BIOLOGICAL STUDY OF THE GEUS RIVER BASIN

by

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INTRODUCTION

As part of a project of the U.S. Army Corps of Engineers to conduct studies of the major river basins on Guam, the Geus River Basin study contracted to the University of Guam was subcontracted to the Division of Fish and Wildlife, Department of Agriculture, Government of Guam.

SCOPE OF WORK

The study involved the inventory of aquatic inhabitants of the river, the flora and fauna in the watershed including notes on the physical features of the river such as flow data, temperature, chemical analysis, geology and climatic factors having a bearing on the total complex ecosystem. The potential future use of the basin is discussed. Much of these data were obtained from various sources cited in the text as well as from notes made during the explorations of the basin.

DESCRIPTION OF THE GEUS VALLEY AND RIVER

Topography

The Geus Valley is located on the southwestern tip of the island near the village of Merizo (Figures 1 and 2).

The Geus River Basin drains an area approximately 4.5 square miles of mostly mountainous land. The mountainous area has the greatest relief on the island with the sharpest and most complex occurring in the lands bordering the basin. On the west lies Mt. Schroeder at an elevation of 322 meters (Figure 3); on the north, Mt. Bolanos (elevation 379 meters) with Mt. Illicho at the immediate headwater area (elevation 371 meters) and on the east lies Mt. Sasalaguan (elevation 337 meters) with Mt. Finosantos (elevation 285 meters) (Figure 4).

The headwater slopes of the Geus are precipitous with a slope of 80 degrees in spots but average 55 degrees. Narrow waterfalls are formed by runoff from the slopes of Mt. Illicho, Schroeder and Sasalaguan. These slopes are primary, secondary and tertiary in nature, varying from precipitous to steep. However, there is no principal or overall slope in the area (1). The only broad valley is located in Biotope 6.

The Geus is a river formed by water runoff, springs and water table drainage. There are two main forks. The actual headwater region lying 500 - 700 feet above sea level develops from drainage rivulets, dropping

