

ENVIRONMENTAL SURVEY OF A
PROPOSED FILL SITE IN AGANA SWAMP

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by

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Environmental Survey Report

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INTRODUCTION

The Marine Laboratory of the University of Guam was contracted by Jones and Guerrero Company, Inc. to conduct an environmental survey for a fill project to enlarge a parking lot at the company's Agana Shopping Center location. Such a survey is requisite for the issuance of a U. S. Army Corps of Engineers permit for any work done in Guam's navigable waters or wetlands.

The area to be filled is a portion of the Agana-Chaot River Basin, which drains westward near the center of Guam (Fig. 1). Because this basin contains the largest expanse of wetland on the island it is an Area of Particular Concern, as defined in the Bureau of Planning's Draft Land-Use Plan, its Community-Design Plan, and its Draft Coastal Management Program. An Area of Particular Concern is identified as a specific geographic area in which natural resource values, geologic constraints or hazards are important in determining the capability or suitability of the land for particular uses.

The proposed fill site is a triangular area covering 6,785.11 m² of wetland behind the Agana Shopping Center Complex on Route 4 and adjacent to the powerline access road through Agana Swamp (Fig. 2). The land would be filled in order to provide parking for employee and company vehicles and to allow access to loading and unloading facilities.

Scope of Work

The areas of study encompassed within this report include the following:

1. a review of existing knowledge about the Agana Swamp as it relates to the proposed fill project;
2. species checklists of the flora and fauna of the area;
3. quantitative estimates of dominant plant species;

4. estimates of relative abundance of other species of organisms in the area;
5. analysis of dissolved chemical components of the standing waters of the area.

Previous Studies

The Agana-Chaot River Basin has been described as consisting of three ecological units or "biotopes" (Randall and Tsuda, 1974). These units are wet land, dissected hilly land, and river estuary. The portion of the basin of interest in the present study consists only of wet land.

The wet land unit is further divided into ecological subunits (called "facies" by Randall and Tsuda). The wet land subunits are designated "marsh land," "swamp land," and "open water."

The distinction between marsh land and swamp land results from physiographic differences. Marsh land lies below the 5-foot contour, and it has predominantly herbaceous vegetation. Swamp land lies between the 5-foot and 10-foot contours, where drainage is better and where woody trees and shrubs are the predominant vegetation. The swamp land forms the perimeter of the marsh land and the edge of limestone hummocks, which are elevated ridges of limestone dominated by woody tree and shrub vegetation (Randall and Tsuda, 1974).

A powerline access road bisects the marsh land immediately adjacent to the study area. This access road has cut off the free flow of the Agana River except in a depression in the east-central area, where water flows over, and probably through, the limestone fill of the roadbed. As a result, the normal drainage of the marsh to the south of the road has been affected (Randall and Tsuda, 1974).

Previous investigators have found that the reed Phragmites karka is the predominant plant in the marsh land (Randall and Tsuda, 1974; Moore et al., 1977). This reed forms dense stands on a substratum of muck, a rich, black mixture of decayed plant matter and clay, silt, and limesand or shell fragments. The muck overlies the argillaceous limestone members of the Mariana geologic formation (Randall and Tsuda, 1974).

The water level in the marsh varies with the season and with the amount of rainfall. Water from the marsh land drains into the Agana River, which has become silted in and overgrown by the marsh east of O'Brien Drive.

The sensitivity of the marsh land to the activities of man was discussed by Moore et al. (1977). These authors point out that dredging, channeling, and filling of the marsh may have adverse effects on the fresh-water lens beneath the swamp. Recommendations were made to preserve the area from further development.

The ecological and socioeconomic importance of the flora and fauna of the Agana-Chaot River Basin, with emphasis on the Agana Springs Nature Reserve, has been discussed by Belk, Merten, and Shafer (1971). It is the opinion of these authors that the nightingale reed-warbler (Acrocephalus luscini luscini) is in danger of extinction due to encroachment on its habitat. Randall and Tsuda (1974) indicated that the endemic white-browed rail Poliolimnas cinereus micronesiae also may be threatened.

MATERIALS AND METHODS

Three transects were established in the survey area parallel to the powerline access road and extending into the marsh from the Agana Shopping Center property (Fig. 3). The plant growth was so dense that it was necessary to use a machete to clear space for each transect.

