TWENTY-SECOND GUAM LEGISLATURE
1994 (SECOND) Regular Session

Introduced
FEB 16 '94

Bill No.: 874(LS)

Introduced By: J. P. AGUON
C. T. C. GUTIERREZ
F. E. SANTOS

AN ACT TO REPEAL AND REENACT SECTION 2 OF PUBLIC LAW 21-101 RELATIVE TO CREATING THE GUAM TERRITORIAL AQUARIUM FOUNDATION TO OVERSEE THE PRE-DESIGN STAGE AND CONTINUED DEVELOPMENT OF THE GUAM TERRITORIAL AQUARIUM; TO REPEAL SECTION 10 OF PUBLIC LAW 18-6 AND TO APPROPRIATE SEVEN HUNDRED AND FIFTY THOUSAND DOLLARS ($750,000) FROM THE TOURIST ATTRACTION FUND TO THE GUAM TERRITORIAL AQUARIUM FOUNDATION FOR THE PRE-DESIGN STAGE OF THE AQUARIUM.

BE IT ENACTED BY THE PEOPLE OF THE TERRITORY OF GUAM:

Section 1. **Legislative findings and intent.** The Legislature finds that the Guam Aquarium Council (GAC) has completed its task as mandated by Public Law 21-101 and has submitted its report and recommendations to the Legislature to create an oversight authority, to be referred to as the Guam Territorial Aquarium Foundation Board to oversee the pre-design stage and continued development of the proposed Guam Territorial Aquarium. GAC also recommended that funding in the amount of Seven Hundred and Fifty Thousand Dollars ($750,000) be provided for the pre-design stage.

It is therefore the intent of the Legislature to approve the GAC report and recommendations and to repeal Section 10 of Public Law 18-6, which provided funding from the Tourist Attraction Fund for the micro-dredging project of Tumon Bay of which Seven Hundred Ninety Seven Thousand Dollars ($797,000) remain unexpended and unneeded, and to reprogram the funds necessary for the pre-design stage of the Guam Territorial Aquarium.

Section 2. Section 2 of Public Law 21-101 is repealed and reenacted to read:

"Creation of the Guam Territorial Aquarium Foundation. There is hereby created within the Guam Economic Development Authority (GEDA)

the Guam Territorial Aquarium Foundation (GTAF) Board, a non–profit corporation, which shall oversee the continued development and administration of the proposed Guam Territorial Aquarium. The Board shall seek to establish funding arrangements from both public and private sources sufficient to maintain the quality of facilities and meet expectations for the on–going management, operations and expansion of the Guam Territorial Aquarium in a cost effective and efficient manner.

The Chairman of the Board of Directors of GEDA shall chair the GTAF Board to include the following:

(a) The Director or his designee of the Marine Laboratory of the University of Guam;

(b) The Mayor or his designee of the Municipality of Yona;

(c) The President or his designee of the Guam Mayors Council;

(d) Two appointed at large from the community by the Governor of Guam;

(e) Two representatives from the Guam Chamber of Commerce selected by its Board of Directors;

(f) The Chairman or his designee of the Board of Directors of the Guam Visitors Bureau;

(g) The Chairman or his designee of the Board of Directors of the Guam Hotel and Restaurant Association;

(h) The Director or his designee of the Department of Education.

Section 3. Upon the creation of the GTAF, GAC shall transfer all accounts, records and materials pertaining to the Guam Territorial Aquarium.

Section 4. Section 10 of Public Law 18–6 is hereby repealed.

Section 5. **Appropriation.** Seven Hundred and Fifty Thousand Dollars ($750,000) are hereby appropriated from the Tourist Attraction Fund to the GTAF to be expended for the pre–design stage of the Guam Territorial Aquarium.

Section 6. The GTAF Board shall report the status and findings of the pre-design stage of the aquarium to the Speaker of the Legislature no later than four hundred and twenty (420) days after the effective date of this Act.

FINAL REPORT

GUAM TERRITORIAL AQUARIUM STUDY

FINAL CONCEPT AND FEASIBILITY APPRAISAL

Prepared for

The Guam Economic Development Authority

and

The Guam Aquarium Council

Prepared by

Montgomery Watson Americas, Inc.
2375 130th Avenue NE, Suite 200
Bellevue, WA 98005
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in association with

Jones & Jones
Architects and Landscape Architects
105 South Main Street
Seattle, WA 98104

and

Economics Research Associates
388 Market Street, Suite 1580
San Francisco, CA 94111

October 18, 1993

MONTGOMERY WATSON

October 29, 1993

Guam Economic Development Authority
Guam Aquarium Council
ITC Building, Suite 911
590 South Marine Drive
Tamuning, Guam 96911

Dear Gentlemen:

We hereby deliver 50 copies of the Final Concept and Feasibility Appraisal report for the Guam Territorial Aquarium Study.

We look forward to working further with you on future portions of this project.

Sincerely,

Ronald D. Mayo
Vice President, Director of Fish Culture Projects

10775 120th Ave., N.E.
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Bellevue, Washington
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SECTION 1

EXECUTIVE SUMMARY

On July 14, 1992 the Guam Economic Development Authority (GEDA), acting on behalf of the Guam Aquarium Council (GAC), authorized a conceptual feasibility study of the Proposed Guam Territorial Aquarium. The study was carried out by a team of consultants consisting of: Montgomery Watson (Project Managers and Engineers-Seattle); Jones and Jones (Architects and Landscape Architects-Seattle) and Economic Research Associates (Economist-San Francisco).

This study was conducted in three stages:

1. Initial Concept and Feasibility Appraisal,
2. Site Analysis and Selection,
3. Final Concept and Feasibility Appraisal.

Products of stages 1 and 2 were reviewed by GEDA and GAC and approved prior to commencing the next stage of work. Throughout the duration of the study the consulting team discussed storyline and design concept alternatives with a number of groups, individuals and boards. The tourism industry was consulted at each stage as were representatives of the University of Guam. Presentations were made to legislative groups, the Governor, Government of Guam department heads and US Federal authorities. The input received was positive and useful at every turn and has been incorporated as part of the proposal.

Mission - The mission of the aquarium is to bring together the peoples of Micronesia through an appreciation of their individual cultures and their historic and current relationships with the sea and to provide opportunities for visitors to become better acquainted with Micronesia and its natural beauty. The objective of interpreting and presenting the biodiversity of the Micronesian ecosystems - from the mangrove and coastal habitats to the abyss of the Marianas trench - needs to be accomplished in a manner that is educational, entertaining and compelling to both residents and visitors.

Community Resource - The aquarium must function as a community resource as well as a prime visitor attraction. It should be a special resource for the people of Guam, providing many opportunities for formal and informal learning as well as a unique setting for island-wide events such as demonstrations, community meetings, civic hearings and a place for hosting special receptions for visiting groups or conferences.

Educational Resource - The aquarium can also increase its potential as an educational resource through a regional network of affiliate organizations and institutions such as Park Service interpretive centers, libraries, elementary schools, colleges, universities (University of Guam, Micronesian Community Center), museums and specialized institutions (Micronesian Area Research Center, Micronesia Mariculture Demonstration Center). Additionally, a network of senior citizen centers could serve as a cultural resource for incorporating and preserving the customs of the people of Micronesia through storytelling and crafts as well as other skill demonstrations.

Gateway to Micronesia - Finally, the aquarium can provide excellent opportunities for outreach programs as a gateway to other Micronesian destinations. It can be an invaluable service to the knowledgeable tourist. Examples of Micronesian outreach destinations that may be characterized include sites such as Nan-Madol, the "Venice of the Pacific"; the stone city of Leluh

in Kosrae; the sculpted hills of Babeldaob; Ngchemiangel Bay; the Megaliths of Badrulchan; Bechiyal Village in Yap; and numerous latte sites on Guam, Rota, and Tinian such as the House of Taga, As Nieves Quarry and Mochong Beach. Spectacular world-class diving sites such as the Rock Islands of Belau and Jelly Fish Lake, the highland forests of Micronesia and indigenous architectural structures such as the meeting houses of Belau, Pohnpei and Yap (Bais, Nahs, and Pebaeys) are other examples. Micronesia is a diver's paradise with big walls, blue holes, coral reefs and historical wreck sites abundant throughout the islands.

Planning Concept - The aquarium will be the first institution of its kind to combine many of the characteristics of a zoological park, botanic garden, cultural center, and aquarium. It will feature the major island ecosystems beginning in the high mountain ridges of the islands and descending to the bottom of the Marianas trench. Certain of these environments (reefs, mangroves, lagoons, freshwater, sea mounds) that are common to a number of areas would be described by focusing on a particular geographic location, such as the "Coral Reefs of Belau," while noting that much of the reef discussion is common to other places. By doing this, a visitor would be introduced to both an aquatic environment and a particular geographic region within Micronesia. In addition, each grouping of exhibits would be used to introduce the visitor to how the people of Micronesia interacted with that aquatic environment (traditional fishing, canoeing, free diving, sailing, traditional coastal management, and navigation). This adds the dimension of the unique interaction of the people of Micronesia with their environment. The conceptual design layout is presented with this executive summary.

Site Selection - Potential sites were pre-screened by GAC and six were evaluated as part of this study. Each of the six sites is owned by the Government of Guam. In comparing the six sites the consulting team considered a wide range of factors in a manner very similar to that found in Environmental Impact Statements. In presenting the results to GEDA and the GAC, the consultant ranked the Tagachang Bay site as best, with the Fadian Point and Latte Point sites ranked next. The Hospital Site and Pago Point were considered to be suitable. The Boat basin site was determined to be unsuited. The GAC and GEDA, after discussions and consultation, tentatively selected the Tagachang Bay site and directed the consulting team to proceed with finalizing a conceptual design and estimates for that site.

Conceptual Design - The Conceptual Design developed for the Tagachang Bay site is illustrated in the body of this report. It consists of a series of separate building and outdoor exhibits that combine aspects of an aquarium, a botanical garden, a cultural center and a museum. Seawater exhibits will use water from seawater wells in a flow-through configuration while the brackish and freshwater exhibits will be based on recirculation systems. The facility will have standby power and water supplies to allow operation even after major storm events. Within the grounds there will be food and gift concessions. Adjacent to the grounds, a restaurant has been sited but not included in cost estimates or revenue projections.

Staging and Capital Costs - If necessary, the project can be constructed in stages with the initial stage being called the Core Facility and the complete project being the Full Facility. It is estimated that the Capital Costs for the Core Facility will be $32 million and the Full Facility, $40 million. A normal construction schedule would allow completion in 1997.

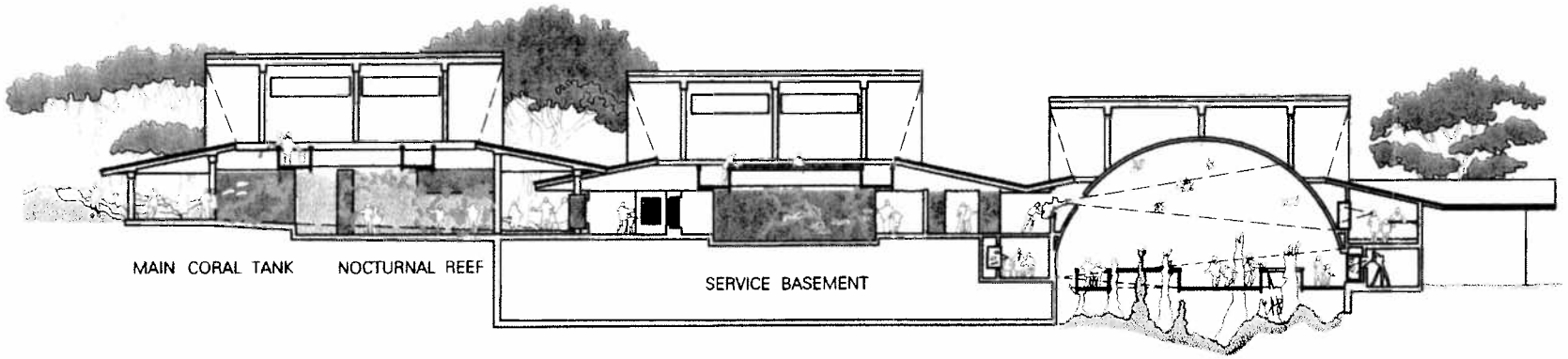
Visitor Projections - The feasibility analysis is based on an annual visitor projections of 475,000 and peak day projections of approximately 1,900. These are based on a total tourist visitation to Guam of 1,440,000 in 1997 and a permanent population of 156,000. The probable length of stay for visitors is projected to be 155 minutes (2 hours and 35 minutes) for the Full Facility (130 minutes for the Core Facility).

Economic Feasibility - Pricing for tourist is $15/visit with residents at $5/visit (reflecting memberships, students and "free days". Revenues, including concessions and rentals are

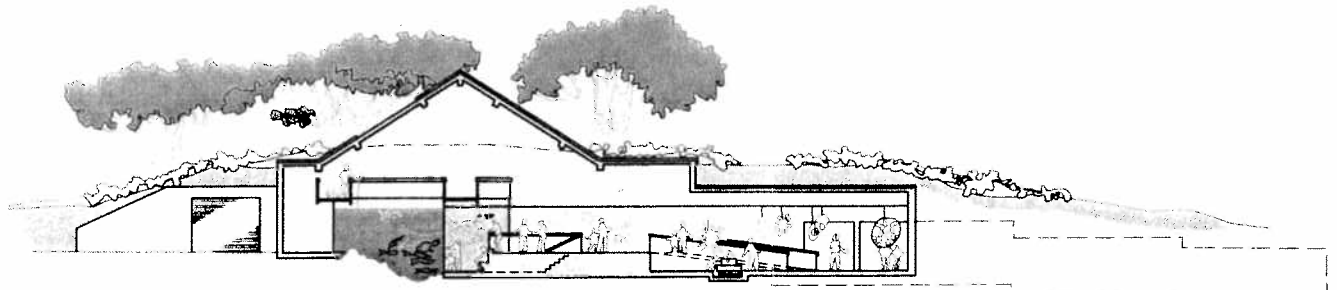
projected to be approximately $10,100,000 per years with the Net Operating Income being $2,600,000. These revenues can support approximately $20 million in project costs. To be economically feasible the remaining capital funding would have to be raised from other sources such as federal grants, Government of Guam grants, private sources and sponsorships, and revenue bonds based on the Tourist Attraction Fund. Such a mixture of revenue based funds, private funds and government grants is typical in most major aquarium project constructed in the last few years. Based on the assumptions made in this instance the project is economically feasible. In addition, this project will meet the need to improve Guam's tourism attractions and will have a significant impact on the economic stability of the industry.

Implementation and Management - The first step in implementation is a commitment by the Government of Guam (based on GEDA recommendations) to proceed with the project. The first step would include the finalization of environmental studies, arranging for financing and the establishment of a governing body. To this end, it is proposed that GEDA create a governing body, the Guam Territorial Aquarium Foundation (GTAF) to act as the overall authority. The GTAF would then oversee design (by a consulting design team) and construction and select (based on competitive proposals) an Operating Contractor to manage the day to day activities. The Operating Contractor's selection would be based on experience in operating similar facilities successfully and the proposed cost. It is anticipated that the Operating contractor would be involved in planning and would contract on a long-term basis.

Public Benefits and Funding - This project will have significant public benefits that can justify the expenditure of public funding. These benefits include education, the stabilization of tourism on Guam, the expansion of tourism in Micronesia, and improvements to employment opportunities on Guam and Micronesia. These benefits justify public funding to some degree.