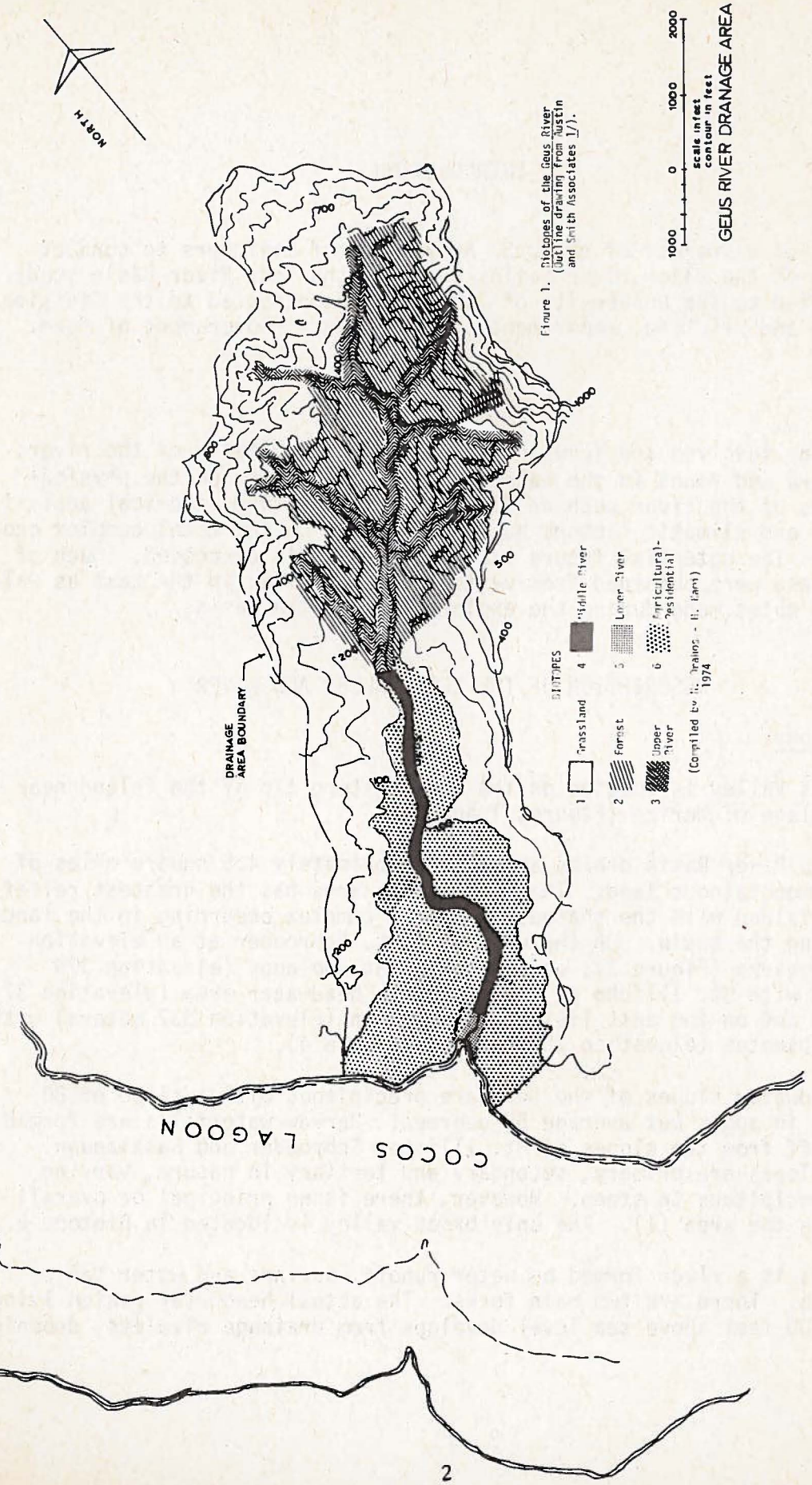

Figure 1. Photomes of the Geus River (Outline drawing from Austin and Smith Associates [7]).

Figure 2. Geus River Basin. Upper left corner, Mt. Bolanos; Upper right corner, Sasalaguan range.

Figure 3. Mt. Schroeder.

to 150 feet within the next half mile, with the remainder of both branches well below 50 feet in the next mile or so. The left fork (facing upstream) is shorter by about one half mile, ending at the east base of Mt. Schroeder as it meets the southwest shoulder of Mt. Illicho. The right main fork of the Geus is fed by one major stream between Mt. Sasalaguan and Mt. Finosantos but is essentially one stream as is the left fork. The main stream bed, below the mountain slopes, is narrow and studded with boulders of various sizes (Figure 5). Small shallow pools and riffles are formed as the river courses through the narrow valley.

The river is also fed by several springs, the largest of which is the Siligan Spring with a normal flow of 30,000 gpd to 70,000 gpd. The normal daily flow of the river is slightly more than 600,000 gpd. However, a maximum flow 1.9 billion gallon per day was recorded on October 19, 1960 (6). During the dry period, the river is dry for about 20% of the year (2). The daily water temperature ranges from 25°C to 28°C with an annual average of 27°C (U.S. Geological Survey Records from 1967 to 1973).

About midway, the river is impounded in a small reservoir with a capacity of about 30,000 gallons built in 1947 by the Government of Guam and renovated in 1970. This impoundment serves as a source of potable water for the village of Merizo (Figure 6). Water from the reservoir is pumped to a 500,000 gallon storage tank by the Pigua Pumping Station located in a shallow valley below the reservoir. According to the Public Utility Agency of Guam, about half a ton of silt is removed from the reservoir periodically, especially after periods of heavy rainfall. A study by an engineering firm concluded that it would be uneconomical to further develop this river as a source of potable water supply (2).

The shallow flood plain and valley below the impoundment is composed of alluvium but is predominantly overlain with Pago Clay* of fair drainage characteristics interspersed with impervious muck land which is used for meadows rather than agriculture. Residences, small garden plots, banana plantations and exotic plantings line the road from the Siligan Spring area to the sea (Figure 7).