To accommodate the differences in size and in abundance of the predominant plant species, estimates of standing crop were determined by different methods. For the reed Phragmites karka, 1-m² quadrats were established at 10-m intervals on each transect line. The numbers of live reeds and dead reeds and stumps were recorded for each quadrat. The identities and abundances of other species occurring in the quadrats were noted. In five of the 1-m² quadrats, live plants, roots, and dead matter were harvested, dried, and weighed to provide an estimate of biomass.

For the fern Acrostichum aureum and the tree Hibiscus tiliaceus, individuals were counted in 3-m x 10-m plots on each transect. Specimens of A. aureum occurring in the 1-m quadrats described above were also harvested, dried, and weighed.

Animals and other plants observed on the transects or on the periphery of the study area were recorded for compilation of species checklists. Fish were observed at the surface of pools or collected by means of a baited trap. Birds were observed with binoculars during 2-hr periods at dawn and at dusk.

Water samples for chemical analyses were collected at three sites in the study area (Fig. 3). A chemically clean bucket was used to collect a bulk sample of water at each site, and subsamples were siphoned into appropriate containers.

Measurement of pH was carried out in the field by means of the glass electrode method (APHA, 1971). All other analyses were performed in the laboratory. Turbidity, specific conductance, settleable solids, dissolved oxygen, and chloride analyses were conducted according to the standard methods in APHA (1971). The methods of Strickland and Parsons (1963) were used in analyses of nitrate nitrogen, nitrite nitrogen, and orthophosphate.

RESULTS AND DISCUSSION

Density

Phragmites karka is the predominant plant species in the study area (Table 1). A statistical analysis of variance showed no significant difference ($.25 < p < .50$) between the number of reeds on different transects. This indicates that P. karka is uniformly distributed in the study area.

The number of reeds per 1-m² quadrat was markedly higher in Quadrat A on Transect III than in other quadrats (Table 1). Reeds in this quadrat were generally shorter and younger than reeds in other quadrats, and less organic debris had accumulated (Table 2). In general, the number of dead reeds exceeded the number of live reeds (Table 2). However, a statistical comparison revealed no significant correlation ($p > .05$) between the number of dead reeds and live reeds in a given quadrat. It was also noted that live P. karka shoots were usually growing close together in pairs.

The second most abundant plant observed in the study area was the giant fern Acrostichum aureum (Table 3). The statistical analysis of variance showed no significant difference ($.10 < p < .25$) between densities on different transects. This indicates that A. aureum is uniformly distributed throughout the study area. However, it was noted that the number of ferns per 3-m x 10-m quadrat appears to increase slightly as the transect extends further into the marsh (Table 3).

The vine Teramnus labialis was recorded in most quadrats (Table 1). It is a relatively small herbaceous vine that grows to the tops of P. karka by twining around the stems of the reed.

The pogo tree Hibiscus tiliaceus was commonly observed in the study area (Table 3). The statistical analysis of variance showed a significant difference ($.025 < p < .01$) between densities on different transects. This difference is due to the trees' requirement of a firmer substratum. Transect III had the most standing water and consequently only one H. tiliaceus was recorded, whereas on Transects I and II the plants were more abundant (Table 3). This variance in the amount of standing water did not affect the populations of Phragmites karka and Acrostichum aureum. Due to the adaptability and dominance of these two species in a wetland environment, their distribution is uniform throughout the study area. This uniformity was further confirmed by the examination of detailed aerial photographs at the Bureau of Planning.

Biomass

To determine the plant biomass for the study area, five 1-m² quadrats were harvested (Fig. 3). Phragmites karka and Acrostichum aureum Plants were then dried and weighed; dry weights are shown in Table 2. Dead matter (including fallen Phragmites and Acrostichum and standing dead Phragmites) was separated from live material. Although other species of plants were recorded for the harvested quadrats (Table 1), their contribution to total biomass was negligible.

The mean dry weight of all live shoots (Phragmites and Acrostichum) was 1.5 kg per m², and that of standing and fallen dead matter was 1.06 kg per m². All roots, whether closely associated with live shoots or not, had a similar appearance and formed a continuous mat. Hence, it is considered here to be live material and can be lumped with live shoots to give a total biomass estimate. This estimate is 4.70 kg per m². Whittaker (1971) summarized live biomass values for a number of ecosystems and reported a range of 3 - 50 kg per m² for swamps and marshes. Hence, the values for Agara Swamp fall in the

lower end of the range reported by Whittaker and below his calculated mean of 12 kg per m².

