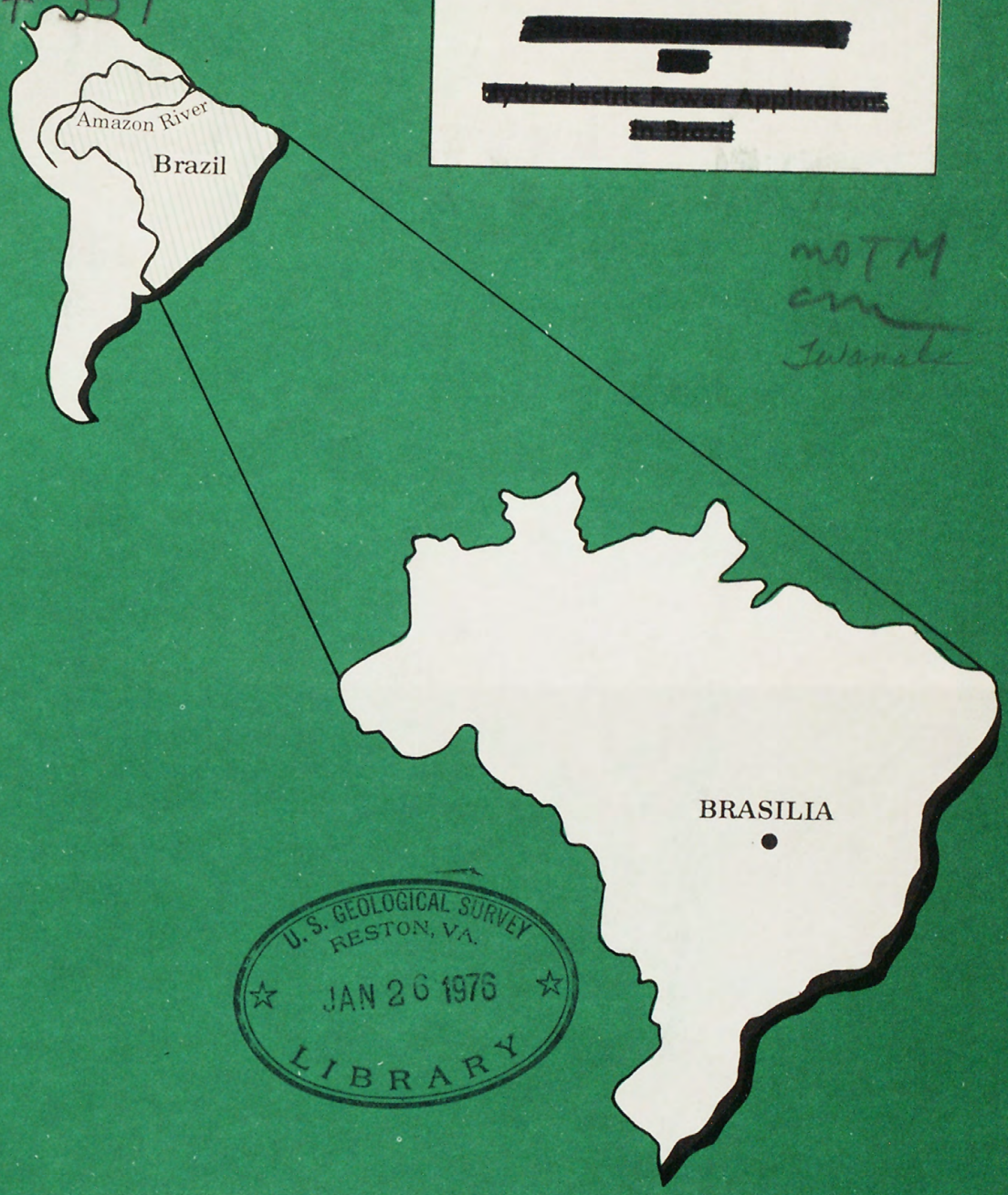

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Streamflow Measurement Network Review for Hydroelectric Power Applications in Brazil

by

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Contents

Illustrations

Brazilian Agency Symbols

CAEEB	- Companhia Auxiliar de Empresas Elétricas Brasileiras
CANAMBRA	- Canambra Engineering Consultants Limited
CEMIG	- Centrais Elétricas de Minas Gerais
CESP	- Centrail Elétricas de São Paulo
COPEL	- Companhia Paranaense de Eletricidade
CPRM	- Companhia da Pesquisa de Recursos Minerais
DAEE	- Departamento de Águas e Energia Eletrica de São Paulo
DNAEE	- Departamento Nacional de Águas e Energia Elétrica
DNMET	- Departamento Nacional de Meteorologia
DNPVN	- Departamento Nacional de Portos e Vias Navegáveis
ELETROBRÁS	- Centrais Elétricas Brasileiras S.A.
FURNAS	- Centrais Elétricas S.A.
LIGHT	- Serviços de Eletricidade S.A.
MME	- Ministério das Minas e Energia
PETROBRÁS	- Petróleo Brasileiro S.A.
SUVALE	- Superintendência do Vale de São Francisco

Introduction

This review of selected segments of the stream-gaging network of Brazil was undertaken by the writer in March and April, 1973, pursuant to an agreement between Companhia de Pesquisa de Recursos Minerais (CPRM) and Centrais Elétricas Brasileiras S.A. (ELETROBRÁS) as a part of the cooperative program of the U.S. Geological Survey (USGS) and CPRM under the auspices of the Ministerio das Minas e Energia (MME) and the U.S. Agency for International Development (USAID). Its primary purpose is to provide an evaluation of the adequacy of streamflow data on streams which are being considered for or are already being utilized for hydroelectric power sources. Some comments are included pertaining to the general coverage hydrologic network. These comments were generated by the examination of the streamflow data useful for power purposes because all gaging stations form a part of the total network for hydrologic investigations. Present plans are that the entire network will eventually be operated by or under the jurisdiction of the MME through the Departamento National de Aguas e Energia Elétrica (DNAEE).

Brazil is a large country, larger than the conterminous United States, and it has been engaged in hydrologic investigations for more than 50 years. The network has been maintained by Federal agencies, State agencies, power companies, and consulting firms and until recently no organizational mechanism existed to coordinate the various activities or to establish uniform standards of data collection, computation, and publication.

It is estimated that stage and/or discharge data have been collected at 2,500 or more sites in Brazil. Because there has been no centralized publication system, it has not been possible to locate with assurance all measurement sites or to ascertain precisely the types and quality of the data collected or available.

For these reasons the suggestions outlined in this report are expected to be modified on the basis of local need and site information, which may not have been evident at the time of the review. For example, specific suggestions have been made to discontinue some stations which appear superfluous or which essentially duplicate other stations. In other instances additions to the network have been proposed. There may be reasons for the continued operation of a given station which cannot be discerned from the available literature. Also coverage may have been established in an area but the evidence has not yet appeared in print. DNAEE is currently (1973) working diligently to overcome a backlog of data computation and publication. Brazil is currently developing at a rapid rate with electric power demands increasing at a 12% annually, a reflection of the tremendous growth of the economy. With this rate of increase likely to continue for the foreseable future, it goes without saying that hydrologic information needed tommorrow must be collected today.

Acknowledgments

The writer wishes to express his appreciation for the cooperation of personnel of ELETROBRÁS, USGS, CPRM, and USAID whose efforts made this study possible. In particular he wishes to thank Engineer Lourival Almeida Oliveira, ELETROBRÁS, who provided helpful advice, consultation and the facilities of ELETROBRÁS. He is also indebted to Engineer Adolfo Felipe Franz of the Porto Alegre office of CPRM who researched data files and assembled and interpreted material to help the writer's review. Others who assisted in various ways are Engineer Carlos Alberto Padua Amarante, Chief, Engineering Department, ELETROBRÁS, and Engineer Joaquim Caracciolo, ELETROBRÁS. He also expresses his appreciation to Mr. S. A.Stanin, Chief of Party, USGS, and to Messrs. W. W. Evett and Don C. Perkins, hydrologists, USGS, for their assistance and advice.

Basin Analyses

For the purposes of this preliminary review only those basins which are of particular interest to ELETROBRÁS for possible hydro-electric development by 1985 have been examined. The basin review comments which follow have been made in the order of priority indicated by Engr. Lourival Almeida Oliveira, Coordinator for Power Resources Group, Engineering Department, ELETROBRÁS.

As indicated, attention was directed primarily to those streams having known power potential and to those stream reaches where hydro-electric plants are in existence or where future development is anticipated. In regions such as the Amazon Basin, which are largely undefined in hydrologic terms, attention was given to the establishment of a few streamflow measurement stations which may or may not be of value in future power development. The feasibility of such development will depend on factors additional to those of hydrologic significance.