The river coursing this valley widens to about 10 meters. Near the mouth, a short bridge spans the river over which Route 4 crosses. The river opens in an alluvial delta formed by silt deposits below the bridge and is bordered by stands of Rhizophora spp., Hibiscus tiliaceus and Nypa palm (Figure 8). A short distance from the delta, the river joins the Mamaon Channel and the sea (Figure 9).

Geology

The Geus Watershed is part of the Umatac formation deposited during early Miocene times composed of three major geologic formations: 1) Volcanic

* Pago Clay is a firm granular, reddish-brown clay with a mottled substrate below 24-30 inches, fairly well drained but subject to flooding (1).

Figure 4. Left, Mt. Sasalaguan; center, Mt. Finasantos.

Figure 5. Stream beds of boulders, riffles and pools of the head water region (Biotope 3).

Figure 6. Small impoundment used as a source of potable water for the residents of Merizo.

Figure 7. Agricultural - Residential Valley (Biotope 6).

Figure 8. Alluvial delta near the mouth of the Geus River (Biotope 5).

Figure 9. Mouth of the Geus River flowing into the Mamaon Channel (Biotope 5).

conglomerates in the highlands 2) Lava Flows and Dikes and 3) Alluvium (1).

1. Volcanic conglomerates in the highlands form the major portion of the Geus Valley slopes and the upper valley floors. The upper parts of the mountains consist of basalt flows with interbedded and bedded tuffaceous shales, sandstones and conglomerates; the lower parts, of thick, moderately hard pillow basalts and dikes. There is some interbedding greyish limestone (1).

   The pH is 4.5 to 6.5, averaging 5.25 in the red lateritic upland soils above the water table and neutral to slightly alkaline in soils permanently below the water table. The zone of corrosion is generally above the water table and probably active below the water table in the zone of fluctuation (1).

   Engineering Characteristics

   Weathered rock can be worked with hand tools; rock must be drilled and blasted. Crushed dike rock can be used for aggregate. Roadbeds, especially on weathered rock, must have adequate drainage. Deep road cuts would need (in weathered rock areas) 2:1 benched slopes and deep fills on weathered rock need 3:1 to 4:1 slopes (1).

2. Lava Flows and Dikes

   Approximately 85% of the Geus Valley terrain is made up of lava flow under structure. The lava flow consists of 70% dark lava, 25% of grayish tuffs and volcanic conglomerates and less than 5% of interbedded grayish limestone. The upper sections consist of massive and bedded tuffaceous shales, sandstones and conglomerates interbedded with basalt flows. The lower sections consist of thick, moderately hard pillow basalts and possible dikes (1).

   Engineering Characteristics

   Foundation conditions for structures on these soils are variable. The bearing capacity of soft weathered rock is poor to fair. Footing support in weathered rock requires drainage construction because saturation of the rock reduces the bearing capacity; heavy towers on soft rotten rock need spread footings. The best foundation sites on weathered rock are on terraces where slumping and creep are less common. The bearing capacity of massive hard rock is excellent but the capacity of fractured or brecciated hard rock is less. Footings on buried hard rock require safeguards against ground water. Sites for heavy structures should be located away from fault and dike zones and should be inland from the edges of cliffs and steep slopes where erosion may weaken footing support (1).

   The area under discussion is steep for a mile except in the lower valley. Roads on terraces in weathered materials have gentle gradients, long radius curves and long alinements whereas roads across steep terrain would have steep gradients, short radius curves and alinements of variable lengths. Extensive cut-and-fill is necessary except on terraces; cuts probably will equal fills in volume. Deep cuts in the soft weathered rock require benched slopes of 2:1; fill slopes are stable at 3:1 to 4:1 and must be stablized to prevent slope wash and sliding. Berms, side drains and ditches in weathered rock must be protected against erosion. Most excavations can be made with power equipment (1).

