

# **THE PALAU MANGROVE MANAGEMENT PLAN**

## **VOLUME I**

**(Version 2.0, 09/29/00)**

**prepared for**

**Bureau of Natural Resources and Development  
Ministry of Resources and Development  
Republic of Palau**

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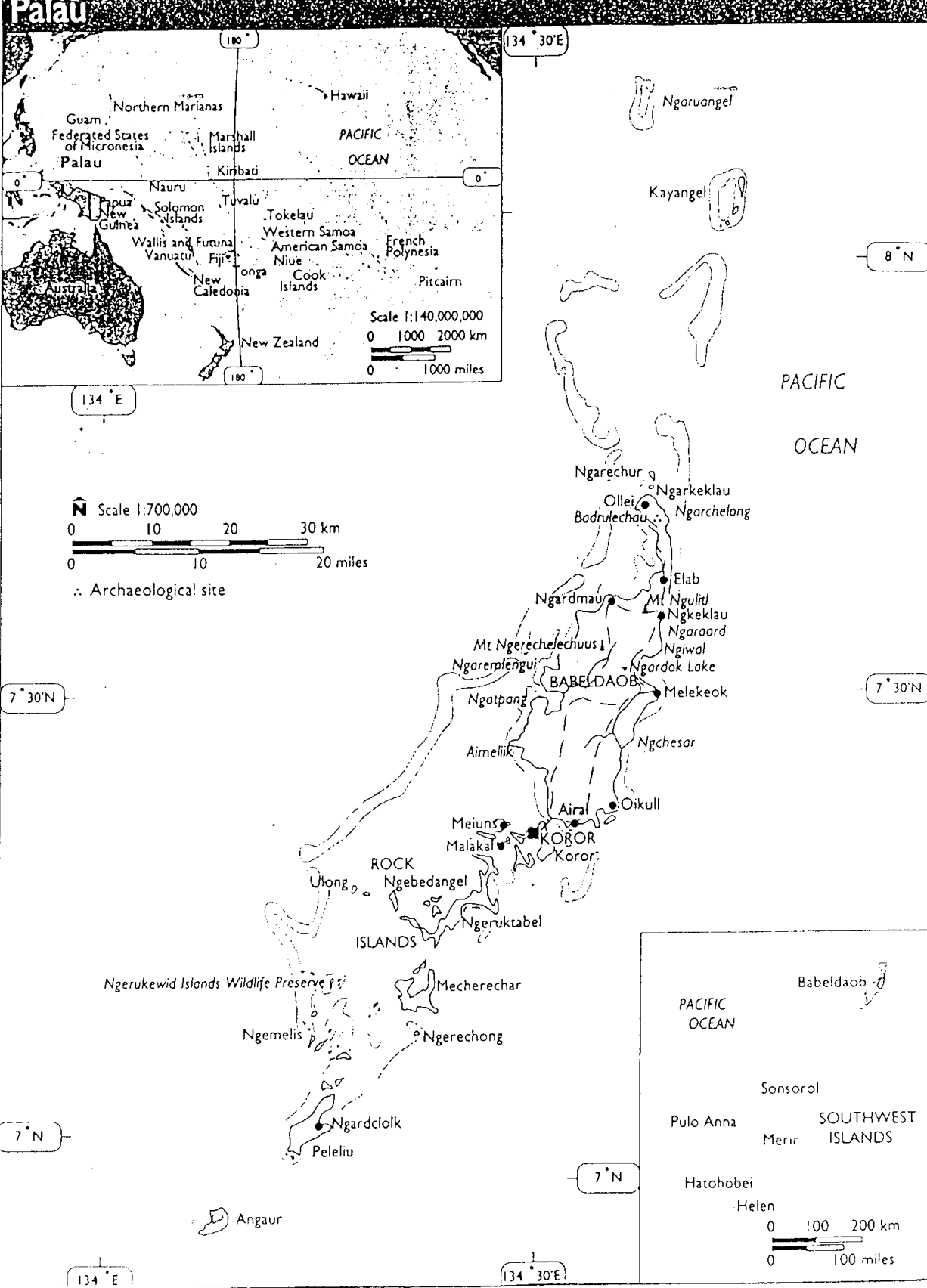


Figure 1-1. Plan Vicinity Map (Source: Republic of Palau National Environmental Management Strategy, Maiava 1994).

## PREFACE

The Palau Mangrove Management Plan provides a framework for managing Palau's mangrove resources. Based on a 4-week mangrove reconnaissance during May 1999, the Plan addresses mangrove management direction and Natural Heritage Reserve System (NHRS) classifications for mangroves. The Plan supports Palau's 2020, Master National Development Plan (1996) and the Palau Natural Heritage Reserve System Act (1991).

Though the Plan focuses on the mangrove resource, carrying out Natural Heritage Reserve System classifications for mangroves creates impacts on other resources and uses as well. The mangrove ecosystems of Palau are products of complex physical and biological processes and interactions. Besides these, are Palau's cultural, traditional, social, economic and political requirements that the mangrove ecosystem must satisfy. The protection and conservation of Palau's mangrove ecosystems are of major importance.

In summary, this Plan presents general management direction and suggested prescriptions for the treatment of Palau mangroves. The principles presented are designed to support an "ecosystem management" approach to mangrove wetlands. No attempt is made to prescribe "cook book" methods for managing particular localities or individual mangrove stands in specific areas. The standards and guidelines presented are intended to provide a range of options and management strategies from which the Palau resource manager may choose for application.

## ACKNOWLEDGMENTS

I would like to thank the following people who provided support and insight into the environmental and social realms of Palau's mangrove resource. On Palau: Demei Otobed, Director (retired), Bureau of Natural Resources (MR&D) and Herman Francisco, Director, Bureau of Natural Resources (MR&D) for their commitment to conserve Palau's mangroves. Marcello Brel, Acting Director of Agriculture and Mineral Resources (BNR/MR&D) for his guidance, logistical coordination and support of mangrove conservation. Ebais Sadang, Chief Forester, Forestry Unit (BNR/MR&D) for logistical support. Special mention goes to Kashgar Rengulbai, Forester/U&CFCoordinator, Forestry Unit (BNR/MR&D), for his logistical support and mangrove conservation commitment; and for sharing Palau's rich culture. Ms. Robin DeMeo, Resource Conservationist, USDA - Natural Resources Conservation Service, for reference materials and maps, and all-around support in Palau's mangrove conservation effort. Katherine Ewel, Jim Allen, Ken Krauss, Tom Cole and Katie Friday, Institute of Pacific Islands Forestry (USDA-Forest Service), for their assistance. As to be expected, special mention goes to Len Newell, Pacific Islands Forester (IPIF, USDA-FS) for his continued financial, technical and professional commitments to mangrove conservation in the Pacific Region. Thanks go to the Los Padres National Forest for their support of mangrove conservation efforts in the Pacific Southwest Region.

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## ACRONYMS AND GLOSSARY

### ACRONYMS

BMP	Best Management Practices
BNRD	Bureau of Natural Resources and Development. As used in the Plan, this includes the Division of Agriculture and Mineral Resources (specifically the Forestry Unit), the Division of Marine Resources, and the Division of Conservation and Entomology, all within the Ministry of Resources and Development.
EA/EIS	Environmental Assessment/Environmental Impact Statement
FSM	Federated States of Micronesia
IPIF	Institute of Pacific Islands Forestry, USDA- Forest Service, PSW-Region 5
NGO	Non-Government Organization
NHRS	Natural Heritage Reserve System
PLAN	Palau Mangrove Management Plan
ROP	Republic of Palau

### GLOSSARY

Afforestation	The planting of trees in unforested areas.
Buffer Zone	a zone, surrounding a mangrove NHRS area, which regulates use to enhance the conservation values of a specific core area.
Bul	Traditional Palauan conservation strategy that restricts or bans fishing and hunting in specific areas or by certain species.
Coastal Erosion Processes	Natural (wind, tidal surge, currents, storms) and human (sand/coral mining, deforestation) events that destabilize shorelines making them susceptible to the removal and/or deposition of sand, sediment and coralline materials.
Commercial	Harvesting of wood and nonwood products above subsistence needs for retail sales.
Core Area	The central or foundational part of a mangrove NHRS area.
D.B.H.	Diameter at Breast Height.
Deforestation	The cutting and removal of forest trees, such that forest regeneration does not occur or is destroyed.
Ecosystem	A system formed by the interaction of living organisms (including people) with their environment.
Ecosystem Management	Management strategies that sustain ecological systems and their diversity while meeting the needs of Palauan society.
Ecotourism	Nature-based tourism (boardwalks, tours).
EA/EIS	A review and assessment of the environmental, social and economic impacts or consequences of human activities.
Nonwood Products	Tangible forest products such as crabs, fish, shellfish, leaves, etc.

Reforestation	The planting of trees in forested or deforested areas.
Silviculture	The practice of manipulating forest stands for wood production and enhanced forest productivity.
Subsistence	Traditional daily levels of wood and nonwood gathering for basic needs
Sustainable Development	Development that meets present needs without compromising the ability of future generations to meet their own.



Above: Bngaol (*R. apiculata*) dominates the landward edge of a mangrove stand on the east-central coast of Babeldaob Island

## EXECUTIVE SUMMARY

At the request of the Palau National Government, an assessment was performed to review the general status of mangroves and develop management options for their conservation. A mangrove management plan was developed for the Bureau of Natural Resources and Development, Ministry of Resources and Development. The Palau Mangrove Management Plan (abbreviated as "Plan"), provides National and State management direction for approximately 8,650.0 acres of Palau's total 11,633.0 acre mangrove estate.

The purpose of the Plan is to provide "Long-term Ecosystem Management for the Sustained Yield and Productivity of All Natural Resources within and Dependent upon Mangrove for the People of Palau" (Mission Statement, Division of Agriculture and Mineral Resources). Mangroves are critical to Palau's island ecosystem as they transform both organic and inorganic inputs from the uplands and ocean, produce wood and non-wood products, maintain fresh and coastal water quality, provide shoreline protection, support a variety of habitats and biodiversity, as well as serving a visually pleasing landscape.

The intent of the Plan is to provide national-level mangrove management direction and guidance that directly supports state ownership and conservation of mangroves resources. It is to be used as a national planning tool that promotes consistent mangrove management and conservation strategies implemented at state and local government levels. The Plan provides a flexible program reflecting a mix of strategies and activities that allow the use and conservation of mangrove ecosystems.

Today, in Palau, the primary loss of mangroves is attributed to land reclamation activities associated with infrastructure improvements and tourism-based developments along coastal shorelines. In the future, it is likely that mangroves throughout Palau will be under considerable pressure as the general population increases and population centers shift with the construction of the Compact Road and proposed Capitol move to Melekeok State. Increases in residential areas and commercial land demands (such as cottage industries, resorts and fish ponds), continued infrastructure expansion, and natural phenomena such as rising sea-levels will likely have adverse impacts on mangroves. Issues, concerns and opportunities such as these drive the Plan.

Four critical Plan elements have been identified. They are essential for developing and carrying-out national and state level mangrove programs. The four critical elements are:

1. **Palau Mangrove Management Direction**. National management direction provides the foundation of Palau's mangrove conservation strategy and serves to support State mangrove conservation efforts. Standards and guidelines are proposed that promote the achievement of the Desired Future Condition for Palau mangrove resources.
2. **Mangrove Protected Area Classifications under the Natural Heritage Reserves System (NHRS)**. The ROP Natural Heritage Reserve System Act (1991) serves as the authority



for establishing mangrove protected areas. Each of the mangrove NHRS area classifications has a specific set of objectives and selection criteria. The three (3) proposed Palau mangrove NHRS area classifications are:

- **Mangrove Preserve.** Designed to preserve outstanding and dynamic mangrove wetlands over time. Represent 679.0 acres or 6% of the total Palau mangrove NHRS area;
- **Mangrove Reserve.** Designed to provide sustainable, multiple-use mangrove forest values and benefits. Represent 7,584.0 acres or 65% of the total mangrove NHRS area, and;
- **Mangrove Special Management Area.** Designed to contribute to the ecological and socioeconomic needs of Palau. Represent 478.0 acres or 4% of the total Palau mangrove NHRS area.

3. **Palau's Mangrove Natural Heritage Reserve System Areas**. The Plan proposes twelve (12) mangrove Natural Heritage Reserve System areas. Seven (7) of these mangrove NHRS areas were recommended in the Palau 2000, Master Development Plan. Five (5) were identified during Plan site visits. They form the foundation of Palau's mangrove conservation strategy, representing 74 percent of the total Palau mangrove estate. Each mangrove NHRS area is comprised of one of the mangrove protected area classifications identified above. Most mangrove NHRS areas are linked with Palau's major watershed basins. The twelve mangrove NHRS areas are essential for sustaining the values and goods associated with Palau's major watersheds, and ultimately Palau's island ecosystem. The proposed Palau mangrove NHRS areas, with associated acreage and state jurisdictions are:

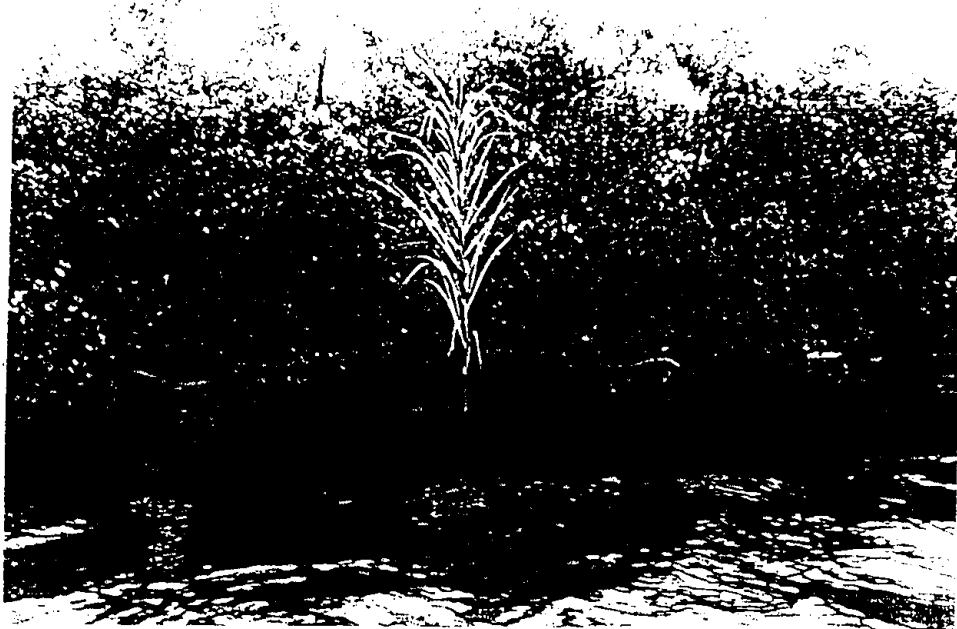
1. Ngaremeduu Mangrove Preserve (579.0 acres). Ngatpang State.
2. Rock Islands Mangrove Preserve (100.0 acres). Koror State.
3. Ngaremeduu Mangrove Reserve (1,070.0 acres) Aimeliik, Ngatpang and Ngaremlengui States.
4. Taoch Ngerdorch-Taprengesang Mangrove Reserve (367.0 acres). Ngchesar State.
5. Airai Bay Mangrove Reserve (1,137.0 acres). Airai State.
6. Diongradid Mangrove Reserve (935.0 acres). Ngaraard and Ngardmau States.
7. Ngemai-Imolech Mangrove Reserve (653.0 acres). Melekeok and Ngiwal States.
8. Taoch ra Imeong Mangrove Reserve (626.0 acres). Ngaremlengui State.
9. Amieliik-Airai Mangrove Reserve (694.0 acres). Aimeliik and Airai States.
10. Northern Babeldaob Mangrove Reserve (928.0 acres). Ngerchelong and Ngaraad States.
11. Peleliu Mangrove Reserve (1,174.0 acres). Peleliu State.
12. Koror Special Mangrove Management Area (478.0 acres). Koror State.

4. **Plan Action Items**. Use of the Plan centers on eight recommendations which are expressed as action items. They identify Bureau of Natural Resources and Development and State management activities important for making the Plan a successful "on-the-ground" program. The eight Action Items are:

- Expand duties of the Urban and Community Forestry Program, Forestry Unit (Division of Agriculture and Mineral Resources), to include Plan responsibilities,
- Integrate Division of Conservation and Entomology, Division of Marine Resources, and Division of Agriculture and Mineral Resources collaboration to enhance Plan success,
- Establish Palau Mangrove Committee,
- Complete Palau Forest Practices Act with incorporation of Plan references,
- Use ROP Natural Heritage Reserve System (1991) Act for mangrove protected areas,
- Develop a national mangrove environmental education and awareness program,
- Develop a mangrove monitoring program, and
- Develop a mangrove timber program, as needed.

These activities are designed to be started during the first five-year planning period, some occurring once, while others are ongoing over many years. Action Item costs range from \$US2,000 to \$US16,000.00 per year.

The mangroves of Palau, represent a significant “natural heritage” for the people of Palau. Palau’s mangroves are among the most productive and biologically diverse ecosystems found within Micronesia. Shoreline protection, wildlife and fisheries habitat, wood commodity production, upland sediment trapping, nutrient buffering, and near-shore water quality - are but a few of the direct and indirect values and benefits of mangrove ecosystems. The Plan represents a significant step in the advancement of National and State mangrove management. Palau’s mangrove ecosystems are truly a national treasure. Every effort should be pursued to ensure their continued productivity, biodiversity and conservation.



Above: Customary “Bul.” Note palm branch (center, forward), placed at mangrove channel entrance in Ngerdmau State. This palm branch represents the symbol of a “bul,” a Palauan custom used for identifying areas where resources such as fish and crab are managed under conservation principles.

## HOW THE PLAN IS ORGANIZED

The Plan contains two volumes:

- ◆ **Volume I**, The Plan. This volume is the core structure of the mangrove management plan. Volume I contains the overall concept of the Palau mangrove management plan itself, and
- ◆ **Volume II**, Plan Appendices. This volume provides more detail for particular Plan components and provides an overview of reference materials used in Plan development. A thorough understanding of these appendices is essential for carrying out specific aspects of the Plan. Volume II of the Plan includes:

Appendix A	<u>Plan Action Items</u> . An overview of activities necessary for implementing key aspects of the Plan, in a grant narrative format.
Appendix B	<u>The Mangroves of Palau</u> . Summary of Palau mangrove species characteristics, silvics and ecology from previously published findings and Plan site visits.
Appendix C	<u>Plan Mangrove Resource Standards and Guidelines</u> . Initial mangrove management actions and Best Management Practices. Designed to assist Palau resource managers achieve the Desired Future Condition of mangroves.
Appendix D	<u>Palau Natural Heritage Reserve System (NHRS): Mangrove Management Direction</u> . Guidelines, management guidance, boundaries, selection criteria, and current conditions of the proposed mangrove NHRS areas.
Appendix E	<u>Palau Mangrove Timber Management Program</u> . Initial development of the proposed mangrove timber program.
Appendix F	<u>Plan Analysis Area</u> . Overview of Palau's environmental and socioeconomic conditions affecting mangrove resources.
Appendix G	<u>Selected References</u> .