The station numbers, and the basin and sub-basin numbers used in the following text and tables are those which were assigned in the DNAEE inventory which has just been published (1973). Where other agency numbers have also been applied to station locations they are shown in the tables for cross-reference purposes.

Paraná Basin (No. 6)

The Paraná River drains much of southern Brazil, and at Guaira, downstream from which it forms the boundary between Brazil and Paraguay, it encompasses a drainage area of 800,000 square kilometers (km^2) with an average discharge of 8,922 cubic meters per second (m^3/s) based on more than 50 years of streamflow record. Its drainage area includes parts of the States of Goias, Mato Grosso, Minas Gerais, Paraná, Santa Catarina, São Paulo, the Federal District of Brasilia, and large areas of Paraguay and Argentina. The population of the Brazil part of the basin is roughly 35 million, a third of the population of the entire country, and a large share of the industrial capacity of Brazil is in the basin.

The principal subbasins in Brazil are the Corumbá, whose headwaters drain the Brasilia area, the Araguari, the Paranaíba, the Grande, the Tietê, the Paranapanema, and the Iguaçu. Hydroelectric power has been developed extensively in several of these basins, especially the Grande, Tietê, and Paranapanema, and planning is under way for additional hydropower at numerous sites on these rivers as well as on the main stem of the Paraná. Specific comments on the streamflow network follow.

Rio Paranaiba Sub-basin (No. 60)
(above Itumbiara, including Rio Corumbá
and Rio Araguari drainages)

Two tentative power sites on the Rio Corumbá upstream from the Itumbiara site on the Paranaíba are planned. Data for the hydrologic studies relating to these plants are reported to be available from Centrais Elétricas de Minas Gerais (CEMIG) stations 711, Caldas Novas, and 712, Pires do Rio though the periods of record are apparently of only a few years duration. DNAEE now has a station on the Corumbá downstream from CEMIG 712, established in 1971, one on Rio do Peixe, and one on a tributary above Pires do Rio. If the CEMIG stations have been discontinued, the DNAEE stations mentioned should provide reasonably adequate information for future power studies at Corumbá and Fecho da Onca sites. Primary support by ELETROBRÁS would be desirable.

For general coverage and future needs relating to both water quantity and quality, at least two stations should be established on streams draining south from the Distrito Federal. The Rio Descoberto and Rio São Bartolomeu seem to be good choices though more detailed information may indicate other stations, and quite possibly, additional streams in the vicinity of Brasilia where data for future needs should be collected, beginning as soon as possible. Such stations should continue to be a part of the DNAEE network. Available information shows that coverage in the Brasilia area has recently been established.

The inflow of the Rio Paranaíba to Itumbiara Reservoir should be measured. Station 553, Ponte Estelita Campos, fills this need and its operation should be continued. If records are available for the Corumbazal station, they will also be useful. Operation of station 552, Cachoeira do Sertão, (records since 1967 only) should be continued to provide flow data for the proposed Cachoeira do Sertao plant. When and if the plant is constructed, it may be impracticable to continue the station and computed records from the plant may have to be used to document the flow regimen at this point.

The Porto da Barra station 551 with a drainage area of 7,350 km^2 has a long-term record and is a valuable segment of the hydrologic network. It should continue as a DNAEE responsibility, with strong support by ELETROBRÁS.

Two tentative plant sites are indicated on Rio São Marcos, roughly 95 and 170 km above its junction with Rio Paranaíba. Apparently there are no long-term discharge data for this reach but two stations are now operated by DNAEE. They are at Ponte São Marcos (since July 1966), and at Fazenda São Domingos (since June 1969). A third station has been proposed at Campo Alegre de Goias but apparently it has not been established. This station would be most useful for hydrologic studies on Rio São Marcos. Support by ELETROBRÁS seems in order.

On the Rio Araguari the proposed plant at Tupaciguara has been deleted from present plans. Station 557, Ponte Melo Viana, (CEMIG 713-B), has records since 1930 at this location and should be continued as an inflow station for Itumbiara reservoir. The station will be of interest to ELETROBRÁS and CEMIG and also will be an important

hydrologic network station for DNAEE. Should its satisfactory operation be affected by backwater from Itumbiara reservoir it should be relocated upstream just far enough to eliminate this problem, and continued in operation as an equivalent station.

Station 555 (CEMIG 719-A) at Santa Juliana should continue, as should the station at Ponte João Candido, 554, on Rio Quebra-Anzol for which published data are now available since October 1959. The latter station appears best suited for incorporation in the Federal network. The additional stations in the upper reaches of Rio Quebra-Anzol which have been established by DNAEE, appear to provide good hydrologic coverage.

Rio Paranaiba
(Rio Grande to Itumbiara)

Station 558, discharge rating curve not defined, about 1.5 km below Cachoeira Dourada dam will be submerged by São Simão reservoir. A flow record at this important point should be continued, and it appears that a plant record will have to suffice. In this connection it is pointed out that records computed from turbine and spillway gate ratings should be verified occasionally by current meter measurements if it is at all possible to do so.

Apparently the station at Meia Ponte, 559, on Rio Meia Ponte will not be submerged by the São Simão reservoir (pool elevation 401 m) and will serve as an important inflow measurement point for 11,500 km^2 of Rio Meia Ponte drainage. The station should be continued.

An additional station upstream in the vicinity of Goiania needs to be added to the network, and it appears that this has been done. The station at Inhumas also is a good addition.

The apparent deficiencies in streamflow data for the streams draining into Rio Paranaíba from the north and west between the Rio Grande and the Rio dos Bois have been remedied by the establishment of a number of new stations which are well distributed for network purposes. Locations appear to have been based on anticipated needs for information and on the availability of sites providing accessibility.

The only station on the main stem Paranaíba between the Itumbiara plant and the Rio Grande is 561 (Fazenda Santa Fe) where the drainage area is 171,000 km^2. The discharge record dates from October 1949.

During filling of the Ilha Solteira reservoir, pool elevation 328.0 m, the station will be submerged, as will 637 at Porto Tabuado on the Paraná a few km downstream from the mouth of Rio Grande. Thus it appears that a plant record at São Simão will be the only feasible method of documenting flow for this reach of the river. Serious consideration should be given to requisite instrumentation and checking of theoretical or manufacturer's ratings of the various discharge elements (gates, overflow sections, turbines) by current meter measurements. The rating of the various plant elements by this method may be difficult and costly or manifestly impracticable. For this reason a recording gage installation below the dam is preferable, if the Ilha Solteira pool does not create a condition of more or less continuous backwater.

Rio Grande Sub-basin (No. 61)

Reaches above FURNAS reservoir appear to be adequately covered. Station 501 at Madre de Deus has records from October 1930. Stations 502 and 503 on Rio Aiuruoca have records exceeding 30 years in length. Numerous other stations also exist covering a wide range of drainage area sizes. Also there are no apparent deficiencies, although it was not always possible to ascertain if a given station was in operation or if the discharge record was available.

The Itutinga station on Rio Grande has a record dating from 1930. Its records are important for system operating purposes. Discharges appear to be calculated on the basis of upstream stations at Madre de Deus (Rio Grande) and Fazenda Laranjeiras (Rio Aiuruoca), and on plant records. As the recording gage below the plant is reported as being in operation it would seem preferable to utilize it for computing discharges unless rating conditions are impracticable.

Stations 505, Rio Grande at Macaia, 507, Rio Verde at Tres Coraçoes, and 508, Rio Sapucai at Fazenda Boa Vista are key stations and should continue in the network although Porto dos Buenos might be substituted for 507. Station 506, Rio Jacare at Usina do Anil, which now has 36 years of published record and covers a relatively, small part (1,410 km^2) of the drainage to FURNAS reservoirs, is of value for system operational purposes. A record below the FURNAS dam would be of value in maintaining a check on the efficiency of the turbines and in scheduling operations at the downstream plants. As there is some question whether a satisfactory discharge record can be obtained below the plant

and above the influence of Peixoto pool it is probable that the computed record of plant use will suffice.

Station 509 at Rifaina has been discontinued because it was flooded by Jaguara pool. Station 510 at Igarapava, records published since January 1969, replaces it, and station 511 at Volta Grande appears to have been established more recently. There seems to be no reason for the continuation of both of these stations so close together. If of course, the Igarapava station is flooded when the Volta Grande Reservoir is filled then 511 should be continued. At this point, however, it appears that 510 which is a recording station and which has several years of record should be continued and 511 discontinued.

The station on Rio Sapucaia at Fazenda Sao Domingos with a catchment area of 6,070 km^2 and a record extending from 1938 to date is a key main stem inflow station which should continue. On Rio Pardo the station at Fazenda Jatai should be eliminated, as the DNAEE station at Porto Joaquim Justino is adequate in this reach. Stations 513, Rio Pardo, and 515, Rio Mogi, are long term stations whose continued operation seems warranted because of the developments in this part of the Pardo basin.