3. Alluvium

   The floor of the Geus Valley is alluvium. Landforms include a nearly level to gently sloping sinuous flood plain, flattened in an alluvial fan in the coastal area. Stream channels are V-shaped and winding in the upper fourth of the valley. The alluvium varies 5 to 150 feet thick, composed of clay sediments. The topsoil is Pago Clay and silts are of varying colors - yellow, brown-red - mixed with organic matter. The subsoils are generally firm to plastic when moist; soft, plastic and sticky when wet and very hard and cracked when dry. Overburden consists of a topsoil zone 0.5 to 1.5 feet thick. Vertical slumping and cracking are caused by alternate wetting and drying of the alluvium materials. The exposed material is subject to columnar-angular jointing; the joint blocks become very hard when dry and firm to soft when wet (1).

   The water table of the alluvium varies in depth from a few feet near the coast to tens of feet inland. The bearing capacity of the alluvium is generally poor (1).

   Engineering Characteristics

   The Alluvium above the water table can be excavated easily with hand or machine tools but the feasibility of pumping and shoring excavations below the water table is unknown. Vertical excavations above the water table will stand for a short time only due to raveling, cracking and slumping. Maximum slopes of 1/2:1 are stable in unshored excavations for a long time. Dikes and diversion ditches are needed to prevent flooding in the wet season. Stream banks not subject to lateral wash stand vertically to heights of 10 feet (1).

   New roads can be constructed easily during the dry season. But in the wet season, culverts must be designed for 100% runoff when the soils are saturated. Road fills on slopes need drainage construction to prevent upslope ponding which produces saturation in the subgrade, thereby causing creeping or slumping on the fluid soil in the subgrade (1).

CLIMATIC FACTORS

Normal rainfall during the course of a year varies from 1 to 12 inches per month in the Geus River Valley. This is supplemented in the stream by water runoff from the mountains where rainfall, during the rainy season, averages 16 inches between the months of August and November (1).

Approximately 100 to 110 inches of rainfalls on this area, with not less than 2 inches during the driest months of February through April. Four inches is the normal maximum in the Geus Valley during these dry months. Because Guam is subject to repeated invasions of very moist, unstable air during the rainy season, especially within the zone of influence of passing typhoons or tropical storms, extreme rainfall intensities are very high. To illustrate: a rainfall of 26.0 inches fell in a single day during a typhoon on October 14, 1953 with a two day total of 48 inches within five miles of the valley at the village of Umatac. A maximum of 7 1/4 inches fell in a 2 1/2 hour period there (1).

Regional planning for water storage necessarily must take into consideration not only the high yearly rainfall average but also the extremely high rainfall potential during the typhoon season. Similarly, drought is a normal feature on Guam which usually occurs as mentioned above but which can deviate from the norm, to run from December through May (1).

TERRESTRIAL FLORA AND FAUNA

The Geus Valley vegetation can be broken down into distinct biotopes - the Upland Savanna, the Ravine Forest and the Agricultural Flood Plain.

Savanna Upland (Biotope 1)

The tops of the mountains bordering the Geus River basin are covered with a combination of Miscanthus floridulus swordgrass, mixed grasses and ferns as follows:

Grasses

Miscanthus floridulus
Dimeria chloridiformis
Curculigo orchioides
Chrysopogon aciculatus
Pennisetum polystachyon
Brachiaria mutica
Scleria caricina
Cenchrus echinatus

Ferns

Ctenitis subglandulosa (rare, in savanna)
Davallia solida
Cyathea lunulata (uncommon)
Sphenomeris chinensis
Thelypteris dentata
Thelypteris unita
Blechnum orientale
Lycopodium cernuum
Cycas circinalis

Shrubs

Melastoma marianum
Tyrtella bennigseniana
Leucaena leucocephala

Ravine Forest (Biotope 2)

The ravine forest composed primarily of Areca catechu (Betelnut), Pandanus spp. (Screw Pine), Cocos nucifera (Coconut Palm), Bambusa spp. (Bamboo), Triphasia trifolia (Limon-china), and Hibiscus tiliaceus (Pago) are dominant along the banks of the Geus River and its tributaries. Interspersed among the ravine forest vegetation, which is typical of southern volcanic soil, are some limestone forest plants found adjacent to limestone outcroppings.