Volume II of the Plan is available for review at the Forestry Unit, Division of Agriculture and Mineral Resources, Koror, Republic of Palau; and at the Institute of Pacific Islands Forestry, 1151 Punchbowl Street, Room 323, Honolulu, Hawaii, 96813.

## 1.1 Purpose and Need for the Palau Mangrove Management Plan (Plan)

This Palau Mangrove Management Plan (Plan) was developed to guide the Division of Agriculture and Mineral Resources (specifically, the Forestry Unit), Division of Marine Resources, and Division of Conservation and Entomology, in the management of Palau's mangrove ecosystems.

The Plan serves as the general mangrove management strategy for the Bureau of Natural Resources and Development, Ministry of Resource Development, herein called "BNRD." It also serves to support mangrove recommendations identified in the Palau 2020, National Master Development Plan (1996), specifically, Chapter 12 - Environmental Planning and Management.

The Plan centers on the need for a national management strategy that sustains Palau's mangrove ecosystems over time. The Plan will help safeguard mangroves for the goods and services of society, while maintaining their critical ecological role. The Plan is driven by the need to regulate human activities within and next to mangroves; and to provide consistent guidance to the States in the management of their mangrove resources. Compact Road construction, cottage industries, ocean-front resort development, and the increasing production and consumption by Palau's growing and shifting population will likely have adverse impacts on Palau's mangrove ecosystems.

## 1.2 Objective of the Plan

Perhaps Palau's strongest mangrove management direction is derived from the Palau 2020, Master National Development Plan (April 1996), Chapter 9 - Agriculture and Forestry, Section 9.4.5.5 (page 9-18), call for Mangrove Management Plan Establishment, stating:

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*"The mangrove forests are among the most important of Palau's resources, providing a filter between land and sea, protection for the shorelines, and serving as a major breeding ground for marine species of all kinds."*

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The goal of the Plan is to provide a flexible management program reflecting a mix of national and state strategies and activities that allow the wise-use and protection of mangroves. The Plan describes specific actions for the proposed five-year planning period. The Plan is designed to be a "living document", meaning that it can be revised and updated, as needed, at any time.

### **The Plan Design Process Accomplishes This By:**

- ◆ establishing national mangrove ecosystem management direction and objectives over the next five-year planning period, with strong opportunities to assist in state mangrove conservation efforts;
- ◆ specifying goals, standards and guidelines for practices necessary to achieve that direction;
- ◆ providing a readily exchangeable framework for incorporating and adjusting mangrove management direction, standards and guidelines and mangrove land use classifications as new information becomes available and/or as conditions change; and,
- ◆ establishing implementation, accomplishment and monitoring action items to ensure the Plan is being carried out.

### **1.3 Plan Critical Elements**

The Plan focuses on four critical elements that are necessary for carrying out mangrove management direction. These essential items are:

1. **Palau Mangrove Management Direction (Chapter 2.0, Volume I)**
2. **Mangrove Protected Area Classifications Under the Natural Heritage Reserve System (Chapter 3.0, Volume I)**
3. **Palau's Proposed Natural Heritage Reserve System for Mangroves (Chapter 4.0, Volume I)**
4. **Plan Action Items (Appendix A, Volume II)**

### **1.4 Ecosystem Management and the Desired Future Condition of Mangrove Resources**

Carrying out the Plan will direct BNRD toward an ecosystem management approach to mangroves. That is, sustaining mangrove ecological systems for the long-term, while providing benefits to Palauan society. This approach will help state governments meet the Desired Future Condition of mangrove resource elements, by specifically identifying what the ideal future condition or circumstance of a particular mangrove resource element should be. Resource elements (such as fisheries and recreation based activities), dependent or independent of mangroves, are considered.

Although the Plan centers on mangroves, this vegetation type has a significant influence on marine resources, wildlife, coastal lands and water quality. Besides these, are Palau's socioeconomic, cultural and political requirements and influences on mangroves. Overall, the Plan will help conserve mangroves and enhance environmental quality, while providing services and commodities in response to Palauan needs.

## 1.5 Plan Relationship to Laws and other Planning Levels and Studies

In Palau, under a Constitutional provision, States have exclusive ownership of their living and nonliving land and sea resources out to twelve (12) nautical miles (Article I, Section 2, ROP Constitution). States are responsible for the management and development of resources within these boundaries (Maiava and Otobed, 1994).

Palau has three major planning levels: national, state and traditional. Aspects of the Plan need to be integrated into all three planning levels to ensure consistent mangrove strategies and policies. Without information sharing and cooperation between these levels, portions of the Plan will be seriously compromised. State and community-based participation is critical to Plan success.

Mangrove management direction is provided at the national level. National level direction provides a solid foundation in which to support consistent state-wide mangrove management efforts. The Environmental Quality Protection (EQP) Act of 1981, Natural Heritage Reserves System Act of 1991, the Palau National Environmental Management Strategy (Maiava, 1994), Palau State of the Environment Report (Otobed and Maiava, 1994), Palau Environmental Legislation Review (Pulea, 1994), and the Comprehensive Conservation Strategy for the Republic of Palau (Cassell, Otobed & Adelbai, 1992), provide national environmental policies related to mangroves.

The Natural Heritage Reserve System Act (NHRS) supports the designation of unique communities of natural flora and fauna into protected areas. NHRS designations are based on nominations by the Bureau of Natural Resources and Development. Protected area management is established by the Ministry of Resources and Development, in consultation with State Government Officials. This act allows for the making and amending of rules and regulations affecting protected areas, and the authority to establish citations and other enforcement mechanisms for mangrove areas.

The foundation for designating the proposed Plan mangrove protected area classifications is through the ROP Natural Heritage Reserves Systems Act of 1991 (RPPL No. 3-51). See Chapter 3.0, Mangrove Protected Area Classifications under the Palau Natural Heritage Reserves System.

The House Committee on Resources and Development (ROP) is developing the "Palau Forest Practices Act." This legislation is intended to regulate the exploitation of forest resources and promote forest conservation strategies. This Act can help translate Plan concepts and terminology into environmental law, while supporting and complimenting the Natural Heritage Reserve System Act of 1991.

Palau has several levels of studies involving lagoon, shoreline, reef, ocean waters

and mangrove. These include the Palau 2020, National Master Development Plan (1996) and the Marine and Coastal Areas Survey Synthesis Report (CORIAL, 1994). Documents such as these provide invaluable information and links to the Plan.

**The Plan will serve as a vehicle for further mangrove planning efforts. It provides a forum for national government, state government, traditional government, non-government organizations and public involvement in the development of a comprehensive mangrove management program for Palau.**



Above: Proposed Airai Bay Mangrove Reserve, Airai State. In the bay, a mangrove fringe borders the landward edge.

## 2.1 Introduction

This chapter represents the first of four critical elements in the proposed Palau Mangrove Management Plan. The Plan guides BNRD personnel toward the achievement of the Desired Future Condition of mangrove resource elements.

## 2.2 Palau Mangrove Management Direction

The Plan emphasizes nationwide mangrove management strategies.

Focusing the Plan at the national-level ensures that the principles of mangrove conservation and protection are consistent throughout the states. Providing national-level mangrove leadership with direct support to the states, as well as promoting community-based mangrove programs and sustainable development schemes, are essential to Plan implementation.

National direction is expressed with a mission statement, goals and objectives, standards and guidelines, and the expected future condition of mangroves. Following through to implement Plan standards and guidelines, especially at the state-level, is critical to translating the Desired Future Condition of mangroves into actual results.

### 2.2.1 Mangrove Management Mission Statement and Objectives

The Mission Statement of the Bureau of Natural Resources and Development, is made up of goals designed in response to management issues, concerns and opportunities identified during the first phase of Plan development. The goals are also decided chiefly by the importance of mangrove and coastal resource conservation.

**The Purpose of the Palau Mangrove Management Plan is:** Long-term Ecosystem Management for the Sustained Yield and Productivity of all Marine and Coastal Natural Resources within, and Dependent upon Mangroves for the People of Palau (Bureau of Natural Resources and Development Mission Statement).



**The Mission of the Bureau of Natural Resources and Development is to accomplish that purpose by:**

- ◆ Providing conservation leadership to the states that promotes the health, biodiversity, productivity and visual qualities inherent in mangrove ecosystems, and ultimately their ecological sustainability;
- ◆ Managing mangroves for coastal erosion prevention, habitat, natural ecological processes and public use;
- ◆ Providing for the protection of environmental quality, cultural resources, public health and safety, private property and users of mangroves;
- ◆ Providing recreation opportunities limited to Palau or not available elsewhere; and,
- ◆ Promoting a work environment that enhances the attraction, training, development and retention of a high performing workforce.

### **2.3 Expected Desired Future Condition of Mangrove Resource Elements**

This section provides brief details of the expected Desired Future Condition of mangrove resource elements under the proposed Plan. Mangrove resource elements include mangrove vegetation, fisheries, marine life, wildlife, coastal lands, watersheds, recreation, Natural Heritage Reserve System, mangrove laws and regulations, and cultural and historic resources. The Desired Future Condition represents the full achievement of mangrove resource element goals and objectives. That is, how the people of Palau visualize the future condition of their mangrove resources (such as the status of mangrove fisheries habitat), whether projected out five or 100 years.

Volume II, Appendix C, Plan Mangrove Resource Standards and Guidelines, further define the Desired Future Conditions listed below by setting the baseline conditions for carrying out Plan direction. Appendix C is critical in understanding the management direction proposed by BNRD. Mangrove management standards and guidelines are what Palau resource managers need to focus on to achieve the Desired Future Condition of mangrove resource elements. The standards and guidelines presented represent the minimum levels of management necessary to reach the Desired Future Condition of mangrove resource elements.

#### **2.3.1 Mangrove Vegetation Desired Future Condition**

Overall, the distribution of mangroves will increase through BNRD conservation strategies and promotion of sustainable development schemes at the state level. The use of mangrove land use categories and best management practices will result in stands with high natural to near-natural appearing conditions and processes. A “no net loss policy” for mangroves will be institutionalized at national and state government levels. In specific areas, mangrove uses will be regulated, helping to maintain mangroves for shoreline protection and ecological processes.

As needed, in site-specific areas, silvicultural treatments can improve mangrove stand productivity and forest health. As a byproduct of these treatments, mangrove forest products can be produced. As needed, mangrove establishment programs will be initiated in degraded mangroves and areas of coastal erosion concern.

### **2.3.2 Fisheries, Marine and Wildlife Resource Desired Future Condition**

An indirect Plan benefit will be the maintenance and enhancement of marine fisheries and wildlife habitats (for example, near-shore coral reefs, sand and mud flats, shoals, seagrass beds, lagoons, shorelines and mangrove channels) within and next to mangroves. This will be accomplished by controlling or restricting levels of mangrove harvesting and conversion in critical habitat or watershed areas.

### **2.3.3 Coastal Lands Desired Future Condition**

Use of the Plan will help protect coastal shorelines from excessive erosion, sand, silt and soil deposition, rising sea-levels and biochemical changes. Maintenance of mangrove fringes will help prevent coastal erosion. Intensive management is focused on coastal areas with known erosion problems or where human activities are adversely affecting mangroves.

### **2.3.4 Watersheds Desired Future Condition**

Mangrove NHRS areas will be identified and linked with the major watersheds of Palau. Many rivers and streams drain into mangrove ecosystems from upper watersheds. Land uses within upper watersheds have the potential to adversely affect mangroves. Monitoring and regulating upland uses are critical to sustaining NHRS mangrove area integrity. A major consideration will be integrating and linking upper watershed land uses and classifications within mangrove NHRS areas. Another major consideration, is the conservation of freshwater swamps and marshes. These freshwater resources are often immediately inland from mangroves and are an important environmental link for maintaining island ecological processes. Reducing annual erosion and sedimentation, increasing average annual water yield, and maintaining biodiversity are focus areas.

### **2.3.5 Recreation Desired Future Condition**

Recreational opportunities will be enhanced as mangrove NHRS areas are designated. The quality of mangrove forest recreation will increase with the regulation of incompatible mangrove activities, the enforcement and awareness of environmental laws, and sustainable development schemes that improve bay and lagoon health. Employment associated with nature-based tourism (for example, mangrove boardwalks, mangrove boat tours, nature tour activities, wildlife viewing and fishing) opportunities will increase within and next to mangrove NHRS areas.

### **2.3.6 Mangrove Natural Heritage Reserve System Desired Future Condition**

Specially designated mangrove land use classifications will increase significantly under the Plan. Under Palau's Natural Heritage Reserve System (NHRS), the following mangrove categories are addressed: Mangrove Preserve, Mangrove Reserve and Mangrove Special Management Area. These designations offer a variety of uses and activities designed to meet the needs of Palauan society, while protecting mangroves and overall environmental quality.

### **2.3.7 Mangrove Resource Law and Regulation Enforcement Desired Future Condition**

Overall, the Plan will promote the development of mangrove related environmental legislation and regulations (for example, Palau Forest Practices Act). Enforcement activities associated with mangrove laws and regulations will be enhanced. The Ministry of Resources and Development is responsible for developing and executing management strategies affecting coastal environments and natural resources, including regulation of their occupancy and uses.

Under the Plan, state administrators and traditional leaders will be more involved in mangrove legislation and regulation development. Their support will improve Plan achievements and help change public perceptions toward mangrove. The Plan provides a forum to solicit and increase BNRD budget, staffing, equipment and training needs.

### **2.3.8 Cultural and Historic Resources Desired Future Condition**

The Plan promotes the preservation of cultural traditions and the historic resources found within and next to mangroves. Emphasis is on the development of a long-term program to maintain cultural traditions (for example, subsistence wood and nonwood product gathering) associated with mangroves and to inventory, evaluate, protect historic resources found within mangroves.

The Plan provides guidelines to help protect and preserve heritage sites. Interpretation of local cultural and historic resources will likely meet a growing demand for the people of Palau and tourists.

## **2.4 Palau Mangrove Management Committee**

The creation of a Palau Mangrove Management Committee is recommended under the umbrella of the Urban and Community Forestry Program, Forestry Unit, Bureau of Natural Resources and Development. The Committee would be responsible for promoting and advancing national and state mangrove policy. See Volume II, Appendix A - Action Item #3: Establish the Palau Mangrove Committee.

The committee supports a “call-when-needed” interdisciplinary team. The team represents a cross-section of representatives from national, state and local governments, the private sector, and the general public. The committee will advise and make recommendations to the Ministry of Resources and Development on national and state mangrove issues. As needed, the committee will help develop national/state mangrove position statements, policy, laws and regulations. The committee will also help develop recommendations for advancing and updating the Plan.



Above: Proposed Ngaremeduu Mangrove Reserve. Landward edge of mangrove along the Ngermeskang River, Ngaremlengui State.

Chapter 3.0  
**Mangrove Protected Area Classifications  
Under the Natural Heritage Reserve System**

---

**3.1 Introduction**

This chapter represents the second of four critical elements in the Plan. Three (3) mangrove protected area classifications have been identified under Palau's Natural Heritage Reserve System. These classifications serve as special use zones or areas. Each mangrove protected area classification has a set of objectives and selection criteria.

It is important for Palau natural resource managers to realize that the Plan "fragments" mangroves between management compartments (for example, between Aimeliik State and Airai State) and protected area system classifications (for example, Mangrove Preserve and Mangrove Reserve). In essence, mangrove ecosystems have no institutional boundaries. Mangrove ecosystem processes transcend jurisdictional and management boundaries. Mangroves and adjacent ecosystems are interrelated, making them more susceptible to cumulative impacts.

These protected area classifications are to be integrated, over time, into the entire Palau mangrove estate (Palau 2020, National Master Development Plan recommendation, 1996, p 12-36). This system will help identify areas of particular emphasis and promote understanding of mangrove ecosystems.

**3.2 Mangrove Protected Area Classifications under the Palau Natural Heritage Reserve System**

**Three (3) Mangrove Protected Area Classifications Have Been Developed for Palau:**

- Category 1: Mangrove Preserve (Natural Heritage Preserve),
- Category 2: Mangrove Reserve (Natural Heritage Reserve), and
- Category 3: Mangrove Special Management Area (Special Management Area under the NHRS)

A Natural Heritage Reserves System (NHRS) was recommended in the Palau 2020, National Master Development Plan (SAGRIC International Pty Ltd., 1996). The Plan uses the same classification system as it takes advantage of the Palau Natural Heritage Reserves Systems Act (1991) and provides for a simpler, more consistent approach to the Palau protected area system. Mangrove NHRS classifications were further refined by categories and objectives assembled from many sources, notably Devoe (1991), Hamilton and Snedaker (1984), Holthus (1987), Salm (1984) and Clough (1993).

During Plan development, site visits were conducted in specific mangrove areas. Coupled with mangrove protected area recommendations in the Palau 2020, Master National Development Plan (1996), mangroves were classified into NHRS categories.

Mangroves were placed into NHRS categories based on the following standards (Devoe, 1991): 1) the presence of threatened, rare, and endangered species, particularly rich biota, or undisturbed old-growth communities; 2) the need to maintain intact mangroves to protect biotic and physical resources from excessive wave action, adverse weather and sedimentation; 3) the need to protect cultural, natural and economic resources; 4) the need to protect and maintain high fisheries or forest productivity; and, 5) to maintain sustainable timber stocking levels, particularly in proximity to wood-consuming communities, businesses or infrastructure.

### **3.3 Descriptions and Objectives for Mangrove Protected Area Classifications under the Palau Natural Heritage Reserve System**

#### **3.3.1 Category 1 - Mangrove Preserve (Natural Heritage Preserve)**

**The Mangrove Preserve, a component of the Natural Heritage Preserve (NHP), is designed to allow natural processes to occur, undisturbed by human activities, thereby protecting unique mangrove areas over the long-term.** The protection and indefinite perpetuation of dynamic mangrove ecosystems must be guaranteed. As more detailed coastal and marine resource research is accomplished, Mangrove Preserves may be identified for other reasons and purposes.

