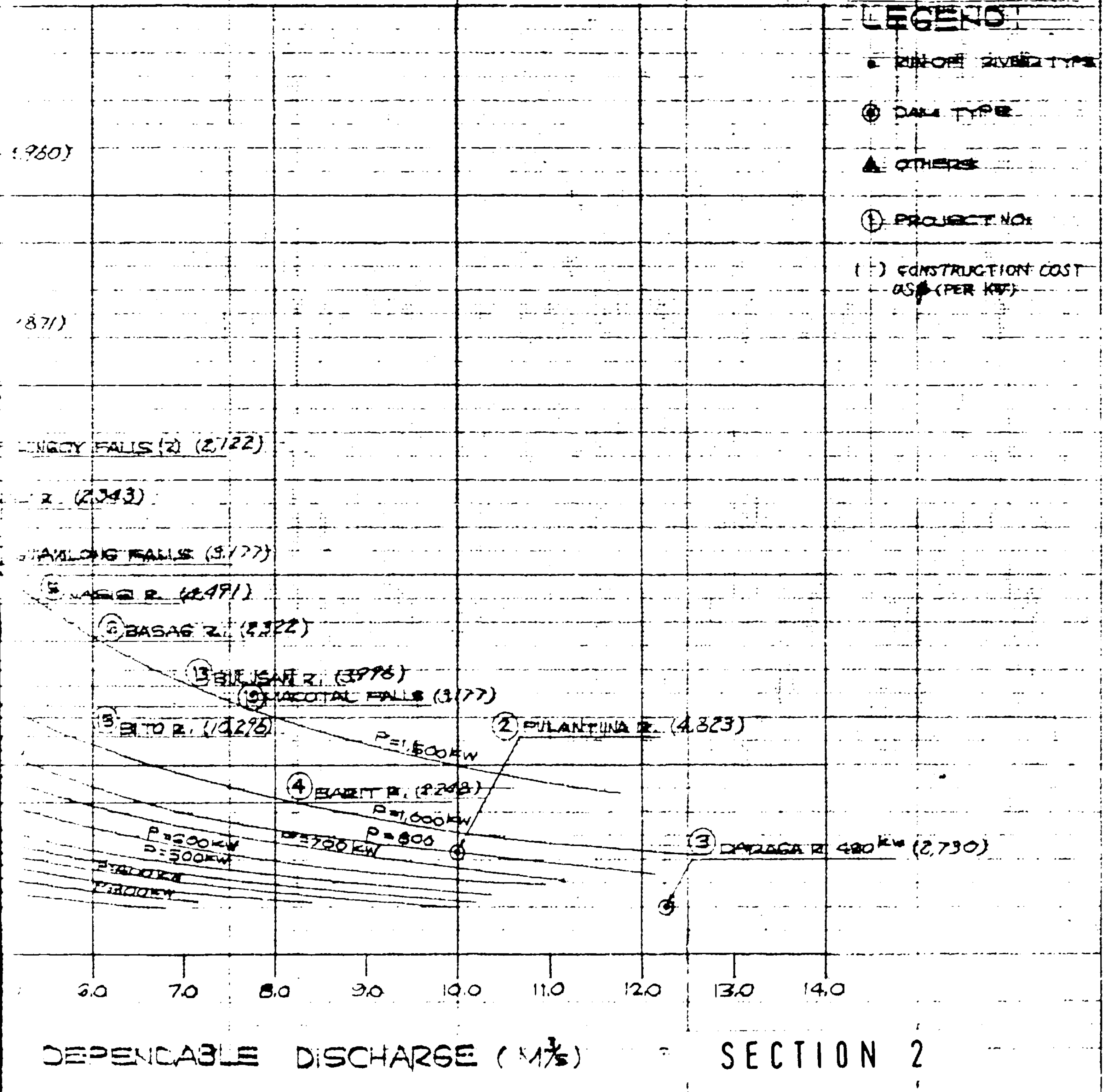
MINI-HYDRO PROJECT BASIC FEATURE IN BICC



SECTION 1

MAXIMUM DEPENDABLE DISCHARG.