Generally, the canopy does not exceed forty feet in height. Visibility beneath the canopy is limited. The undergrowth is dense, thorny and generally difficult to walk through, particularly since much of the growth is on steep river bank slopes. The transition zone between the savanna and the ravine forest is especially difficult to walk because of the rank growths of Miscanthus floridulus (Swordgrass). No structural timber is present in the valley.

The general character of the vegetation indicates that the forest is not a climax forest but is of a secondary nature. The bamboo flats, in isolated spots on the upper valley floor, probably were cultivated in ancient times. These areas are minor clearings, hemmed in by the steep slopes, and are subject to periodic, deliberate fires.

The following plants are found in the Ravine Forest Area (Biotope 2):

Trees, Shrubs and Vines

Cananga odorata
Artocarpus mariannensis

Artocarpus incisus
Triphasia trifolia
Pandanus fragrans
Pandanus dubius
Areca catechu
Hibiscus tiliaceus
Bambusa vulgaris
Flagellaria indica
Musa nana
Cocos nucifera
Timonius nitidus
Pipturus argenteus
Morinda citrifolia
Capsicum frutescens
Piper guahamense
Dioscorea bulbifera
Entada pursaetha
Medinilla rosea
Abrus precatorius
Hernandia nymphaeifolia
Pithocellobium dulce
Mangifera indica
Antigonon leptopus

Casuarina equisetifolia
Ficus prolixa
Ficus tinctoria
Ceiba pentandra
Muntingia calabura
Carica papaya
Leucaena leucocephala
Freycinetia reineckei
Cynometra ramiflora
Glochidion marianum
Mikania scandens
Ipomoea triloba
Cordia subcordata
Guamia mariannae
Nypa fruticans
Rhizophora apiculata
Rhizophora mucronata
Avicennia alba
Tectona grandis
Melastoma marianum
Cordyline fruticosa
Diospyros discolor

Ferns

Asplenium nidus
Microsorum punctatum
Davallia solida
Humata heterophylla
Pyrrosia adnascens
Dicranopteris linearis
Nephrolepis hirsutula

Cycas circinalis
Cyathea lunulata (scarce)
Adiantum philippense (Uncommon)
Sphenomeris chinensis
Pteris spinescens
Vittaria elongata
Angiopteris durvilleana (uncommon)

Grasses and Other Vascular Plants

Commelina spp.
Rhoeo spathacea
Bidens pilosa
Phragmites karka
Curcuma domestica
Hyptis capitata
Hyptis spicigero
Elephantopus mollis
Digitaria pruriens
Stachytarpheta indica

Mimosa pudica
Eragrostis tenella
Teramnus labialis
Alocasia macrorrhiza
Cyperus spp.
Spathoglottis plicata
Emilia javanica
Taeniophyllum mariannense
Desmanthus virgatus

Plants were classified according to B. C. Stone's Flora of Guam (4).

Rare or Uncommon Plants

The fern Ctenitis subglandulosa is listed by Stone (4) as rare. It is found only on the Geus valley savanna slopes as far as is known today. We did not have time to search for it and no samples were in the University of Guam Herbarium. Another uncommon plant found in the valley was the Philippine Maidenhair fern Adiantum philippense, growing on steep river banks in moist, shady areas on the headwaters of the left fork of the river.

Cyathea lunulata, a tree fern, is also an uncommon fern found on southern volcanic soils as well as the Giant Fern, Angiopteris durvilleana. While both fern species are found in other parts of Guam, only a few of these ferns are found in the Geus Valley, particularly near the cool upper headwaters savanna/forest ravine margins.

Agricultural - Residential (Biotope 6)

The flood plain area of the valley is the most disturbed biotope. This area has been cleared of almost all of the native vegetation and replaced with small plots of vegetable crop farms and residences surrounded by many exotic tropical plants (Figure 7).

Mammals

The Geus Valley contains a very limited population of Guam Deer, Cervus mariannus and the feral pig, Sus scrofa. The Polynesian Rat, Rattus exulans, the Norway Rat, Rattus norvegicus, the Roof Rat, Rattus rattus, the House Mouse, Mus musculus and the Musk Shrew, Suncus murinus are common.