**Access to Mangrove Preserves is allowed, however, human activities and uses are greatly restricted.** Manipulative human activities (for example, commercial timber harvests, commercial mangrove crabbing, commercial fishing, land reclamation, fish ponds, agricultural expansion, residential house construction, causeways, etc.) are prohibited. This category should be used to prevent human activities that have the potential to adversely affect mangrove ecosystem processes. Non-manipulative scientific research (for example, mangrove vegetation growth and yield studies) and limited educational and recreational opportunities (for example, nature tours) may be allowed, if determined not to have adverse affects on mangrove health. Extractive resource use, such as mining, commercial logging, or large scale commercial fishing or crabbing is not permitted in Mangrove Preserves.

As appropriate, only acceptable levels of traditional subsistence wood and nonwood product gathering are allowed. Allowed uses are authorized by state administrators, customary protocol and BNRD- preferably by special use permit. Subsistence uses are frequently monitored to ensure they are within acceptable levels.

Two (2) Mangrove Preserves are proposed for Palau. The Ngaremeduu Mangrove Preserve represents approximately 579.0 acres (234.0 ha) or 5 percent of the total Palau mangrove estate. The Rock Island Mangrove Preserve, represents approximately 100.0 acres (40.0 ha). In total, Mangrove Preserves account for a total of 679.0 acres (275.0 ha) or about 5 percent of Palau's mangrove estate.

**Mangrove Preserve Management Objectives include:**

- ◆ Protect and preserve mangrove ecosystems of unique character, limited distribution, high biological diversity, suspected high productivity, genetic value, distinguished amenity values and scenic merit;
- ◆ Maintain mangrove ecosystem processes in a natural or near-natural state in support of critical habitat, coastal protection and overall island ecosystem health; and,
- ◆ Prevent human habitation from causing adverse or irreversible impacts to mangrove ecosystems and adjacent habitats (for example, mudflats, coral reefs, seagrass beds, bays, lagoons, and freshwater swamps and marshes).

**3.3.2 Category 2 - Mangrove Reserve  
(Natural Heritage Reserve)**

**The Mangrove Reserve, a component of the Natural Heritage Reserve, is designed to support sustained multiple uses that contribute primarily to Palau's island ecological needs, and secondly to Palau's socioeconomic needs.** Mangrove Reserves also contribute to the recreational, educational and cultural needs of Palauan society. Mangrove Reserve status will protect unique and dynamic mangroves from human over-exploitation; and assure that natural conditions necessary to protect significant mangrove ecological values are provided for.

Mangrove Reserves protect the natural resources of an area by preventing unsustainable forms of resource extraction. The integrity of mangrove resources are maintained for future generations. Subsistence mangrove wood and nonwood resources are managed to provide for optimal production under sustained-yield programs. Protection measures for marine fisheries, wildlife, watershed, recreation, scenic values, biodiversity, genetics, etc. are integrated into all Mangrove Reserves.

**Public access is allowed, with restrictions.** Human activities and uses may be restricted to ensure Mangrove Reserve integrity. Only acceptable levels of traditional subsistence wood and nonwood product gathering are authorized. Subsistence activities will be monitored by state administrators, customary protocol and BNRD. If monitoring shows unacceptable levels of subsistence exploitation, action will be taken to enforce national, state and traditional regulations.

Manipulative human activities (for example, timber harvesting, land reclamation, fish ponds, agricultural expansion, residential house construction, causeways) may be permitted if EA/EIS processes show no significant impacts or extraordinary circumstances, or if mitigation measures are developed to reduce impact levels. Non-manipulative scientific research (for example, mangrove vegetation growth and yield studies) and recreational-educational opportunities (for example, boardwalks and nature tours) are permitted, if guaranteed not to adversely affect mangrove ecosystems.

Nine (9) Mangrove Reserves are proposed for Palau. They are: Ngaremeduu Mangrove Reserve, Airai Bay Mangrove Reserve, Taoch Ngerdorch-Taberngesang Mangrove Reserve, Ngamai-Imolech Mangrove Reserve, Diongradid Mangrove Reserve, Taoch ra Imeong Mangrove Reserve, Aimeliik-Airai Mangrove Reserve, Peleliu Mangrove Reserve, and Northern Babeldaob Mangrove Reserve. These Mangrove Reserves represent 7,584.0 acres (3,083 hectares) or 65% of the total Palau mangrove estate.

**Mangrove Reserve Management Objectives Include:**

- ◆ Protect dynamic mangrove areas of biological and ecological value, including the protection of adjacent ecosystems and habitats;
- ◆ Support multiple uses and values through environmentally sound management strategies; and
- ◆ Provide for recreational, educational and scientific opportunities and purposes.

**3.3.3 Category 3 - Mangrove Special Management Area  
(Special Management Area)**

**The Mangrove Special Management Area, a component of the NHRS Special Management Area, is designed to contribute primarily to Palau's socioeconomic needs, with strong consideration for sustaining mangrove ecosystems.** Emphasis is on promoting sustainable development strategies that assist in maintaining mangrove ecological values and benefits.

Mangrove Special Management Areas are intended to identify mangroves of special interest or use. They are devised to help manage specific mangrove stands where existing uses or proposed actions need to be assessed, monitored and possibly regulated

**Public access is unrestricted. Human activities are allowed, but may have restrictions.** Activities would require EA/EIS processes to identify and mitigate adverse impacts on mangrove resources. Mangrove Special Management Areas have a variety of considerations including residential, urban, industrial, tourism, infrastructure, agricultural, mariculture, solid waste, wastewater treatment and coastal protection measures. Traditional subsistence wood and nonwood product gathering are allowed. Limited



commercial timber production activities may be authorized. The Mangrove Special Management Area is designed to contribute significantly to the wood product and economic needs of Palau's communities.

One (1) MSMA is proposed for Palau, the Koror Mangrove Special Management Area. The Koror MSMA represents 478.0 acres (193.0 hectares) or 4% of the total Palau mangrove estate.

**Special Mangrove Management Area Objectives include:**

- ◆ Promote sustainable development schemes that support coastal conservation and maintain animal habitats;
- ◆ Protect shorelines from erosion, excessive sedimentation, and biochemical changes;
- ◆ Provide for the optimal sustained yield of mangrove forest products for subsistence and commercial purposes;
- ◆ Provide economic opportunities in the form of goods and services; and
- ◆ Provide protection to state and private lands.



Above: Tourism Development, Koror State. Note land reclamation activity converting mangrove fringe to artificial sand beach.

#### 4.1 Introduction

The proposed mangrove Natural Heritage Reserve System (NHRS) area system for mangroves is the third of four critical elements in mangrove management direction. Mangrove NHRS areas comprise one or more of the protected area classifications discussed in Chapter 3.0. State collaboration and support is essential for implementing the proposed Palau mangrove NHRS strategy.

A total of twelve (12) mangrove NHRS areas are recommended for Palau. Seven (7) mangrove NHRS areas were recommended in the Palau 2020, National Master Development Plan (1996). Because of Plan site visits, an additional five (5) mangrove NHRS areas were identified. The twelve mangrove NHRS areas form the foundation of Palau's mangrove protected area system. Two (2) Mangrove Preserves, nine (9) Mangrove Reserves and one (1) Mangrove Special Management Area are proposed for Palau. In combination, they represent approximately 8,651.0 acres (3,502.0 hectares) or 74 percent of Palau's total mangrove estate.

#### 4.2 Proposed Natural Heritage Reserve System (NHRS) for Palau Mangroves

The following section briefly describes Palau's twelve (12) mangrove NHRS areas. For more detailed information, see Appendix D, Palau Natural Heritage Reserve System: Mangrove Management Direction. Appendix D provides an overview of mangrove NHRS area guidelines and selection criteria, specific mangrove NHRS area management direction, existing conditions, vegetation classifications and proposed boundary locations.

##### 4.2.1 Ngaremeduu Mangrove Preserve

The Ngaremeduu Mangrove Preserve, representing approximately 579.0 acres (234.0 ha) of mangrove on the west-central coast of Babeldaob Island, is an outstanding example of Palau's dynamic coastal ecosystems. The Ngaremeduu Mangrove Preserve sits at the base of the 19,908.0 acre (8,060 hectare) Ngaremeduu Bay Watershed, the largest watershed basin on Babeldaob Island. This mangrove NHRS area is essential for filtering sediments and buffering nutrients entering Ngaremeduu Bay from adjacent uplands, and provides critical habitat for the endangered saltwater crocodile.

**Ngaremeduu Mangrove Preserve encompasses one (1) state jurisdiction:**

<u>Ngetpang State</u>	579.0 acres of Mangrove Preserve
-----------------------	----------------------------------

#### 4.2.2 Rock Islands Mangrove Preserve

The Rock Islands Mangrove Preserve, although limited in size at an estimated 100.0 acres (40.0 hectares), is yet another example of Palau's mangroves which are unique, have exceptional amenity values, and are vital to marine and fisheries resources. Mangroves, in the Rock Islands, are associated with protected coves and marine lakes.

##### **Rock Islands Mangrove Preserve encompasses one (1) state jurisdiction:**

<u>Koror State</u>	100.0 acres of Mangrove Preserve	0.40 km <sup>2</sup>
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#### 4.2.3 Ngaremeduu Mangrove Reserve

The Ngaremeduu Mangrove Reserve, representing approximately 1070.0 acres (435.0 ha) of mangrove on the west-central coast of Babeldaob Island, represents an outstanding example of Palau's dynamic coastal ecosystems. The Ngaremeduu Mangrove Reserve also sits at the base of the 19,908.0 acre (8,060 hectare) Ngaremeduu Bay Watershed, the largest watershed basin on Babeldaob Island. This mangrove NHRS area is essential for trapping sediments and processing organic matter and nutrients entering Ngaremeduu Bay from adjacent uplands, and provides critical habitat for the endangered saltwater crocodile. The Ngaremeduu Mangrove Reserve serves as an important buffer zone around the Ngaremeduu Mangrove Preserve.

##### **Ngaremeduu Mangrove Reserve encompasses three (3) state jurisdictions:**

<u>Aimeliik State</u>	184.0 acres of Mangrove Reserve	0.74 km <sup>2</sup>
<u>Ngetpang State</u>	338.0 acres of Mangrove Reserve	1.367 km <sup>2</sup>
<u>Ngaremlengui State</u>	548.0 acres of Mangrove Reserve	2.217

#### 4.2.4 Ngemai-Imolech Mangrove Reserve

The Ngemai-Imolech Mangrove Reserve, representing approximately 653.0 acres (264.0 hectares), is on the east, north-central coast of Babeldaob Island and is the largest mangrove area on Babeldaob's east side. The Ngemai-Imolech Mangrove Reserve sits at the base of the 4,199.0 acre (1,700.0 hectare) Ngemai watershed, the fifth largest drainage basin on Babeldaob Island. This mangrove area is critical for maintaining critical marine and fisheries habitat; and filtering sediments and buffering nutrients entering Ngemai Bay from adjacent uplands.

##### **Ngemai-Imolech Mangrove Reserve encompasses two (2) state jurisdictions:**

<u>Melekeok State</u>	213.0 acres of Mangrove Reserve
<u>Ngiwal State</u>	440.0 acres of Mangrove Reserve

#### 4.2.5 Airai Bay Mangrove Reserve

The Airai Bay Mangrove Reserve, totaling approximately 1,137.0 acres (460.0 hectares), is on the south coast of Babeldaob Island. The Airai Bay Mangrove Reserve sits at the base of the 6,422.0 acre (2,600.0 hectare) Taoch Ngerikiil watershed, the third largest water drainage basin on Babeldaob Island and the source of Koror's domestic water supply. This mangrove area is critical for maintaining water quality, marine and fisheries habitat, trapping sediments, and processing organic matter and nutrients entering Airai Bay, Babeldaob's second largest semi-enclosed embayment and estuary.

**Airai Bay Mangrove Reserve encompasses one (1) state jurisdiction:**

Airai State      1,137.0 acres of Mangrove Reserve

#### 4.2.6 Taoch Ngerdorch-Taperngesang Mangrove Reserve

The Taoch Ngerdorch-Taperngesang Mangrove Reserve, representing approximately 367.0 acres (149.0 hectares), is on the east, south-central coast of Babeldaob Island. The Taoch Ngerdorch-Taperngesang Mangrove Reserve sits at the base of the 11,016.0 acre (4,460.0 hectare) Ngerdorch watershed, the second largest watershed on Babeldaob Island. This mangrove area is critical for filtering sediments and buffering nutrients out welling from the Taoch ra Ngerdorch, one of Palau's longest river systems, which drains from Lake Ngardok.

**Taoch Ngerdorch-Taberngesang Mangrove Reserve encompasses one (1) state jurisdiction:**

Ngchesar State      367.0 acres of Mangrove Reserve

#### 4.2.7 Diongradid Mangrove Reserve

The Diongradid Mangrove Reserve, representing approximately 935.0 acres (379.0 hectares) on the west-northwest coast of Babeldaob Island, is an outstanding example of Palau's fringe mangrove type. The Diongradid Mangrove Reserve sits at the base of the 5,681.0 acre (2,300.0 hectare) Diongradid Watershed, the fourth largest drainage basin on Babeldaob Island. This mangrove area is essential for shoreline protection, filtering sediments, and processing organic matter and nutrients entering the near-shore corals from Taoch ra Iuekei, Diongradid River, Ngolsang channel, Ouang channel, Desengong channel, Taoch ra Klebeang channel and several un-named channels.

**Diongradid Mangrove Reserve encompasses two (2) state jurisdictions:**

Ngaraard State      412.0 acres of Mangrove Reserve

Ngardmau State      523.0 acres of Mangrove Reserve

#### 4.2.8 Taoch ra Imeong Mangrove Reserve

The Taoch ra Imeong Mangrove Reserve, representing approximately 626.0 acres (253.0 hectares), is on the west, north-central coast of Babeldaob Island. The Taoch ra Imeong Mangrove Reserve sits at the base of a small watershed, bordered on the east by two mountain peaks, Ngerueach and Etiruir (Rois Mlengui), respectively. This mangrove area is critical for filtering sediments and buffering nutrients from the Taoch ra Imeong, Taoch ra Ngerutecher, and Chometubet.

**Taoch ra Imeong Mangrove Reserve encompasses one (1) state jurisdiction:**

<u>Ngaremlengui State</u>	626.0 acres of Mangrove Reserve
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#### 4.2.9 Aimeliik-Airai Mangrove Reserve

The Aimeliik-Airai Mangrove Reserve, representing approximately 694.00 acres (280.0 hectares) of fringe mangrove on the west-south central coast of Babeldaob Island, is an notable example of Palau's unique coastal ecosystems. The Aimeliik-Airai Mangrove Reserve is critical for shoreline protection, safeguarding near-shore reefs by filtering sediments and buffering nutrients entering from adjacent uplands, and serving as critical habitat for marine and fisheries resources.

**Aimeliik-Airai Mangrove Reserve encompasses two (2) state jurisdictions:**

<u>Aimeliik State</u>	470.0 acres of Mangrove Reserve
<u>Airai State</u>	224.0 acres of Mangrove Reserve.

#### 4.2.10 Northern Babeldaob Mangrove Reserve

The Northern Babeldaob Mangrove Reserve, representing approximately 928.0 acres (375.0 hectares) of mangrove on the northern tip of Babeldaob Island, is an outstanding example of Palau's coastal ecosystems. This mangrove area is vital for maintaining critical marine and fisheries habitat, filtering sediments and buffering nutrients, and protecting shorelines from coastal erosion.

**Northern Babeldaob Mangrove Reserve encompasses two (2) state jurisdictions:**

<u>Ngerchelong State</u>	720.0 acres of Mangrove Reserve <del>x 4017</del>
<u>Ngaraard State</u>	208.0 acres of Mangrove Reserve.

#### 4.2.11 Peleliu Mangrove Reserve

The Peleliu Mangrove Reserve, representing approximately 1,174.0 acres (475.0

hectares), supports the second largest mangrove area in Palau, outside Babeldaob Island. This Mangrove Reserve is critical for maintaining water quality, filtering sediments and buffering nutrients, shoreline protection, and serving as critical habitat for the endangered saltwater crocodile and other marine and fisheries resources. The Peleliu Mangrove Reserve is also important as a supporting ecological link to Palau's largest area of seagrass beds.

<b>The Peleliu Mangrove Reserve encompasses one (1) state jurisdiction:</b> Peleliu State 1,174.0 acres of Mangrove Reserve
--

#### 4.2.12 Koror Mangrove Special Management Area

The Koror Mangrove Special Management Area representing approximately 478.0 acres (194.0 hectares), is important for protecting shorelines and maintaining water quality around Koror, Palau's most highly urbanized and populated setting. The Koror Mangrove Special Management Area provides benefits by protecting the shorelines adjacent to Toachel Mid and Liebuchel channels from strong tidal currents and motorboat wash. It also helps maintain shorelines and water quality adjacent to the communities of Nberbeched, Ikelau, and Ngerkeseuaol by filtering sediments, buffering nutrients and organic matter. This special designation will help maintain a visually pleasing environment around Koror. The Nagesaol mangrove area is the largest on Koror, and the second largest mangrove area south of the Toachel Mid channel.

<b>Koror SMMA encompasses one (1) state jurisdiction:</b> Koror State 478.0 acres of Mangrove Special Management Area
--

#### 4.3 Mangrove NHRS Area Summary

These mangrove NHRS areas, form the core foundation for managing Palau's mangrove resources. They provide invaluable goods and services - many of which are essential for maintaining and sustaining Palau's island ecosystem. As the mangrove NHRS areas are purposely tied to Palau's largest watersheds, they offer a holistic ecosystem approach to mangrove management efforts.

State support of the proposed Palau mangrove NHRS area strategy is essential for Plan success. National mangrove guidance and direction is appropriate as it strengthens current and future State mangrove conservation activities. In combination, national and state government support of the proposed mangrove NHRS areas ensures the perpetuation of Palau's major mangrove ecosystems. Over time, the proposed mangrove NHRS areas will provide the people of Palau with significant values and benefits.