ECT BASIC FEATURE IN BICOL REGION



SECTION 2

2. Selection of Potential Mini-Hydro Power Sites

Nineteen (19) sites mentioned above were selected to be based upon the mini-hydro site assessment criteria and as follows:

a) Characteristics of the catchment area and river discharge

b) Estimated plant capacity

c) Availability of the hydrological data and access road to the project site

d) Factors affecting implementation (transportation, topography, geology, effect of flood during construction)

e) Length of distribution line

f) Operation and maintenance

g) Engineering and technology, and

h) Power use program

The nineteen (19) sites have each been surveyed in the field and the collected data were analyzed. As a result, Mini-Hydro power development projects in the Bicol Region were found to be technically feasible and justifiable, although not always in economic terms.

3. Hydrological Data and Analysis

1) Streamflow Gauging Stations

In the Bicol Region there are 50 streamflow gauging stations which are distributed in 25 watersheds.

The rainfall data at 16 sites near the proposed Mini-Hydro Power sites were also collected.

2) Availability and Accuracy of streamflow Data at Proposed Site

There are 50 gauging stations in the Bicol Region at present. Measurement have been made since 1946, but some of them have fragmental records. Thus, some availble data are not sufficient enough for statistical analysis.

For lack of streamflow gauging station at the proposed mini-hydro power sites, the following procedure was adopted to estimate the dependable river discharge for each mini-hydro power plant site:

a) If the streamflow gauging station and the proposed site are located on the same river, the accuracy of the measured data was checked and then analyzed for an estimate of the dependable flow by using specific discharge.

b) If the streamflow gauging station and the proposed site are not located on the same river, but the proposed site is in the vicinity of the gauging station with similar watershed conditions and characteristics, the dependable discharge at the proposed site was estimated as in (a) above.

c) If the streamflow gauging station and the proposed site are not located on the same river, and that the watershed conditions and characteristics of the proposed site and hydrological station are not similar, the dependable discharge was estimated by evaluating the river discharge through the use of the neighboring rainfall data.

d) If the streamflow gauging station and proposed mini-hydro power site are not located on the same river, but that an existing power station is located upstream, the operating flow of the existing upstream power station was taken into consideration to estimate the dependable discharge at the proposed site.

e) If the discharge record and rainfall data are not available, the available discharge was estimated on the basis of the measured streamflow data during the field survey together with the consideration of the hydrological characteristics of the Bicol Region.

4. Flow-Duration Curve

The flow-duration curves are used and essential as a design criteria for the plant capacity and annual produced energy. These curves are made ploting values of river flow (daily, weekly, or monthly) in order of magnitudes as ordinate and per cent of time as abscissa, as shown in Fig. 4-1. The river discharge at each gauging station was converted to the discharge per unit catchment area of 100 km^2 (a specific discharge).

Flow-duration curve based upon the day as a unit of time will give a curve more correct and reasonable, especially for the run-of-river type of the mini-hydro power development study than a curve based upon week or month.

Here, the flow-duration curve of which ordinate are expressed as a ratio to the average discharge of a river are very similar even on different rivers, as shown in Fig. 4-2. (Ref. under Note)

This curve is so called a characteristic flow-duration curve in the Bicol Region and very useful for study of mini-hydro power development. Especially, in case where scarce or no river flow records are available, it gives a procedure of approximating a flow-duration curve by the average flow of a river, correlating the records of precipitation or other conditions.

Note: As shown in Fig. 4-2, the forms of duration curve of Nasisi and Pinangapugan Rivers are not so similar as other rivers. This reason is estimated as follows:

(1) Nasisi River
The soil condition of catchment area is exposed of volcanic deposit and the seepage water from the neighboring catchment areas is gathering to this river.

(2) Pinangapugan River
The river is located in the island and also very near the seashore. This gives the river an abnormal effect by precipitation.