All of the above were introduced to the island either intentionally or accidentally. Suncus murinus was first detected on Guam in 1953 and within three years was common on the entire island (3). They are common scavengers of the forest, villages and agricultural areas. The Norway and the Roof Rats are found primarily within Biotopes 4 and 6 while the Polynesian Rat is found in all the vegetative biotopes.

There is no evidence that the Mariannas Fruit Bat, Pteropus mariannus frequents the valley.

Reptiles

The monitor lizard, Varanus indicus, was not seen and is scarce in this southern region. The Gecko, Hemidactylus frenatus as well as the Blue-tailed Skink, Emoia cyanura, the skinks Emoia callisticta werneri and

Carlia fuscum, are common in Biotope 2. Anole carolinensis, the American Chameleon, is found primarily in Biotopes 4, 5 and 6 near residences.

The Philippine Rat Snake, Boiga irregularis and the Blind Snake, Typhops braminus, are present but not in any abundance. The Blind Snake burrows in moist humus and can be found near habitation as well as in the forest ravines whereas the Philippine Rat Snake is found primarily near habitation.

Amphibians

The giant marine toad, Bufo marinus, native to Mexico and South Central America, is common and was introduced to Guam in 1937 (5). The secretions of its large parotid glands are poisonous to some animals. Its introduction to Guam is said to have been made in the hope of controlling destructive insect pests, slugs and centipedes (5).

An unidentified small green tree frog, 1 1/8 inches long inhabits the valley. Dr. Donald M. Davis, Herpetologist at the University of Guam, believes it to be an Australian species but not a Hyla.

Birds

There is a great paucity of birds in the Geus Valley. Occasionally, the following species are found: Philippine Turtle Dove, Streptopelia bitorquata dusumieri; White Tern, Gygis alba candida; Chinese Least Bittern, Ixobrychus sinensis and a Tattler, Heteroscelus sp. The Eurasian Tree Sparrow, Passer montanus saturatus and the Chestnut Manikin, Lonchura malacca jagori are frequently found but are not regarded as common.

Land Snails

The Giant African Snail, Achatina fulica, was accidentally introduced to Guam during World War II and spread rapidly throughout Guam. Pigs are reported to serve as a partial control (3) (possibly on the young found while grubbing for roots) as well as the predator snails Euglandina rosea, Gonaxis kibwigiensis and Gonaxis quadrilateralis. These three snails were introduced to control the Achatina. How successful these predator snails may have been is uncertain as no studies have been made to assess their effects.

AQUATIC BIOTOPES AND FAUNA

There appear to be three distinct biotopes formed by the Geus River - the Headwater Region, the Mid-Valley Region and the Lower Valley Region (Figure 1).

Headwater Region (Biotope 3)

This biotope is characterized by a narrow, boulder strewn river bed with the water flowing rapidly between these boulders collecting in small irregular pools and spilling over shallow riffles, to pass through more boulders, pools and riffles (Figure 5). This area extends from the base of the mountains and terminates at the small water impoundment.

A single water sample taken from this biotope and tested for fecal contamination indicated counts (23 FC/100 ml) well below the Federal Water Quality Standards.

Two species of gobies, Microsicydium elegans (Steindachner), Sicyopterus macrostetholepis (Bleeker), and the fresh-water eel, Anguilla marmorata Quoy and Gaimard, are the fishes commonly found in this biotope (Table 1). A third goby, Chonophorus guamensis, (Cuvier and Valenciennes) may possibly occupy this biotope but was not collected.

Of the gobies, the small attractive goby, M. elegans appears to be more numerous than the larger goby, S. macrostetholepis. Although all of the eels collected from this biotope were small (TL 111 mm to 402 mm), the number taken (41) indicates that they are fairly abundant in this biotope.

The aquatic invertebrates include the large fresh-water shrimp, Macrobrachium lar, and small shrimps of the genus Atya and Caridina. Also a single species of aquatic snail, Neritina pullegera (Linn.) occupy this biotope.

Mid-Valley Region (Biotope 4)

The stream bed in this biotope is of loose pebbles and alluvium with very few boulders (Figure 10). The river is quite free running, forming shallow riffles at places and shallow pools at others. This section of the river extends from below the impoundment through the flat open valley to the bridge spanning Route 4.