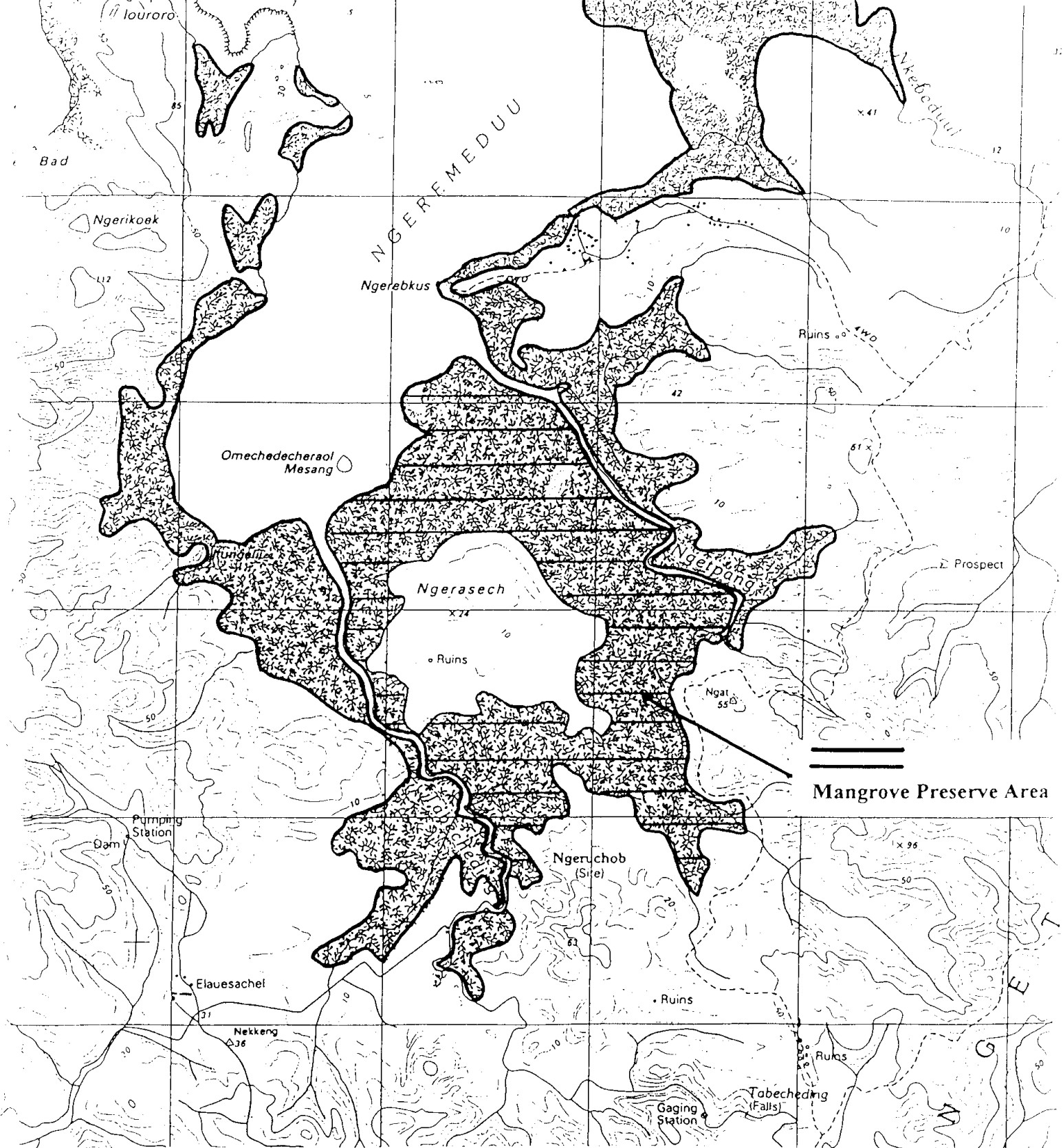
Figures 4-1 through 4-10

**Proposed Mangrove NHRS Area Maps  
(Plan)**

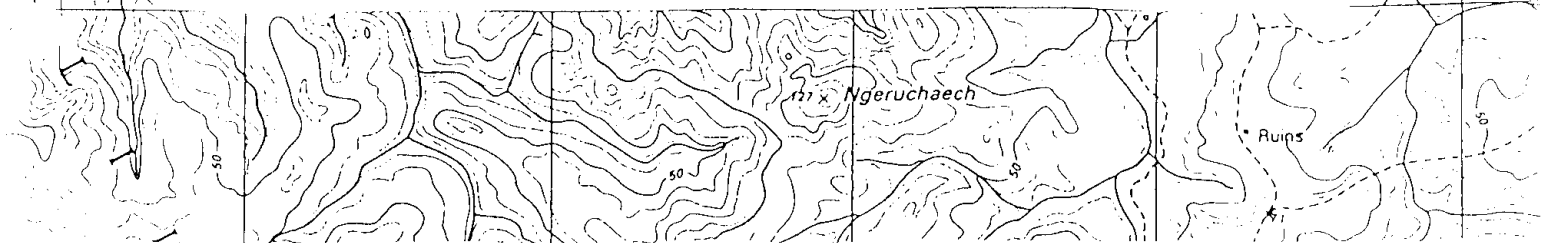
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- 4-9 Peleliu Mangrove Reserve
- 4-10 Koror Mangrove Special Management Area  
(No map available for Rock Islands Mangrove Preserve.)



Above: A small stand of mangrove (center, mid-ground) in a protected cove within the proposed Rock Island Mangrove Preserve, Koror State. The signs (white rectangles) advise boaters not to enter for fisheries conservation purposes



**Figure 4-1: Ngaremeduu Mangrove Preserve and Ngaremeduu Mangrove Reserve (Southern and Central Portion)**







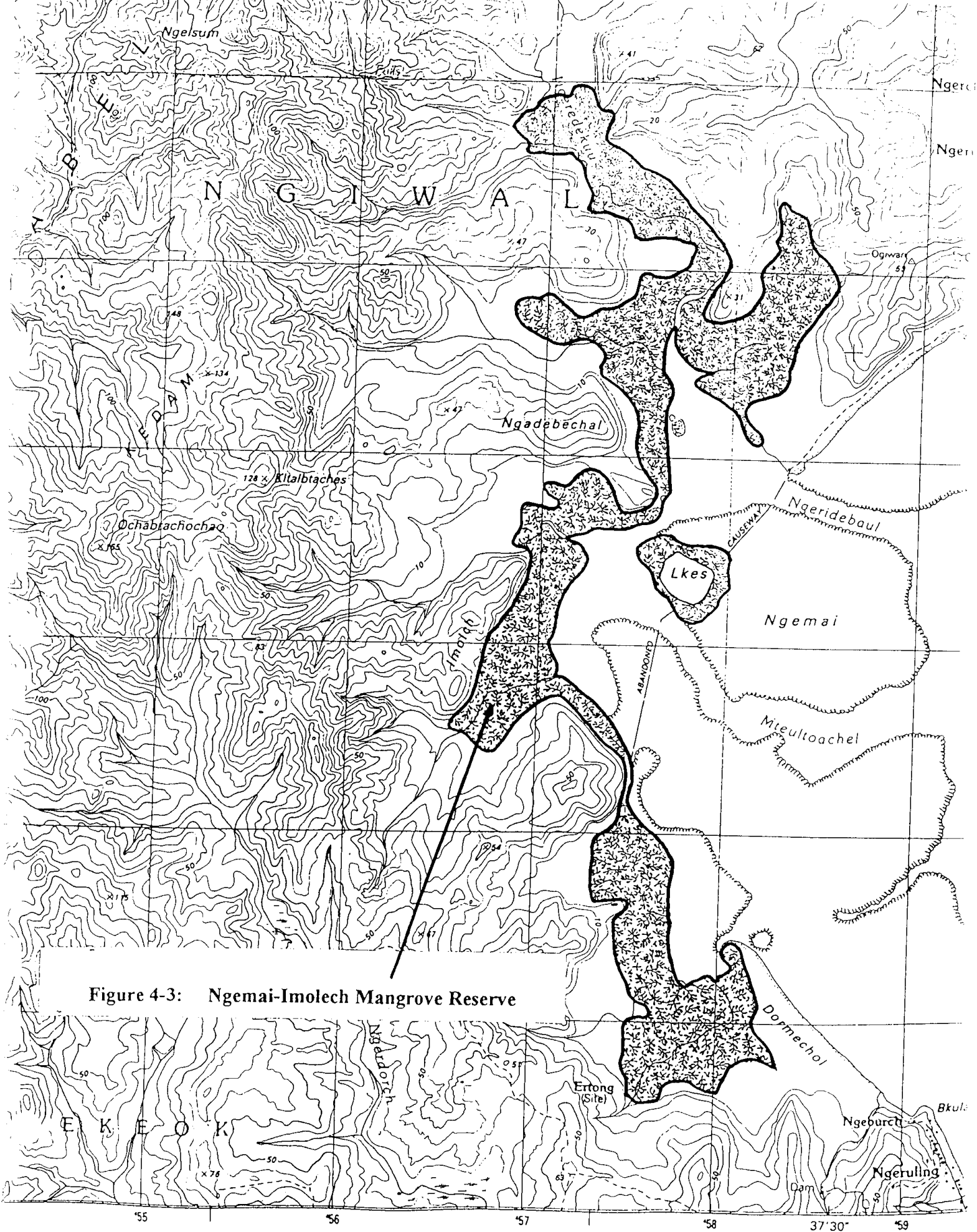


Figure 4-3: Ngemai-Imolech Mangrove Reserve

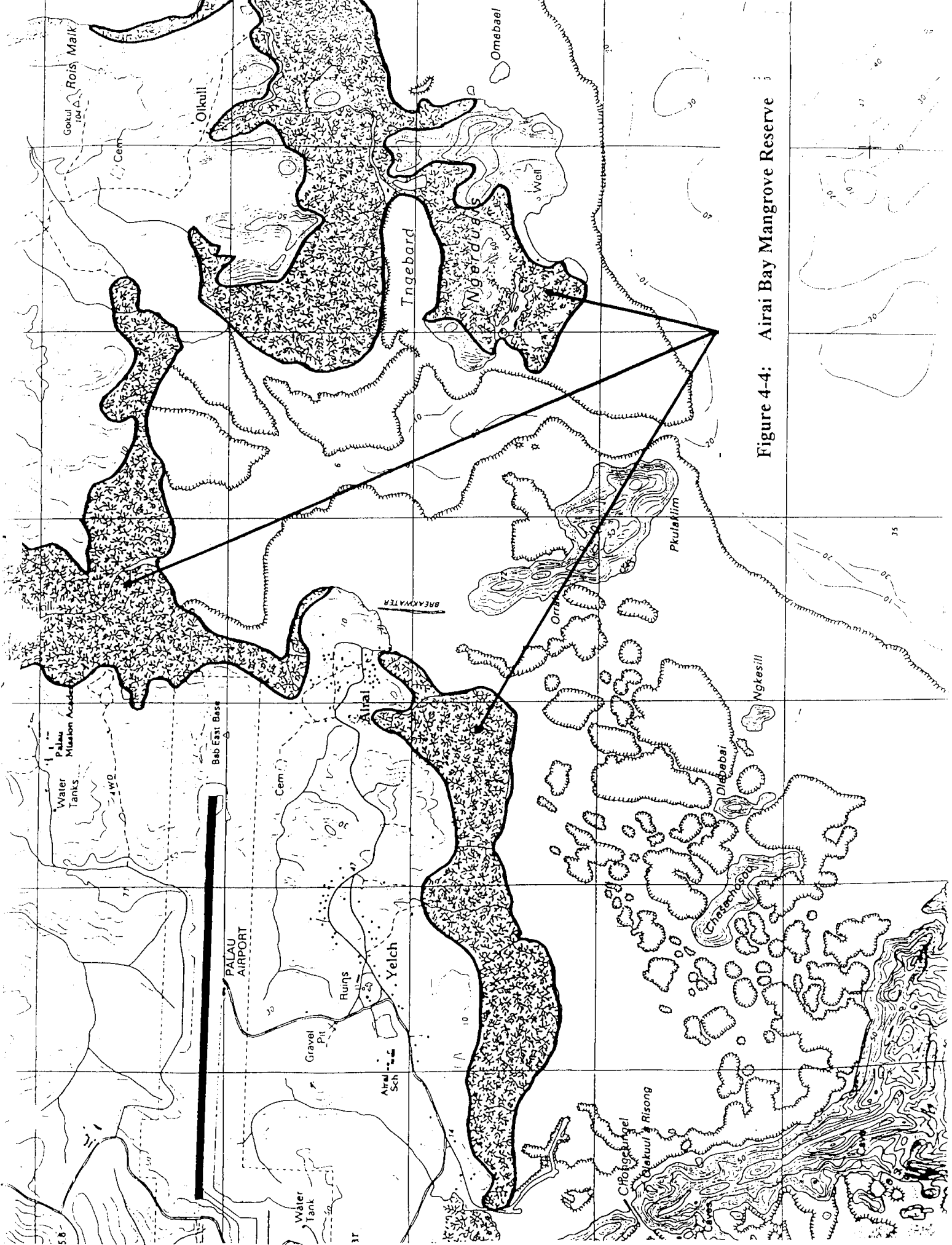
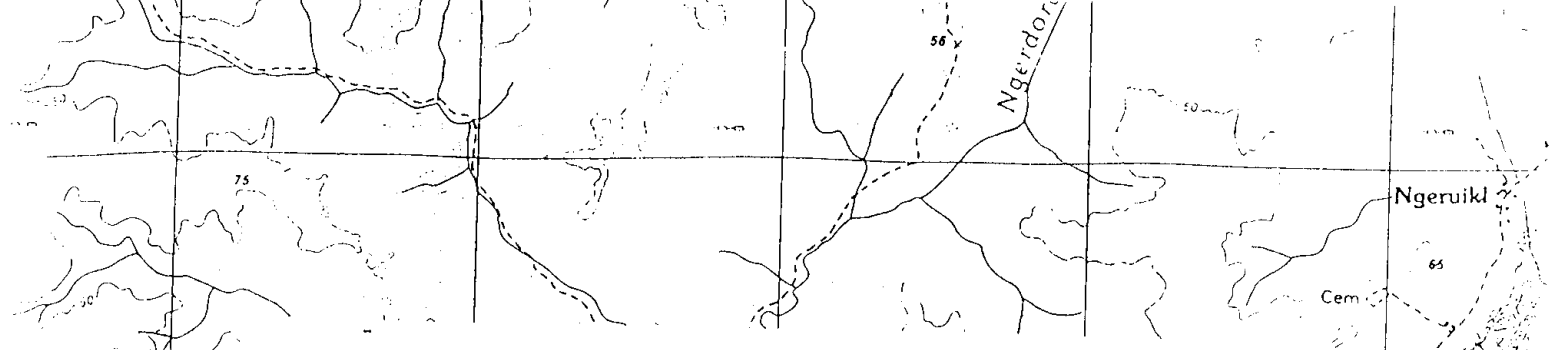
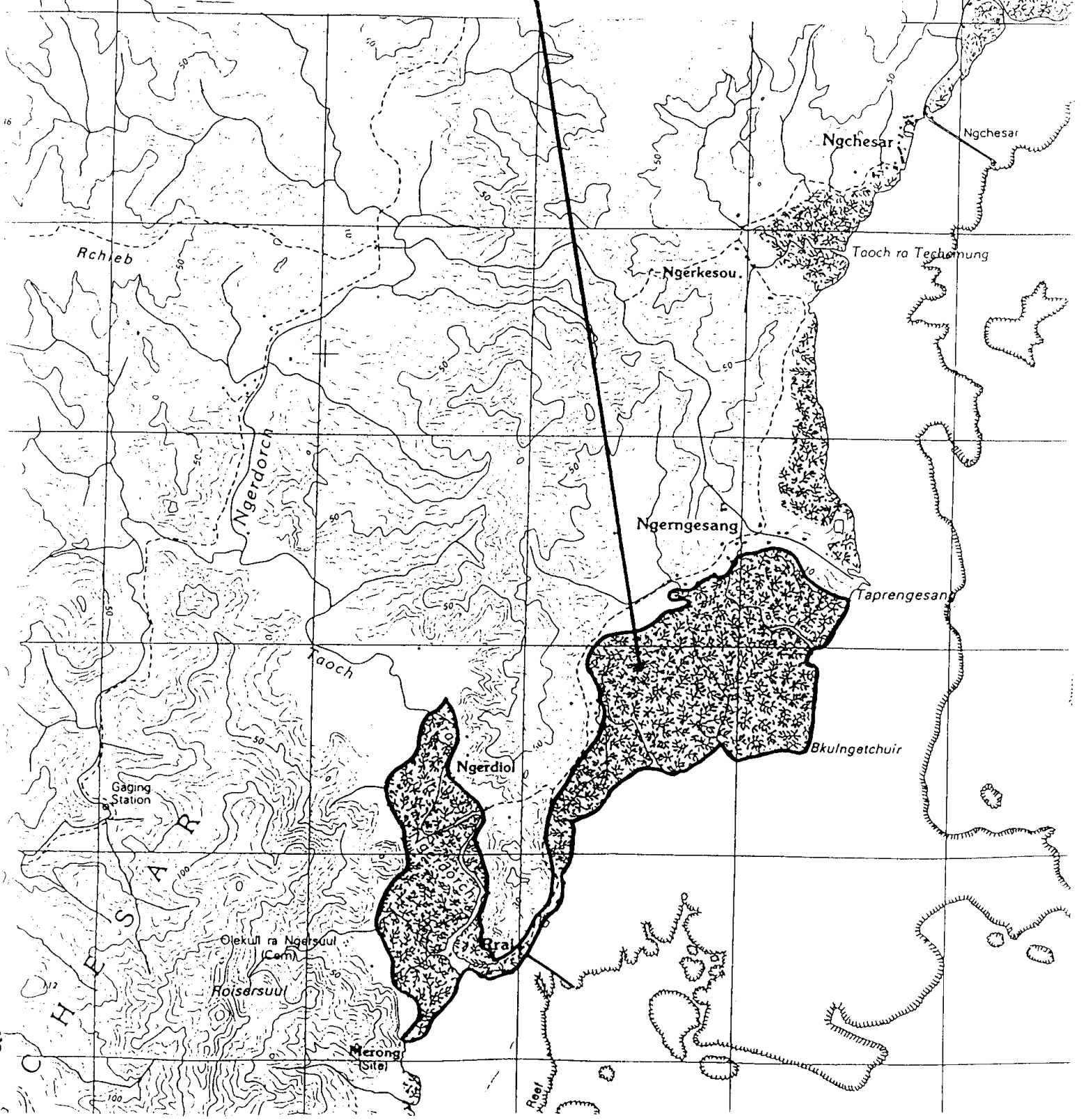