Fig. 4-1 DESIGN CRITERIA FOR INSTALLED CAPACITY FLOW DURATION CURVE PER 100 KM^2

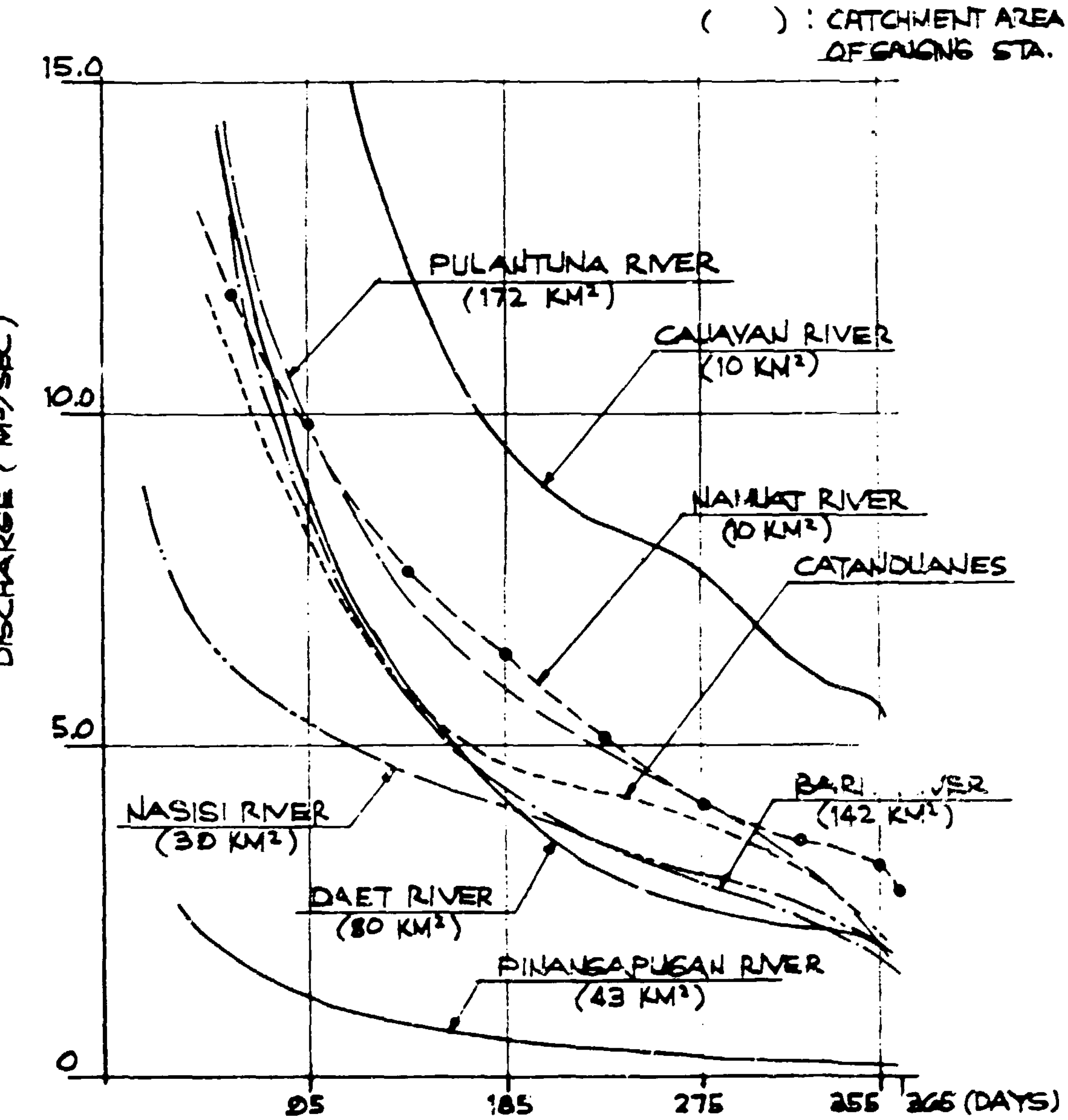


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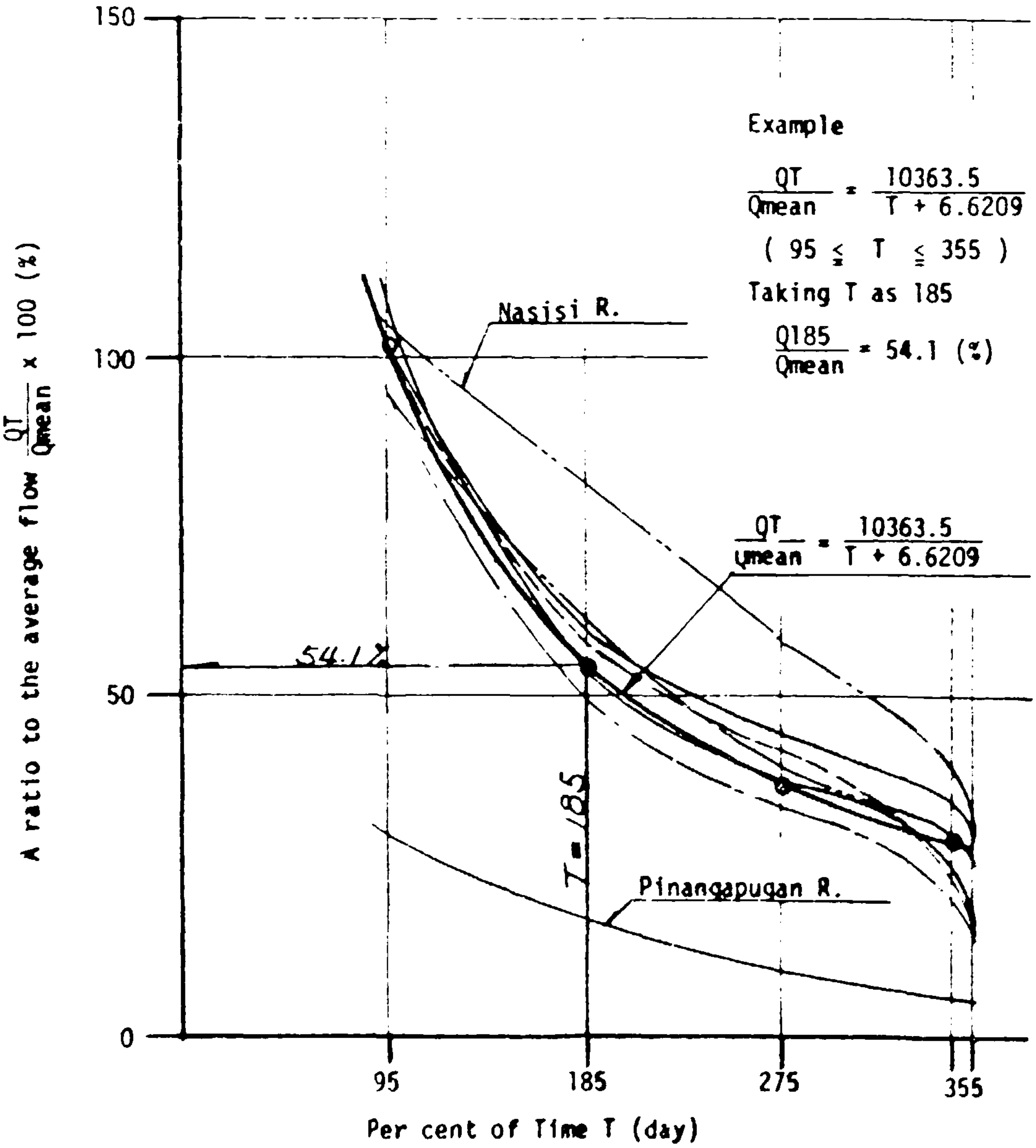
Fig. 4-2. Flow Duration Curve as a ratio to the average flow



5. Scale of Hydro Power Development

For the determination of the most optimum development scale, the value (Benefit-Cost) must be decided to have the most optimum value, taking into consideration various factors such as potential capacity at proposed site, existing demand, load factor and evaluation of kw and kwh of the substitutional power facilities. Almost all of the proposed potential sites can be classified into two basic areas i.e, one, areas where the generated power can be easily connected to the large existing power grids, and two, areas where lighting is not developed or isolated areas.