CORAL GARDENS **SEA AT NIGHT** **PREDATORS OF THE PASS** **CHALLENGER DEEP**



OPEN SEA **RESTLESS SEA** (BEYOND)

Scale 1/4"=1'-0"

GUAM TERRITORIAL AQUARIUM - EXHIBIT SECTIONS

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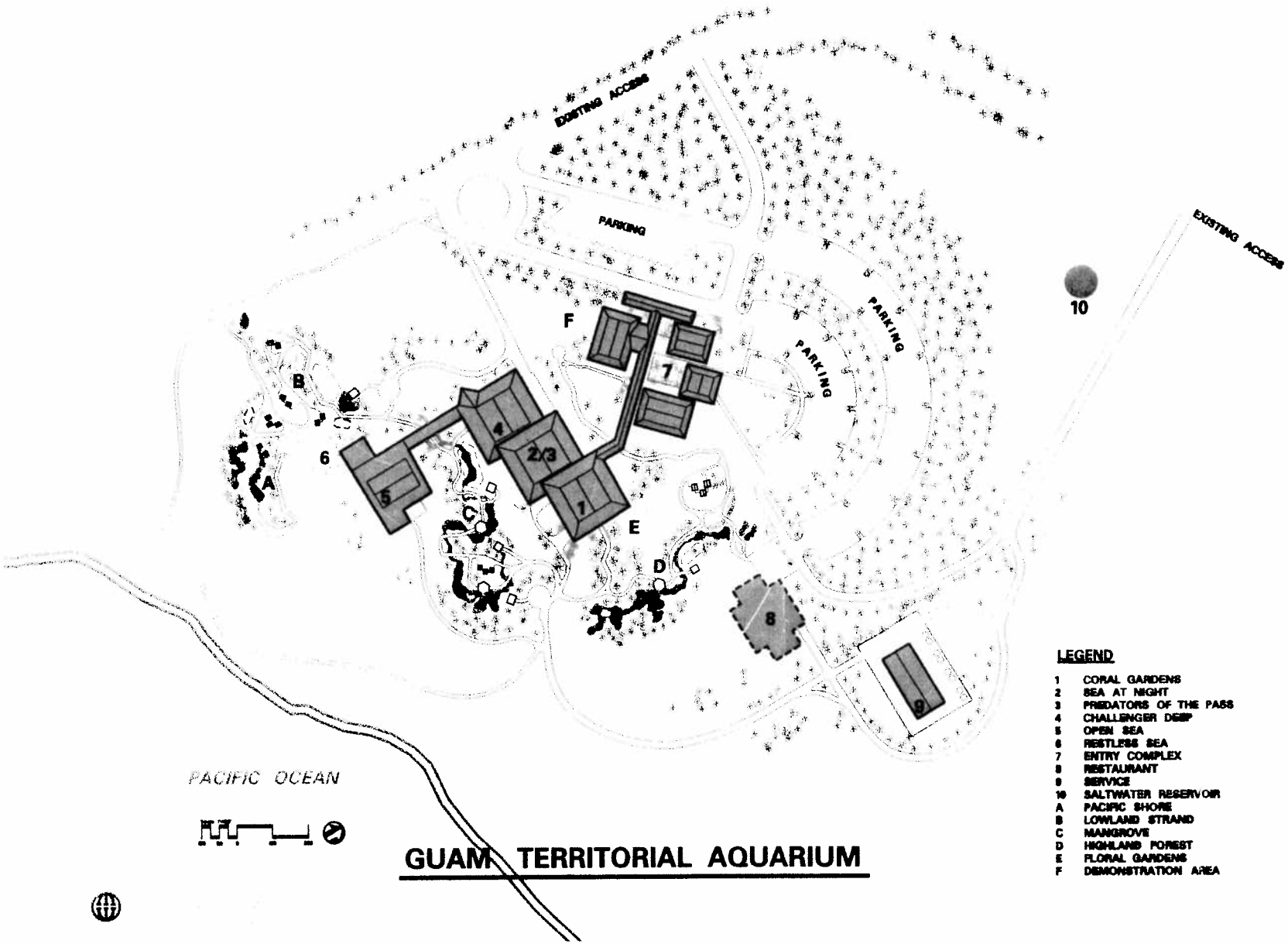

GUAM TERRITORIAL AQUARIUM

LEGEND

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2	SEA AT NIGHT
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4	CHALLENGER DEEP
5	OPEN SEA
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8	RESTAURANT
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A	PACIFIC SHORE
B	LOWLAND STRAND
C	MANGROVE
D	HIGHLAND FOREST
E	FLORAL GARDENS
F	DEMONSTRATION AREA

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SECTION 2

THEME, STORYLINE, AND CONCEPTUAL DESIGN

INTRODUCTION

This section presents the theme, storyline, and architectural and exhibit concepts developed for the aquarium.

THEME

The purpose of defining a theme is to set out the philosophy and intent of the aquarium, providing a touchstone for the building program and for future decisions.

Mission

The mission of the aquarium is to bring together the peoples of Micronesia through an appreciation of their individual cultures and their historic and current relationships with the sea and to provide opportunities for visitors to become better acquainted with Micronesia and its natural beauty.

Education

The principal objective of the aquarium is to present the biodiversity of the Micronesian ecosystems - from the mangrove and coastal habitats to the abyss of the Marianas trench - through the creation of natural habitats in an educational, entertaining and compelling manner.

Community. The aquarium can function as a community and educational resource for the people of Guam, providing many opportunities for formal and informal learning. The aquarium could provide a unique setting for island-wide special events, demonstrations, community meetings, civic hearings and a meeting place for hosting special receptions for visiting groups or conferences.

The aquarium can also increase its potential as an educational resource through a regional network of affiliate organizations and institutions such as Park Service interpretive centers, libraries, elementary schools, colleges, universities (University of Guam, Micronesian Community Center), museums and specialized institutions (Micronesian Area Research Center, Micronesia Mariculture Demonstration Center). Additionally, a network of senior citizen centers could serve as a cultural resource for incorporating and preserving the customs of the people of Micronesia through storytelling and crafts as well as other skill demonstrations.

Finally, the aquarium can provide excellent opportunities for outreach programs as a gateway to other Micronesian destinations. It can be an invaluable service to the knowledgeable tourist.

This approach can also contribute to the financial independence of the aquarium.

Outreach Destinations. Micronesian outreach destinations can provide archaeological excursions to sites such as Nan-Madol, the "Venice of the Pacific"; the stone city of Leluh in Kosrae; the sculpted hills of Babeldaob; Ngchemiangel Bay; the Megaliths of Badrulchan; Bechiyal Village in Yap; and numerous latte sites on Guam, Rota, and Tinian such as the House of Taga, As Nieves quarry, and Mochong Beach.

Eco-tourism and diving explorations can include geologic sites such as the Rock Islands of Belau, hiking excursion through the forests of Micronesia as well as unique architectural destinations to indigenous meeting houses of Belau, Pohnpei and Yap (Bais, Nahs, and Pebaeys). Diving excursions include abundant destinations throughout the islands such as Jelly Fish Lake, numerous big walls, blue holes, coral reefs, and historical wreck sites.

STORYLINE

The storyline concept for the aquarium follows a biogeographical approach across a transect through various Micronesian environments (Figure 1 - Transect of Micronesia). The proposed concept covers a range of environments through a series of indoor and outdoor exhibits beginning in the mountains of the high islands and descending to the deepest part of the ocean, the Challenger Deep (Figure 2 - Thematic Organization). Multicultural references and interpretive resources are provided along the visitor sequence. This approach sets the basis for a unique and imaginative storyline which will appeal to a broad range of visitor interests.

The visitor first enters a **Core Area** which provides opportunities for orientation (Figure 3 - Site Use Plan). This core also contains a multi-purpose theater, gift shop, book shop, administrative center, and other services. Leaving the core area the visitor encounters sculpted earthworks with lush vegetation and is immersed in the **Floral Gardens** - an upland counterpoint to the coral reefs of Micronesia. The experience of a coral reef is next presented within the **Coral Gardens** then the **Sea At Night**.

Crossing the reefs, the visitor experience shifts into the oceanic realm with the **Predators of the Pass**, containing over 15 species of sharks and other predators occupying niches at the top of the food chain, A long descent into the **Challenger Deep** follows for deep sea exploration and hands-on demonstrations.

The **Open Sea** is designed to showcase both the "smallest and largest of all". The centerpiece of this exhibit is the large biomass pelagic tank highlighting the largest of all with the plankton gallery showing the smallest of all. The visitor continues and emerges into a simulated storm at sea, a combination of oceanic currents, basins, tides and winds as experienced on an atoll to confront the **Restless Sea**.

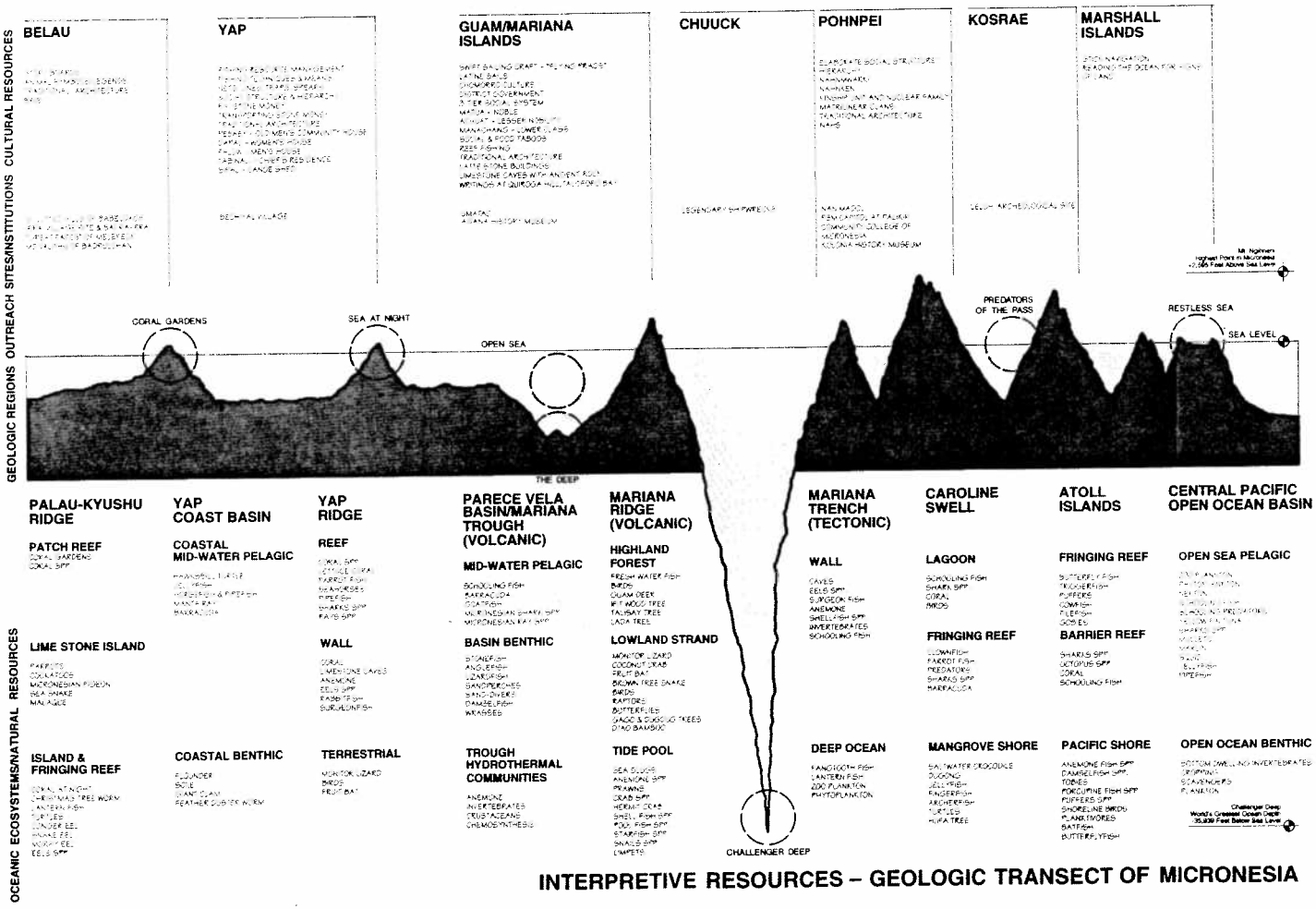
The **Pacific Shore** provides tide pools containing aquatic life in a variety of viewing and touch tanks including rock ledges with cliff birds. The visitor then comes to the **Lowland Strand** with coconut palms and crabs, monitor lizards and megapodes.

The Mangrove exhibit provides opportunities to understand how upland areas are created through the growth of mangrove trees and allows a close look at the diverse fauna inhabiting these areas, from saltwater crocodiles and mud skippers to mangrove birds and waterfowl.

A gradual climb into the **Highland Forest** takes the visitor to a lush forest with waterfalls, birds, freshwater shrimp and plants.

CONCEPTUAL DESIGN

The aquarium will be the first institution of its kind to combine many of the characteristics of a zoological park, botanic garden, cultural center, and aquarium. The proposed Bio-Geographic concept covers a range of ecosystems beginning in the high mountain ridges of the islands and descending to the bottom of the Marianas trench. Certain of these environments (reefs, mangroves, lagoons, freshwater, sea mounds) that are common to a number of areas would be described by focusing on a particular geographic location, such as the "Coral Reefs of Belau," while noting that much of the reef discussion is common to other places. By doing this, a visitor



INTERPRETIVE RESOURCES – GEOLOGIC TRANSECT OF MICRONESIA

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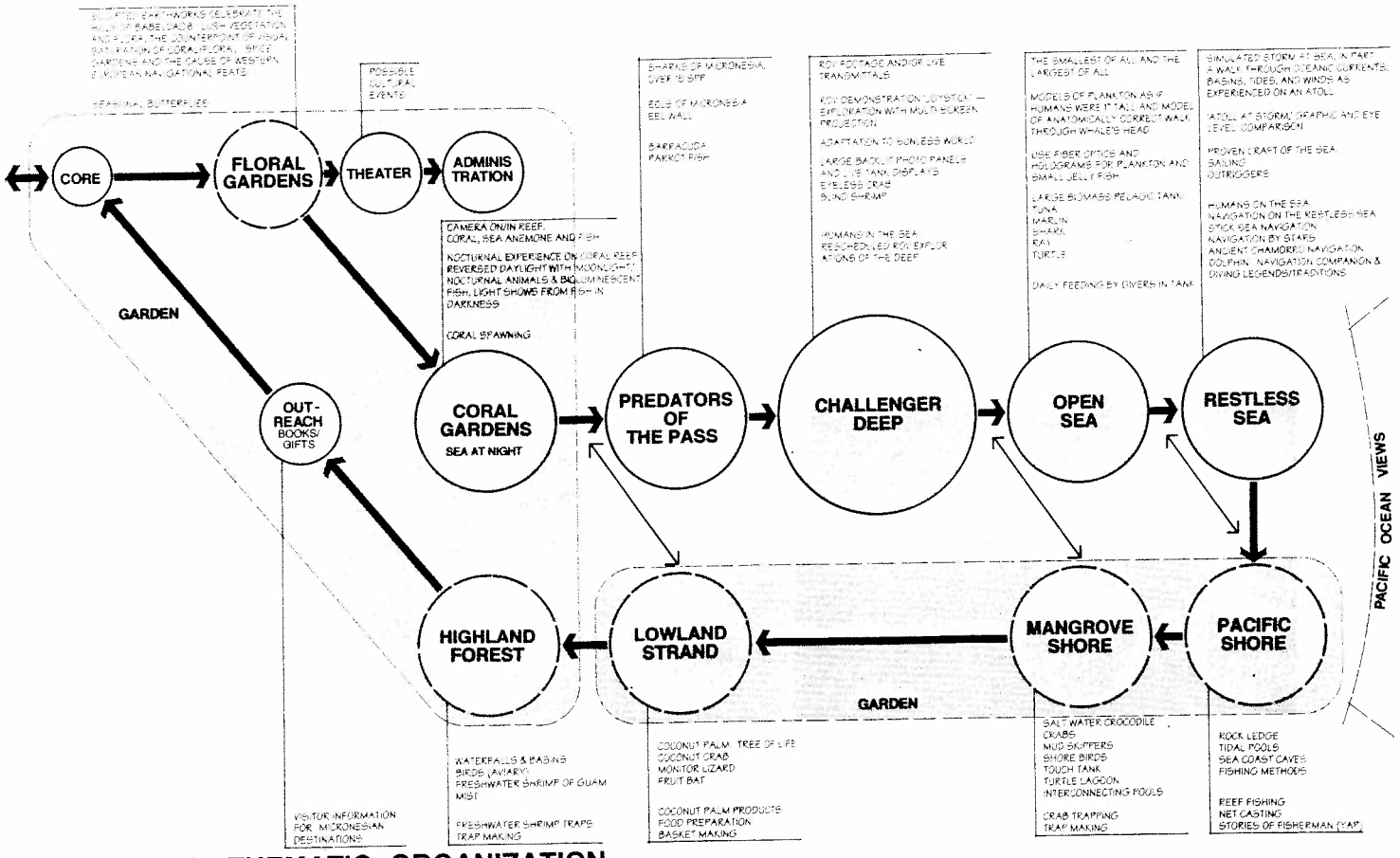