A single water sample taken from this biotope showed a fecal count of 200 FC/100 ml, which is just on the border line of safe water according to Federal Water Quality Standards. It is suspected that the counts would be variable depending on the run off from the pig pens, chicken coops and pastures along the bank of the river.

Although no organisms were collected from this section of the river, a visual check of the area revealed juvenile Kuhlia rupestris (Lacepede) to be the most abundant fish species occupying this habitat. Other

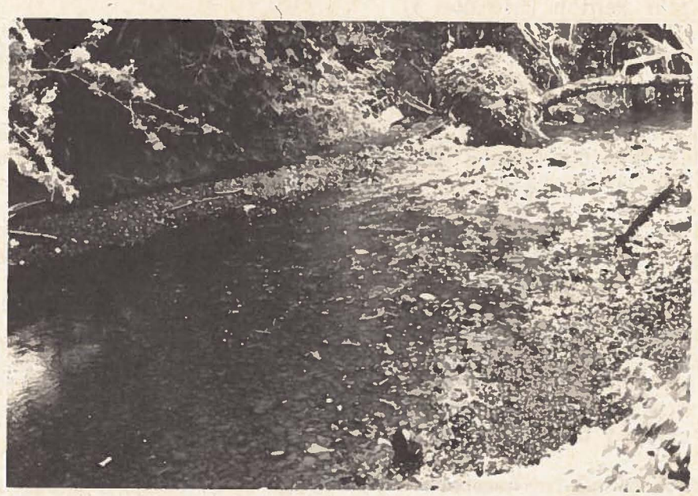

Figure 10. Stream bed of loose pebbles and alluvium (Biotope 4).

fishes observed in this section of the river were Tilapia mossambica (Peters), S. macrostetholepis and Chonophorus guamensis (Cuvier and Valenciennes).

The smaller species of goby, M. elegans, as well as the small Atyid and Caridinid shrimps, common above the impoundment, were not observed in this biotope. However, the large shrimp, M. lar, was seen.

The absence of the small shrimps and gobies from this section of the river may possibly be attributed to heavy predation by juvenile K. rupestris which dominate this biotope.

Lower Valley Area (Biotope 5)

This biotope includes the area from the bridge to the alluvial delta adjacent to the Mamaon Channel (Figure 7 and 8). This portion of the river is influenced by tides and therefore is estuarine in nature. Salinity measurements taken during high tide from an area just below the bridge showed a reading of 4.4 o/oo while down river near the alluvial delta, the salinity increased to 7.7 o/oo. The river bed in this area is of coarse alluvial deposits.

Water samples collected routinely from the mouth of the Geus River by inspectors from the Guam Environmental Protection Agency indicate this area to be highly contaminated by fecal matter (13,000 + FC/ml).

It is apparent that as the river flows along the residential - agricultural valley (Biotope 3), the rate of contamination increases because the number of pig pens, chicken coops, pastures and probably leakages from septic tanks along the river bank increases.

Numerous species of fish commonly associated with estuarine habitat were observed but not collected. Among the species observed in this section were adult and juvenile K. rupestris, large adult T. mossambica, half beaks Zenarchopterus dispar (Valenciennes), tarpon Megalops cyprinoides (Forskal), A. marmorata, an unidentified eleotrid, numerous juvenile mullets, Mugil sp., and Periopthalmus sp. The mullets were the most abundant fish in this biotope. Near the bridge, several large shrimps, M. lar, were also seen.

The fiddler crab, Uca sp., was also observed on the banks near the mouth. Numerous holes, presumed to be Cardiosoma burrows, were found in the delta area.

Table 1. Aquatic Organisms Collected or Observed at the Three Aquatic Biotopes.