Station 517 at Porto Jose Americo is essentially the same as one listed by CANAMBRA (CEMIG) at Porto Velho. This has one of the longest flow records in Brazil and is a key station for an area of 119,000 km^2. A relatively new station on the Rio Grande at Quicaca, just downstream from the Agua Vermelha power site, has a drainage area of 139,900 km^2, an increase of only 18%. It appears that the Quicaca

station, 520, will be in backwater from the Ilha Solteira Reservoir when it fills (Power Study of South Central Brazil Part A, Minas Gerais, App. 14, Pl. 2, May 1972) a process now under way. If the backwater situation does develop the station will, of course, go out of operation. Conversely, if it can be continued as a conventional stage-discharge station, it may be considered of marginal value. A station should be maintained, however, at either Porto Velho or Porto Jose Americo, with Porto Colombio as an alternate, unless it is inundated by the Marimbonda reservoir.

Because of the extensive existing and projected developments in the Rio Grande basin, many of the streamflow stations referred to in the preceding paragraphs are of primary interest for hydropower and related hydrologic studies and for system operations purposes. These stations measure a large share of the inflow to the vast FURNAS plant reservoir and provide a basis for the estimation of the flow from the ungaged areas. Those judged to be of particular importance are Fazenda Laranjeiras (Aiuruoca), Macaia and Madre de Deus (Grande), Fazenda Boa Vista (Sapucai), Porto dos Buenos (Verde), Fazenda San Domingos (Sapucai), San Jose do Rio Pardo and Porto Joaquim Justino (Pardo). Porto Velho (Grande) was destroyed by flood in 1968 but rebuilding is justified unless satisfactory records are being obtained at the Porto Colombio station.

The integrated nature of the power system in the Rio Grande drainage indicates that efficient operation will eventually require real time, or near real time, information on flows entering and in transit through the system. Consideration of digital telemetry is in

order if such has not already been done. Should a decision to proceed with such an operational information network be made it is suggested that its installation be done in steps. Inflow to FURNAS reservoir could be instrumented at about three key stations for transmission to a central control point. As competence in the operation of the data transmission system develops it can be expanded to cover the critical control points in the power system, and other parameters such as rainfall can be added. Telemetry is, of course, costly but the magnitude of the investment in the Rio Grande power system and the importance of its safe and efficient operation may justify the added cost.

Paraná Basin (No. 6)
(Main stem)

Station 637, Rio Paraná at Porto Tabuado will be in the pool of the Ilha Solteira plant so it will be of no further value as a discharge station and it may be eliminated. Published information also shows that station 638 at Ilha Solteira is affected by the Jupiá plant so its continued operation seems of questionable value. With regard to station 639 at Jupiá Ponte it has already been noted by the CAEEB-MECO Group that the records are affected by the Jupiá plant upstream. As it is a non-recording gage it is agreed that it should be discontinued in favor of the recording gage record being obtained at Jupiá-Jusante, 640.

The drainage area at Jupiá-Jusante is 470,000 km^2 and the next downstream station is at Porto São Jose, 641, where the drainage area is 670,000 km^2. As there are no main stem developments proposed at this time for this reach of the river no additional discharge stations are warranted. Some 200 km downstream from Porto São Jose is the station at Guaira, 642, where the drainage area is 800,000 km^2. This is an important station of hydrologic and international significance. That this has been recognized is obvious because the discharge record has been continuous since October 1920. The station should be continued indefinitely even though adequate discharge information for hydraulic design purposes has now been collected. It is reported that there is some uncertainty concerning the rating curves used to compute the discharge and that the rating analysis is being re-studied. When a decision has been made as to the applicable ratings to be used the

existing published records should be corrected as may be appropriate.

Because of the importance of this station a recorder installation is recommended and the collection of at least reconnaissance level water quality data ought to be started. As a minimum is suggested that samples for the "standard" USGS type analysis be collected about twice a year, once at low flow and once at high flow.

Rio Tiete Sub-basin (No. 62).

Appendix 8, Volume II of the CANAMBRA Report, Power Study of South Central Brazil, lists 26 stations in the Tiete Basin. Drainage areas range from 360 km^2 at Jundiai to 70,400 km^2 at Ilha Seca. The general coverage of the basin seems reasonably adequate and no need for additional streamflow data is readily apparent. As has been stated earlier, however, there may be situations which are not described in the material available for review which might indicate a need for special purpose data.

For station 585, Rio Tiete at Ibitinga, the recorder installation suggested by the CAEEB-MECO report should be accomplished unless the gage will be affected by backwater from the Promissão plant. The river profile shown in Appendix No. 2 of the Rio Tiete Basin Report by CANAMBRA, 1964, indicates a pool elevation of 385 m above the Promissao dam. If there has been no change in this plan it is possible that the Ibitinga station will be submerged at full pool level in which case it should be discontinued.

Station 586, at Promissao, apparently will be the only station which will be operable in the lower reaches of Rio Tiete after it is fully developed, except for 588, the long-term Lussanvira station which apparently is not being affected by backwater from the Jupia pool. A cursory examination of the discharge figures for Promissão, Rorto Rio Prado, and Lussanvira for the 13-year period 1959-71 shows that the Porto Rio Prado discharges are too low. As this station will eventually

be submerged if the Tres Irmaos plant is constructed it should be considered for discontinuation. It would be advisable to review the accuracy of the gage height records and rating curves for these stations to see if the apparent discrepancy can be explained.

The very complex water management system in the upper Tiete in connection with the diversion to the Henry Borden plant does not appear to lend itself to or have need of additional streamflow data. The published records for the Rasgão station represent actual flow past the gage. It is not clear, however, why these observed flows have been subtracted from the flows at downstream main stem stations. Generally, USGS practice is to publish observed flows at gaging stations, and to publish storage changes and diversions individually so that the user of the records can make his own interpretation and adjustments.

Numerous stations have been established in the Tiete basin. Their density in the upper basin appears questionable, and a strong effort at coordination of the activities of the various agencies operating stations should be made. Presumably there are many special purpose needs for flow information in this populous region but it is difficult not to conclude that there is unnecessary duplication of effort.

Paranapanema Sub-basin (No. 64)

The upper Paranapanema basin (Rios Itapetininga, das Almas, and Apiai-Guacu) has a good distribution of stations both geographically and by drainage area size. At station 605 at Piraju where the flows are affected by regulation from the Jurumirim plant it would be desirable to install a recorder to improve the accuracy of the stream-flow record. This station plus DNAEE station on Rio Itarare at Fartura measure more than 85% of the inflow to Xavantes plant and stations 608, 609 and 610 (Porto Ermidão, Santa Cruz do Rio Pardo, Porto Jau) should provide adequate flow information for the Lucas N. Garcez plant. Flow data provided from station Usina Canoãs should provide adequate flow information for the projected Canoas plant.

Considering the tentative developments on Rio Tibagi the Tibagi station should be reactivated if a suitable site can be found. Should this be impracticable a station at or near the projected Santo Antonio site should be given serious consideration. Apparently a gage height record is still being collected at the site to which the Tibagi station was moved in October 1959 and a number of discharge measurements have been made. Possible a re-analysis of the data would be useful as continuation of this relatively long record may be of greater hydrologic value than a new station. The site appears to be a very short distance upstream from the mouth of Rio Iapo which might result in a backwater condition, or a slope-affected rating at times. Ratings can be developed for stations affected by changing slopes but such ratings are more complex, require an auxiliary gage to measure the fall in the reach,

and the gages should be recorders. Such situations should be avoided if possible because of the additional work and cost involved.

The station at Jataizinho, 612, is an important station for Rio Tibagi and it should continue unless it should become affected by backwater from the Capivara plant under construction. A station at Salto Maua is recommended for establishment if a suitable gaging site is available in this reach.

Station on Rio Pirapora at Itaguaje, drainage area 5,160 km^2, is a useful general coverage station. After 15 or 20 years of record have been obtained it may be found that adequate hydrologic information for the then existing needs is available, particularly in view of the stations now in operation in the upper reaches of this strea m.

For the reach of the Paranapanema below Itaguaje there seems no necessity for the operation of both Porto Ceará and Porto Euclides da Cunha. The difference in drainage areas is only 2,900 km^2,about 3%. One of these stations should be discontinued. While the downstream station of the two is a recorder, which ordinarily would be a determining factor in selecting it for continuation, it appears that it will be subject to backwater from the pool of the Ilha Grande plant, when and if constructed, at times. At maximum pool level (elevation 258 m), in fact, backwater will reach to the Jupiá plant some 500 km upstream.