The roots of Acrostichum were found to weigh nearly twice as much as Phragmites roots (Table 2) because of their huge rhizomes. Primarily as a result of this, it appears that Acrostichum contributes slightly more than Phragmites to the total live biomass (2.72 kg per m² for the former vs. 2.0 kg per m² for the latter). However, most dead material was Phragmites.

It must be kept in mind that these values are estimates based on only five harvested quadrats and that more extensive sampling would result in more definitive values.

Flora and Fauna

A checklist of flora observed in the study area is given in Table 4, which also shows visually estimated relative abundances. Phragmites karka and Acrostichum aureum are the predominant species. The tree Hibiscus tiliaceus and several small vines are widely distributed, but not abundant in the area.

Plants observed on the periphery of the study area are not obligate wetland species. These include grasses, such as Saccharum spontaneum and Bambusa vulgaris; herbaceous and woody vines, such as Mikania scandens and Clerodendrum inerme; and small trees, such as Muntingia calabura and Leucaena leucocephala.

These "border plants" were not present at the time the shopping-center site was filled. Only Phragmites karka and Acrostichum aureum were found at that time (Tsuda, personal communication).

Other plant species previously reported as occurring in the wetland of the Agana-Chaot River Basin are listed in Table 5. These species may also occur in our study area, but they were not observed by us.

Table 6 presents a checklist of fauna observed during the present study. The most commonly noted insect was the ant Polyrachis dives. These are large, black ants that build paper nests in the tops of the reed Phragmites karka, about 3-m above the ground. Two nests were recorded from Transect I, and several others were observed adjacent to that transect.

Schools of the mosquito fish Gambusia affinis were observed in pools along the border of the study area. Baited traps yielded ten Sarotherodon mossambicus and one Clarias batrachus from one pool, but failed to produce a catch in another pool. A workman at the site reported that he saw a large eel in one of the pools.

Young specimens of the toad Bufo marinus were commonly observed. Tadpoles were very abundant in the pools.

Four species of birds were found to be associated with the study area. The most common species was the tree sparrow Passer montanus. These birds congregated in flocks of up to 10 in the small trees near the border.

The black drongo Dicrurus macrocercus harterti frequented the power lines along the access road. From its perch, the drongo swooped down over the marsh to catch flying insects.

The Philippine turtle dove Streptopelia bitorquata dussumieri and the Chinese least bittern Ixobrychus sinensis were observed flying to and from the marsh between the study area and a hummock just beyond it.

Animal species previously reported as occurring in the wetland of this area are listed in Table 7. Two endemic species of birds, the nightingale reed-warbler Acrocephalus luscinioides luscinioides and the white-browed rail Poliolimnas cinereus microdesis, are reported as endangered (Belk et al., 1971;

Randall and Tsuda, 1974). Although these species were not observed by us, the marsh area is their reported habitat.

Water Chemistry Analyses

Results of water chemistry analyses are given in Table 8. This table also indicates analyses of water samples from locations near the study area (Zolan et al., 1978) to allow for comparison.

The pH of standing water in the study area ranges from slightly acidic to slightly basic. These values represent essentially neutral pH as compared to the more basic pH of waters from nearby sites.

Turbidity and settleable solids are related parameters. Turbidity of water in the study area is lower than turbidity from the Agana Bay storm drain. This would be expected due to the large volume of run-off associated with water in the drain. Samples from a nearby well have lower turbidity than samples from the study area. This would also be expected because water in the well was filtered as it percolated down to the water table.

Settleable solids are higher in water from the study area than in water from the well or storm drain. High productivity and accumulation of organic debris probably cause this.

Specific conductance is determined by the concentration of ions present in water. Specific conductance values from the study area are several times smaller than those from the other sites.

Dissolved oxygen is very low in samples from Stations 1 and 2. The distinct odor of hydrogen sulfide was noticed at these sites as the substratum was disturbed by our field work. The presence of this gas indicates that anaerobic respiration is occurring in the muck. Station 3 has a level

of dissolved oxygen comparable to those of Agana Bay. The difference between levels of dissolved oxygen at Station 3 and at Stations 1 and 2 is probably the result of photosynthetic activity by Potamogeton lucens, an aquatic plant found only on Transect III.

Chloride levels in the marsh are higher than those of well water but lower than those of the storm drain, where mixing of run-off and seawater occurs. Dissolved nitrate nitrogen, nitrite nitrogen and orthophosphate levels are lower than levels in samples from the storm drain.