	BIOTOPES		
	3	4	5
FISHES			
Microsicydium elegans	X		
Sicyopterus macrostetholepis	X		
Chonophorus guamensis		0	
Anguilla mamorata	X	0	0
Kuhlia rupestris		0	0
Tilapia mossambica		0	0
Mugil sp.			0
Zenarchopterus dispar			0
Megalops cyprinoides			0
Caranx sp.			0
Eleotrid			0
Periopthalmus sp.			0
SHRIMPS			
Atya sp.	X		
Caridinia sp.	X		
Caridinia sp.	X		
Macrobrachium lar	X	0	0
MOLLUSK			
Neritina pullegera	X		
CRABS			
Cardiosoma sp.			0
Uca sp.			0

X Collected
0 Observed but not collected.

DISCUSSION

The upper Geus River Valley is one of the more singular areas at the extreme southern tip of Guam, for it is (1) already a surveyed Government of Guam Conservation Reserve Area; (2) it is isolated; (3) it is basically forested albeit without valuable timber resources; (4) it has greater potentials for recreation than it now serves; and, (5) at present, it serves as the principal potable water supply of the village of Merizo.

There is reputed to be a unique and rare fern on its mountainous savanna slopes, the Ctenitis subglandulosa fern. In some of its headwater areas are other uncommon ferns: the Philippine Maidenhead, Adiantum philippense, the Giant Fern, Angiopteris durvilleana and the Tree fern, Cyathea lunulata. These ferns are found only in the southern half of Guam in isolated spots and, therefore, add to the singularity of the Geus River Valley.

The flora of the ravine forest (Biotope 2), once disturbed, is regaining its former natural state but the vegetation of the upland savanna (Biotope 1) and the flat valley (Biotope 6) are highly disturbed: the savanna by frequent fires and the valley by cultivation and urbanization.

The upper valley supports only a small population of game animals. Hunting activities are minimal. Since the area is uninhabited, it is relatively undisturbed except for periodic burning of bamboo areas and small clearings. The flora of the ravine forest is typical of the southern forests. This by itself is of significant importance and the forest should be preserved in its natural state.

Biotope 3, if left in its present state, would serve as an excellent area for picnicking, camping, hunting, hiking and nature study. Biotopes 4, 5 and 6 have been disturbed by man and have lost their value as natural scenic areas.

As the population of Guam doubles and triples in future years, the significance and importance of the Geus River Valley will increase many times not only for its beauty, its watershed capacities and capabilities but for being a "green island" in the midst of urbanization, a place for relaxation and contemplation.

The fresh-water fishes and shrimps which inhabit the Geus River are common to other rivers of the island. The Geus River, basically being narrow and shallow, would be highly susceptible to any physical alterations of its banks or of the slopes of the surrounding mountains.

Any major clearing of vegetation and exposure of the soil to erosion either along the banks or slopes of these mountains could easily result in heavy siltation of the river beds.

The major predator of the small gobies and shrimps within Biotope 3 is the eel, A. marmorata. The spillway of the impoundment (Biotope 4) forms a barrier preventing the entry of another major predator, the perch-like K. rupestris into this biotope.

In Biotope 4, the presence of K. rupestris and A. marmorata form a formidable predator combination against the gobies and shrimps. Therefore, the smaller species of gobies and shrimps are absent from this biotope.

Biotope 5 essentially is an estuary and most of the species commonly found in Guam estuaries can be expected to occupy this habitat.

The river may support limited recreational fishing for eels and large shrimps but strict conservation regulations on the various species will be needed to accomplish this.

RECOMMENDATIONS

It is recommended that because the upper Geus River Valley is of such singular importance to the southern portion of Guam, namely the Merizo environs, that the following recommendations be considered and be implemented wherever possible:

1. That the upper Geus River Valley remain in its present state - a natural government conservation reserve area, to be used primarily for outdoor recreation such as hiking, hunting, fishing, nature study and picnicking;

2. That no land clearing of any kind be done in the upper savanna and that clearing in the narrow upper valley be highly restricted;

3. That recreational fishing for eels and large shrimps be allowed but based on strict conservation regulations, compatible with the reproductive abilities of the species present;

4. That reforestation of the upland savanna be given priority rating to maintain and improve the area for beauty, timber reserves, game and to increase the water holding capabilities of the land; and,

5. That fire control measures should be instituted.

LITERATURE CITED

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