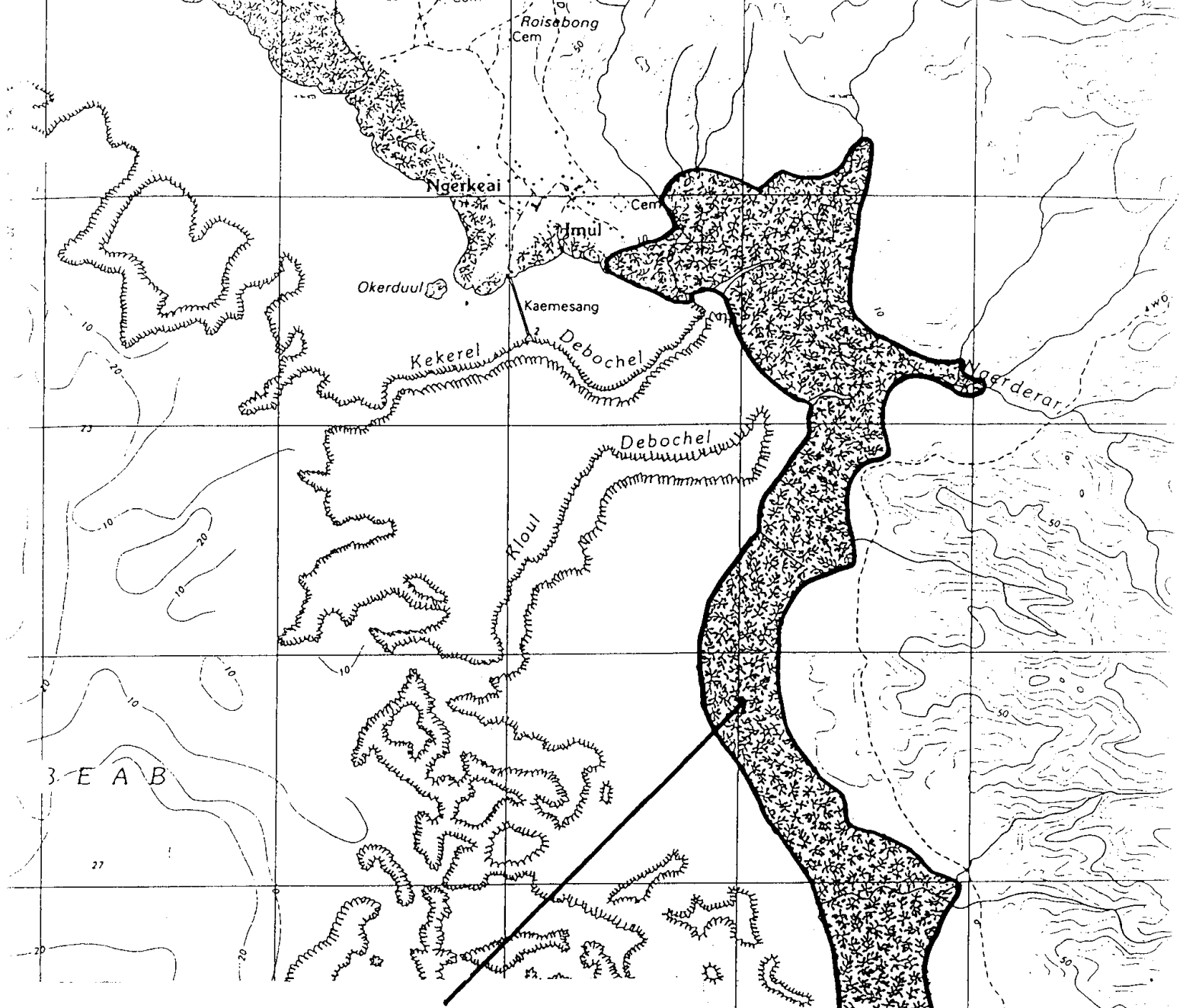
Figure 4-4: Airai Bay Mangrove Reserve



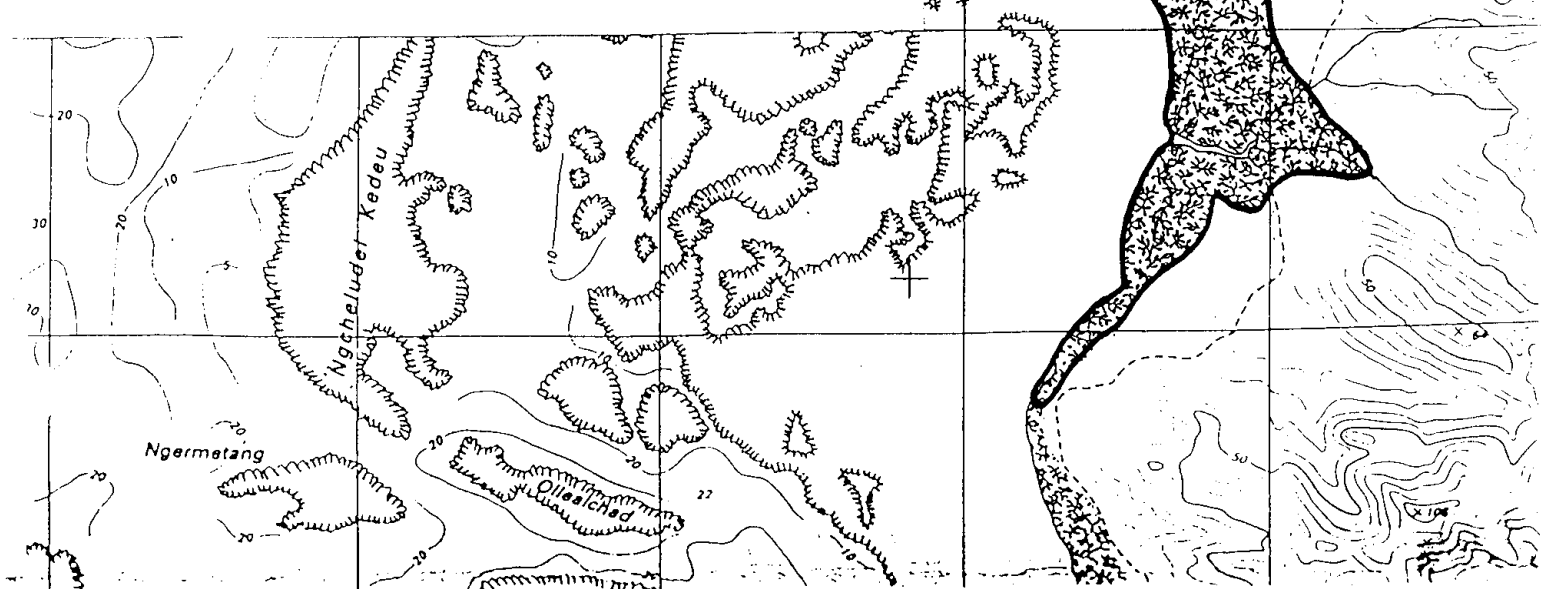
**Figure 4-5: Taoch Ngerdorch-Taperngesang Mangrove Reserve**







**Figure 4-7: Aimeliik-Airai Mangrove Reserve**





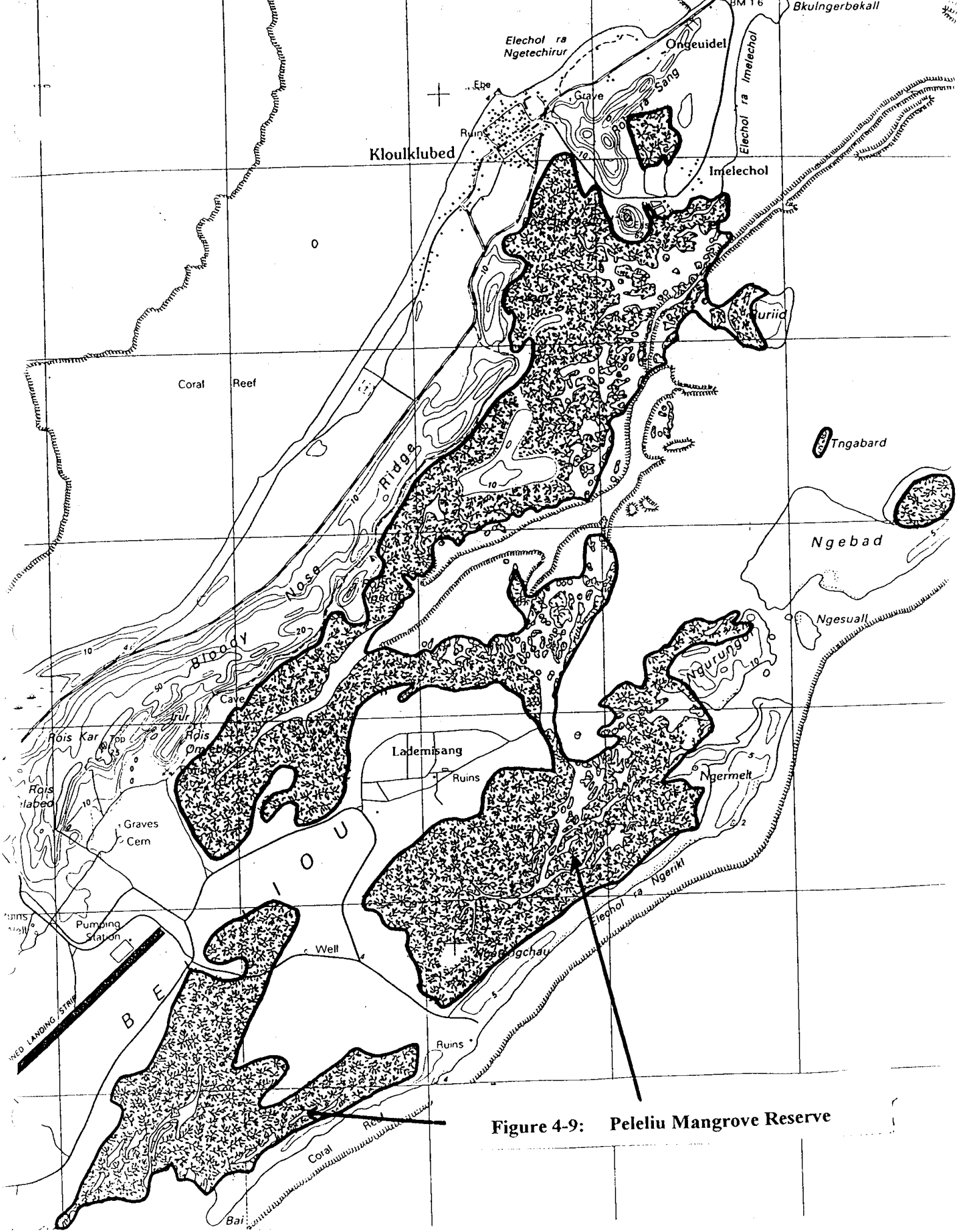


Figure 4-9: Peleliu Mangrove Reserve





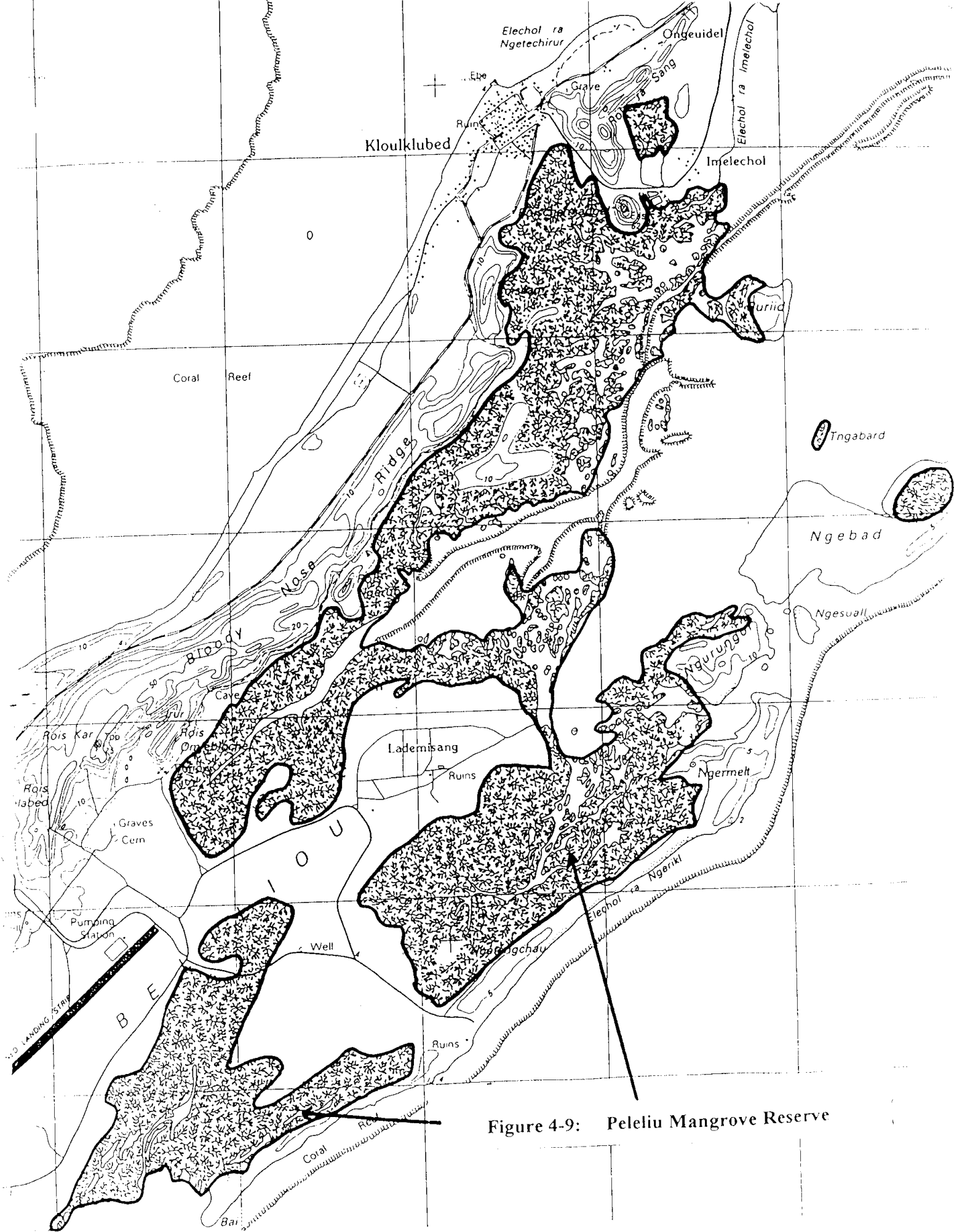


Figure 4-9: Peleliu Mangrove Reserve

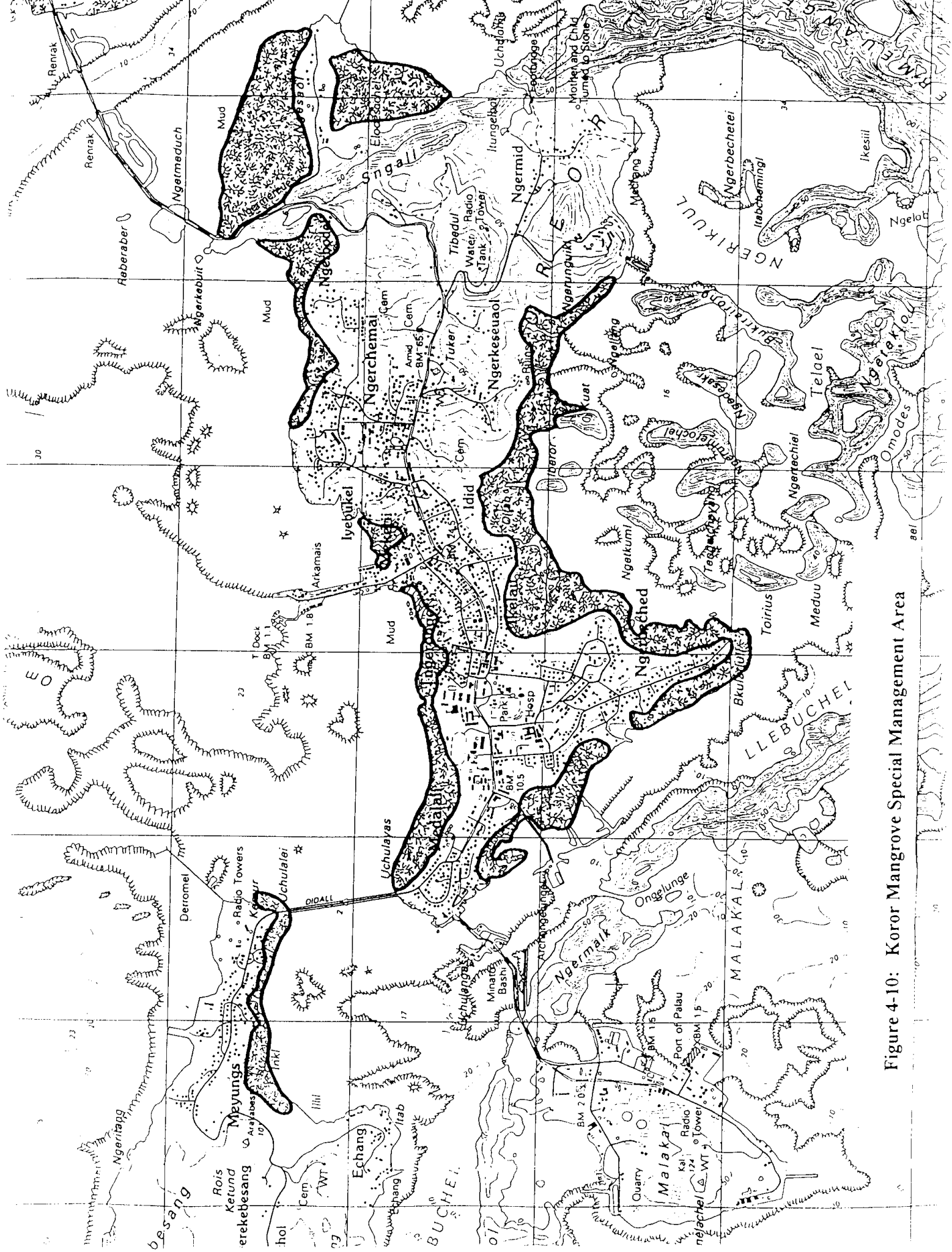


Figure 4-10: Koror Mangrove Special Management Area

# **THE PALAU MANGROVE MANAGEMENT PLAN**

**(Version 2.0, 09/29/00)**

## **VOLUME II**

### **PLAN APPENDICES**

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**September 29, 2000**

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## APPENDIX A PLAN ACTION ITEMS

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### A.1 Introduction

This section represents the fourth and final critical element of the Plan. It addresses guidance and recommendations necessary for advancing the Plan into a working on-the-ground program. These recommendations, identified as "Action Items," will help direct the Bureau of Natural Resources and Development, Ministry of Resources and Development and State Governments, toward the Desired Future Condition of mangrove resource elements. Using these Action Items to solicit mangrove project funding and personnel requests from general funding sources, cooperating agencies, donor agencies and NGO's are critical to Plan implementation.

### A.2 Plan Action Items

Plan implementation is centered on Action Items, designed around a basic grant narrative format. These grant narratives supplement the Plan by estimating program scope, planning, budget, staffing and training needs. Detailed programs of work and appropriate funding documents (for example, grants and ROP general funding mechanisms) need to be developed in detail for each Action Item. Annual adjustments and changes are anticipated to reflect changing priorities, conditions and budgets.