Other Observations

The pools on the border of the area are of recent origin, as they were not present in 1974 (Tsuda, personal communication). They may have formed as a result of alterations in drainage patterns brought about by the fill project for the Agana Shopping Center. Although this has created new habitats, future encroachment would increase the flood damage potential (U. S. Army Engineer District, Honolulu, 1975), since the basin serves as a reservoir during times of flooding. However, the increase in flood damage potential is proportional to the extent of an encroachment and thus should be small for a small fill project.

During the present study, a drainage pipe extending from the Town House site to a pool at the edge of the marsh was installed. Although no water samples were collected for before-and-after comparison, the pool had become black in color by the end of the study.

CONCLUSIONS AND RECOMMENDATIONS

The study area is populated by characteristic marsh land species. We observed no endangered species, but the range of some endangered birds may extend into this portion of the wetland. The fill will result in some loss of wetland habitat.

If the area is filled, "border plants" will probably colonize the edge of the new fill and thus extend their influence further into the swamp at the expense of wetland species.

Areas other than the actual fill site will be affected by the project. Drainage patterns may be altered in such a way as to affect adjacent habitats in the river basin and to increase flood damage potential, to some degree. The proposed fill project is small and therefore its impact on the environment may be small.

Little is known, in quantitative terms, of the productivity of Guam's marsh land. This study was necessarily limited to preliminary measurements of standing crop. A long-term study of biological productivity would be desirable before any additional major alterations are proposed for the Agana Swamp.

For the proposed small fill project, all operations should be strictly confined to the specified boundaries and not allowed to encroach on adjacent areas. Storm drainage should not be directed into wetland adjacent to the fill site in a concentrated flow, and serious consideration should be given to possible ways of avoiding any storm drainage into the wetland. Any such drainage that is diverted into the swamp should be periodically monitored for water quality.

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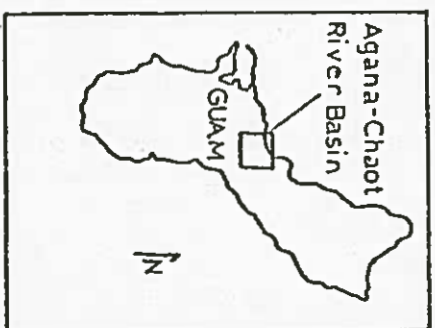
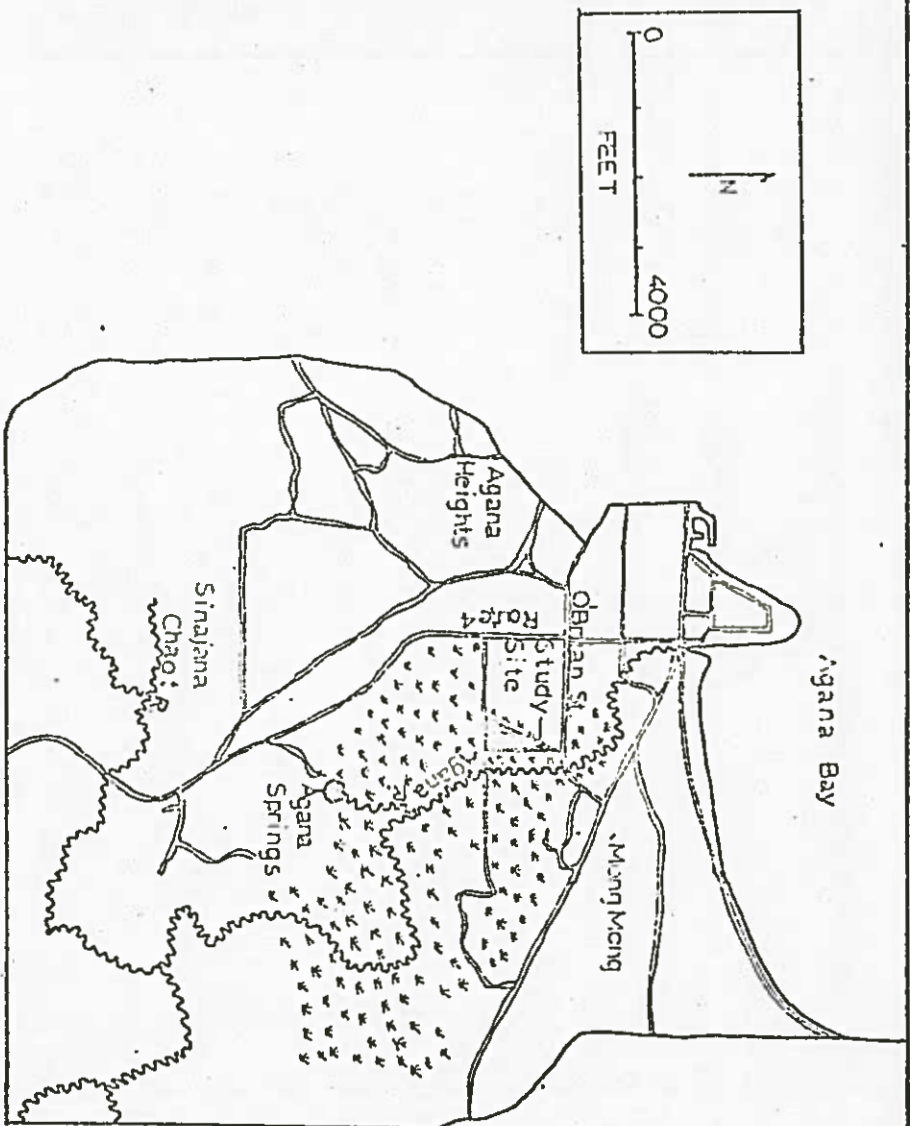