Rio Ivai

One projected plant is indicated for the Rio Ivai at Ibatuba, but no streamflow stations are shown as being in existence in the basin.

It is recommended that the collection of a streamflow record be initiated without delay, preferably near the site of the projected Itatuba plant.

Rio Piquiri

Similarly, a new station should be established on Rio Piquiri at a site near the proposed Salto dos Apertados plant to provide hydrologic information on this stream.

Rio Ivinhema

This is a relatively large basin for which no streamflow data are in evidence. While a large proportion of the lower basin will be flooded by the Ilha Grande reservoir, if constructed, it does appear that general information type of flow data may be needed. A station in the upper reaches in the vicinity of Dourados is suggested, along with another station at a point below the confluence of the main branches.

Rio Pardo Sub-Basin (No. 63)

General coverage seems adequate but the location of station 632 on Rio Inhandui, apparently a very short distance upstream from its junction with Rio Pardo, should be examined. If the situation is close to the mouth of the Inhandu and if there is inadequate fall it could be affected by backwater at times when Rio Pardo is in flood, thus causing inaccuracies in the discharge record.

Rio Iguaçu Sub-basin (No. 65)

The Rio Iguaçu has a total drainage area of about 67,000 km^2 and is about 550 km in length from east to west with a relatively uniform width of about 120 km. The total fall from the headwaters to the toe of the proposed Capanema dam near the lower end of the basin is about 650 m and this fall combined with relatively high and fairly uniformly distributed flows provide considerable potential hydropower.

A number of sites are being studied, the more important ones being Osorio, Salto Santiago, Segredo, Areia, and Lanca. Streamflow records at 13 gaging stations for a 25 year period were used by the consultants in preparing an inventory of hydropower resources in the basin, and ELETROBRÁS is now using 8 of these as key stations in its further studies.

The streamflow data used seem adequate and for analyses at the proposed sites flows have been computed on the basis of relative drainage areas and unit runoff. Several comments may be in order recognizing that they may cover ideas which have already been considered.

For the Salto Grande site it is suggested that flow calculations also be made using data from União da Vitoria and Jaganda stations as the index for the runoff from the intervening area. For the Areia site a similar check would be in order using also the records, if available, from the DNAEE station Faixinalzinho.

For the Segredo site it is noted that DNAEE has a station at Porto Santa Maria about 15 km downstream. If records are available they should be used to verify the computation of the intervening area

runoff. The Porto Santa Maria records could also be used to check the computed flows for the Santo Santiago site.

The ratio applied to Aguas de Vere flows to derive figures for the Salto Grande site on Rio Chopim seems somewhat high. Perhaps a correlation could be made using DNAEE stations at Ponte do Vitorino and Balso do Santana. Flows computed for Salto Caxias and Capanema sites might also be compared with data derived from DNAEE station a Estreito do Iguaçu, if records are available.

The general coverage in the basin appears adequate for present needs, and lacking knowledge of specific problems which may be anticipated no recommendations for additional streamflow stations are made. It does appear, however, that some reconnaissance type information on sediment transport and water quality should be obtained.

A sampling of suspended sediment during one or two high flow periods of Rio Negro, União de Vitoria, and Estreito de Iguaçu would provide an indication of the sources of sediment and whether it would be a problem in the siltation of reservoirs. The sampling should be repeated once during a low flow period, and particle sizes should be measured for one set of high flow samples and for the low flow samples. A standard USGS chemical quality analysis at the most downstream station during low flows at least once yearly is recommended because little or no such information is available, and because of the international importance of the river.

A deficiency which is evident is the lack of information on gage elevations. Knowledge of gage datum (zero) elevations is of importance in assessing slope effects and in determining points at which reservoir stages will affect upstream gaging stations or other developments. Elevation data are also useful in flood plain delineation, in regression analyses for estimating flow from ungaged areas, and for other hydraulic design purposes.

East Atlantic Basin (No. 5)

Paraíba Sub-basin (No. 58)

The Paraíba is an important river which drains some 57,000 km^2 in an area which roughly parallels the coastline from just east of Sao Paulo to 300 kilometers east-northeast of Rio de Janeiro where the river flows into the Atlantic Ocean. There are 30 hydroelectric powerplants in the basin, and one installation consisting of 3 plants in tandem just outside the basin which utilize water diverted from the Paraíba system. Additional hydro developments are projected at 5 sites, one on Rio Buquira, one on Rio do Peixe, one on Rio Paraibuna, and two on Ric Paraíba.

Gaging station coverage throughout the basin is excellent. The DNAEE inventory lists 206 active stations and an additional 41 which have been discontinued. There are so many stations in some reaches that consideration should be given to eliminating some of them. It is apparent that there is a need for the coordination of stream gaging work among the various agencies as there are a number of situations where drainage area differences are inconsequential or where separate gages are maintained in almost identical locations. Decisions of this nature probably should be made by DNAEE in consultation with the operating agencies and after consideration of the relative quality of the discharge records being obtained.

The stations which appear to be of most interest to ELETROBRÁS for operational and planning purposes are:

Rio Paraíba at Guararema

Rio Buquira at Barragem Buquira

Rio Paraíba at Funil

Rio Paraíba at Vargem Alegre

Rio Paraíba at Barra do Piraí

Rio do Peixe at Torreoes

Rio Paraibuna at Juiz de Fora

Rio Paraibuna at Sobragi

Rio Paraíba at Sapucaia

Rio Paraíba at Ilha dos Pombos

Rio Novo at Piau

Rio Muriae at Itaperuna

Amazon Basin (No. 1)

The Amazon, the largest river on earth, drains an area of some 5.8 million square kilometers and has an average discharge to the sea of 160,000 cubic meters per second.

The February 1973 DNAEE inventory of gaging stations lists 53 active stations in the basin and 22 stations which have been discontinued. Station density, therefore, is about one gaging station per 150,000 square kilometers. Obviously, hydrologic coverage in terms of streamflow is meager. Additional streamflow information is essential for assessing hydroelectric power potential and for water management and control needs which may be expected to emerge.

The present power demands of the Manaus and Belem regions are supplied from thermal plants. Studies by the Steering Committee for the Power Study of Amazonia have provided market forecasts until 1985, and have indicated locations for a number of possible hydropower developments. ELETROBRÁS operates gaging stations at some of these sites.

As indicated above, streamflow data may be considered as deficient in all but a few sections of the Amazon basin, and for purposes of assessing the general hydrologic characteristics of the region almost any number of stations could be established which would provide useful information. It is necessary, however, to be practical and to proceed only with such work as will be related to those areas where development is under way or expected in the reasonably near future. Another aspect should be considered and that is the future value of flow data for

important streams which form international boundaries, or which cross international boundaries.

The major streams in this category include the following:

Rio Oiapoque

Rio Tacutu

Rio Negro

Rio Icana

Rio Uaupes

Rio Japura

Rio Ica

Rio Solimões (gaged at Esperança)

Rio Javari

Rio Juruá

Rio Purus

Rio Acre

Rio Abuná

Rio Mamoré (gaged at Guajara-Mirim)

Rio Guaporé (consider sites near Santa Isabel and Principe da Beira)

The establishment of gaging stations on some of these streams may be impractical because of inaccessibility, high cost, or political considerations. In the sparsely populated areas it may be many years before serious interest in the utilization of the streams develops.

It is appropriate, therefore, that decisions to install stations on these streams be made by those most familiar with the situation which

exists both in Brazil and in its neighboring countries. When stations are established consideration should be given to the collections of some basic data on water quality because with the general abundance of water in most parts of Brazil the matter of quality may be expected to become an important factor in the future.

Juruá Sub-basin (No. 12)

In addition to the stations presently operated by ELETROBRÁS, stations have been ordered in the upper Rio Moa drainage in the area roughly east of Acampamento and north of Boa Vista. A station on Rio Juruá at Cruzeiro do Sul (fig. 2) is now in operation, apparently with support by DNAEE, DNPVN, DEMET, and ELETROBRÁS. The station was established in 1967 and the DNAEE inventory indicates prior gaging at this locality from 1928 to 1969 by DEMET. If these earlier discharge records actually exist (which is doubtful), they should provide a reasonable basis for hydrologic assessments in this reach of the river. It should be noted that DEMET may also have records at Eirunepe some 250 kilometers downstream, but it is probable that only stage data have been collected.

The selection of a station site on Rio Moa will require examination of the best available maps and aerial photographs (which may be available from PETROBRAS) and a field reconnaissance by an experienced surface water hydrologist. The area appears to be isolated so if a station is installed it would be desirable to equip it with a recorder capable of long term operation without attention so as to provide an optimum amount of information in a minimum of time.