Above: Ngis (*Pemphis acidula*), photo center, can be found growing on select Rock Islands with other strand vegetation, just above the tidal influence. On Palau, traditional uses of Ngis include tool handles and pestle and mortar.



The following section describes Plan Action Items. These Action Items guide Plan development and are initiated by BNRD, in partnership with the state and local community implementation efforts during the first five-year planning period. Action items are not listed in a sequential order. They are to be used concurrently in developing a program of work for implementing the Plan at state and local government levels.

**ACTION ITEM #1:**      **Expand the authority of the Urban and Community Forestry Program (Forestry Unit), Bureau of Natural Resources and Development, to include Plan mangrove management duties and responsibilities.**

**Background:**

- Assigning Plan responsibility to the Urban and Community Forestry Program (Forestry Unit) is essential for mangrove conservation efforts. The overall goal is to create a core group of Forestry Unit personnel involved with Plan activities. This Forestry Unit program supports an established communication network with local communities, as well as a staff with the technical skills necessary to initiate mangrove conservation activities.

**Purpose:**

- To establish a mangrove management team within the Urban and Community Forestry Program (Forestry Unit). To coordinate Plan activities between the State Governments and the Division of Agriculture and Mineral Resources, Division of Marine Resources and Division of Conservation and Entomology.
- To assist in the development of an annual Plan program of work and budget. Perform daily activities in support of Plan.

**Description of Activities:**

- The Urban and Community Forestry Program (Forestry Unit) serves as the lead in coordinating Plan activities and in assuring that community voices are heard.
- Develop effective communication networks with appropriate government, state, local and ngo representatives.
- Identify and assign BNRD personnel to carry out the Plan (determining who, what, where, when and how are key Plan components).
- Carry out Plan standards and guidelines to achieve the direction necessary to reach the Desired Future Condition of mangrove resource elements.
- Coordinate state government and community meetings in order to promote Plan understanding and public acceptance. Use workshops to enhance

- public mangrove awareness, and serve community needs and concerns. Identify and develop detailed funding needs based on Plan action items. Develop Plan grant and project funding requests from donor agencies and ngo's.
- Executing Agency: Urban and Community Forestry Program, Forestry Unit, BNRD.

**Potential Benefits:**

- Plan duties and accountability assigned within BNRD. Lead taken by Forestry Unit.
- Desired Future Condition of mangrove resource elements achieved by standard and guideline implementation.
- National and State mangrove policy development.

**Budget and Time Estimates:**

- A general provision annually to cover Forestry Unit administrative and operational Plan costs. Costs include salary and material/supplies for up to two employees (three months each spread over 12 months) and for two employees (1 month spread over 12 months).
- Time frame: Initiate Year 1, Ongoing.
- Estimated Total Funding Cost per Year = US\$15,000.00

**ACTION ITEM #2:**

**For enhanced Plan success and mangrove conservation, integrate Division of Conservation and Entomology, Division of Agriculture and Minerals Resources, and Division of Marine Resources, Bureau of Natural Resources and Development management efforts.**

**Background:**

- Blending Division of Conservation and Entomology, Division of Agriculture and Minerals Resources, and Division of Marine Resources responsibilities is essential for Palau mangrove conservation efforts. Creates a core group of BNRD personnel to oversee and coordinate Plan activities.

**Purpose:**

- To establish a mangrove management team within BNRD, using an integrated team/program approach.
- To develop an annual BNRD program of work and budget supporting the Plan and state implementation efforts. Each division performs activities in

support of the Plan.

**Description of Activities:**

- BNRD coordinates inter-divisional Plan activities.
- Identify and assign BNRD personnel to carry out the Plan (determining who, what, where, when and how are key Plan components).
- Focus on Desired Future Condition of mangrove resource elements using Plan standards and guidelines.
- Support and coordinate state government and community Plan meetings. Use workshops to enhance public Plan understanding.
- Identify and develop BNRD appropriated funding needs based on the Plan. Develop Plan grant and project funding requests from donor agencies and NGO's. Work closely and in collaboration with local NGO's mangrove conservation programs.
- Executing Agency: BNRD

**Potential Benefits:**

- Integrated mangrove program delivery. Assigns Plan duties and accountability throughout BNRD.
- Desired Future Condition of mangrove resource elements more likely to be achieved.
- National and State mangrove policy development will be better coordinated.

**Budget and Time Estimates:**

- A general provision annually to cover BNRD administrative and operational costs associated with Plan. Costs include salary and supplies for up to four employees (one to two months each spread over 12 months).
- Time frame: Initiate Year 1, Ongoing.
- Estimated Total Funding Cost per Year = US\$12,000.00

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**ACTION ITEM #3: Establish the Palau Mangrove Committee**

**Background:**

- Plan success is increased by establishing a "call-when-needed" mangrove management committee under the umbrella of the Urban and Community Forestry Program, Forestry Unit (BNRD).
- The committee would promote and advance national and state mangrove policy, legislation and regulation development.
- This action item provides, with minimal costs, an excellent pathway for

- national and state mangrove policy, legislation and regulation.
  - Coordination between Palauan natural resource managers is an essential component of Plan success.
- Purpose:**
- As needed, the Forestry Unit assembles specialists from a diverse cross-section of disciplines, including the public. To advance Plan development and implementation, provide mangrove leadership, articulate mangrove policies, and develop national and state mangrove conservation strategies.
  - Based on an interdisciplinary team approach, the committee would advise and make recommendations to the BNRD regarding Plan advancement.
  - Committee "advisors" include personnel from State Governments, BNRD, Bureau of Lands and Surveys, Bureau of Public Works, Palau National Tourism Association, Division of Environment and Sanitation Services, Environmental Protection Authority, Environmental Quality Protection Board, USDA-NRCS, National Marine Fisheries Service, Palau Community Action Agency, Palau Resource Institute, The Nature Conservancy, Palau Conservation Society, Coral Reef Research Center, and interested community representatives.
- Description of Activities:**
- Further guide Palau mangrove policy and legislation development. Support and participate in Plan implementation at the state level.
  - Work with the Attorney General's Office in developing environmental legislation and regulations. Seek mangrove conservation partnerships.
  - Executing Agency: Forestry Unit, BNRD.
- Potential Benefits:**
- Increased cooperation between federal, state and local agencies resulting in coordinated mangrove conservation efforts.
  - Improved consistency and interpretation of federal and state mangrove management policies.
  - Eliminates duplicating of government, cooperating agency and NGO mangrove programs.
  - Improved Plan success.
- Budget and Time Estimates:**
- Time frame: Initiate Year 1, Ongoing.
  - A general provision annually to cover administrative costs, specialist consultations, and technical assistance for workshops and conferences. Estimated Total Funding Cost per Year = US\$4,000.00 to US\$8,000.00

**ACTION ITEM #4:**

**Implement the Palau Natural Heritage Reserve System (1991, RPPL No. 3-51) for Mangroves**

**Background:**

- Now is the time to formalize the Natural Heritage Reserve Systems Act authority for nominating and designating site-specific mangrove areas.
- Legally designating Mangrove Preserves, Mangrove Reserves and Mangrove Special Management Areas would help to ensure Plan success.
- The designation of mangrove NHRS areas will require state government, traditional leadership, community and public support and acceptance.

**Purpose:**

- Use authority of the Natural Heritage Reserve System Act to formally designate proposed Plan mangrove protected areas.



Above: The Ngaremeduu Mangrove Preserve and Ngaremeduu Mangrove Reserve encircles Ngaremeduu Bay.

**Description of Activities:**

- Formally nominate the Negaremeduu Mangrove Preserve, Rock Island Mangrove Preserve, Negaremeduu Mangrove Reserve, Aimeliik-Airai Mangrove Reserve, Airai Bay Mangrove Reserve, Ngemai-Imolech Mangrove Reserve, Taoch Ngerdorch-Taperngesang Mangrove Reserve, Taoch ra Imeong Mangrove Reserve, Peleliu Mangrove Reserve, Northern Babeldaob Mangrove Reserve, Diongradid Mangrove Reserve, and Koror Mangrove Special Management Area.
- Work with the Bureau of Lands and Survey for mangrove NHRS area legal descriptions and boundary marking. Assure mangrove NHRS areas are properly documented. Determine best method for marking mangrove NHRS area boundaries (for example, buoys in water ways and signs on landward edges) and initiate boundary demarcations.
- Coordinate meetings with traditional leaders and communities to promote Plan understanding and support.
- Continue to refine land uses allowed or prohibited in mangrove NHRS areas.
- Executing Agency: BNRD, in close consultation with national and state planners and community leaders.

**Potential Benefits:**

- Mangrove NHRS areas are established and protected by law.
- Plan success increases. Long-term ecological and socioeconomic benefits are realized.

**Budget and Time Estimates:**

- Time frame: Initiate Year 2 or 3, for a three to five-year period.
- NHRS mangrove designations, Bureau of Lands and Survey coordination, documentation, and GIS layer development, materials and supplies for boundary marking: Estimated Total Funding Cost per Year = US\$8,000.00 to US\$16,000.00, one time cost.

**Action Item #5:** Complete "Palau Forest Practices Act" with emphasis on incorporating Plan related language and terminology, as needed. Tie "Palau Forest Practices Act" and the Plan to the "Natural Heritage Reserves System Act," as appropriate and needed.

**Background:**

- Incorporating Plan language and terminology into the draft "Palau Forest Practices Act" will strengthen and broaden legislation.
- Using the "Natural Heritage Reserve Systems Act" as the authority to create a system of mangrove protected areas is reasonable and efficient. Supports designation of other protected area classifications (for example, Forest or Watershed Reserves).

**Purpose:**

- Institutionalize Palau Forest Practices Act in order to strengthen mangrove conservation efforts. Utilize authority of the Natural Heritage Reserves System Act for establishing mangrove protected areas.
- Formally designate proposed mangrove Natural Heritage Reserve System classifications: Preserve (Natural Heritage Preserve), Reserve (Natural Heritage Reserve), and Special Management Area (Natural Heritage Special Management Area).
- Executing Agency: Ministry of Resources and Development, with close consultation with Attorney General's Office and legislators.

**Description of Activities:**

The following draft recommendations are made in consideration for inclusion into the draft "Palau Forest Practices Act" or if, needed, an amendment to the "Natural Heritages Reserve System Act." Discussions and review by the Attorney General's Office and state legislators is essential before incorporating any of the referenced recommendations, and ROP legislative protocol must be followed.

**Palau Forest Practices Act Comments:**

- Page 1, line 3: Consider inserting a new section between existing Section 1 and Section 2.
- New section untitled: "Section 2. Purpose. The purpose of this act is to provide for the maintenance of functional watersheds, to protect important watershed, forest and mangrove areas, and to provide for the conservation and management of forest and mangrove ecosystems."

- Page 4, line 8: Consider the need for inserting a new section entitled: “Section 5. Establishment of Natural Heritage Reserve System for Forest and Mangrove Protected Areas. Pursuant to Section 3 of RPPL No. 3-51, the Bureau of Natural Resources and Development is hereby empowered, authorized and instructed to designate and nominate, under the management of the Ministry of Resources and Development, in consultation with State Government Officials, the following ROP Nature Heritage Reserve Systems:”

- Category 1: Watershed, Forest and/or Mangrove Preserve (Natural Heritage Preserve),
- Category 2: Watershed, Forest and/or Mangrove Reserve (Natural Heritage Reserve),
- Category 3: Watershed, Forest and/or Mangrove Special Management Area (Natural Heritage Reserve Special Management Area).

Each category would be followed by (1) Definition of Category, (2) Boundary Marking and Maintenance Needs/Responsibilities, (3) Permitted Uses in each Category, and (4) Uses Prohibited in each Category.

These categories could be addressed with an amendment to the Natural Heritage Reserves System Act (1991), if deemed necessary and more appropriate by Ministry of Resources and Development. It is important that Plan developments do not overly delay passage of the Palau Forestry Practices Act.

**Potential Benefits:**

- Broadens scope (watershed, forest, mangrove) of developing Palau Forest Practices Act.
- Specific mangrove NHRS areas are identified and designated.

**Budget and Time Estimates:**

- Time frame: Initiate Year 1 and continue until Palau Forest Practices Act is executed; and/or, the Natural Heritage Reserve Systems Act (1991) is amended, if needed and appropriate. This could take three to five years depending on legislative processes and Plan finalization needs.
- Attorney General’s Office and legislative staff complete the Palau Forest Practices Act; or legislative consultant salary, travel and per diem for short-term assignment to finalize Palau Forest Practices Act or amend Natural Heritage Reserves Act. Estimated Total Funding Cost per Year = US\$2,000.00 to US\$7,000.00.



**ACTION ITEM #6:****Palau Mangrove Environmental Education and Awareness Program****Background:**

- Without increased State Government and public mangrove environmental awareness and support, Plan success could be jeopardized.

**Purpose:**

- Public educated about role of mangroves in maintaining island ecosystem health. Plan goals and objectives are promoted.
- To increase national, state and community understanding of mangrove ecosystems, their vulnerability, services, and conservation needs.

**Description of Activities:**

- Develop a mangrove environmental education program at national, state and community levels. Focus is on mangrove conservation and Plan understanding.
- Network with National Education Board, Job Training Partnership Act, National Education and Training Council, Palau Community Action Agency, Palau Community College, Palau Resource Institute, South Pacific Regional Environment Program, Institute of Pacific Islands Forestry (USDA-FS), USDA-Natural Resources Conservation Service, Palau Conservation Society, the Nature Conservancy, plus others. Work with partners to develop mangrove education programs that target schools, communities and government levels.
- Complete Palauan language transcribing of the mangrove video produced by the Institute of Pacific Islands Forestry ("Micronesian Mangroves, Harvesting and Caring for our Mangrove Forest" and "Mangroves Where We Live, Building Roads and Homes while Conserving our Mangrove Forests and Reefs"). Obtain two dozen video copies for public programs.
- Focus mangrove programs at communities next to proposed mangrove NHRS areas. State and traditional leaders, and school systems require a major effort.
- An environmental awareness program that targets the year 2001 (or when possible) as "The Year of the Environment" or "Year of the Keburs (Mangrove)." Programs such as these would be useful in developing national mangrove ecosystem pride.
- Executing Agency: BNRD

**Potential Benefits:**

- BNRD personnel skill levels focused on feasible and critical Plan component.

**Budget and  
Time  
Estimates:**

- Enhanced public mangrove awareness and Plan support.
- Time frame: Initiate development of mangrove education component during Year 2. Implement program during Year 3 to 4. This component will require at least five years, but will undoubtedly require a long-term commitment.
- A provision annually to cover teaching materials, visual aids, supplies, environmental education curriculum development and workshop participant salary. Estimated Total Funding Cost per Year: US\$5,000.00 to US\$10,000.00.

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**ACTION ITEM #7 Palau Mangrove Monitoring Program Development**

**Background:**

- Enhance Plan success by developing a mangrove NHRS area monitoring program that assesses mangrove health and use. Routine mangrove NHRS area patrols provide updated accounts of human activities and environmental conditions.
- Monitoring upper watershed uses that have the potential to adversely affect fresh water quality and mangrove NHRS areas is an important consideration.

**Purpose:**

- To assess mangrove exploitation levels and provide mangrove users with Forestry Unit personnel contacts. Identify mangrove areas of special concern or interest. A strong BNRD field presence is required to ensure Plan success.
- To initiate a GIS database for mangrove NHRS areas. Use GIS systems and remote sensing techniques for mangrove resource monitoring.

**Description  
of Activities:**

- Monitor program centers on regular mangrove patrols (by foot, vehicle and boat). Emphasis is on identifying and monitoring human activities within and next to mangrove NHRS areas. Develop public volunteer programs to assist with monitoring activities.
- Coordinate mangrove project planning activities with state and traditional leaders. Meet frequently with key state and community leaders.
- Identify mangrove NHRS areas being over-exploited.
- GIS Mangrove Database Development: procure copies of a Data Element Dictionary for Forest Resources from cooperating agencies or vendors;

identify Forestry Unit employee for on-island training opportunities in digitizing vegetation layers with Bureau of Lands and Surveys GIS staff, procure Forestry Unit computer equipment (e.g., Pentium 2/3 with adequate hard drive space, printer and arc-view software, and resource level GPS unit).

- Provide wetland monitoring methodology and theory training.
- Executing Agency: BNRD, with a specific focus by Forestry Unit.

**Potential Benefits:**

- Increased mangrove NHRS area field presence. Enhanced Plan success.
- GIS monitoring capabilities provide long-term database development and trends.

**Budget and Time Estimates:**

- Time frame: Initiate Year 1, Ongoing.
- Maintenance of existing Forestry Unit fiberglass patrol boat, outboard motor and accessories (life preservers, first-aid kits, flares, etc.). Estimated Funding Cost per Year = US\$1,000.00 to US\$15,000.00.
- Bureau of Lands and Survey memorandum of understanding/agreement for assisting in GIS applications and database management. Training of a Forestry Unit employee. Procure GIS data element dictionary for forest resources. Estimated Funding Cost per Year = US\$2,500.00 to US\$5,000.00 (two to four years, as needed).
- Wetland monitoring and remote sensing training. Estimated Funding Cost per Year = US\$2,000.00 to US\$8,00.00 (as needed).
- Procurement of Pentium 2/3 processor with adequate hard drive space for GIS applications, printer/plotter, arc view software, resource grade GPS unit. Estimated Funding Cost per Year = US\$4,000.00 to US\$7,000.00 (one time cost).

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**Action Item #8 Palau Mangrove Timber Program Development**

**Background:**

- As needed, develop a mangrove timber program within the Forestry Unit that supports sustainable production forestry next to wood consuming communities; and provides a mechanism for mangrove establishment activities.