Figure 1. North West section of the Agana-Chaot River Basin showing study site. (X indicates wetland)

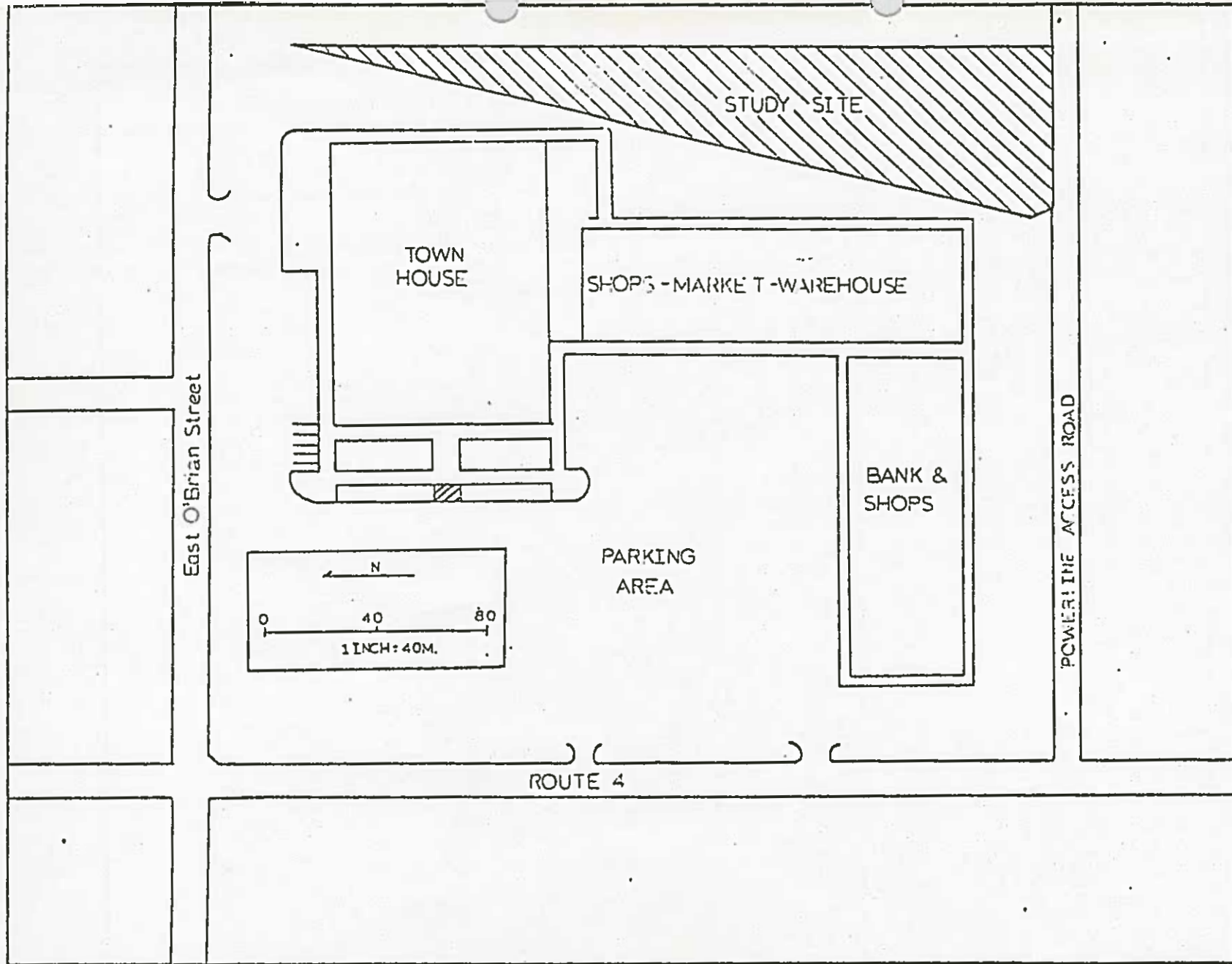


Figure 2. Agana Shopping Center Complex showing the study site.