CONCEPT – THEMATIC ORGANIZATION

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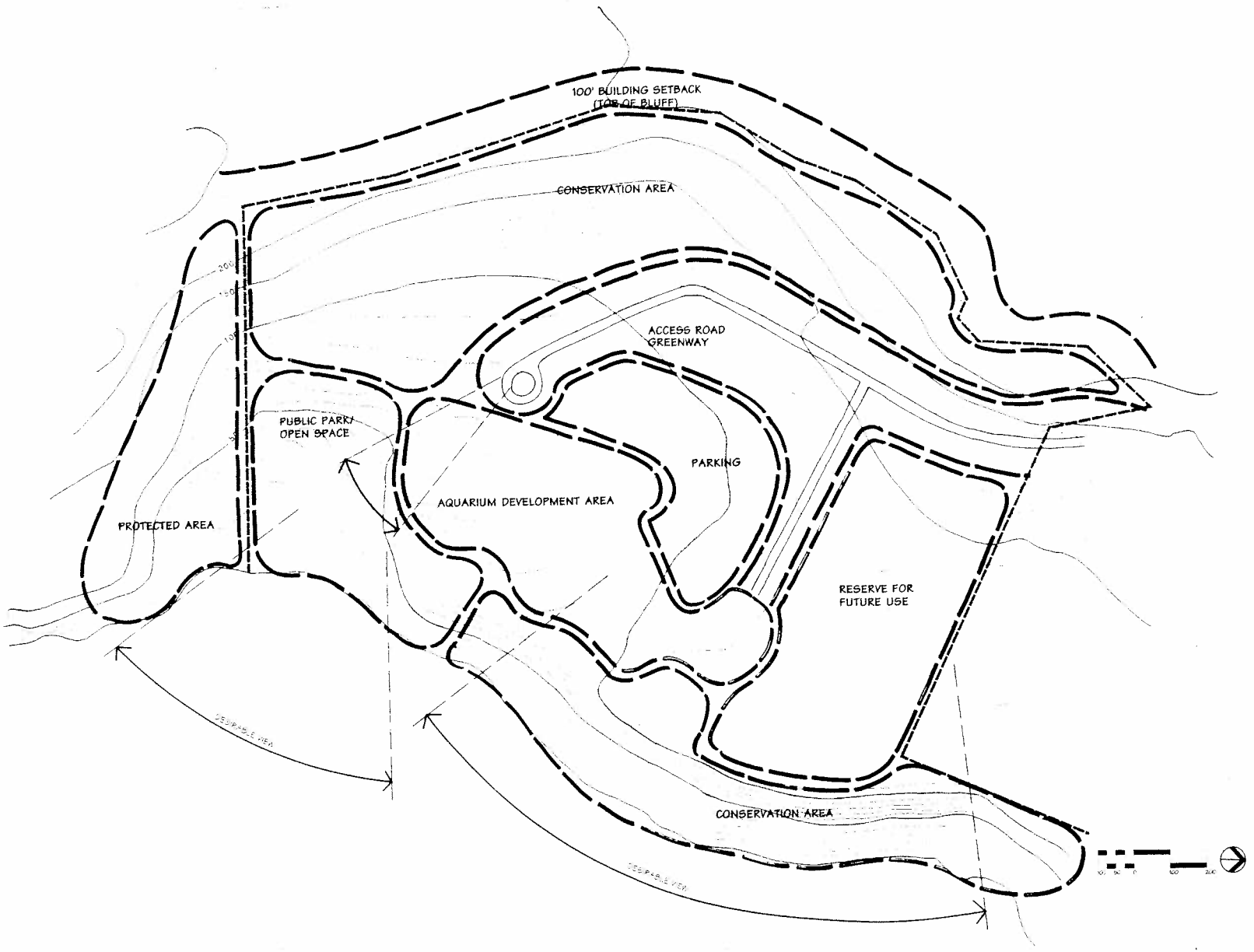

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GENERALIZED SITE USE DIAGRAM

would be introduced to both an aquatic environment and a particular geographic region within Micronesia. In addition, each grouping of exhibits would be used to introduce the visitor to how the people of Micronesia interacted with that aquatic environment (traditional fishing, canoeing, free diving, sailing, traditional coastal management, and navigation). This adds the dimension of the unique interaction of the people of Micronesia with their environment.

Drawings 4-12 show concept plans of the interior and exterior exhibits.

Interpretation

Exhibits will communicate on three levels of information.

Visual/Sensory: will combine movement and color, providing visitor immersion into habitats. These exhibits appeal to children too young to read, special education and handicapped visitors, and other visitors that just like to look at beautiful fish and colorful plants. Video demonstrations support the visual communications of themes and concepts.

Interactive: flora and fauna of Micronesia must be identified, some of their unusual characteristics pointed out, and basic concepts presented, such as their existence, species-survival, adaptability, symbiosis, chemosynthesis, and evolutionary concepts. This level stresses hands-on activities, demonstrations, video and audio systems enabling the visitor to interact with the exhibit.

Interpretive: this information is presented through graphics, written text, and audio-visual material. Interpretive information should address children, adults, and the 'expert' public, ranging from brief displays and graphics to great detail and in-depth references.

Exterior Exhibits

The story line and theme are presented in a multi-level exhibit concept through a series of ecosystems representative of aquatic life, botanical gardens, terrestrial fauna, birds, and cultural aspects of the people of Micronesia. This approach introduces the visitor to both a natural habitat and a particular island region within Micronesia.

The Mangrove exhibit makes reference to Belau and Yap, and incorporates cultural interpretive stories about story boards, stone money, and social hierarchy.

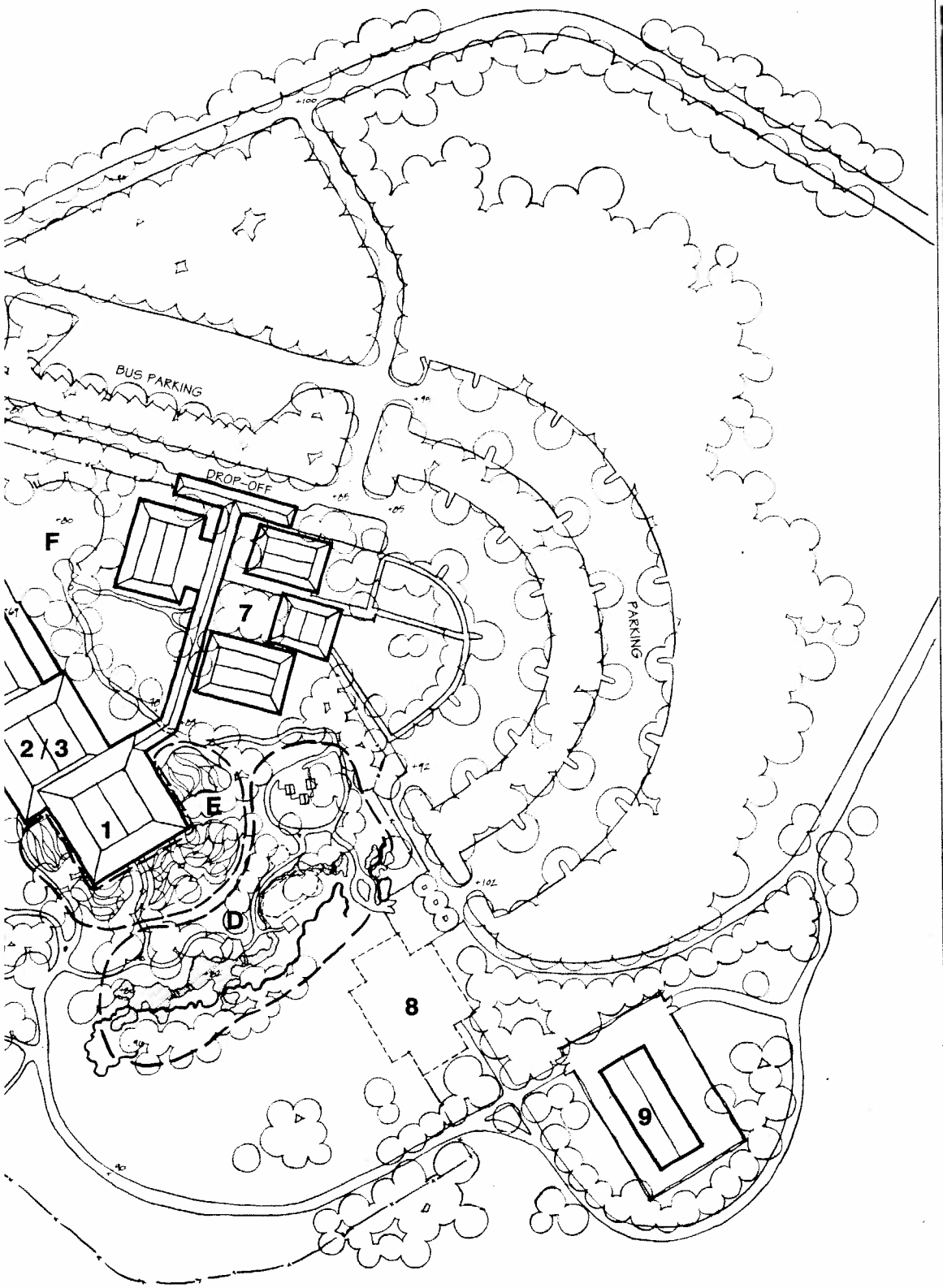
The Pacific Shore references the Mariana Islands: Guam, Rota, Saipan and Tinian. The Chamorro culture is evident throughout this sequence with cultural interpretive stories about latte stone construction, sailing and flying praos.

The Lowland Strand makes reference to Chuuck and the Marshall Islands, their traditions and the navigational trade.

The Highland Forest references Pohnpei and Kosrae incorporating traditional storylines, architecture and two intriguing archaeological sites.

Architectural Plan

General. The architectural character of the aquarium, especially in relation to its setting, is one of the most important factors in the planning and design of the facility. The lasting impressions on the visitor will be formed not only by the beauty of the outdoor setting and exhibitry but also by the compelling nature and presentation of the indoor exhibits themselves. To this end, the building should function as an integral outgrowth of the site. It should take advantage of the slope of the



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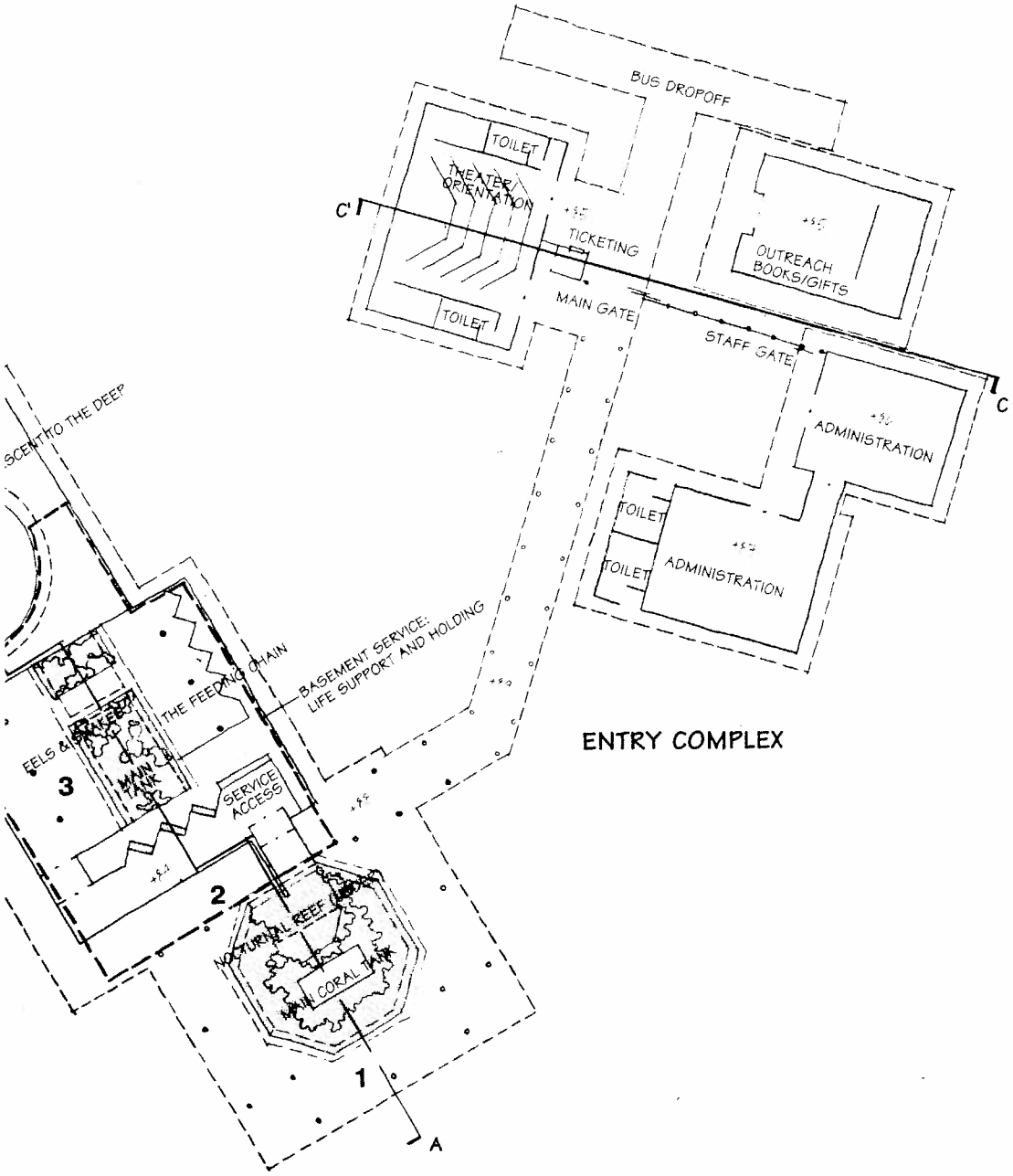
CONCEPT: SITE PLAN