Purus Sub-basin (No. 13)

ELETROBRÁS operates two stations on Rio Acre. The upstream station is at Xapuri, drainage area 13,800 km^2, and the downstream station is at Rio Branco, drainage area 23,700 km^2. Both stations

Figure 2.--Downstream view of channel from gaging station on Río Juruá-Cruzeiro du Sol, Acre. A staff section at water's edge is seen over the top of the thatched boat roof.

have been in operation since about September 1967, and both have rather poorly defined high-water ratings. There are no seriously considered power sites on this stream and it is suggested that ELETROBRÁS may wish to discontinue the support of these stations.

Branco Sub-basin (No. 14)

In the upper reaches of Rio Branco on Rio Cotingo several hydropower developments are contemplated. Streamflow estimates have been based on very short periods of streamflow record with long term estimates by rainfall-runoff correlations. As a minimum, the station at Cachoeira Bandeira Branca (2,080 km^2) should be continued, preferably with a recording gage. Also, it would be desirable to have an additional station in the vicinity of the projected Bacurau plant to refine the flow estimates which have been used in this area.

In the vicinity of the projected Caracarai development there is a station operated by ELETROBRÁS since January 1967. Drainage area at the gage is 125,000 km^2 and the rating is reasonably well defined up to a discharge of about 7,000 m^3/s. This station should be continued as long as there is interest in power development. An effort should be made to obtain additional high water measurements to refine that portion of the rating curve. There is indication that additional records have been collected at points about 50 and 150 km upstream but details concerning them are not evident.

For the small plant projected on Rio Mucajai the station at Fazenda Sto. Amaro should provide adequate flow data although the rating curve was not available for inspection.

Madeira Sub-basin (No. 15)

Two plants are projected for Rio Madeira in the Territory of Rondonia. The sites are at Cachoeira Santo Antonio (fig. 3) and Salto do Jirau. Records at Porto Velho some 115 or so kilometers downstream from the Santo Antonio site are available for a period of over 40 years. The rating for the station is fair although the measurements scatter somewhat for discharges above about 6,000 m^3/s. For design purposes it might be useful to install a staff gage above the Santo Antonio falls and rate it by boat measurements. Color photographs of the falls and river indicate good possibilities for an excellent rating and the site is accessible by road.

It is noted that the pool of the Salto do Jirau plant, if constructed, will submerge the gage at Abuna. If this plant is built the Abuna gage should be relocated far enough upstream to be out of the backwater influence.

On Rio Jamari two ELETROBRÁS stations are in operation. They are at Ariquemes, drainage area 6,800 km^2, and Cach. do Samuel, drainage area 14,800 km^2. Ratings for both of these stations are good and while the periods of record are short they should provide reasonable data for hydropower analyses when used in conjunction with long term rainfall records. It is noted that correlations have been made with the long term record for Rio Madeira at Porto Velho. As the ratio of the Porto Velho drainage area to the drainage areas of the Jamari stations is very large the correlations should be used with judgment, and it appears that this has been done.

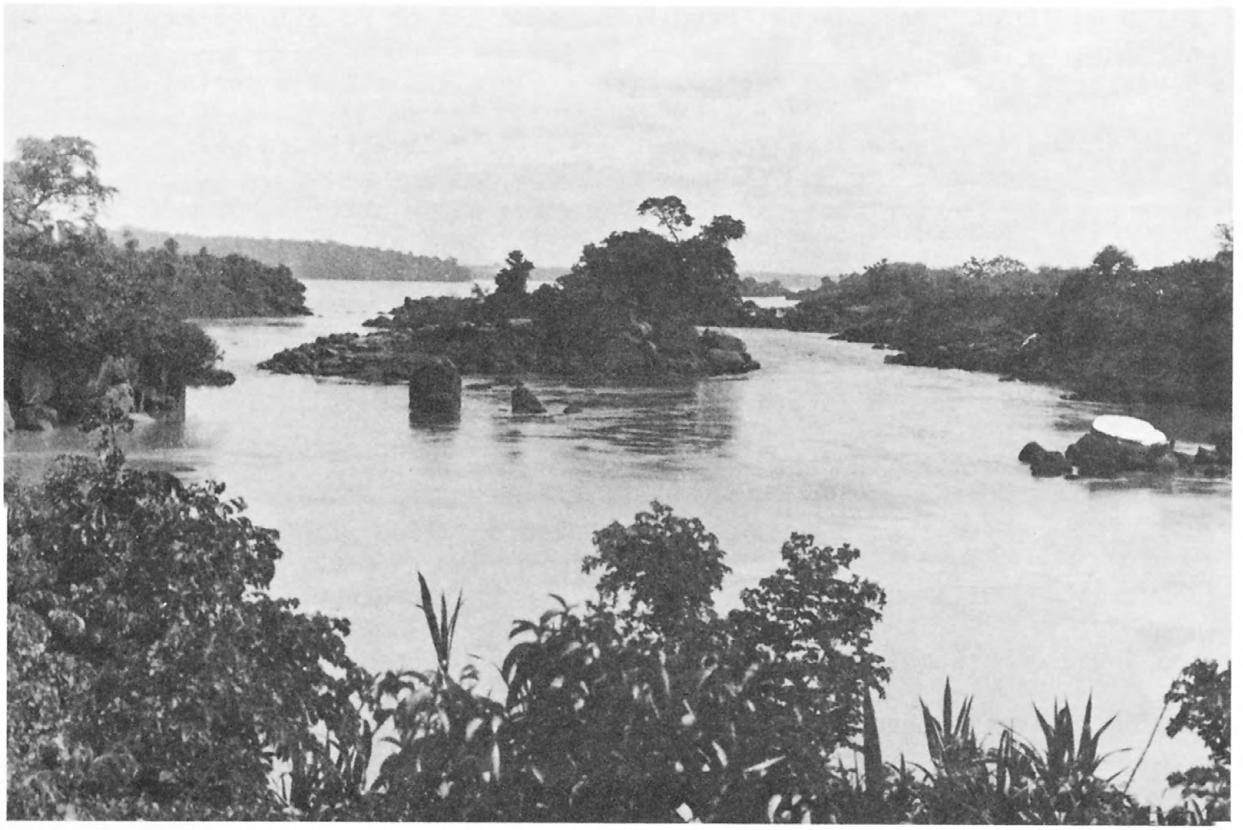

Figure 3.--View downstream of right channel of Rio Madeira below main rapids - Cachoeira Santo Antonio, Rondonía

Stations desired in the area east of Guajara Mirim are primarily for hydrologic information purposes as no data on runoff characteristics of relatively small basins have been collected. Because of difficult logistics in this remote area, site selection will be governed largely by accessibility. Use of recording gages is recommended so that the data obtained will be of maximum utility. There are several streams in the locality and a low level aerial reconnaissance probably would be the best means of making tentative site selections prior to ground inspection. One stream suggested for consideration is Rio Ouro Preto below the swampy area shown east of Guajara-Mirim. Another which might provide a better index in this area would be Rio Laje at a point downstream from its dendritic upper branches. Field inspection may disclose more suitable locations.

Erepecuru Sub-basin (No. 16)

The rating for the Erepecuru station at Vista Alegre appears to be slope affected. It is not evident how the discharges are being computed but the rating shows an apparent loop effect with rising stage measurements having flows 20-30% in excess of those made during constant or falling stages. It seems that it would be desirable to examine the reasons for this and if necessary to relocate the station to a site with a good control so that more accurate discharge records could be obtained. If this is not feasible the operation of the gage as a slope station, which requires an auxiliary gage to measure fall, should be considered. Best results on slope stations are obtained when both the base gage and the auxiliary gage are recorders, and when the datum (elevations of the zero points) of each gage is known.

Tapajos Sub-basin (No. 17)

On the Rio Tapajos a discharge station has been considered near the mouth at Santarem. As stated below for the Xingú, such a location is of questionable utility for discharge determination purposes. The next upstream station is at Itaituba, established in 1968. There is some evidence that a station is also being operated near Lorena about 100 or more kilometers upstream and that sediment data are also being obtained. Because of the importance of this basin, additional discharge data at several other points would be useful. Suggested locations are below the confluence of Rio Juruena and Rio Teles Pires, and on Rio Teles Pires near Aldeia Caiabi in Mato Grosso. On Rio Curua-Una it is understood that the gage at Cach. do Palhao is in operation and this would appear to satisfy the needs of ELETROBRÁS adequately.

Xingú Sub-basin (No. 18)

The Rio Xingú drains a large area and except for the station at Porto de Moz at the mouth, where discharge records may be questionable because of variable backwater effects, there is only one station indicated at Altamaira. A station farther upstream in the basin would be highly desirable. A location below the entrance of Rio Fresco would be good for areal coverage purposes if accessibility is not too difficult.