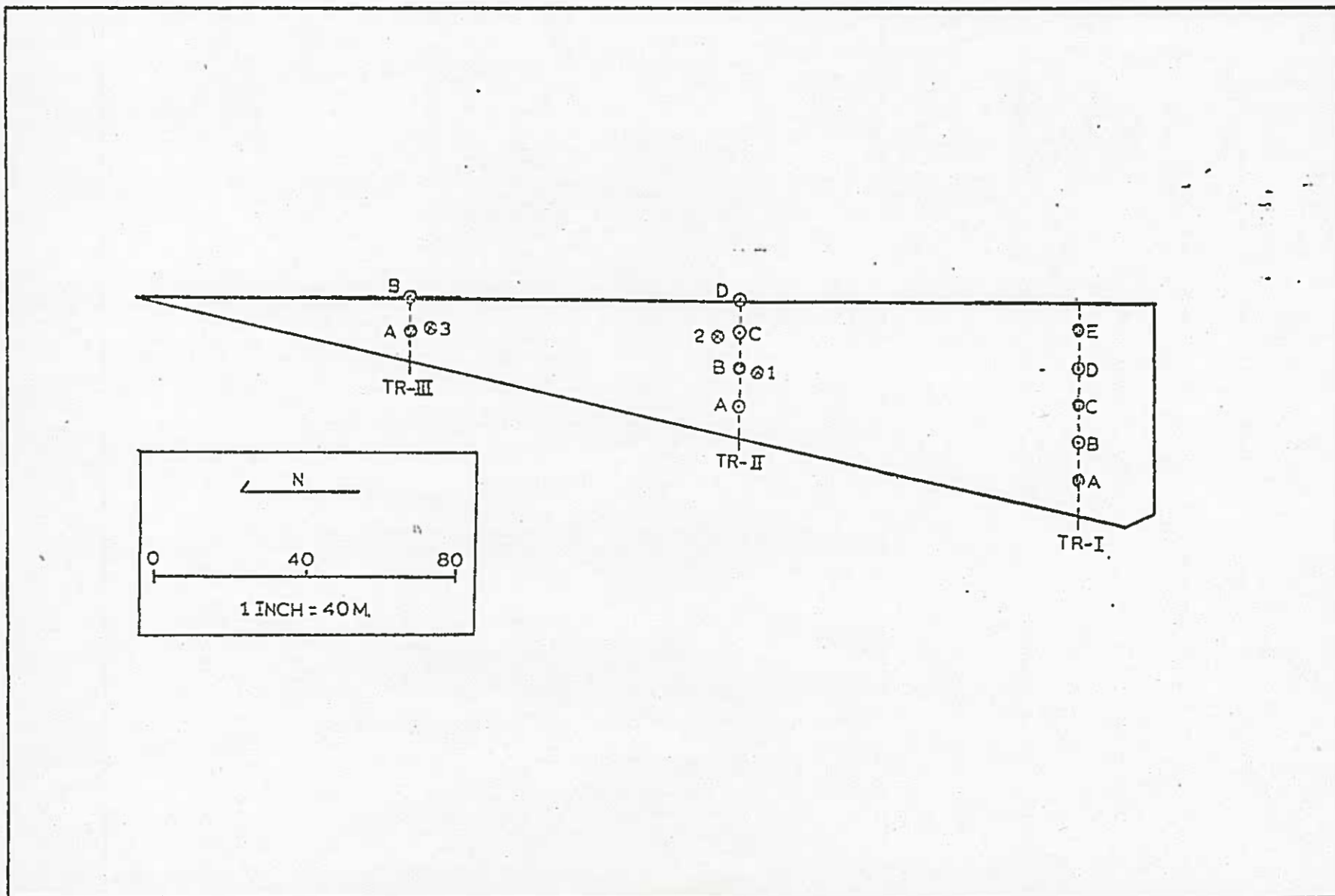


Figure 3. Transect locations showing counted (⊙) and counted and harvested (⊗) quadrats, along with water sampling sites (⊗).