ENTRY COMPLEX

3 PREDATORS OF THE PASS
"WHO EATS WHOM: THE FEEDING CHAIN"

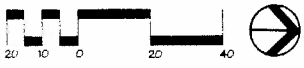
SHARKS (OVER 15 SPP. IN MICRONESIA)
EELS
SEA SNAKES
BARRACUDA
PARROT FISH
NAPOLEON WRASSE
GIANT CLAMS

2 SEA AT NIGHT

NOCTURNAL REEF
CORAL SPAWNING
BIOLUMINESCENT FISH

1 CORAL GARDENS

CORAL
SEA ANEMONE
REEF FISH



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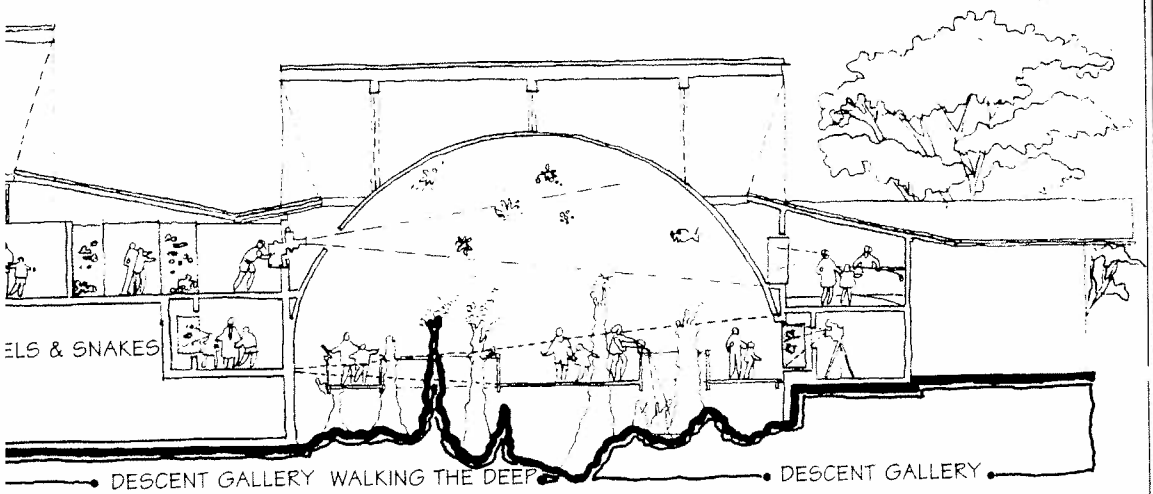
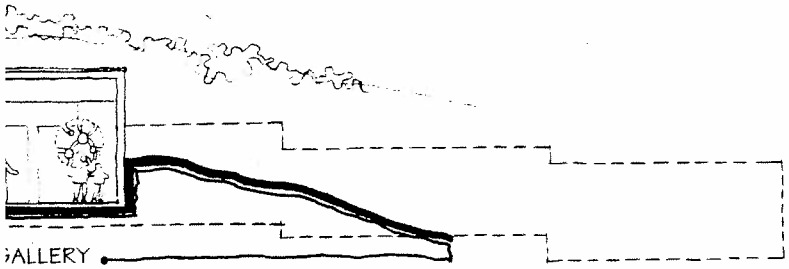
CONCEPT: BUILDING PLAN

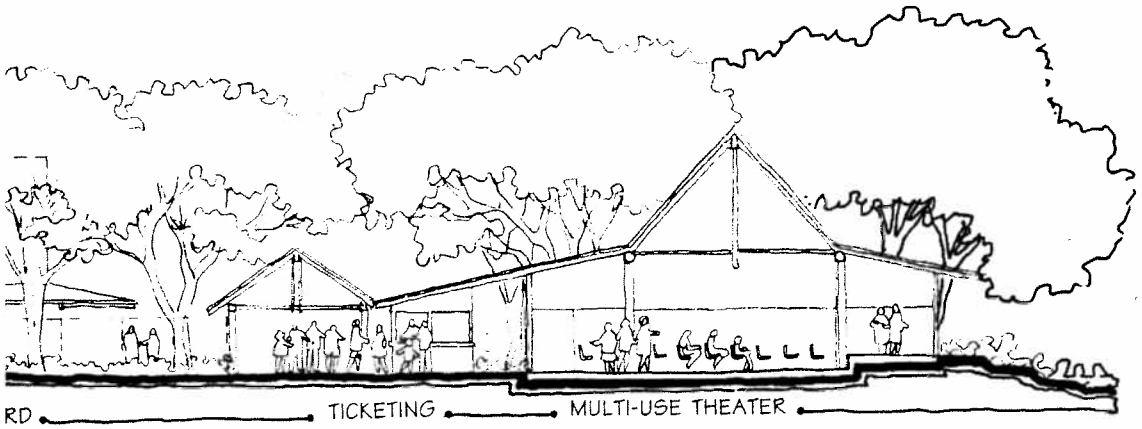


S

CHALLENGER DEEP



RESTLESS SEA (BEYOND)



NTRY COMPLEX

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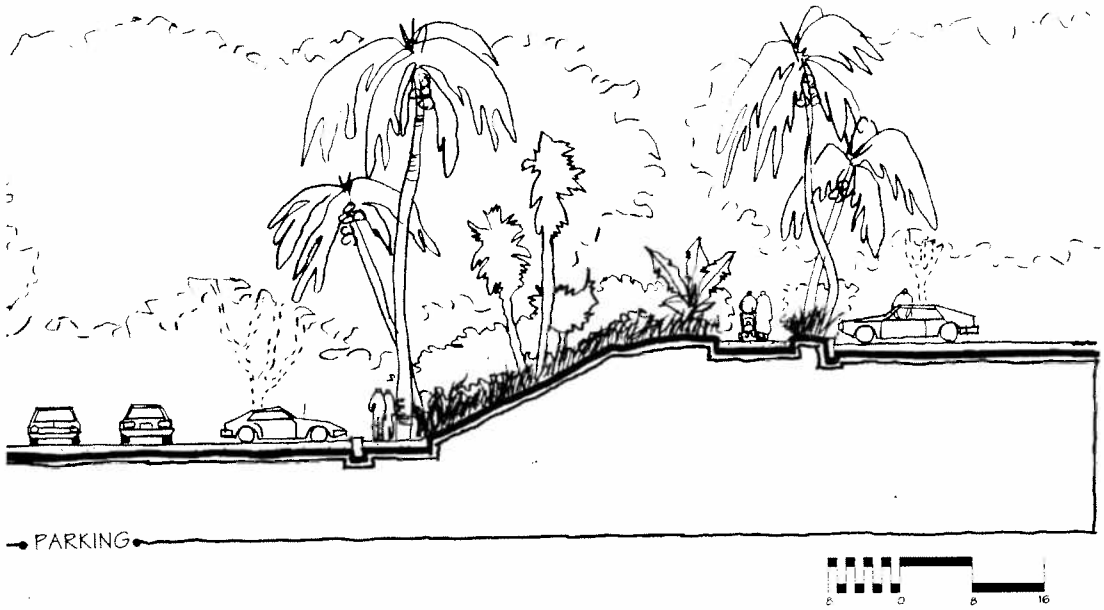
BUILDING SECTIONS



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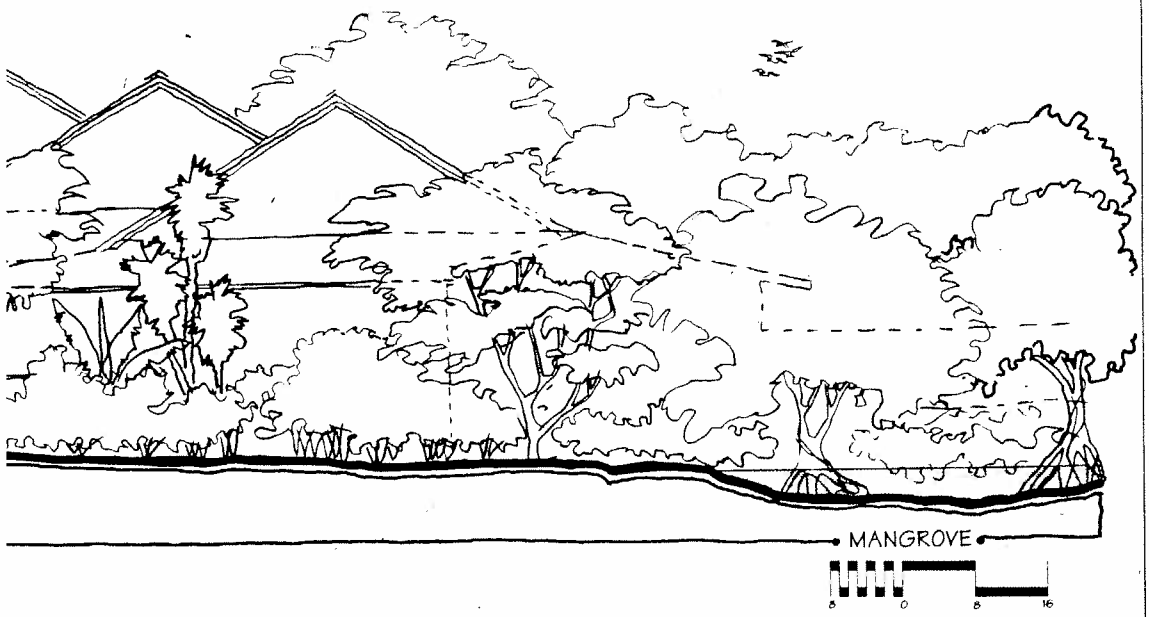

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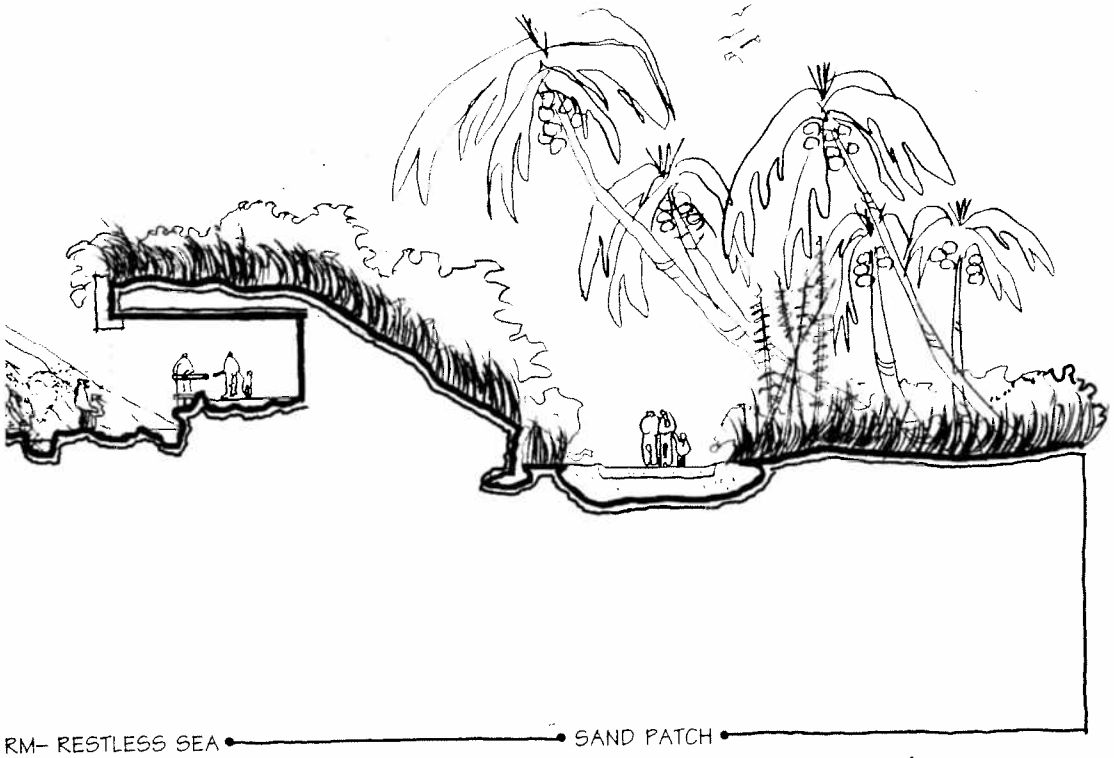

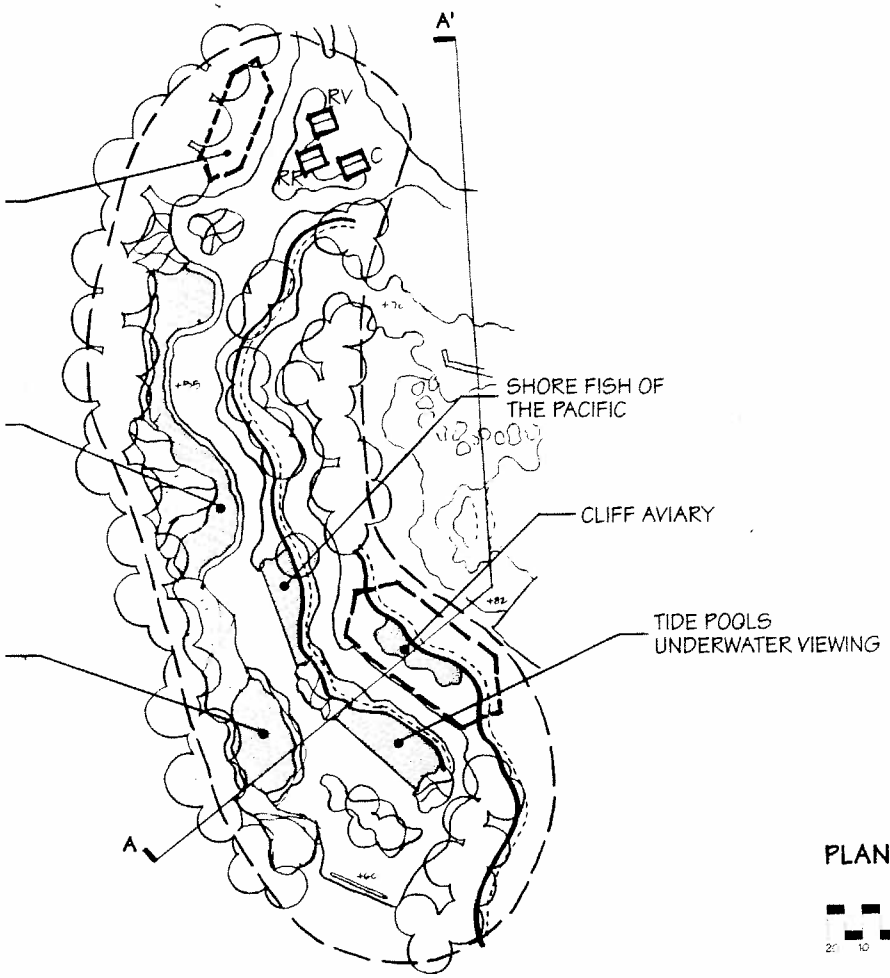

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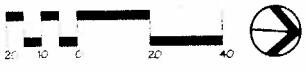