In the former case, the value (Benefit-Cost) should be decided on the most optimum basis. Also, it is recommended that the development scale must be as large as possible for the totally sound development of the Philippines, especially securing and improving the energy supply conditions through lessening its dependence on the imported oil.

On the other hand, in the later case, the development of the proposed sites must be considered mainly from the social point of view, such as spread of electrification and expansion of the local industries, although the economical point of view also should be taken into consideration. In this sence, the development scale must be not large, but small. Taking into consideration the above mentioned philosophy and also the characteristics of mini-hydro power development, the criteria for the estimation of the available maximum discharge was decided.

Generally speaking, the available maximum discharge must be analyzed using the continuous observed data for at least more than ten years. But, as stated previously, the available data from the Bicol Region are not suitable for the statistical analysis considering its accuracy and observation period. In this sence, it is difficult to determine the drought, abundant rainfall and normal rainfall year by the statistic analysis. Thus, the available maximum discharge was estimated using the average flow-duration curve shown in Figure 4-1. The criteria for the determination of the anailable discharge is as inset below.

i. For the proposed site of run-off river type the available maximum discharge is set at 185-day's discharge of flow-duration curve, i.e., 185-day's discharge is not less than the discharge which is continuing for 185 days per year.

ii. For the proposed site with reservoir or small regulating pondage the anailable maximum water was decided at 95-day's discharge of flow-duration curve, i.e., 95-day's discharge is not less than the discharge which is continuting for 95 days per year.

Reflecting upon the field survey results and hydrological analysis, detailed studies for the selected 19 sites were made, based upon the assessment criteria stated previously. As the results of the studies, the power development scale in the entire Bicol Region was determined at 5015 kw, having an annual generating energy of 33.2 Gwh. The power development scale at 19 sites ranges from 35 kw ∿ 825 kw, classified by development scale are as set in.

Development scale	Number of sites	Average generating capacity
P > 700 kw	2	782.5 kw/site
700 > P > 400	1	490.0
400 > P > 200	8	280.0
200 > P > 100	4	130.0
P < 100	4	57.5

6. A Few Comments

As a result of field investigations and the subsequent studies, the following comments were drawn with regard to the mini-hydro power development in the Bicol Region.

6-1 It seems that it is needed to take consideration as to design the systematical development throughout the river basin and project area taking the integrated control system for the operation and maintenance. Therefore, a random development should be avoided due to the cost increase trend in the construction and running operation; essentially compared with the conventional hydro-electric power plant.

6-2 In general, the mini-hydro power plant utilization factor* for the rural electrification is low to result the high generating cost. Thus, it is hoped that the following matters be thought over.

a) Aiming at the uprise of plant factor to the fuller extent, it is necessary to take the plant factor higher through the planning of establishing the regional small-sized industries and increasing the electric power demand. In reality, the rural electrification and the rural development are being closely contacted and inseparably related each other.

b) Furthermore, through the connecting operation of the induction generators respectively to the surrounding located existing power grid systems it is essential to design the uprise of plant factor and the reduction of generating cost by selling business of the surplus generated energy.

c) In case it is possible to be cheaper in the construction cost comparatively of the small regulating pondage, it is hoped to design the regulating power generation station.

Note: *In 1945 and around, the load factor in the rural area or village of Japan showed only 15 per cent. In the survey conducted in the isolated island, Catanduanes in 1978, it were marked about 26 per cent.

6-3 It is acquainted that the smaller the mini-hydro power plant in the scale is the bigger the personnel expense rate occupied in the generating cost. So, it is desired to introduce the half-automatic method to the each station by the remote control system combining some stations.

6-4 The river discharge characteristics in the Bicol Region is relatively stable compared with other regions in the Philippines. For example, the utilization factor for a 185-day discharge is more than 80 per cent.

6-5 The flow-duration curve as a ratio to the average flow is very useful for study of the mini-hydro power development and the curve based upon the day as a unit of time is desirable for the run-of-river type power station.