Marajo and lower Amazon tributaries Sub-basin (No. 19)

The one station on Rio Jari at Sto. Antonio da Cachoeira probably supplies all flow information needed at present; but should this stream be considered for power or other purposes in the future, a station near the mid-point of its basin would be necessary. On Rio Maicuru the DNAEE discharge and sediment station at Arapari probably is adequate for current needs. Should Rio Curua become important for power purpose, a station northwest of Alenquer should be established.

Araguari Sub-basin (No. 30)

In the Territory of Amapá there is some hydropower already developed and expansion of installed capacity is projected. The Araguari and its tributaries are the principal sources for hydropower in the locality and a number of gaging stations are in operation. While these rivers are not large by Brazilian standards their yields are among the highest observed (42.88 $l/s/s/km^2$, Araguari at Paredão Montante). It is probable that firm power can be increased by the construction of additional storage upstream on Rio Araguari and Amapari. To evaluate this potential a station on Rio Araguari just below the mouth of Rio Murare, or farther upstream if measuring conditions are better, is suggested. An additional station on Rio Ampari just below Rio Ita would also be desirable.

São Francisco Basin (No. 4)

According to the SUVALE, 117 gages are operated in the São Francisco basin and at 98 of these discharge records are collected. Most of the discharge stations are equipped with recorders. The hydrologic work is done by a private contract agency and it appears that SUVALE intends to continue this method of operating its streamflow measurement program. The largest number of stations is in the upstream (southern) part of the basin which is roughly south of latitude 16°S. This is also the high yield part of the basin as its northern sector is a part of the so-called drought polygon of Brazil where precipitation is scanty.

Ambitious projects for water storage, power development, and irrigation are in existence, under way, or proposed and their success will depend largely on the management of the water from the upstream part of the basin. This area is well covered with gaging stations and there are no obvious gaps; in fact, there are stream reaches where the density of stations seeems rather high. Rio Sambrura is a case in point. Another is the apparent duplication of effort on Rio Para at Valho da Taipa where separate agencies operate stations at or near the same location. It might also be questioned whether stations are necessary at both Ponte do Chombo and Ponte Olegario on Rio São Francisco. There may be sound reasons in the cases just cited. From a general hydrologic coverage point of view, however, there appears to be an unnecessary expenditure of effort for a marginal amount of

added information. There appear to be other similar types of situations. There was not time available, however, during this short review to examine all stations in detail, nor is it the purpose of this study to assess the reasons for the operation of every gaging station.

With respect to existing power plants on Rio Para, Rio São Jorge, Rio Paraopeba, and Rio dos Velhos and its tributaries, it appears that streamflows are well documented by existing stations.

Inflow to the huge Tres Marias reservoir is apparently well documented. However, this may be a situation where the telemetry of hydrologic data to a central control or dispatch point might prove to be extremely valuable in system operations. Additional developments in this reach of the river are projected at Formoso and at Bica Grande. If these projects are constructed the management of the water resource will become an element of even more critical importance, not only for the installations mentioned, but for those planned in the downstream reaches of the São Francisco basin. If telemetry is considered seriously (perhaps it already has been) the locations of the key inflow stations to Tres Marias should be reviewed carefully to assure that optimum information will be entered into the telemetry network. This network would provide a base for mathematical modeling of the hydrologic system, and it could be expanded by the input of more discharge and rainfall data as the water utilization structures in the basin are built and become more interdependent.

For the Formoso plant hydrologic design data are available from gaging stations at Pirapora, drainage area 62,100 km^2, a short distance

below the site, and at Três Marias upstream where the drainage area is 50,600 km^2. If more specific site information should be needed, staff gages could be installed temporarily, to develop a relationship with the Pirapora gage.

At the Bica Grande projected site a gaging station has been in operation since 1959 that should provide all flow information required.

A small plant is projected at Queimado on Rio Preto. The closest gaging station appears to be at Unai (drainage area 5,800 km^2) some 40 or 50 km downstream, with records available since 1964. Hydrologic data for plant design purposes appear deficient but in view of its small size the Unai records may be adequate. Recent information indicates that this site is no longer projected for development.

Doce Sub-basin (No. 56)

Three stations provide inflow information for the Brecha plant. The most important of the three is at Porto Firme on Piranga and the other two (Fazenda Varginha, Seriquite) cover the two major tributaries. These three records, in conjunction with those for the Ponte Nova station on Rio Piranga should provide a reasonable basis for hydrologic analyses for the projected Pilar plant.

For the Candonga plant there are three key records, one is Ponte Nova, as noted above, and the other two are Fazenda Ocidente on Rio Gualaxo and Acalcaca on Rio Carmo. No additional streamflow data would seem to be required in connection with this plant.

The next projected plant is at Oculos on Rio Doce between Rio Matipo and Sacramento where the drainage-area is about 15,900 km^2. DNAEE operates a station at Ponte do Peres about 15 km upstream and above Rio Matipo. The records are probably adequate for design purposes and it further appears that a CEMIG station at Oculos may still be in operation. Even if it has been discontinued its records will be of great value. Studies for the Inferno site can be based on the Oculos records with intervening area inflow estimated on the basis of the station at Bom Jesus do Galho on Rio Sacramento.

At the Escura site a station has been in operation since 1939. The Escura gaging station records and those for the Valadares station, along with tributary inflow figures for the Rio Santo Antonio, provide

a basis for hydrologic studies for the Baguari, Valadares, and Capim sites.

For the projected, Galilea site the records for the station on Rio Doce at Tumititinga (54,900 km^2) CEMIG No. C-509 (fig. 4) and those for the DNAEE station at Barra do Cuite (60,300 km^2), should be about all that are needed for the hydrologic analyses. If thought necessary for verifying ungaged inflow areas the records for Dom Caciti station on Rio Caratinga can be utilized.

Close to the Resplendar projected site is a DNAEE operated station (No. 56948) which has been in existence since 1938. The drainage area at the station is 63,000 km^2 and the records at this point should satisfy hydrologic data requirements.

The next projected site on Rio Doce is at Almores and it appears that flow data for the Resplendar gage along with those for the major intervening tributary, the Rio Manhuaçu which is gaged at S. Sebastian Encruzilhada are adequate for assessing the flow characteristics. A typical view of the Rio Doce valley between Almores and Resplendar is shown in figure 5.

The Mascarenhas plant, the farthest downstream on Rio Doce, is indicated as being under construction. A gaging station has been operated by CEMIG at this site, drainage area 74,300 km^2, but no current activity is reported. If this is correct, it is suggested that consideration be given to reactivating the station as a recording gage. If this is not feasible the station at Colatina (DNAEE No. 56994), records since 1937, drainage area 77,400 km^2, can be utilized to

Figure 4.--Staff gages and ferry on left bank at station on Rio Doce - Tumiritinga, Minas Geraís