LEGEND

C CULTURAL INTERPRETATION
RV REVENUE CENTER
RR RESTROOM
H HOLDING BUILDING

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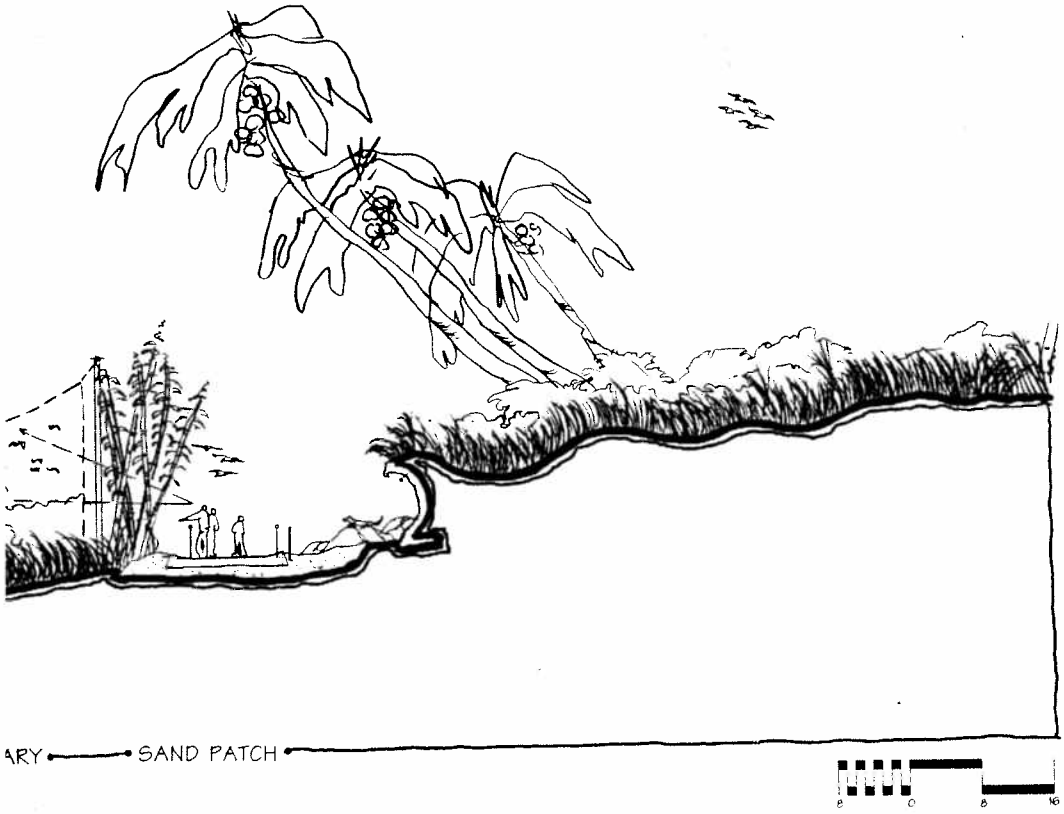
PACIFIC SHORE



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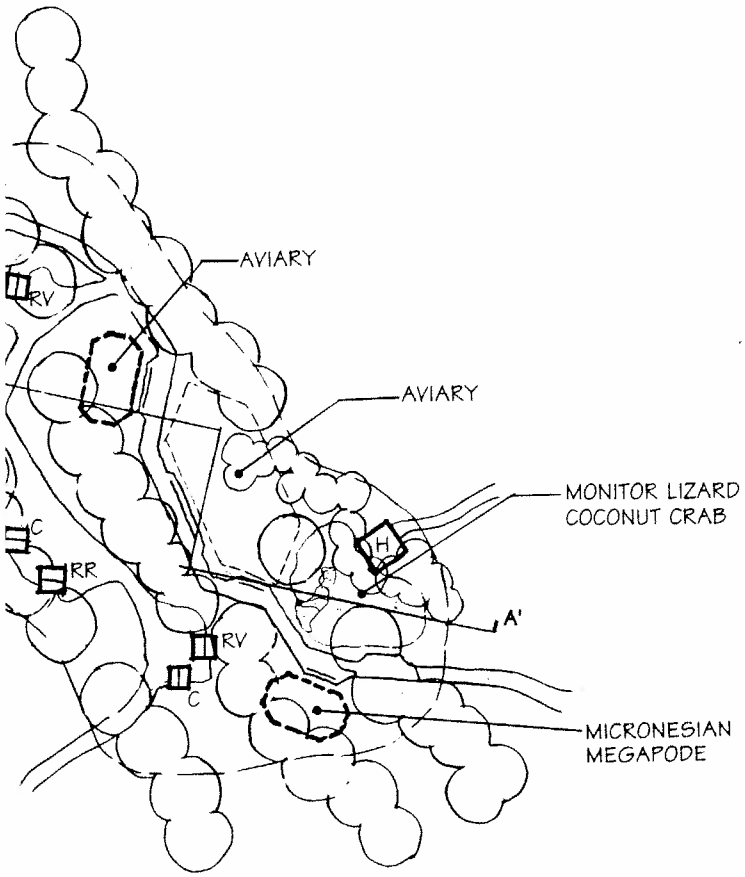

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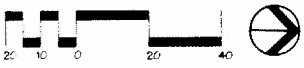

LEGEND
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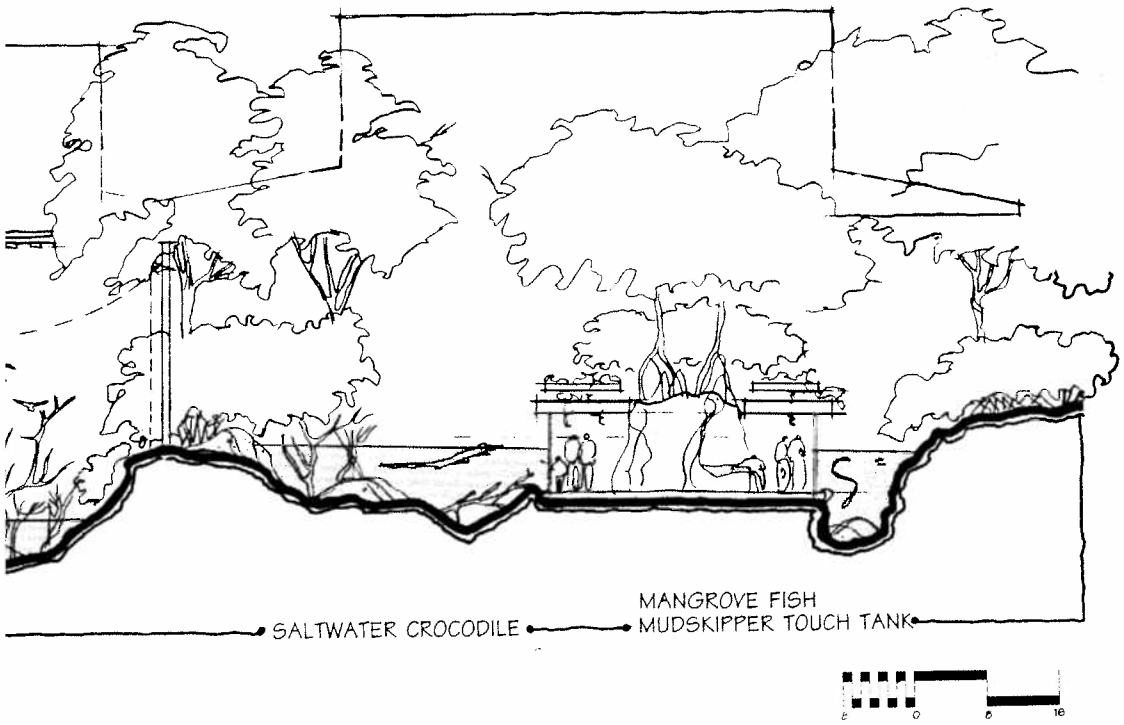
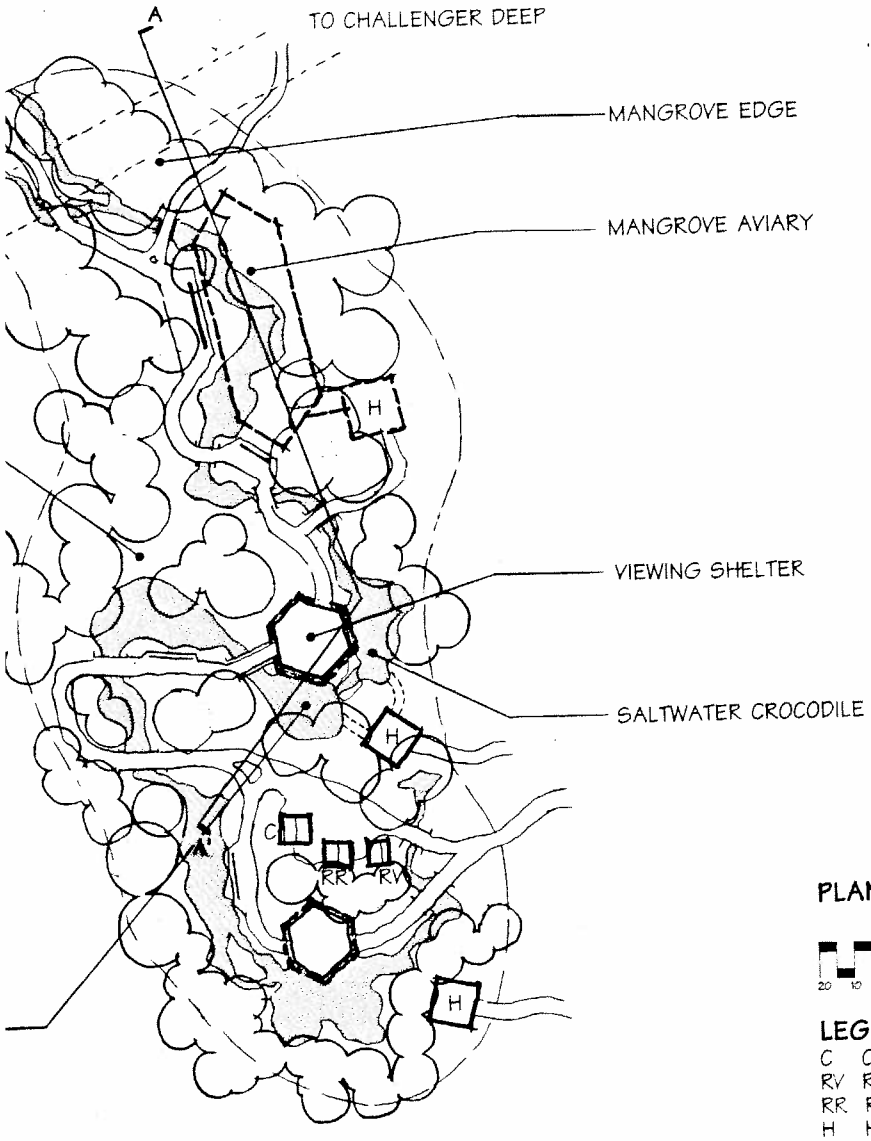
LOWLAND STRAND





PLAN

LEGEND
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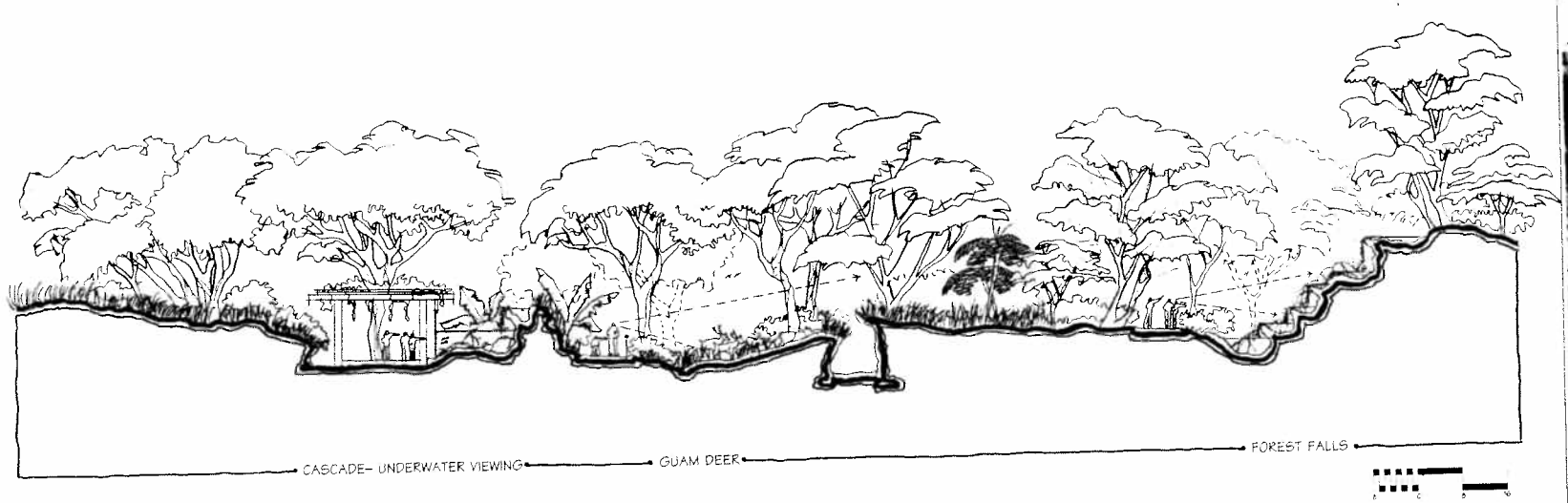
MANGROVE



SECTION A-A'