**Purpose:**

- This component centers on community/social forestry programs. Programs promote sustainable subsistence and commercial wood production, coastal

<b>Description of Activities:</b>	<ul style="list-style-type: none"> <li>● protection strategies and mangrove ecosystem restoration. Forestry programs direct mangrove harvest activities to predetermined areas helping to reduce unregulated harvest activities.</li> </ul>
<b>Potential Benefits:</b>	<ul style="list-style-type: none"> <li>● Identify stands within mangrove NHRS areas suitable for silvicultural treatments.</li> <li>● Consult closely with IPIF, SPREP and other cooperators on the development of silvicultural prescriptions and treatments which support community subsistence and commercial wood products.</li> <li>● Mangrove establishment efforts focus on ecosystem restoration and shoreline protection activities.</li> <li>● Support coastal revegetation efforts with mangrove nursery establishment.</li> <li>● A mangrove "no net-loss" program is implemented.</li> <li>● Forestry Unit personnel training in timber management principles, methods, and activities.</li> <li>● Executing Agency: Forestry Unit</li> </ul>
<b>Budget and Time Estimates:</b>	<ul style="list-style-type: none"> <li>● Forestry unit skill development in sustainable timber sale program administration.</li> <li>● Sustained subsistence and commercial timber production practices.</li> <li>● Reduced environmental impacts from unregulated harvest activities.</li> <li>● Growth and yield research opportunities, and increased stand productivity.</li> <li>● Mangrove nursery program development</li> </ul> <ul style="list-style-type: none"> <li>● Time frame: Initiate Year 3 or 4, Ongoing.</li> <li>● A general provision annually to cover mangrove vegetation program development, administrative costs, specialist consultations, technical assistance for workshops and conferences, training for forestry personnel in small timber sales and mangrove nursery management. Estimated Total Funding Cost per Year = US\$2,500.00 to US\$10,000.00.</li> </ul>

### **A.3 Implementation of the Plan**

Plan implementation will be appraised through a program of monitoring and evaluation. The purposes of this program are to:

- Inform BNRD of the progress toward achieving Plan objectives and the effects of applying mangrove standards and guidelines.
- Identify need for and timing of Plan Action Items, amendments or revisions.
- Help determine Plan cost and staffing needs.
- Help BNRD decide whether activities on adjacent lands and upper watershed are affecting Plan goals.

#### **A.4 Plan Accomplishment Process**

When practical, after approval of the Plan, the Minister (Ministry of Resources and Development), with recommendations and approval from the Director (BNRD), the Chief (Division of Agriculture and Mineral Resources), and Head Forester (Forestry Unit), will ensure that, subject to valid existing rights, all planning, permits, contracts, cooperative agreements, regulations, and other instruments of occupancy and use of mangroves are consistent with Palau law and the Plan. Subsequent administrative processes affecting mangroves, including budget proposals, should be based on the Plan. The Minister (Ministry of Resources and Development) may change proposed mangrove management direction and schedules to reflect developing national mangrove policy and differences in annual budgets and appropriated funds.

The Minister (Ministry of Resources and Development) has the authority to develop and carry out regulations regarding the use of mangrove wetlands. This authority requires the development of regulations, reviews by the Attorney General's Office (to ensure conformity with law), revisions and amendments (as needed), public notice period, and adoption (if no serious or compelling reasons against regulations or portion of) requiring the President (ROP) approval.

#### **A.5 Plan Revisions**

The BNRD, will monitor Plan accomplishments to validate the management direction, treatment activities, assumptions and data base. Necessary adjustments will be made to improve accomplishment success. Changes, some possibly significant, should be planned annually. At a minimum, the Plan will be reviewed at five-year periods to ensure management direction is consistent with national and state environmental policies, as well as to verify the Desired Future Condition of mangrove resource elements. The Minister (Ministry of Resources and Development), with approval and recommendations from the Director (BNRD), Chief (Division of Agriculture and Mineral Resources), and Head Forester (Forestry Unit) will be responsible for deciding the extent and need for revisions based on budget, changed conditions, management emphasis and mitigation measures.

#### **A.6 Evaluating the Plan**

Plan accomplishments for each fiscal year should be documented in report fashion. Report contents should include, at the minimum, the following information:

- General management reviews that show Plan program and activity accomplishments; revision needs and mangrove resource conditions should be included.
- Ongoing inventories and monitoring programs, involving soil or shoreline erosion or accretion, water quality, heritage Resources, animal and fish Resources, mangrove forest product demand and unregulated timber harvest assessments, are essential tasks.

#### A.7 Plan Annual Monitoring Program

Evaluation of site-specific monitoring program results should be documented and progress toward Plan objectives, goals and action items assessed. Results will be evaluated for action or adjustment. If objectives are not being met, find out the cause, rectify cause or modify the Plan, as appropriate. Recommendations should be made. Such recommendations may include:

- No action needed, monitoring shows that Plan goals, standards and guidelines are being achieved. Continue Plan implementation.
- Modify mangrove NHRS area prescriptions. Modify on-the-ground activities, standards and guidelines, and allocation of mangrove land base.
- Initiate Plan revision.
- Action needed to improve mangrove NHRS area classifications. Review action to decide if Plan revision is required. Revise, make no adjustments, and continue monitoring.
- Revise project schedule and associated outputs.



Above: Traditional Palauan outbuilding constructed with mangrove poles.

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## APPENDIX B THE MANGROVES OF PALAU

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### B.1 The Mangrove Forest Resource of Palau

This section outlines the mangrove vegetation found on Palau. Appendix B reviews the current and historic status of Palau mangrove use, discusses mangrove ecological values as goods and services, summarizes Palau mangrove species attributes, and displays select Palau mangrove statistics from previously published literature.

### B.2 Background

Palau's mangrove resources have been used for traditional subsistence needs for hundreds of years. Mangroves are used for fuelwood, structural materials for boats, houses, roofs, floors and fences, posts and poles, handicrafts and storyboards, fishtraps and dyes for preserving fishing nets.

Today, mangrove continues to be harvested primarily for subsistence uses on Palau. Cutting activities have typically occurred where timber extraction is easiest (convenient landward access and close to roads, channels, and shorelines). Evidence of cutting is present in just about every mangrove stand. Where observed, Plan site visits showed that most mangrove harvest activities were not recent (based on stump and stem wood condition, evidence of human activity, etc.). Cutting activities were estimated at being between two to five plus years old. Only several small harvest areas, with nominal wood extraction, appeared to have been cut within the last one to two year period. Some areas have likely been lightly to moderately exploited over many years. Mangrove harvest activities have been unregulated. Mangrove harvesting has not been done from scientific silvicultural prescriptions, but rather on the material needs of harvesters.

Currently, mangrove exploitation for subsistence needs is considered within a sustainable range. This presumption is attributed to several factors: 1) Palauan's strong mangrove conservation ethic, 2) Palauan's traditional harvest method is based on an individual tree selection system, 3) the preferred local construction materials for subsistence and commercial needs are imported lumber or non-mangrove species such as the upland tree species Btaches (Calophyllum inophyllum) and Ukall (Serianthes kanehirae), and 4) the preferred cooking fuels are kerosene and gas. If petroleum fuels are not available, then upland tree species, such as Elebiob (Alohionia carolinensis), are preferred for fuelwood. As noted throughout the world, if preferred subsistence and commercial wood commodities become difficult to gather or fall from preferred status, substitute wood species (such as mangrove in Palau's case) could experience over-exploitive consumption levels.

Harvesting is generally by an individual tree selection method based on preferred size classes (generally diameters ranging from 2.0 to 12.0 inches with lengths up to 16.0 feet). However, several small clearcuts, ranging in size from 0.2 to 0.4 acres were observed during Plan site visits. Current harvest practices generate excessive wood waste. Wood utilization standards are very low. This may be attributed to trees getting "hung-up" during felling activities, resulting in two to three trees being cut to remove the preferred tree (Tom Cole, personal communication, IPIF, June 1999). Sporadic harvest activities for fuelwood and structural materials approach commercial levels. These harvest activities will likely become more prevalent with Palau's growing population.

Current mangrove species supply and demand dynamics are unknown for Palau. Presently, Palau has no mangrove forest products industry. Mangrove resource influence in the national economy is virtually nonexistent on a wood commodity/production level. Approximately two to four portable sawmills and one to two stationary saw mills are currently in operation on Palau. Due to Palau's expansive mangrove area, implied productivity and trainable timber management workforce, opportunities exist for commercial production.

Today, the primary loss of Palau's mangroves is caused by road construction, shoreline tourism resorts, community/commercial boat access, inter-islet causeways, and residential improvements. During Plan development, plans were reported for expanded fish pond enterprises. The mariculture industry, if not properly planned, could have adverse affects on Palau's mangroves.

In the future, it is likely that Palau's mangroves will be under considerable pressure as the consumption and production of a growing population increases, population centers shift, land demands increase and phenomena such as rising sea-levels affect coastal areas.

The real socioeconomic issue of the mangrove forests on Palau is not as a forest industry, but for maintaining and enhancing island ecological processes. When related to coastal shoreline protection and stabilization, primary productivity and energy flow, nutrient buffering and release, sediment screens and filters, marine and fisheries habitat, salt spray deflection and storm energy dissipation - the Palau mangrove resource exhibits a virtually priceless economic and ecological benefit. This is why the mangrove forest industry is not a primary goal of the BNRD.

The historical perspective shows heavy mangrove harvesting throughout Babeldaob Island, particularly by the Japanese. The Japanese used mangrove, primarily Bngaol (*R. apiculata*) and Tabechel (*R. mucronata*), for charcoal production. Japanese charcoal kilns were set-up in many localities throughout Babeldaob Island. Mangrove was also used for structural purposes (primarily outbuildings), by the Japanese. Exact silvicultural and harvest treatments are unknown. Nevertheless, it is believed that trees were removed based on dimensional needs and through high grading. Mangrove regeneration and stand development could possibly be deduced from these areas.



### B.3 Palau's Mangrove Vegetation

Because of differences in soil, fresh and salt water mixtures, erosion and accretion, tidal inundation, water temperature, protection from wind and waves, salinity, biochemical processes and species biology, mangroves adapt to a range of environmental conditions along coastal areas. Some species are found in or immediately next to ocean waters, others prefer the landward edge where salinity levels, tidal inundation and soils are more accommodating.

Palau's mangrove species are confined to the intertidal coastal flats where they are generally subject to tidal overwash twice daily. Here they can form dense, virtually impenetrable continual forest cover ranging in-depth from a few meters to approximately one mile from the seaward to landward edge. Their distribution is roughly stratified by horizontal gradients that are generally aligned parallel to the shoreline. Stand structure ranges from single clumps to dense overstocked stands. Tree forms range from stunted and shrub-like, to trees 50.0 to 70.0 feet in height and 40.0 plus inches d.b.h. In Palau, mangrove typically grow in stands of medium sized trees (Cole et al. 1987).



Above: Kashgar Rengulbai, Palauan Forester, examines a mangrove stand dominated by Bngoal (*R. apiculata*).

Within Palau's mangrove habitat types, eighteen (18) mangrove species and associated species have been confirmed (Duke, 1999). These species, found in various structural and compositional arrangements are:

<u>Genus Species</u>	<u>Local Name</u>	<u>Local Use/Historic Use</u>	<u>General Habitat Zone</u>
<u>Acanthus ebracteatus</u>	Kollil	medicinal (?)	I
<u>Acrostichum speciosum</u>	Okuam	medicinal (?)	I
<u>Avicennia alba</u>	Unknown	lumber (?)	I
<u>Bruguiera gymnorhiza</u>	Denges, Kodenges	lumber/posts/poles/firewood	I,F,R
<u>Ceriops tagal</u>	Biut	structural materials/posts/poles	I, R
<u>Dolichandrone spathacea</u>	Rriu	handicrafts	I
<u>Excoecaria agallocha</u>	Ias	no known use (?)	F
<u>Heritiera littoralis</u>	Ebibech	handicrafts, storyboards	I,R
<u>Lumnitzera littorea</u>	Mekekad	lumber/boat keel	I,R
<u>Nypa fruticans</u>	Toechel	roof thatch/broom/basket weavings	I,R
<u>Pemphis acidula</u>	Ngis	tool handle/pistil-mortar	F
<u>Rhizophora apiculata</u>	Bngaol	lumber/posts/poles/firewood	F,R,I
<u>Rhizophora X lamarckii</u>	Tebechel	lumber/posts/poles/firewood	F,R,I
<u>Rhizophora mucronata</u>	Tabechel	lumber/posts/poles/firewood	F,R
<u>Rhizophora stylosa</u>	Bngaol	lumber/posts/poles/firewood	F
<u>Scyphiphora hydrophyllacea</u>	Kuat	tool handle/firewood	R,I
<u>Sonneratia alba</u>	Urur	lumber/posts/poles	I,F,R
<u>Xylocarpus granatum</u>	Medulokebong	building materials/posts/poles/crafts	I,R

I = Interior    F = Fringe    R = Riverine

Palau mangrove vegetation types have been classified by Cole and others (1987). These classifications are:

#### SIZE CLASSES:

- Stratum MN0 - Short, shrub like stands smaller than 5.0 in (12.5 cm) at breast height (d.b.h.)
- Stratum MN1 - Trees averaging less than 12.0 in (30.0 cm) in d.b.h., but 5.0 in (12.5 cm) or more in d.b.h.
- Stratum MN2 - Trees averaging 12.0 in (30.0 cm) or more in d.b.h.

#### DENSITY CLASSES:

- High - Crown closure of main canopy over 70 percent.
- Medium - Crown closure of main canopy between 30 and 70 percent.
- Low - Crown closure of main canopy less than 30 percent.

#### VEGETATION TYPE CODES:

- MN Mangrove, various size and density classes apply.
- MN.R Mangrove with Rhizophora component.
- MN.SW Mangrove with swamp forest component.
- MN.AT Mangrove with atoll forest component.
- MN.N Mangrove with nypa palm component.
- MN/SV Mangrove with secondary vegetation understory component.
- MN.D Mangrove with evidence of disturbance.

#### **B.4 Palau Mangrove Species and Associated Mangrove Species**

The following review of Palau's mangroves is derived from a variety of sources, notably, Fosberg (1960) and Stemmermann and Proby (1978).

##### **B.4.1 Acanthus ebracteatus (Kollil)**

Kollil, an indigenous shrub, was found on the landward edges of developed mangrove stands. It can be found growing on ground exposed to periodic tidal influence and along mangrove channels on elevated mud banks. During Plan site visits, Kollil was occasionally found in the transition zone between freshwater swamp and mangrove.

##### **B.4.2 Acrostichum speciosum (Okuam)**

During Plan site visits, Okuam was found primarily on the landward edges of developed mangrove stands and lowland coastal marshes. It can be found growing along mangrove channels on elevated mud banks. Okuam, is an indigenous semi-aquatic fern to Palau.

##### **B.4.3 Avicennia alba (Dadait)**

Dadait was found in the landward edges, and sometimes in the seaward middle, of developed mangrove stands where it can be found in stands mixed with all of Palau's mangrove species. Dadait is generally confined to areas inundated by normal high tides and other exceptional tides. During Plan site visits, Dadait was observed several times within the landward edges of developed stands.

##### **B.4.4 Bruguiera gymnorhiza (Denges, Kodenges)**

Denges was found in the seaward middle and landward edges of developed mangrove stands where it can be found in stands mixed with all of Palau's mangrove species. Denges can be found along the less saline waters of bays and river mouths, and long distances up stream and river channels with apparently little tidal influence. Denges is generally confined to areas inundated by normal high tide's and other exceptional tides. During Plan site visits, Denges was also found on select Rock Islands, in small, interior basin depressions (some with a thick mat of

algae covering the soil), well above high tide levels.

In Palau's 1988 inventory of mangrove forest types, Denges's plot frequency of occurrence was 60 percent, with a total volume of 16,000 cubic meters (Cole et al. 1988). In the Federated States of Micronesia (FSM), Denges, which is relatively shade tolerant, had the FSM's third highest annual diameter growth with a mean increment of 0.35 cm/year (Devoe and Cole, 1998). On Palau, Denges is used as building materials for houses and out-structures (sawn lumber, posts and poles), and fuelwood. Denges is known for its durable timber qualities, with rot and insect resistant wood properties. During World War II, the Denges propagule was used as a food supplement by Palauan's (Marcello Brel, personal communication, May 1999).

#### **B.4.5 Ceriops tagal (Biut)**

Biut was generally found in the middle portion of developed mangrove stands and along channels where it can be found in stands mixed with all of Palau's mangrove species. Biut is indigenous to Palau. During Plan site visits, Biut was found along mangrove channels and in the middle interior of developed mangrove stands.

In Palau's 1988 inventory of mangrove forest types, Biut's plot frequency of occurrence was 60 percent, with a total volume of 6,000 cubic meters (Cole et al. 1988). On Palau, Biut is used for structural purposes (lumber, posts and poles), especially for roofing (Marcello Brel, personal communication, May 1999).



Above: Okuam (Acrostichum speciosum), an indigenous semi-aquatic fern, can be found growing along the landward edge of Palau's mangrove stands.

#### **B.4.6 Dolichandrone spathacea (Rriu)**

Rriu was found on the landward edges of developed mangrove stands, with apparently little tidal influence. During Plan site visits, Rriu was found in the transition zone between freshwater swamps and mangroves, above high tide levels.

On Palau, Rriu is used for handicrafts. Rriu seeds are chewed by Palauan's when betel nut is scarce. The leave of Rriu is also used for betel nut wrapping (Marcello Brel, personal communication, May 1999).

#### **B.4.7 Excoecaria agallocha (Ias)**

Ias is generally found in the coastal strand mangrove interface, and periodically along mangrove channels. Ias was not observed during Plan site visits. On Palau, Ias has no apparent use. Ias is known to be a poisonous tree by Palauan's (Marcello Brel, personal communication, May 1999).

#### **B.4.8 Heritiera littoralis (Ebibech)**

Ebibech is generally found in the landward edges of developed mangrove stands, along mangrove channels and rivers, occasionally on the mangrove-coastal strand interface and along riparian influxes into mangroves. Ebibech is indigenous to Palau. Ebibech was not observed during Plan site visits. Ebibech is considered a scarce or rare tree species by Palauans (Marcello Brel, personal communication, May 1999). On Palau, Ebibech is used for handicrafts and storyboards.

#### **B.4.9 Lumnitzera littorea (Mekekad)**

Mekekad was generally found in the middle to landward edges of developed mangrove stands, where it can be found in mixed with all of Palau's mangroves species. Occasionally, Mekekad may also be seen near the seaward edge of mangrove stands. Mekekad is indigenous to Palau. During Plan site visits, Mekekad was found frequently along mangrove channels and middle interiors of developed stands.

In Palau's 1988 inventory of mangrove forest types, Mekekad's plot frequency of occurrence was 40 percent, with a total volume of 75,000 cubic meters (Cole et al. 1988). Of the mangrove species on Palau, Mekekad is known to have the strongest wood characteristics. It is used for flooring material, house construction and house posts. Mekekad grows relatively straight making it easy to mill into boards. In the past, Mekekad was used to make boat keels. Mekekad flowers are a preferred pollen nectar of the Palauan Fruitbat (Rattus exulans) (Marcello Brel, personal communication, May 1999).

#### B.4.10 Nypa fruticans (Toechel)

Toechel is usually the only palm found in mangroves. Toechel was generally found in the landward edges of mangrove and brackish estuaries, and along mangrove channels with high fresh water levels. Toechel is indigenous to Palau. During Plan site visits, Toechel was common along mangrove channels and the middle interior of developed mangrove stands.

On Palau, the fronds of the palm are used for house and outbuilding roof thatching, brooms, basket weaving. The fruit of Toechel is known to be edible and can be made into a juice drink (Marcello Brel, personal communication, May 1999).