Table 2. Dry weights (in grams) of material harvested from quadrats. See Fig. 3 for locations. Values given are means ($\bar{Y}$), standard deviations (s), coefficients of variation (CV).

Weighed Material	Transect I Quadrat			Transect II Quadrat	Transect III Quadrat	$\bar{Y}$	s	CV
	A	C	E	B	A			
Dead matter	1794	1904	2387	2215	1002	1860.4	535.3	28.77
Live <u>Phragmites</u> shoots	717	1121	669.6	741	1372	923.9	308.3	33.37
<u>Phragmites</u> roots	1065	932	870.1	1400		1066.9	236.6	22.18
<u>Acrostichum</u> leaves (live)		736	340.6	936		670.9	303.0	45.16
<u>Acrostichum</u> roots (live)		1109	1939	3092		2046.7	995.9	48.66

Table 3. Abundance of Acrostichum aureum and Hibiscus tiliaceus along transects. See Fig. 3 for locations. Numbers represent counts in successive 10-m x 3-m quadrats.

Species	Transect I Quadrat					Transect II Quadrat				Transect III Quadrat	
	A	B	C	D	E	A	B	C	D	A	B
<u>Acrostichum aureum</u>	5	9	13	25	13	12	21	26	28	11	7
<u>Hibiscus tiliaceus</u>	2	3	5	3	4	4	3	3	3	1	0

Table 4 . A checklist of the flora observed in the study area. A = abundant, predominant throughout the area; C = common, encountered with regularity throughout the area; S = seldom, present only in localized areas; R = rare, only one or two specimens observed in the area.

Species	Abundance
DIVISION CYANOPHYTA	
Oscillatoriaceae	
<u>Oscillatoria lutea</u> Ag.	S
DIVISION PTERIDOPHYTA	
Aspidiaceae	
<u>Thelypteris interrupta</u> (Willd.) Iwatsuki	C
Pteridaceae	
<u>Acrostichum aureum</u> L.	A
DIVISION ANTHOPHYTA	
Dicotyledon	
Compositae	
<u>Mikania scandens</u> (L.) Willd.	S
Labiatae	
<u>Hyptis capitata</u> Jacquin	S
Leguminosae	
<u>Leucaena leucocephala</u> (Lam.) deMit.	S
<u>Teramnus labialis</u> (L.f.) Sprengel	C
Malvaceae	
<u>Hibiscus tiliaceus</u> L.	C
Potamogetonaceae	
<u>Potamogeton lucens</u> L.	S
Schizaeaceae	
<u>Lygodium auriculatum</u> (Willd.) Alston	S
Tiliaceae	
<u>Muntin gia calabura</u> L.	S
Verbenaceae	
<u>Clerodendrum inerme</u> (L.) Gaerth.	S
Monocotyledon	
Gramineae	
<u>Bambusa vulgaris</u> Schrader ex Wendl and	R
<u>Phragmites testudinalis</u> (Retz.) Trin. ex Steud	A
<u>Saccharum spontaneum</u> L.	S
Palmae	
<u>Cocos nucifera</u> L.	R

Table 5. Plant species previously reported as occurring in the wet land of Agana-Chaot River Basin (Randall and Tsuda, 1974), but not observed in this study.

Species

DIVISION CYANOPHYTA

Nostocaceae

Anabaena sp.

Oscillatoriaceae

Schizothrix calicola (Ag.) Gomont

Desmidiaceae

Microsporaceae

Microspora sp.

Oedogoniaceae

Oedogonium sp.

DIVISION PTERIDOPHYTA

Aspidiaceae

Heterogonium pinnatum (Copel.) Holttum

Hymenophyllaceae

Cephalomanes boryana (Kunze) van den Bosch

Parkeriaceae

Ceratopteris thalictroides (L.) Brongniart

DIVISION ANTHOPHYTA

Dicotyledon

Labiatae

Hyptis sp.