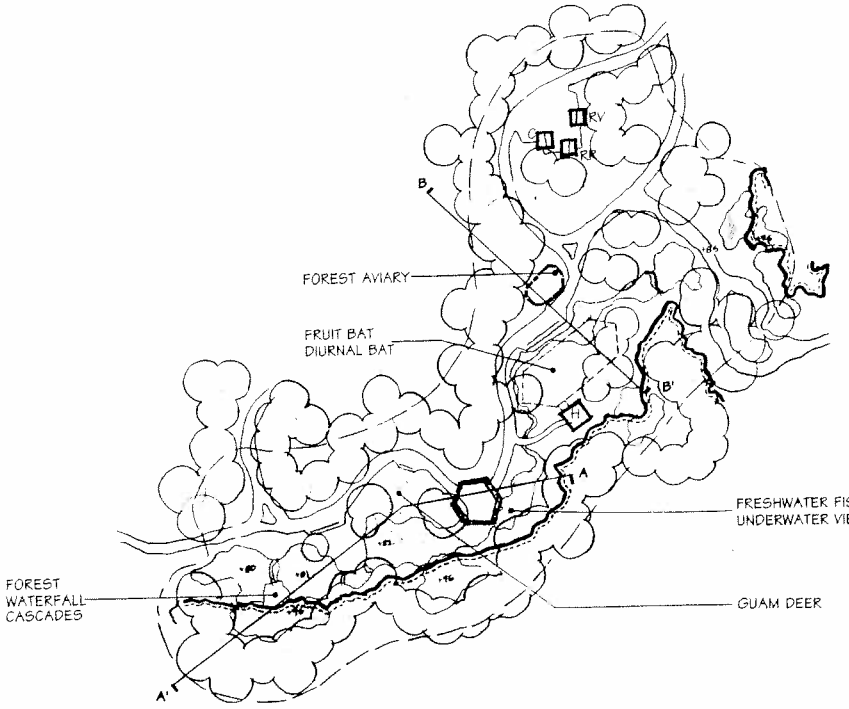
ISLAND REFERENCES
POHNPEI
KOSRAE

EXHIBITS
FOREST BIRDS
- POHNPEI LORIKEET (LORY)
- RED JUNGLE FOWL
- ROCK DOVE
- BLACK NODDY
- GRAY WHITE-EYE

GUAM DEER
FRUIT BAT
DIURNAL BAT
FRESHWATER SHRIMP
FRESHWATER FISH
- GUAM RAIL
- SLEEPER GOBI
- FRESHWATER EELS

BOTANIC
IFL WOOD TREE
TAUSAY TREE
LADA TREE
WILD HIBISCUS
BREADFRUIT (DUG DUG)
PANDANUS
BANYAN
BAMBOO

DEMONSTRATIONS
FRESHWATER FISHING
TRAP MAKING



PLAN

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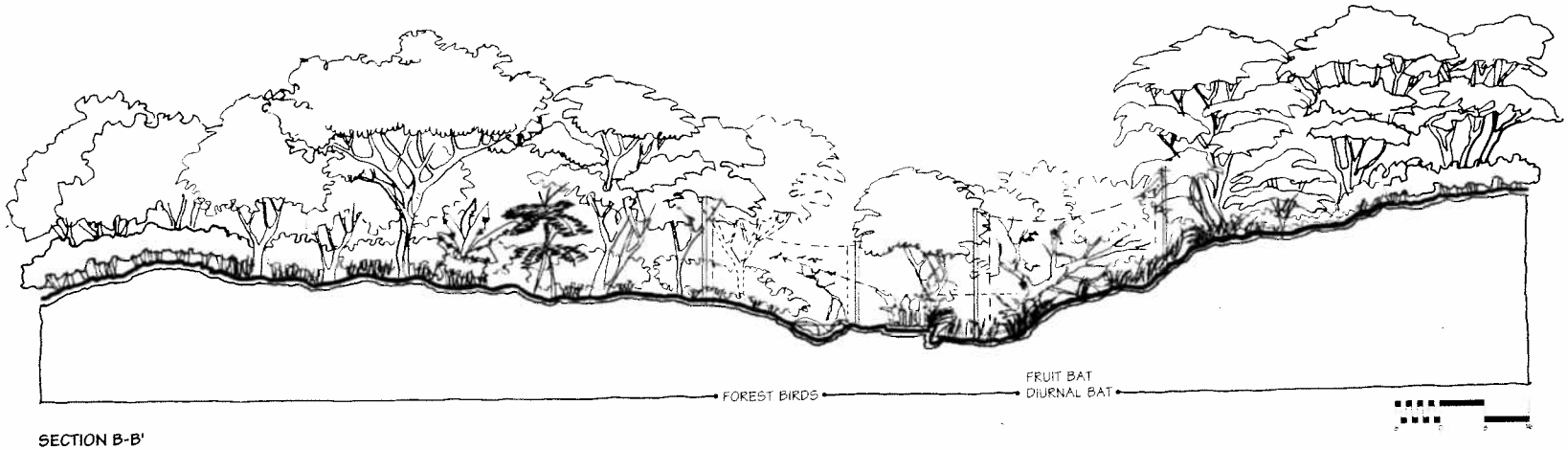
HIGHLAND FOREST



SECTION B-B'

NOTE: SEE SHEET 11 FOR PLAN LOCATION

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HIGHLAND FOREST

land, the views to the ocean, the prevailing wind, and significant site features such as rock outcrops, walls, ledges and promontories.

The architectural concept plan provides for a flexible facility that maintains beach access, parking and services for community use at all times while providing additional facilities such as a multi-use theater, demonstration area, and shops as well as meeting areas that can be used by local residents and the community in general. The plan provides an optional site for a recommended 250-person, full service restaurant for use by aquarium visitors, tourists, and island residents. This restaurant can be a unique architectural facility, immersed in the Highland Forest with selected views of the ocean.

Architectural Character. The aquarium is envisioned as a trek through selected oceanic and nearshore ecosystems that would be encountered along a transect through Micronesia. Buildings housing indoor exhibits are in turn surrounded by outdoor exhibits within appropriately planted garden grounds. This arrangement offers visitors a variety of sequential exhibit experiences as they pass in turn through indoor and outdoor areas.

To achieve this effect the aquarium structure proper offers a variety of access points to the outdoors along the exhibit route. It is organized as a series of joined pods connected by outdoor porches or breezeways that serve as congregating or demonstration areas. Visitor support areas and the administrative core are extensions of the pod structure within the garden setting. The outreach book shop could be a particularly handsome pavilion in the garden, perhaps even incorporating traditional architectural elements.

The architectural form should be derivative of the vernacular architecture of the people of Micronesia, particularly in respect to ceiling height and natural cross ventilation. Like traditional architectural forms, the building pods rely on symmetry, repeated elements, and steep, gabled roofs. Concrete, stone and wood will be encouraged in structures creating architectural forms that optimize microclimates by capturing breezes and by providing shade. Large attic spaces provide inexpensive storage areas and tank access while contributing to cross ventilation and minimization of mechanical spaces.

The exterior exhibits provide a series of individual shelters that are used as rest areas, exhibit viewing sheds and cultural interpretive areas at each exhibit area. These shelters are an extension of the pod and breezeway sequence that enrich the visitors' experience while serving as resting or meeting areas.

Small revenue centers located within each one of the outdoor exhibits provide visitors with opportunities for specialized retail and could be operated by the aquarium staff, groups of senior citizens or youth groups to promote economic activities.

This proposed architectural concept provides different alternatives for the public to visit the aquarium. The sequential alternative follows the story line through the main aquarium building and then through a series of outdoor exhibits as described in the story line. This sequence can be reversed beginning with the outdoor exhibits and then through the aquarium building or it can be altered to suit individual tastes or preferences through use of a number of egress/access points to the aquarium building. Nature trails and recreational pathways lead from the exhibits to the beach for a closer look to the ocean or to explore the coastal rock formations and plants. Aquarium visitors can visit the beach and return to the grounds through a control gate.

Finally, the aquarium can be experienced in a more casual way by alternating indoor and outdoor exhibits from structure to garden through the connecting covered walkways, protective overhangs and garden shelters.

The architectural facilities, indoor and outdoor exhibits and all other supportive structures should be designed to weather typhoon forces, such as the recent Typhoon Omar (1992), and experience only modest damage and loss of serviceability. This could be accomplished using state of the art technology for storm design. The use of natural or created land forms to provide resistance to strong winds is particularly appropriate within the outdoor exhibits and garden settings of the facility.

Aviaries and mesh structures will be designed to allow free passage of wind, thus increasing stability.

Other outdoor structures (ponds, walls and holding facilities) should be of materials such as concrete, tiles or blocks that will resist storms and corrosion.

Exterior shelter structures will be bolted or welded, rather than nailed to withstand storm forces.

Some aspects of the outside exhibitry will be designed for storage during storms. Other semi-permanent materials (such as mats or thatch) will be sacrificial if necessary, but additional materials should be available for quick replacement.

PLANT MATERIALS

General

Native plants adapted to Guam habitats and resistant to, or quickly recovering from, typhoon damage should be used. The use of exotic or foreign plants is not appropriate to the island's ecosystem and should be minimized.

Plants will be installed with stabilizing aids such as net fabric mesh over root balls. Dense plantings will provide interlocking root balls better suited to storm survival than single plants. Normal maintenance will control overgrowth of plants.

Planting should occur following the typhoon season to allow a period for the plants to become established.

Dense planting and broadleaf native plant materials can help provide protective shade and create an pleasant overall environment.

Nursery Collections

An off-site plant nursery, in a well sheltered area, should be created to allow for rapid replacement of damaged plants after storms as well as to provide plants for normal maintenance. This could be in cooperation with the Guam Department of Agriculture as part of other activities they may have in ornamental plants.

It is an inescapable fact that typhoons will impact the landscape to some degree. The ability to quickly repair the damage is important. This should be addressed in the operating plan by providing a reserve fund and supplies for repairs, and the authority for the aquarium staff to carry them out without waiting for the decisions of others.

The Selection of Species to be Exhibited

Each illustration of an individual exhibit suggests plants and animals appropriate for the exhibit. The suggestions are a basis for further refinement during design. Before final selections are made a number of factors will need to be considered. Some examples follow:

- A basic principle is that plants and animals not native to Micronesia will not be included, except perhaps: where the importations occurred in the distant past, where the species are clearly embedded in the cultural history of the islands or where they may be central to a particularly noteworthy story to be told. (An example of an imported animal that might be included would be the Guam Deer. An animal that would be excluded would be a parrot. The brown tree snake would be part of a noteworthy story.)

- Some suggested animals may be substituted either for reasons of "show" value, availability or curatorial preference. In some instances enclosures may be too costly, making adequate facilities impossible and thus resulting in substitutions. (A salt water crocodile is an example of an animal that could be a very compelling exhibit but whose "cost of containment" could be prohibitive.)

- Some desirable plants and animals may be excluded for reasons of difficult or costly procurement. Non-native (to Guam) species need particularly stringent review to prevent unwanted proliferation.

- Some plants and animals are threatened or endangered and their collection and display would not have benefits great enough to justify their inclusion. A mitigating factor might be the inclusion of breeding programs to increase the numbers available for reintroductions or to increase scientific knowledge that would benefit the animal.

- Corals are of special significance to the exhibit program. Corals also are of special importance to Guam and Micronesia and their harvest at more than a very modest scale is not appropriate. In responding to this, a basic principle is that we will not initially attempt to use live coral in large quantities in the displays. Rather, we would maximize the use of coral models that would be supplemented with small units of live coral grown by the marine lab or carefully collected from the reefs of Guam. Then, as time goes by and the reliable culture of larger live coral displays is demonstrated, the coral models could be gradually replaced.

- Beyond the simple issue of protecting endangered species, the "in-house" culturing of exhibit animals (especially fishes) is an appropriate way to make sure fishes are available for exhibit at a minimal cost. Tanks are provided for that purpose in the conceptual design and it is assumed that such activities will minimize the impact of the aquarium on native species.

- The holding and culturing needs of some of the suggested plants and animals is not well known and/or inferred from other similar animals. It may be that any one exhibit may be selected over another for this reason.

- In every instance, the importing, holding and display of plants and animals in this project is subject to approval of the Guam Department of Agriculture. They have broad authority to determine what conditions will apply and where approvals can be denied or withdrawn. However, their interest and concerns are not unlike those of the management of this aquarium as now conceived. We will rely on this commonality of interest and careful and timely communication to insure that appropriate approval from the Department of Agriculture will be available for exhibit plants and animals.

These issues are not uncommon in the evolution of the design and construction process for zoos and aquariums. Typically, they are dealt with, in part, as part of the permitting and design process and in part in the operation of the facility.

SECTION 3

ENGINEERING

PROCESS WATER SUPPLY

The process water systems are those systems that provide water to the individual exhibits, both indoors and out, and to the holding tanks located in various parts of the facility.

Criteria

The criteria used in developing the design of the process water supply is defined as follows:

Quantity of Water. The quantity of water is based on the volume of the individual tank being considered and the detention time required. At this stage of the design we propose detention time typically in the 60-120 minute range with some being more and some being less. Table 3-1 describes the flow criteria used.

Types of System. There are two fundamental types of systems used in this facility. One is a **flow-through system** that is based simply on water being pumped from the supply through the tank and discharged back into the ocean. The other type is a **reuse system** that involves water being discharged from an individual exhibit, filtered, disinfected, and returned to the exhibit. The choice between the two types of systems is somewhat arbitrary in the saltwater systems. For purposes of this conceptual design we have chosen a reuse system for the open sea exhibit and flow-through systems for the rest of the saltwater systems, though the restless sea exhibit in the wave tank would probably have some ozone added to provide for prophylactic disinfection.

The brackish water system and freshwater system of the mangrove exhibit and the highland forest exhibit respectively will be reuse systems. This is because there is not likely to be adequate freshwater available to operate either of the systems on a flow-through mode.

System Descriptions

Tank Volumes and Flows. Table 3-1 is a summary of the tankage size and the life support system criteria which define flows. In general terms, the seawater required for the operation of the system is approximately 1,800 gallons per minute and the freshwater required for the operation of the system is approximately eight gallons per minute. The total volume of tankage for the aquarium is approximately 368,000 gallons.

Process Water System Illustrations. The layout of the process water system is illustrated on Figure 13. Schematic diagrams of the various water treatment systems and the process water supply is presented on Figure 14.

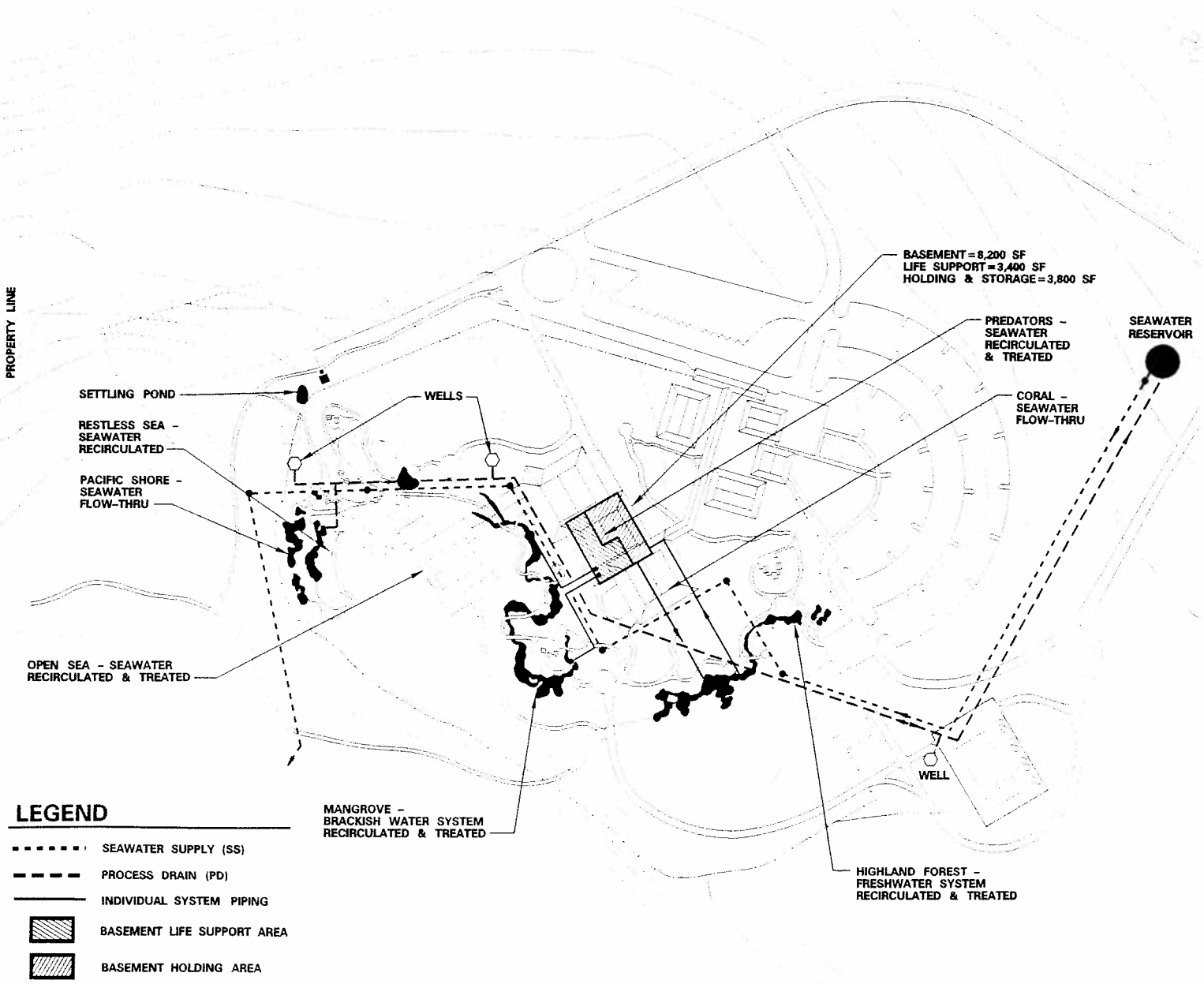
These treatment systems will be modified as more information is available. It is expected that this will have little impact on costs as most possible changes are easily accomplished with equipment, for the most part, already defined.