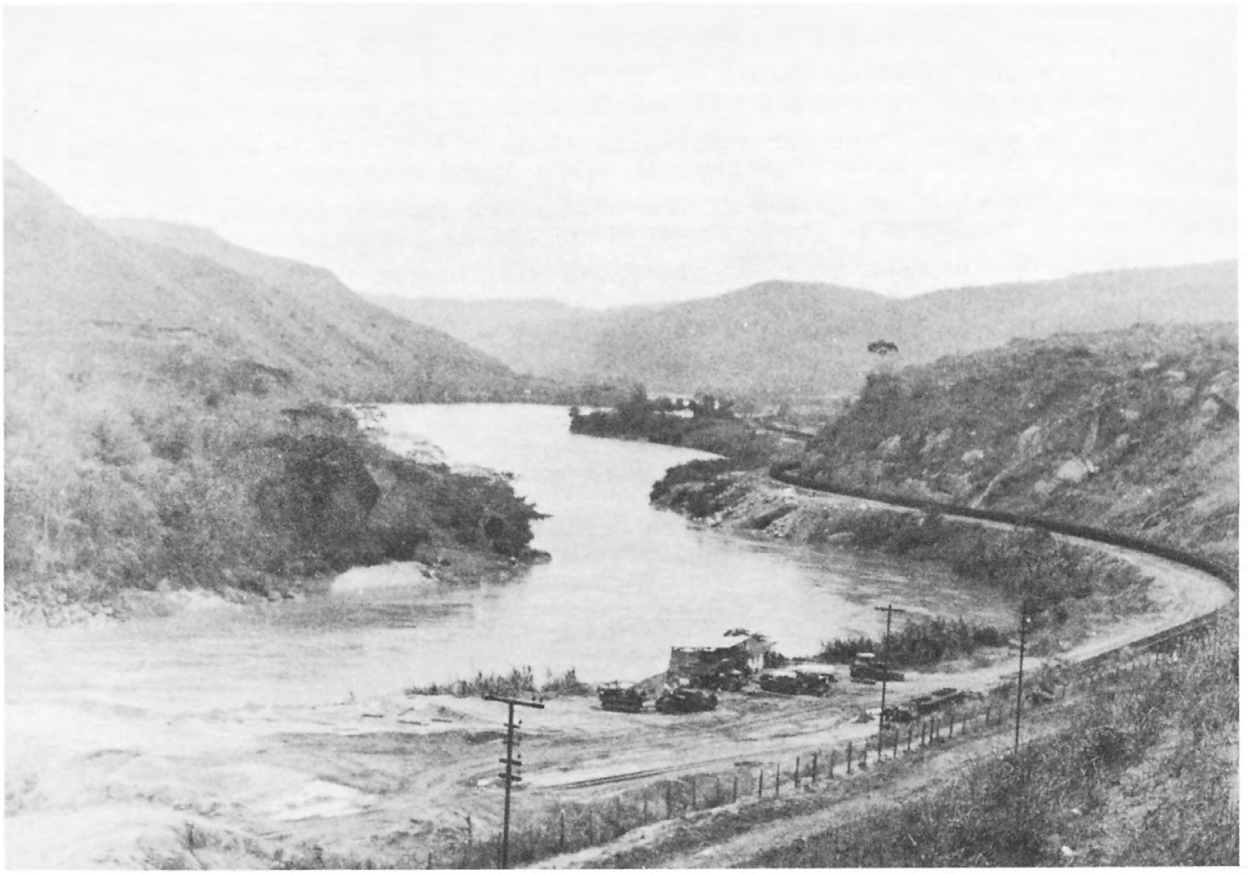

Figure 5.--A view of the Rio Doce valley between Almores and Resplendar, Minas Gerais

document the flow regimen below all hydropower developments. Perhaps the better selection would be Colatina but the station should be recorder equipped in order to provide accurate definition of the regulated flows.

For the existing plants on the various tributaries in the Rio Doce basin it appears that current gaging station coverage is adequate and no additional stations are recommended. One further observation is that as development proceeds the flows will become more severely regulated. Accurate records on regulated streams ordinarily require a recording gage so one or two stations in the upper basin might be considered for upgrading to recorder status at the appropriate time. In fact, the station at Cachoeira Oculos warrants a recording installation at this time.

Summary

Streamflow data in the south and southeast, the most populous and intensively developed part of Brazil, are generally adequate for hydropower-system operating and planning purposes. This is also true in the São Francisco basin where the stream-gaging network provides excellent coverage. In all these areas there is evidence of unnecessary duplication of work. There are situations where as many as three and occasionally four different agencies have operated gaging stations at or near the same location, with no evidence of coordination. This condition, it appears, will be phased out as DNAEE assumes responsibility for the entire hydrologic network.

As previously indicated, the hydrologic network in Brazil is in a period of transition and DNAEE is in process of incorporating all stations, or nearly all, into a unified Federal network. Such unification should be beneficial, as it will provide for the application of uniform standards of accuracy in data collection and computation, a single station indexing and numbering system to replace the existing multiplicity of station numbers, a Federal report series to assure the publication and availability of results, and the elimination of unnecessary duplication of effort. To develop a unified Federal network in a country as large as Brazil is, of course, a tremendous undertaking and is not without problems. Of great importance is the elimination of redundant stations and the careful selection of optimimum gaging sites in terms of river hydraulics for inclusion in the network.

Insofar as ELETROBRÁS is concerned there are two principal problems. One of these is to obtain streamflow data on a timely basis so that hydrologic studies can be pursued effectively and at the proper time in the planning of hydropower plants and systems, a complex and critical procedure. The other problem is to be assured that the streamflow data, upon which plant designs are predicated or upon which systems models are based, are accurate and reliable. To meet the question of timeliness it appears that DNAEE should give priority to the processing of discharge data for those stations of hydropower interest. Such a priority should not be difficult to achieve. Also it is essential that training be a continuing process for the personnel involved in the collection of field data and for those who supervise the work. The past training courses conducted by USGS personnel in cooperation with CPRM and DNAEE have been helpful, but can only be considered a beginning in the continuing process.

In the Amazon Basin, as has been stated, streamflow data are deficient from a purely scientific point of view. For the power needs that presently exist, however, the streamflow data now being collected are generally adequate, although a few additional stations have been suggested for hydrologic assessment purposes which may arise in the future.

The availability of sediment transport and water-quality data has not been reviewed, however, some data of this type are being collected. The transport and deposition of sediment in reservoirs is, of course, an element of concern to ELETROBRÁS. Heretofore, sediment has not been considered a serious problem, but on streams which transport

heavy loads of sediment it would be of value to know the approximate rates of deposition that may be expected for long-range planning purposes.

For projected telemetry installations the gaging stations should be carefully selected and all possible measures taken to ensure that stilling wells and recorders are operating properly and that the structures are adequate to shelter the required instrumentation. The station rating should also be kept up to date with prompt reporting of results each time a discharge measurement is made so that shifts in the rating can be taken into account in system operating decisions.

A few final comments are in order. (1) It is emphasized that recording gages are nearly always essential if accurate discharge records are to be obtained on regulated streams. In upgrading the network priority should be given to the installation of recording gages at such sites. An analog recorder record is also essential where suspended sediment data are collected. (2) Lack of gage datum information is a widespread deficiency. With the gradual maturing of the streamflow network and the increasing sophistication of hydrologic investigations it would be highly desirable to begin the elimination of this deficiency by the establishment of a vertical control network. This would be a major undertaking as existing control lines and ties to mean sea level are not widespread. In some areas it obviously will be impracticable to consider conventional spirit leveling at this time, but photogrammetric bridging techniques may be employed in some of them to establish elevations of adequate

accuracy for present needs. Altimetry using aneroid barometers may also be considered although this is the least desirable alternative. (3) In the vicinity of existing and projected reservoirs a knowledge of ground-water levels and behavior could prove useful in documenting changes resulting from reservoir operations and in assessing bank storage and water budgets.

A listing of gaging stations and sites of interest in hydropower development, particularly to ELETROBRÁS, is attached. The list is subject to modification as needs change.

Gaging Stations and Sites of Interest
in Hydropower Development

DNAEE No.	Other Nos.	River	Station Name	Remarks
Parana Basin				
		Paranaíba Sub-Basin		
60.085.005	551-CAEEB C-724	Paranaíba	Porto da Barra	CEMIG
60.120.000	552-CAEEB	Paranaíba	Cach. do Sertao	CEMIG
60.002.000	-	Sao Marcos	Pte. Sao Marcos	DNAEE
60.003.000	-	Sao Marcos	Campo Alegre de Goias	-
-	553-CAEEB C-721	Paranaíba	Ponte E. Campos	CEMIG
60.320.000	554-CAEEB	Quebra Anzol	Pte. J. Candido	DNAEE
60.320.002	C-716			CEMIG
60.235.000	555-CAEEB C-719-A	dos Velhos	Santa Juliana	CEMIG
60.400.000	C-713-B	Araguari	Pte. M. Viana	DNAEE
60.400.002	557-CAEEB			CEMIG
60.570.000	C-711	Corumba	Caldas Novas	CEMIG
60.600.000	-	Corumba	Corumbazal	-
60.680.000	559-CAEEB	Meia Ponte	Meia Ponte	DNAEE
60.880.000	561-CAEEB C-702	Paranaíba	Faz. Santa Fe	CEMIG
		Rio Grande Sub-Basin		
61.030.000	503-CAEEB	Aiuroca	Fazenda Laranjeiras	CEMIG
61.055.000	501-CAEEB	Grande	Madre de Deus	DNAEE
61.055.005	C-851-B			CEMIG
61.145.000	505-CAEEB	Grande	Macaia	DNAEE
-	506-CAEEB	Jacare	Usina do Anil	CEMIG
61.145.005	C-834-D			CEMIG
-	508-CAEEB C-826	Sapucai	Faz. Boa Vista	-
61.537.000	-	Verde	Porto dos Buenos	DNAEE
61.740.000	510-CAEEB C-813-A	Grande	Igarapava	CEMIG
61.786.000	512-CAEEB	Sapucai	Faz. Sao Domingos	DNAEE
61.788.000	CESP	Paulista		CESP
61.887.000	514-CAEEB	Pardo	Sao Jose do Rio	DNAEE
61.887.002		Pardo	Pardo	DNAEE
61.887.004				
-	515-CAEEB	Mogi	Passagem	DNAEE
61.930.000	-	Pardo	Pte. Joaquim Justino	DNAEE
61.941.000	517-CAEEB	Grande	Porto Jose Americo	