Malvaceae

Abelmoschus moschatus (L.) Medicus

Monocotyledon

Araceae

Alocasia macrorhiza (L.) Schott

Colocasia esculentia (L.) Schott

Pistia stratiotes L.

Ceratophyllaceae

Ceratophyllum demersum L.

Cyperaceae

Cyperus spp. (various species)

Table 5. continued

Species
Monocotyledon (continued)
Gramineae
<u>Eragrostis pilosa</u> (L.) Beauvois
Hydrocharitaceae
<u>Hydrilla verticillata</u> (L.f.) Royle
Pontederiaceae
<u>Eichhornia crassipes</u> (Mart. & Zucc.)

Table 6. A checklist of fauna observed in the study area.

Species
PHYLUM ARTHROPODA
Class Diplopoda
<u>Trigoniulus lubricinus?</u>
Class Insecta
Order Dermaptera
Chelisochidae
<u>Chelisoches morio</u> "nymph"
Order Hymenoptera
Formicidae
<u>Polyrhachis dives</u>
PHYLUM CHORDATA
Class Osteichthyes
Cichlidae
<u>Sarotherodon mossambicus</u> (Peters) [= <u>Tilapia mossambica</u>]
Clariidae
<u>Clarias batrachus</u> (Linnaeus)
Poeciliidae
<u>Gambusia affinis</u> (Baird & Girard)
Class Amphibia
Bufonidae
<u>Bufo marinus</u> (Linnaeus)
Class Reptilia
Scincidae
<u>Emoia</u> sp.
Class Aves
Ardeidae
<u>Ixobrychus sinensis</u> (Gmelin)
Columbidae
<u>Streptopelia bitorquata dussumieri</u> (Temminck)
Dicruridae
<u>Dicrurus macrocerus harterti</u> S. Baker
Ploceidae
<u>Passer montanus</u>

Table 7. Animal species previously reported as occurring in the wetland of the Agana-Chaot River Basin (Randall and Tsuda, 1974), but not observed in this study.

Species
PHYLUM PROTOZOA
Vorticellidae
<u>Vorticella</u> sp.
PHYLUM ARTHROPODA
Class Crustacea
Palaemonidae
<u>Macrobrachium</u> <u>lar</u> (Fabricus)
PHYLUM MOLLUSCA
Class Gastropoda
Neritidae
<u>Septaria</u> <u>porcellana</u> (Linnaeus)
PHYLUM CHORDATA
Anguillidae
<u>Anguilla</u> <u>bicolor</u> McClelland
<u>Anguilla</u> <u>marmorata</u> Quoy & Gaimard
Cichlidae
<u>Tilapia</u> <u>zillii</u> (Gervais)
Cyprinidae
<u>Cyprinus</u> <u>carpio</u> Linnaeus
Eleotridae
<u>Eleotris</u> <u>fuscus</u> (Schneider)
Gobiidae
<u>Chonophorus</u> <u>guamensis</u> (Valenciennes)
<u>Stiphodon</u> <u>elegans</u> (Steindachner)
Poeciliidae
<u>Poecilia</u> <u>reticulatus</u> (Peters)
Class Reptilia
Testudinidae
<u>Pseudemys</u> <u>scripta</u> (Schoepff)
Class Aves
Ploceidae
<u>Munia</u> <u>atriaepilla</u>

Table 7. continued

Species
Class Aves (continued)
Rallidae
<u>Gallinula chloropus guami</u> Hartert
Scolopacidae
<u>Gallinago megala</u> Swinhoe
Sylviidae
<u>Acrocephalus luscini</u> <u>luscini</u> (Quoy & Gaimard)

Table 8. Results of water chemistry analyses. See Fig. 3 for station locations.

Station	Field pH	Turbidity (NTU)	Specific Conductance (μ mho/cm)	Settleable Solids (mg/l)	Dissolved Oxygen (mg/l)	Chloride (mg/l)	Nitrate Nitrogen (mg/l)	Nitrite Nitrogen (mg/l)	Ortho- Phosphate (mg/l)
1	6.95	6.0	72	0.2	1.18	35.5	.002	.000	.002
2	7.00	4.3	65	1.1	0.41	35.2	.002	.002	.003
3	7.20	2.4	80	0.4	4.32	34.1	.001	.003	.005
Well A-5 [11/22/77]**	7.47	0.14	440	-	-	21.7	-	-	-
East Agana Bay [Storm Drain]**	7.74	20	2,555	<.1	4.22	745	1.06	.047	.022

**Mean values from Zolan et al., 1978