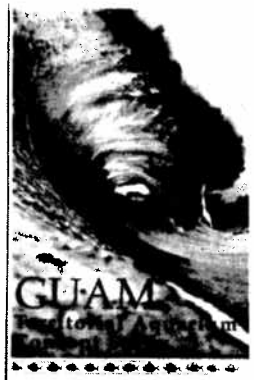
For example the entire inflow can be disinfected (at 0.5 mg/l) with the addition of six pounds of ozone per day and 300 feet of 12-inch pipe. This increases oxygen costs by 13% and electrical cost by 1%. The impact is 2% of the combined costs or $2,000 per year. Further, it may be that this additional cost at the supply-side will be offset by resulting lesser requirements in other areas.

TABLE 3-1

TANKAGE AND LIFE SUPPORT SYSTEM SUMMARY

	Location	No. of Tanks	Area SF	Avg. Depth Feet	Water Type	System Type	SW as a Volume Gallons	Make Up Detention Minutes	FW as a Nominal GPM	Make Up % of Nom. Make Up	SW Req'd GPM	% of Vol. /day	FW Req'd GPM
Highland Forest - Treat.	Outside	1	777	2.5	FW	R-Pump, Filt., Ozone	14,530	60	242			25%	2.5
Highland Forest - Falls	Outside	1	777	2.5	FW	R-Pump Only	14,530	6	2,422			0%	0.0
Highland Forest - Holding	Bsmt	2	50	2.5	FW	R-Pump, Filt., Ozone	1,870	60	31			25%	0.3
Mangrove	Outside	1	750	4.5	BW	R-Pump, Filt., Ozone	25,245	120	210	2%	4.21	25%	4.4
Mangrove - Holding	Bsmt	3	50	2.5	BW	R-Pump, Filt., Ozone	2,805	120	23	2%	0.47	25%	0.5
Pacific Shore	Outside	1	330	3	SW	FT-Flow Thru	7,405	180	41	100%	41	0%	0.0
Restless Sea	Outside	1	1900	4	SW	R-Pump, Ozone	56,848	24	2,369	2%	47	0%	0.0
Coral - Main	Inside	1	1500	12	SW	FT-Flow Thru	134,640	180	748	100%	748	0%	0.0
Coral - Secondary	Inside	10	6	2	SW	FT-Flow Thru	898	120	7	100%	7	0%	0.0
Predators - Main	Inside	1	800	8	SW	FT-Flow Thru	47,872	90	532	100%	532	0%	0.0
Predators - Secondary	Inside	10	6	2	SW	FT-Flow Thru	898	120	7	100%	7	0%	0.0
Challenger Deep-Small	Inside	20	6	2	SW	FT-Flow Thru	1,795	120	15	100%	15	0%	0.0
Open Sea - Main	Inside	1	1500	12	SW	R-Pump, Filt., Ozone	134,640	90	1,496	2%	30	0%	0.0
Open Sea	Inside	1	60	8	SW	FT-Flow Thru	3,590	120	30	100%	30	0%	0.0
-Lrg. Secondary													
Open Sea-Secondary	Inside	10	6	2	SW	FT-Flow Thru	898	120	7	100%	7	0%	0.0
SW Holding	Bsmt	9	50	2.5	BW	FT-Flow Thru	8,415	120	70	100%	70	0%	0.0
SW Holding	Bsmt	2	320	5	BW	FT-Flow Thru	23,936	120	199	100%	199	0%	0.0
SW Holding	Service	10	50	2.5	BW	FT-Flow Thru	9,350	120	78	100%	78	0%	0.0
Misc. FW Tanks	Inside	10	6	2	FW	R-Pump, Filt.	898	120	7	0%	0	25%	0.2
						Outside	104,028	Gals	Totals		1,818		7.87
						Inside	326,128	Gals					
						Bsmt	37,026	Gals					
						Service	9,350	Gals					
						Total	367,829	Gals					





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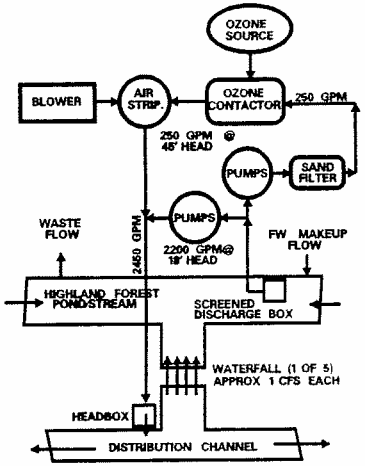
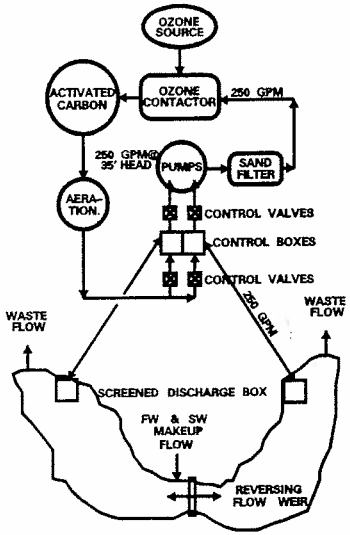
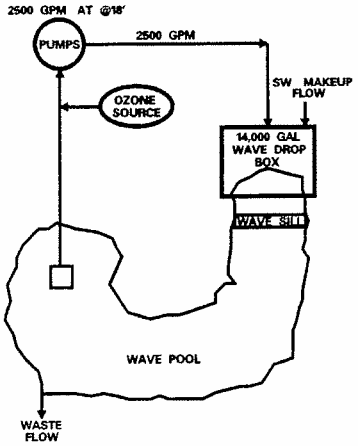
PROCESS FLOW DIAGRAM



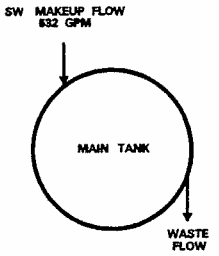
HIGHLAND FOREST FRESHWATER SYSTEM
SCHEMATIC FLOW PLAN



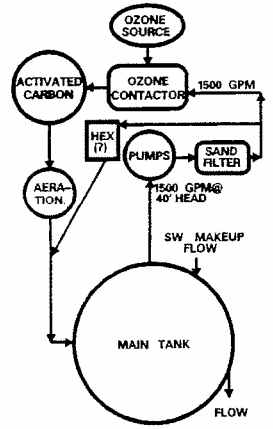
MANGROVE BRACKISHWATER SYSTEM
SCHEMATIC FLOW PLAN



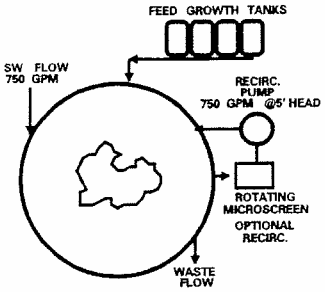
RESTLESS SEA SEAWATER SYSTEM
SCHEMATIC FLOW PLAN



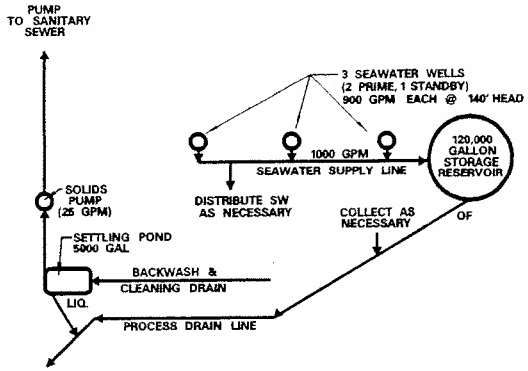
PREDATORS SEAWATER SYSTEM
SCHEMATIC FLOW PLAN



OPEN SEA SEAWATER SYSTEM
SCHEMATIC FLOW PLAN



CORAL TANK SEAWATER SYSTEM
SCHEMATIC FLOW PLAN



PRIMARY PROCESS SEAWATER SUPPLY SYSTEM
AND PROCESS DRAIN SYSTEM
SCHEMATIC FLOW PLAN

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WATER TREATMENT SYSTEM
SCHEMATICS

Life Support System Space Requirements. Space requirements for the life support systems are illustrated on Table 3-2. These space requirements are defined based on a number of other life support systems. These estimates are considered appropriate to this level of design. In general terms, 4,500 square feet is required with the majority of it being provided as a basement under the Predators of the Pass building.

Process Water Supply Energy Requirements The energy requirements for the process water supply are shown on Table 3-3.

Saltwater Storage. A saltwater storage tank of approximately 120,000 gallons is provided to allow short-term shut downs in the process water supply system. Basically, at full operation such a storage tank would provide for an hour of storage. It is not likely that a larger amount would be required as full standby generator capacity is being provided and as the wells themselves will be protected from storms.

Hydrogeology and Test Well

Test drilling at the Tagachang Bay aquarium site indicates excellent potential for development of seawater production wells[1]. The following discussion summarizes the results of the test drilling project.

Purpose. The primary purpose of the test drilling was to determine if permeable limestone sediments extend to a depth of more than 200 feet below sea level at the site. The existence of permeable limestone at depth, rather than low permeability volcanics, would suggest good potential for successful seawater wells at the site. In addition to geology information gained from the well, a pumping test was conducted to estimate the relative permeability or transmissivity of the formation penetrated by the boring.

Description of the Test Well. Test well drilling began on February 16, 1993, and was completed on February 18, 1993. Marianas Drilling, Inc. was the drilling contractor. Stewart Mohar was the driller. The well was drilled with an air-rotary drill rig, tricone bit, and foam drilling fluid. The borehole is 8-inches in diameter and extends to a total depth of 250 feet. Twenty feet of 8-inch steel surface casing was installed to prevent caving at the borehole collar. Following completion of drilling and testing, the casing was capped to prevent unauthorized entry.

The well drilling log indicates that the entire section penetrated from 3 to 250 feet consisted of light brown-white limestone. The three feet of overburden above the limestone was a silty sand.

Drilling penetration rates were measured for each 25-foot section of borehole. Penetration rates provide an indication of rock hardness and a relative indication of permeability. The average penetration rates for 25-foot sections of the borehole ranged from 1.8 to 3.4 minutes per foot. There was no discernable trend of increasing or decreasing penetration rate with depth. As a result, it appears that the rock hardness is relatively uniform with depth, which likewise suggests that the permeability may be similar throughout the entire section of formation penetrated.

Test Pumping. A twelve-hour pumping test was conducted on February 19, 1993. Pumping equipment consisted of a 9-stage submersible pump with a 30 hp motor and 4-inch column pipe. The pump was set at a depth of 180 feet. Water level was measured with an electric line well sounder and flows were measured using a 4-inch orifice weir. Static water level prior to the start of pumping was 23.6 feet below the measuring point.

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[1] The hydrogeology of the Tagachang Bay site is also discussed in Section 6.

TABLE 3-2
LIFE SUPPORT SYSTEM SPACE REQUIREMENTS

	Water Type	System Type	Nominal GPM	Space as % Full LS	Area GPM/SF	Area SF
Highland Forest-Treat.	FW	R-Pump,Filt., Ozone	273	100%	0.51	532
Highland Forest-Falls	FW	R-Pump Only	2,422	20%	4.47	542
Mangrove	BW	R-Pump, Filt., Ozone	210	100%	0.47	450
Pacific Shore	SW	FT-Flow Thru	41	10%	2.00	21
Restless Sea	SW	R-Pump. Ozone	2,369	20%	4.45	532
Coral - Main	SW	FT-Flow Thru	748	10%	6.89	109
Coral - Secondary	SW	FT-Flow Thru	7	10%	2.00	4
Predators - Main	SW	FT-Flow Thru	532	10%	6.30	84
Predators-Secondary	SW	FT-Flow Thru	7	10%	2.00	4
Challenger Deep-Small	SW	FT-Flow Thru	15	10%	2.00	7
Open Sea-Main	SW	R-Pump,Filt., Ozone	1,496	100%	0.81	1,846
Open Sea-Lrg.Secondary	SW	FT-Flow Thru	30	10%	2.00	15
Open Sea-Secondary	SW	FT-Flow Thru	7	10%	2.00	4
Misc.FW Tanks	FW	R-Pump, Filt.	7	60%	0.33	22

Ozone Gen. Space Bsmt	300	SF
LS Area in Basement	2,828	SF
Other Area in Basement	272	SF
Pumping Area Open Ocean	532	SF
Other Area elsewhere	539	SF
Total Area	4,471	SF

TABLE 3-3
ENERGY & OXYGEN REQUIREMENTS

Pumping Energy Requirements

	Nom. FlowGPM	Nom. Head Feet	Calc. HP @ 65%	
Highland Forest Treatment Pumps	250	45	5	
Highland Forest Falls Pumps	2200	18	16	
Mangrove Pumps	250	35	4	
Restless Sea Pumps	2500	18	18	
Open Sea Pumps	1500	40	24	
Water Supply Well Pumps	1800	140	101	
			167	HP
			2,988	KWH/Day

Ozone Energy & Oxygen Requirments

	Nom. Flow GPM	Ozone mg/L	Ozone lbs/Day	KWH /day @ 4.00	Oxygen lbs/day 6%
Highland Forest Treatment Pumps	250	1.5	4.50	18	75
Mangrove Pumps	250	1.5	4.50	18	75
Restless Sea Pumps	2500	0.2	6.00	24	100
Open Sea Pumps	1500	1.5	27.02	108	450
Misc.	100	1	1.20	5	20
			KWH/Day	173	721

Summarized Process Requirements Annual Cost

		SF	Units	Unit Pr.	Annual $
Electrical Energy	KWHrs/Yr	15%	1,326,865	$0.06	$79,612
Oxygen	lbs/Yr	15%	302,462	$0.06	$18,148
		Process Energy and Oxygen Costs			$97,760

The well was pumped at an approximate rate of 400 gpm with an average drawdown of only 0.2 feet. The pumping water level stabilized within one minute of the start of pumping. Visible turbidity cleared after less than 30 minutes of pumping. At the completion of the 12-hour test, the water level in the well recovered to static water level in less than one minute.

Pumping test data demonstrated a specific capacity of approximately 2,000 gpm per foot of drawdown. This specific capacity suggests a very high aquifer transmissivity, probably in excess of 2,000,000 gpd/ft. This value is typical for relatively clean limestones in Guam and suggests excellent production potential.

Salinity Profile. Prior to abandonment of the borehole[2], a conductivity or salinity profile should be conducted to determine the depth and thickness of the brackish and freshwater zones, and the corresponding depth to seawater salinity at the well site. A salinity profile might be determined at minimal cost by lowering a two-strand electrical wire down the hole and measuring changes in resistivity with depth. Conversely, a thief sampler could be used to obtain depth-specific samples for on-site salinity analysis. A profile will assist future design of seawater production wells at the site, including determination of minimum casing depth for production wells.

Summary. Results of the test drilling at Tagachang Bay suggest excellent seawater production potential. Based upon the drill log, pumping test data, and water quality analysis, a well field could be developed at the site that could produce in excess of 5,000 gpm of 32 to 34 ppt salinity.