DNAEE No.	Other Nos.	River	Station Name	Remarks
		Tietê Sub-Basin		
62.335.000	-	Tietê	Edgar de Souza	DNAEE
62.380.000	-	Tietê	Porto Gois	DNAEE
62.515.000	-	Sorocaba	-	DNAEE
62.605.000	-	Jaguari	-	DNAEE
62.715.000	-	Piracicaba	-	DNAEE
	581-CAEEB			Select One
62.725.000	-	Tietê	Barra Bonita	DNAEE
62.790.000	585-CAEEB	Tietê	Ibitinga	
	586-CAEEB	Tietê	Promissão	
62.822.000	24-CESP	Tietê	Porto Queixada	
62.885.000	588-CAEEB	Tietê	Lussanvira	DNAEE-CESP
62.885.002	22-CESP			
		Paranapanema Sub-Basin		
64.220.000	605-CAEEB	Paranapanema	Piraju	-
	95-CESP			
64.260.000	-	Itarare	Fartura	-
64.273.000	92-CESP	Paranapanema	Porto Ermidao	Select One
64.275.000	608-CAEEB	Paranapanema	Porto Ermidao	
64.320.000	91-CESP	Rio Pardo	Sta. Cruz do Rio	
64.323.000	609-CAEEB	Rio Pardo	Pardo	
64.335.000	90-CESP	Paranapanema	Porto Jau	Select One
64.335.002	610-CAEEB	Paranapanema	Porto Jau	
64.340.000	-	Paranapanema	Usina Canoas	
64.485.000	-	Tibagi	Tibagi	-
64.490.000	-	Tibagi	Salto Maua	-
64.507.000	612-CAEEB	Tibagi	Jataizinho	-
	94-CESP			
* (81.530.000	782-CAEEB	Juquia	Barra Assungui	DNAEE Station
* (	615-CAEEB	Paranapanema	Porto Ceara	-
		Piquiri Sub-Basin		
64.820.000	-	Piquiri	Porto Formosa	DAEE
		Ivai Sub-Basin		
64.675.000	-	Ivai	Porto das Bananeiras	-

* Southeast Atlantic Basin

DNAEE No.	Other Nos.	River	Station Name	Remarks
		Iguaçu Sub-Basin		
65.060.000	CAEEB-105	Iguaçu	São Mateus do Sul	DNAEE
65.155.000	CAEEB-110	da Varzea	São Bento	DNAEE
65.200.000	-	Rutinga	Pontilhao	DNAEE
65.310.000	CAEEB-104	Iguacu	Uniao da Vitoria	DNAEE
65.825.000	CAEEB-120	Jordao	Santa Clara	DNAEE
65.880.000	-	Iguaçu	Salto Santiago	COPEL
65.895.000	CAEEB-103	Iguaçu	Salto Osorio	COPEL-DNAEE
65.895.002				Select One
65.960.000	CAEEB-123	Chopim	Aguas do Vere	DNAEE
East Atlantic Basin				
		Paraíba Sub-Basin		
58.105.000	807-CAEEB	Paraíba	Guararema	DNAEE
58.105.001				CESP
58.105.002				LIGHT
58.142.000	809-CAEEB	Buquira	Barragem Buquira	-
58.240.000	-	Paraíba	Funil	LIGHT
58.315.000	-	Paraíba	Vargem Alegre	DNAEE
58.315.001	-			
58.320.000	814-CAEEB	Paraíba	Barra do Pirai	DEMET
58.321.000		Paraíba	Barra do Pirai	DNAEE-LIGHT
58.322.000		Paraíba	Barra do Pirai	Select best
58.322.001		Paraíba	Barra do Pirai	
58.323.000		Paraíba	Barra do Pirai	
58.480.000	-	Paraíbuna	Juiz de Fora	DNAEE
58.512.000	-	Peixe	Torreões	DNAEE
58.520.000	-	Paraibuna	Sobragi	DNAEE
58.521.001				
58.630.000		Paraíba	Anta	DNAEE
58.630.000		Paraíba	Sapucaia	Select best DEMET-LIGHT
58.630.001		Paraíba		
58 652.001	815-CAEEB	Paraíba	Ilha dos Pombos	LIGHT
58.750.000	816-CAEEB	Novo	Piau	DNAEE
58.940.000	-	Muriae	Itaperuna	DNAEE

DNAEE No.	Other Nos.	River	Station Name	Remarks
Amazon Basin				
		Selected Sub-Basins		
12.500.000	-	Juruá	Cruzeiro do Sul	DNPVN
12.500.002				DEMET
15.400.002	-	Madeira	Porto Velho	DNPVN
		Madeira (Xipamanu)	Abuna	DEMET
15.430.000	-	Jamari	Ariquemes	ELETRO-BRAS
15.460.000	-	Jamari	Cac. do Samuel	ELETRO-BRAS
		Mucajai	Faz. Sto. Amaro	
		Cotingo	Cac. Band. Branca	
14.710.000	-	Branco	Caracarai	DNPVN
16.200.000	-	Jatapu	Base Siderama	ELETRO-BRAS
16.500.000	-	Mapuera	Estirao da Angelica	ELETRO-BRAS
16.650.000	-	Trombetas	Cach. da Porteira	ELETRO-BRAS
16.800.000	-	Erepecuru	Vista Alegre	DNPVN
18.120.000	-	Curua-Una	Cach. do Palhao	CELPA
		Possible New Stations		
		Moa	Acampamento	
		Mamore	Ouro Preto or Guajara-Mirim	
		Lage	Guajara-Mirim	
		Cotingo	Bacurau	
		Jari	St. Ant. da Cach.	
		Corua		
		Maiçuru		
Atlantic North-Northeast Basin				
		Araguari	Paredão Montante	
		Possible New Stations		
		Araguari	Downstream from Rio Murare	
		Amapari	Downstream from Rio Ita	

DNAEE No.	Other Nos.	River	Station Name	Remarks
São Francisco Basin				
		Selected Sub-Basins		
40.100.000	-	São Francisco	Ponto Das Andorinhas	DNAEE-CEMIG
40.130.001	-	Pará	Ponte do Vilela	CEMIG
40.450.000	CAEEB-904	Pará	Porto Pará	CEMIG-SUVALE
40.845.000	-	Paraopeba	Santa Cruz	DNAEE
40.850.000	-	Paraopeba	Ponte da Taquara	DNAEE-CEMIG
40.960.000	-	Indaia	Fazenda Bom Jardim	CEMIG SUVALE
40.975.000	-	Borrachudo	Fazenda São Félix	DNAEE
41.020.002	CAEEB-907	São Francisco	Três Marias	CEMIG
41.090.002		Abaeté	Ponte Abaeté	DNAEE-CEMIG
41.130.000				
41.130.001	CAEEB-909	São Francisco	Pirapora	DNAEE
41.130.002	C-126-C			CEMIG
41.130.003				SUVALE
41.160.000		Das Velhas	Gulpiara	-
41.185.000		Itabirito	Usina Esperanca	-
42.160.000	-	Jequitai	Faz. Mandacaru	SUVALE
42.210.000	-	São Francisco	Cac. da Manteiga	SUVALE
Atlantic Coast Basin				
		Rio Doce Sub-Basin		
56.075.000	-	Piranga	Porto Firme	DNAEE
56.085.000	-	Turvo Sujo	Serquite	DNAEE
56.090.000	-	Turvo Limpo	Faz. Varginha	DNAEE
56.110.000	C-536-B	Piranga	Ponte Nova	DNAEE-CEMIG
56.305.000	C-535-A	do Carmo	Acaiaca	DNAEE-CEMIG
56.330.000	-	Gualaxo do Norte	Faz. Ocidente	DNAEE

DNAEE No.	Other Nos.	River	Station Name	Remarks
56.430.000	-	Doce	Ponte do Peres	DNAEE
56.540.000	-	Doce	Cach. de Oculos	CEMIG
56.565.000	-	Sacramento	Bom Jesus do Galho	DNAEE
56.660.000	-	Piracicaba	Nova Era	DNAEE
56.720.000	C-525-B	Doce	Cach. Escura	DNAEE-CEMIG
56.775.000	CAEEB-852	Santo Antonio	Ferros	DNAEE-CEMIG
56.810.000	CAEEB-851 C-519-B	Guinhães	Faz. Meloso	CEMIG
56.830.000		Santo Antonio	Nague do Meio	DNAEE
56.850.000		Doce	Gov. Valadares	DNAEE
	C-509	Doce	Tumiritinga	CEMIG
56.941.000	-	Doce	Barpa do Cuite	DNAEE
56.948.000	-	Doce	Resplendor	DNAEE
56.990.000	C-502	Manhuaçu	São Sebastião da Encruzilhada	DNAEE CEMIG
56.994.500	-	Doce	Colatina	DNAEE