Water Quality Study

Test Well Water Quality. Three water samples were collected during test pumping of the Tagachang Bay well for laboratory analysis at the Water and Energy Research Institute of the Western Pacific at the University of Guam. Salinity of the samples ranged from 3.2 to 3.3 percent compared to an average seawater salinity of about 3.4 percent. Total dissolved solids (TDS) ranged from 34.5 to 35.6 ppt, which is equivalent to seawater TDS. Chloride ranged from 18.0 to 18.7 ppt., only slightly less than the average of about 19 ppt for seawater.

As the well was not cased through the freshwater and brackish sections of the aquifer, the water sample does not indicate the water quality to be expected from a completed seawater production well. Instead, it provides an indication of the water quality from the most permeable zones along the entire length of the borehole, and is therefore a mix of the freshwater, brackish water, and seawater sections of the aquifer. Also, given the minimal drawdown in the well (0.2 feet), the setting depth of the pump (180 feet) may influence the zone from which the water is drawn. Nonetheless, the water samples obtained by pumping from the uncased borehole indicate excellent potential to develop deep wells with water quality that closely approximates seawater chemistry.

Background Water Quality Information. Water quality data from the seawater wells at the Fadian Pt. aquaculture center was obtained[3]. While the information is somewhat limited, it does compare the well water to ambient sea water and it is likely to be somewhat valid for the project

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[2] Borehole Abandonment. Guam Environmental Protection Agency (GEPA) regulations require that the borehole be abandoned if not developed into a production well within a one-year period after drilling. We have contracted with Marianas Drilling to perform this work for a price of $1,250. Therefore, unless The Guam Economic Development Authority (GEDA) obtains an extension from GEPA for keeping the boring open, the borehole must be abandoned by mid-February 1994.

[3] Approximately 3 miles north and in a similar geologic zone. These wells have been in operation for over 12 years (with some periods of disuse.).

site[4]. This is shown on Table 3-4. Additional sea water well monitoring during six months of 1989 at the aquaculture center showed well seawater nitrate concentrations consistently around 0.14 mg/L with the highest measurement approximately 0.21 mg/L.

TABLE 3-4

WATER QUALITY OF AMBIENT SEA WATER AND SEA WATER WELLS FADIAN PT. MARICULTURE CENTER (mg/L)

Location	Calcium	Magnesium	Total Hardness	NO3-N	PO4-P
Ambient	327	1320	6250	<0.10	<0.002
Wells	319	1250	5950	0.11	0.006

This water quality is clearly suited to fish rearing and suited to discharge into the ocean. The effluent parameters of main concern here are the nutrients nitrate and phosphate. Phosphate levels in the well water are well below discharge criteria for Category M-2 waters (Table 3-5). Nitrate levels in the Fadian Pt. well water is typically well under the discharge criterion concentration of 0.2 mg/L.

Water Supply Summary. Based on the information reviewed, seawater wells are suitable as the primary seawater supply for this facility both in terms of quality and quantity.

Process Effluent Disposal

To dispose of the process water from this facility there are several options. Disposal into the domestic sewage system is unlikely to be acceptable because of the large quantities of seawater involved. However, some small portion of the process water could be disposed in the domestic sewage system if necessary to dispose of solids that might be found in the backwash and cleaning drain. (This is water that is generated when ponds are cleaned or when the filters are backwashed.) In general terms, this flow should not exceed 5,000 gallons a day. We would expect to work with the PUAG (Public Utilities Agency of Guam) to insure that this can be disposed of in the public sewer system with the rest of the domestic sewage from this facility.

The second option would be disposal of process water into wells on the site. This is a relatively expensive solution and if possible, one which we would prefer to avoid because of the possible interference with the supply.

The preferred option for disposing of the process effluent is to discharge it directly back into the onshore waters of this site. The following section discusses the water quality classification of this site and the criteria for discharge into marine waters.

Process. Marine waters offshore from the Tagachang Bay site are classified as Category M-2[5], Good, by the Guam EPA. Water in this category must be of sufficient quality to allow for the propagation and survival of marine organisms, particularly shellfish, corals and other reef related

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4 Water quality test for nitrate and phosphate were not undertaken for the Tagachang Bay test well as the period of pumping was fairly short. It was felt that the Fadian wells would be fairly representative of project wells after long use.

5 This is not the most stringent category.

resources. Other important and intended uses include mariculture activities, aesthetic enjoyment and compatible recreation inclusive of whole body contact and related activities.

General criteria applicable to all discharges to territorial water bodies are that no discharge shall:

- cause visible floating materials, debris, oils, grease, scum, foam, or other floating matter which degrades water quality or use;
- produce visible turbidity, settle to form deposits or otherwise adversely affect aquatic life;
- produce objectionable color, odor, taste, directly or by chemical or biological action;
- injure or are toxic or harmful to humans, animals, plants or aquatic life; and
- induce the growth of undesirable aquatic life.

Specific numerical water quality criteria for Category M-2 marine waters is listed on Table 3-5.

Process Effluent Disposal Summary

Based on our estimates of the change in water quality within the system due to the rearing of fish, the likely water quality of the supply, and the effluent criteria defined above, we are of the opinion that the direct discharge option is acceptable and we will assume this for preliminary design. Clearly it will require work with Guam EPA to validate this conclusion and this will be handled in later stages of the engineering work for this project.

DOMESTIC WATER AND SEWER NEEDS

Flow Criteria

The peak day attendance at this facility is estimated to be approximately 2,200 people based on the high range projections. An examination of information from other facilities would suggest that the freshwater supply required to handle this type of attendance is 25 gallons per day per capita. On that basis the domestic water requirements would be approximately 55,000 gallons per day for visitors.

In addition there is a requirement for irrigation of the landscape areas. Irrigation requirements assuming 1/2 inch per day over six acres will be 90,000 gallons per day.

Restaurant and concession use of water, over and above the values defined above, are estimated to be 50,000 gallons per day.

On the basis of the above we will assume that the peak domestic water requirements for this facility will be 200,000 gallons per day with the average day being 100,000 gallons per day.

We assume that these quantities will be available from PUAG. This is based on preliminary discussions with that agency.

Domestic Sewage

The domestic sewage likely to be generated in this facility is approximately equal to the domestic water requirements, less irrigation, plus possible flows from the process cleaning waste of the facility. Based on the above, the domestic sewage quantities likely to be generated would be

TABLE 3-5

WATER QUALITY CRITERIA FOR CATEGORY M-2 MARINE WATERS

ANALYTE	CRITERION
Fecal coliform	mean count ≤ 70/100 ml during any 30 day period no sample > 400/100 ml at any time
pH	ambient range from 7.0 - 9.0 units no variation from ambient > 0.5 units
Nutrients	
Phosphorus	Orthophosphate (PO_4-P) ≤ 0.05 mg/L
Nitrogen	Nitrate-nitrogen (NO_3-N) ≤ 0.20 mg/L
Dissolved Oxygen	No decrease below 75% saturation at any time 4.6 mg/L at 30° C, 5.0 mg/L at 26° C
Salinity	No alteration of more than +10% above ambient except due to natural conditions
Total Filterable Suspended Solids	No increase > +10% above ambient No increase > 20 mg/L except due to natural conditions
Turbidity	No increase > 1 NTU above ambient except due to natural conditions
Radioactive Materials	No discharge
Temperature	No change > 1° C above ambient
Oil or Petroleum Products	
No discharges allowed that:	are detectable as a visible film, sheen, or results in visible discoloration of the surface with a corresponding oil or petroleum product odor, cause damage to fish, invertebrates or objectionable degradation of drinking water quality, forms an oil deposit on the shores or bottom of the receiving body of water.
Pesticides	Concentrations shall not exceed 1% of the 24-hour LC50 value determined using the receiving water in question and the most sensitive species of aquatic organisms affected.
Toxic substances	Shall not exceed 5% of the 96-hour LC50 at any time or place The 24-hour average concentration shall not exceed 1% of the 96-hour LC50

approximately 110,000 gallons per day on a peak day and we will assume 80,000 gallons per day on an average day.

We assume that the sewer service will be available from PUAG. This is based on preliminary discussions with that agency.

Fire Protection

In this preliminary conceptual design we have not evaluated fire protection and cannot do so until greater detail is available as to the building types. However, we assume that significant fire protection flows are available from the PUAG system and that these can be augmented by domestic freshwater supply storage to be provided on site. The domestic water and sewer lines required to provide service are illustrated generally on Figure 15, the Utilities Plan. In discussing this with PUAG, they've indicated services available on the highway above the site but we have not analyzed this in greater detail. Our assumption is that PUAG will make provisions for receiving the domestic sewage and providing the water requirements for the facility.

OTHER ENGINEERING ELEMENTS

Road and Access

Access to the site is on an existing road illustrated on Figure 15. The existing access road will require repaving with an asphaltic overlay and significant improvements at the intersection with the highway. In simplest terms we had defined these improvements as being the addition of a left turn lane and traffic signals.

Electrical

The energy requirements for operating the process water system average 132 kilowatts. The peak requirements would probably not exceed 140 as all systems are designed to operate continuously.

The peak air-conditioning requirement is estimated to be 144 kilowatts with the average demand of approximately 40 kilowatt hours. On this basis, the combined average, plus an allowance for lighting and miscellaneous loads, would be 200 kilowatts with the peak demand at approximately 290 kilowatts.

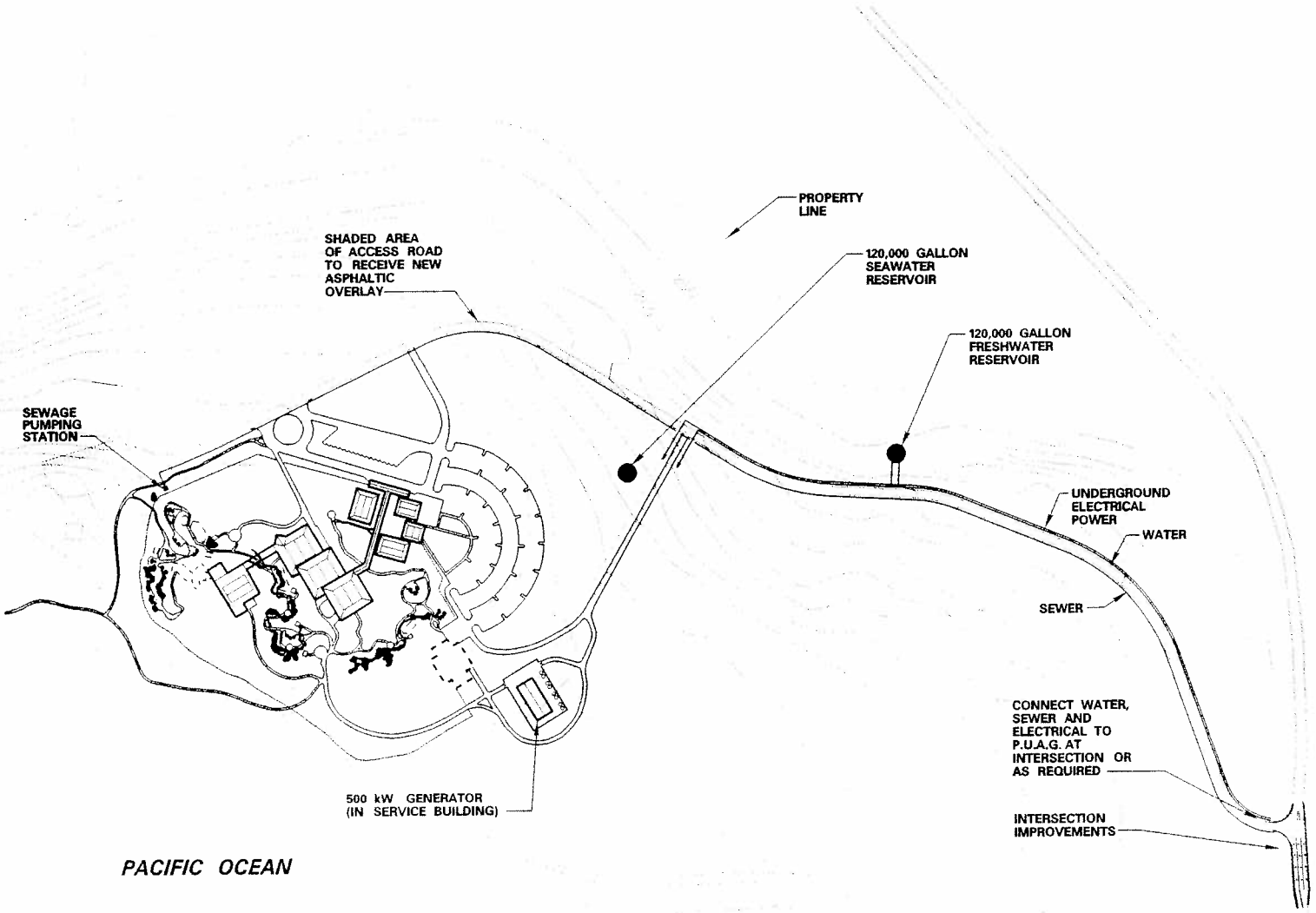
The energy requirements noted here can be met from the island grid except during periods of power outages. To provide for these periods of power outages we propose that the electrical system would include an emergency generator with a nominal rating of 500 kilowatts.

Lighting

Low intensity lighting will be provided in the area of the outdoor exhibits although visitors normally will not be on the grounds after dark. However, as there will be occasional groups renting the facility at night, we will want to have some night lighting for outside exhibits. In addition, portable lights will be provided to allow outdoor construction at night when major maintenance is required.

Other Issues

Foundation Conditions. The observation and some understanding of the geological conditions of the site indicate that the foundation conditions are relatively normal and special foundation systems such as pilings will not be necessary.



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ERA Economics Research Associates
SAN FRANCISCO, CALIFORNIA

UTILITIES PLAN

Tunneling and Rock Excavation. As part of the Open Ocean and Restless Sea exhibits a certain amount of tunneling and rock excavation will be required in the limestone of coral origin. This is well within normal construction capabilities.

Surface Water Drainage. As part of the site landscaping surface water drainage will be provided through a system of inlets and pipes.

Security Fencing. Security fencing will be provided as necessary to protect the animals in the exhibits from unwanted entry and vandalism.

Telecommunications. It is assumed that the telecommunications will be provided through the island-wide telephone system.

Plant Material/Nursery. As discussed in Section 2, a plant nursery will be required to be established and in operation for approximately three years before the beginning of the operation of this facility. Basically, the purpose of this nursery will be to grow materials to be used in the outdoor areas of this facility and to provide a storage space for large trees and plants salvaged from other parts of the island that can be used in the aquarium. The operation of this nursery could be by the Department of Agriculture or by a private contractor selected through a public bidding process.

Freshwater Storage. A freshwater storage tank will be provided with the capacity of approximately 120,000 gallons. This size was selected based on several relatively independent criteria.

- 120,000 gallons will provide fire flow of 500 gallons per minute for two hours in the event of island-wide water system failure.
- The 120,000 gallon storage can also provide for the operation of this facility during periods of water system failure such as may occur after typhoons. While it is expected that the visitor population during such periods would be lower than normal it is still likely that they will visit this facility in lieu of other attractions during post-typhoon periods. Estimating the water requirement for such periods is difficult but, tentatively assumed to be on the order of 30,000 gallons per day. Thus the storage tank could provide for the visitor needs plus the approximately 10,000 gallons per day required for the exhibits. This system would provide for three days of operation.