#### B.4.11 Pemphis acidula (Ngis)

Ngis was found in the mangrove-coastal strand interface and as coastal strand exposed to tidal influences. Pemphis can be found on dry limestone rock (Rock Islands) and the interior depressions of Rock Islands. During Plan site visits, Ngis was observed on select Rock Islands with other strand vegetation, just above the tidal influence. On Palau, Ngis is used for tool handles, and pestle and mortar (Marcello Brel, personal communication, May 1999).



Above: Dense stand of Tebechel (R. mucronata). Note subsistence harvesting activities for pole size materials in the foreground.

#### **B.4.12 Rhizophora apiculata (Bngaol)**

Bngaol was usually found behind Tabechel (R. mucronata) a short distance inland from the seaward edge. Bngaol commonly occupies a zone somewhere between the middle and landward (interior) edge of developed mangrove stands, where it can be found in stands mixed with several of Palau's mangrove species. Occasionally, Bngaol can be found at the seaward edge in areas inundated by normal high tides around river mouths and bays. Bngaol is indigenous to Palau. During Plan site visits, Bngaol was found often between the middle to landward edge of mangrove stands, sometimes in stunted, pure stands. A single albino Bngaol tree was observed in the Ngarmiskang River, on the western side of Babeldaob Island (Duke, 1999).

In the Caroline Islands, Bngaol can reach heights of approximately 85.0 feet with diameters up to the 16.0 inch size class. In the FSM, Bngaol had the slowest annual diameter growth with a mean increment of 0.24 cm/year (Devoe and Cole, 1998).

On Palau, Bngaol is used for a variety of structural functions (lumber for house rafters and beams, posts, poles). Bngaol is known for its strong wood qualities. It is a preferred Palauan firewood. The bark of Bngaol has been processed into tannin for preserving fishing nets. Propagules were used for rope materials, fish traps, taro tool and coconut husking. Historically, the propagule was used for spear points and for combs (Marcello Brel, personal communication, May 1999).

#### **B.4.13 Rhizophora X lamarckii (Tebechel)**

Tebechel, a hybrid of Bngaol (R. stylosa) and Bngaol (R. apiculata), is newly reported on Palau (Duke, 1999). No additional information was available at the time of this study. Uses are believed to be similar to Bngaol and Tebechel.

#### **B.4.14 Rhizophora mucronata (Tebechel)**

Tebechel was usually found on the seaward edge along riverine corridors and mangrove channels with high tidal flushings quite a distance inland. Tebechel is confined to areas inundated by medium to high tidal surges. Tebechel tends to be absent in the interior and landward edge of developed mangrove stands, and in bay estuaries dominated by fresh water river flows. Tebechel is indigenous to Palau.

In Palau's 1988 inventory of mangrove forest types, Tebechel's plot frequency of occurrence was 100 percent, with a total volume of 46,000 cubic meters (Cole et al. 1988). In the Caroline Islands, Tebechel can reach heights of approximately 65.0 feet with diameters up to the 12.0 - 16.0 inch size class. In the FSM, Tebechel, had the second highest annual diameter growth with a mean increment of 0.37 cm/year (Devoe and Cole, 1998).

On Palau, Tebechel is known for its lumber, post, and pole qualities. It is a preferred

Palauan firewood. Tebechel propagules are also used for rope materials, coconut husking, taro tool and coconut husking. Historically, the propagule was used for spear points and combs (Marcello Brel, personal communication, May 1999).

#### **B.4.15 Rhizophora stylosa (Bngaol)**

During Plan site visits, Bngaol was found on the seaward edge of mangrove fringes where it commonly occupies sandy, coralline, or rocky shorelines. Several albino Bngaol trees were observed on Urukthapel Island, in the Rock Islands (Duke, 1999).

On Palau, Bngaol is known for its lumber, post, and pole qualities. It is a preferred Palauan firewood. Tebechel propagules are also used for rope materials, coconut husking, taro tool and coconut husking. Historically, the propagule was used for spear points and combs (Marcello Brel, personal communication, May 1999).

#### **B.4.16 Scyphiphora hydrophyllacea (Kuat)**

Kuat is generally found along mangrove channels in the middle to landward edge of developed mangrove stands, where it can be found in stands mixed with several of Palau's mangrove species. It can also be found at the mangrove-coastal strand interface. Kuat is often found growing with Mekekad (L. littorea). Kuat is indigenous to Palau. On Palau, Kuat is used for tool handles and firewood (Marcello Brel, personal communication, May 1999).

#### **B.4.17 Sonneratia alba (Urur)**

During Plan site visits, Urur was found in the seaward middle and landward areas of developed mangrove stands, where it was found in stands mixed with all of Palau's mangrove species. However, Urur can be found as the dominate species on the seaward edge of developed mangrove stands, particularly on the east and west coasts of Babeldaob Island. Urur is generally confined to areas inundated by normal to medium-high tides. Urur is indigenous to Palau.

In Palau's 1988 inventory of mangrove forest types, Urur's plot frequency of occurrence was 20 percent, with a total volume of 54,000 cubic meters (Cole et al. 1988). In the Caroline Islands, Urur can grow to approximately 98.0 feet in height, with diameters up to the 40.0 - 44.0 inch size classes. In the FSM, Urur had the highest annual diameter growth with a mean increment of 0.37 cm/year (Devoe and Cole, 1998).

On Palau, Urur is used for lumber, posts and poles, primarily for outbuilding structures. Urur is known for its rot resistant wood characteristics. Urur flowers, are one of the Palauan Fruitbat's (Rattus exulans), preferred pollen nectar's. The fruit of Urur, is used to make a child's top-like toy (Marcello Brel, personal communication, May 1999).



#### B.4.18 Xylocarpus granatum (Medulokebong)

During Plan site visits, Medulokebong was found along channels and on the landward edges of developed mangrove stands, mixed with all of Palau's mangrove species. Medulokebong requires tidal influence, so is usually found within the upper limits of the normal high tide zone and occasional in the exceptional tide zone.

In Palau's 1988 inventory of mangrove forest types, Medulokebong plot frequency of occurrence was 80 percent, with a total volume of 9,000 cubic meters (Cole et al. 1988). In the Caroline Islands, Medulokebong can reach heights over 65.0 feet, with diameters up to the 16.0 inch size class. In the FSM, Medulokebong had the fourth highest annual diameter growth with a mean increment of 0.31 cm/year (Devoe and Cole, 1998). On Palau, Medulokebong is used for building materials (flooring, posts, poles). It is noted for its wood carving properties where it is used for carving handicrafts and storyboards (Marcello Brel, personal communication, May 1999).

#### B.5 Palau Mangrove Forest Statistics

The following tables give a statistical summary and perspective of the mangrove forest resource on Palau:

Table B.5.1 - Palau Total Land Area and Mangrove Wetland Area (adopted from Cole and others, 1987).	
Total Land Area, Acres (ha)	Mangrove Wetland Area, Acres (ha)
102,840 (41,619)	11,633 (4,708)

Table B.5.2 - Mangrove Area by Republic of Palau Island Groups, 1979 (adopted from Cole and others, 1987).				
Babeldaob	Other High Islands	Coral Islands	Rock Islands	Total
-----Acres (hectares)-----				
9,942 (4,025)	506 (205)	1,075 (435)	106 (43)	11,633 (4,708)

Table B.5.3 - Mangrove Area of the High Islands of Koror, Malakal, and Ngerkebesang, Republic of Palau, 1979 (adopted from Cole and others, 1987).			
Koror	Malakal	Ngerkebesang	Total
-----Acres (hectares)-----			
467 (189)	0 (0)	40 (16)	507 (205)

Table B.5.4 - Mangrove Area of the Coral Islands of Peleliu, Angaur, Kayangel, Republic of Palau, 1979 (adopted from Cole and others, 1987).			
Peleliu	Angaur	Kayangel	Total
-----Acres (hectares)-----			
1,075 (435)	0 (0)	0 (0)	1,075 (435)

Table B.5.5 - Mangrove Area of selected Rock Islands by State, Republic of Palau, 1979 (adopted from Cole and others, 1987).				
Airai	Koror	Ngerchelong	Peleliu	Total
-----Acres (hectares)-----				
2 (1)	0 (0)	5 (2)	99 (40)	106 (43)

Palau Mangrove Growth Rates:

Mangrove growth rates in Micronesia are generally low, most likely from excessive competition and partially from low site (Devoe, 1992). It is unlikely that full potential growth rates will ever be achieved in Palau mangroves since this can only take place under intensive management for commodity production. Growth rates are indicators of health and vigor and should be considered in managing the mangrove stands of Palau. See Table B.5.6, FSM Mean Annual Increment By Mangrove Species.

**Table B.5.6 - FSM Mean Annual Increment by Mangrove Species (adopted from Devoe and Cole, 1998).**

Species	Mean Annual Diameter Growth inches/year (cm/yr)
R. apiculata	0.10 (0.25)
R. mucronata	0.15 (0.37)
X. granatum	0.12 (0.31)
B. gymnorhiza	0.14 (0.35)
S. alba	0.19 (0.49)

**Table B.5.7 - Palau Mangrove Forest Area by Size and Density Classes (adopted from Cole and others, 1987).**

Size Class Type	LDC	MDC	HDC	Total
	-----acres (hectares)-----			
Mangrove MN0	0	0	1,134 (459)	1,134 (459)
Mangrove MN1	15 (5)	0	8,386 (3,395)	8,401 (3,400)
Mangrove MN2	0	0	411 (166)	411 (166)

Mangrove MN0 - Trees smaller than 5.0 in (12.5 cm) d.b.h.

Mangrove MN1 - Trees larger than 5.0 in (12.5 cm) d.b.h., less than 12.0 in (30.0 cm) d.b.h.

Mangrove MN2 - Trees averaging larger than 12.0 in (30 cm) d.b.h.

Crown Closure: LDC<30%; MDC 30%-70%; HDC>70%



Above: Kashgar Rengulbai, Palauan Forester, examines a mangrove stand dominated by Medulokebong (*X. granatum*) and Bngaol (*R. apiculata*).

#### **B.6 Mangrove Functional Zones and Ecological Values**

In general, Palau has three functional mangrove zones: 1) Fringe Zone, flooded by sea water at every tide, 2) Riverine Zone, flooded by both salt water and fresh water, and 3) Interior Zone, flooded occasionally, even frequently, by both tides and river water (Katherine Ewel, IPIF, personal communication, April 1999).

Different kinds of mangrove forests provide varying degrees of good and services (Ewel et al 1998a):

- ◆ Riverine mangroves (along rivers and channels) are important for trapping sediments, processing nutrients and organic matter, serving as a detritus source to nearshore waters, serving as a sink for nutrients (especially phosphorous), providing food and habitat for

animals, providing aesthetically pleasing environments and supporting all other mangrove goods and services.

- ◆ Interior mangroves (landward side of developed stands) are important as a sink for nutrients and carbon (especially carbon and nitrogen), improving water quality, and providing plant products, and all other mangrove goods and services.
- ◆ Fringe mangroves (outermost seaward edge of developed stands) are important for protecting shorelines, and all other mangrove goods and services.

## **B.7 Mangrove Goods and Services**

Mangroves provide a diversity of goods and services. Fringe, riverine and interior mangrove forests all play different, yet critical environmental and socioeconomic roles, many that overlap in the benefits they provide. Understanding the importance and best use of the different parts of mangrove forests may help formulate management policies that support sustained supplies of goods and services (Ewel et al. 1998a). The following section briefly identifies values associated with Palau's mangroves.

### **B.7.1 Mangrove Values: National and State Implications**

In Palau, mangroves are under state government authority, where they are still undervalued for their natural ecological contributions and socioeconomic significance. National, state and traditional leaders must be aware of mangrove values associated with the goods and services they provide.

For comparison purposes, the following mangrove valuing information is provided. Based on 1996 mangrove valuation studies in Kosrae (FSM) - when converted to a land area basis, the economic values of mangrove per hectare (one hectare = 2.47 acres) are US\$426.0 to US\$640.0 per year (net) in 1996 prices. A sustainable stream of US\$426.0-640.0/hectare/year would produce a real present value of US\$4,239.0 to US\$6,350.0 per hectare if discounted at 10 percent (Drew and Naylor, 1998). Estimated income from Kosrae mangrove forests in 1996 for fuelwood was about US\$278,000.0, mangrove crabs about US\$550,000.0 and fish about US\$170,000.0, for a total of almost US\$1,000,000.0 (Drew and Naylor, 1998). FSM mangroves play a critical role in maintaining a healthy island environment and providing local socioeconomic benefits.

### **B.7.2 Shoreline Protection**

With Palau's limited land base, using mangrove vegetation to stabilize shorelines is desirable, and economically and ecologically feasible. Mangroves provide an effective coastal protection structure with greatly reduced costs (both from a construction and maintenance viewpoint). They are renewable and self-maintaining.

One of the most important and recognized services that mangroves provide is the protection of infrastructure from storm surges, tidal waves and floods. This is because: 1)

mangrove boundaries show the extent of normal flooding and therefore the zone where human development should stop, and 2) mangrove vegetation decreases the rate of flow which water passes over land, slowing the destructive force of flood waters approaching land (Ewel et al. 1998a).

The roots of mangrove trees in both the fringe and riverine mangrove zones help bind surface soils together. Therefore, both fringe and riverine mangrove zones are particularly important for protecting shorelines from erosion. Basin mangrove zones provide this service as well, by reducing water velocity and adding flood storage capacity behind fringe and riverine mangroves (Ewel et al. 1998a).

### **B.7.3 Sediment Trapping**

Leaving mangroves intact provides Palauan society with the service of trapping and retaining upland sediments. Riverine mangroves are particularly important, because river waters usually carry a heavier sediment load than ocean tides (Ewel et al. 1998a). Basin mangroves trap the smallest sediment particles, those carried past fringe and riverine mangroves, as well as trap sediments deposited by upland runoff along the landward edge of mangroves (Ewel et al. 1998a). Fringe mangroves also trap riverine sediments and sediments recirculated by nearshore waters (Ewel et al. 1998a).

Fringe, riverine and interior mangroves trap excessive sediments caused by human activities, such as road building and upland deforestation, in turn, helping to prevent these sediments from washing into nearshore seagrass beds and coral reefs (Ewel et al. 1998a). However, this service is limited, as excessive sediment build-up kills mangrove trees. Road building and the subsequent sediment discharge resulting from this activity, is one of the primary causes of mangrove related mortality in Micronesia.

Mangroves also help protect shorelines from sea level rises. Projected rates of accelerated sea level rise range from 0.395 to 0.787 inches per year (Twilley, 1998). Mangroves can tolerate, although under stress, sea level rise ranging from 0.035 to 0.047 inches per year (Twilley, 1998). The continued existence of mangroves in the intertidal zone is dependant on many factors that contribute to sediment deposition at a rate that balances sea level rising. It is possible that thoughtful manipulation of sediment delivery to mangroves could ensure survival, even in the face of rising sea levels (Ewel et al. 1998a)

### **B.7.4 Organic Matter and Nutrient Processing**

Leaf litter produced by mangroves represents a source of organic matter and nutrients that may be transported to adjacent coastal waters and utilized by fish and other marine Resources (Twilley, 1998). Fringe mangroves play an important role in providing a source of detritus to nearshore waters (Ewel et al. 1998a). High productivity and relative short residence times of mangrove leaf litter in riverine and fringe mangroves (due to flooding frequency), make them

particularly important in organic matter export, except where interior zones are much larger (Ewel et al. 1998a). Mangrove sites with frequent tides and river inundations are more productive, and higher proportions of leaf fall are exported to coastal waters (Twilley, 1998)

Interior mangrove forests may rank lower in organic matter export because of lower flooding frequency, but they may have higher rates of organic matter and nutrient accumulation (Ewel et al. 1998a). The natural free service of mangroves as a nutrient sink can reduce environmental impacts associated with excessive nutrients into coastal waters.

### **B.7.5 Water Quality**

Mangroves provide the service of nutrient processing that can directly improve coastal water quality. Mangroves have the capacity of nitrogen removal by denitrification and by nutrient burial in mangrove soils (Twilley, 1998). However, the increased use of coastal areas for industrial, residential and recreational activities make coastal zones more susceptible to excessive nutrients and toxic materials, possibly disrupting ecological processes and the free service mangroves provide in maintaining water quality.



Above: Mangroves provide important ecological services by filtering and trapping sediments, buffering organic matters, recycling nutrients and maintaining water quality

Another highly potential and beneficial role mangroves can play includes a natural and environmentally suitable means of domestic wastewater treatment or effluent polishing. A treated wastewater discharge into mangrove wetlands from a simple two or three cell oxidation pond system provides an economical and technological means of wastewater disposal. Low levels of treated wastewater would not adversely affect mangrove ecosystems or adjacent coastal waters. Engineering mangroves for wastewater treatment, rather than removing them, can be a positive feedback to sustain human activities in the coastal zone (Twilley, 1998). However, to safeguard human health, waste effluent should be retained in an area free from contact with humans or commonly eaten fish and shellfish (Ewel et al. 1998a).

#### **B.7.6 Animal Habitat**

Mangrove forests provide habitat and food sources for many land and sea animals. Mangroves support complex food chains, especially to estuarine dependent fisheries, making them a vital environmental link to island health.

Mangroves provide critical habitat for a variety of fish species. See Table B.1, Estimated Area of Mangrove Fishing Habitat by State. Fish consumed by Palauan's use mangroves for spawning, nursery, shelter and feeding grounds. For example, snappers, milkfish and groupers use mangroves in larval, juvenile, or adult stages (Hamilton and Snedaker, 1984). Habitat availability for juvenile and adult fish is likely highest in fringe and riverine mangrove forest zones, and portions of basin forests where tidal channels provide access (Ewel et al. 1998a). Mangroves export organic nutrients (decomposing leaf litter) to nearshore waters providing a food source for primary consumers such as molluscs and crabs, which are in turn eaten by fish.

Mangroves provide habitat for a variety of invertebrates such as insects, crabs, shrimp and snails. Insects associated with the forest canopy of mangroves (for example, ants, bees, and spiders) seem to be typical terrestrial insects. Insects use mangroves as food, shelter and hatchery purposes. Insects in turn are an important food source for other animals foraging in mangroves, such as fruitbats and birds.

Crabs play a critical role in mangroves. Not only do crabs provide an important element in the human food chain, they also provide an important role in maintaining health mangrove ecosystems. The mangrove crab (*Scylla serrata*) and land crab (*Cardisoma carnifex* and *C. hirtipes*) are two of the common crab species found in mangroves. The presence of crabs that consume mangrove leaf litter increases the effectiveness of mangrove nutrient cycles (Ewel et al. 1998a). Crabs, with their burrowing activities, can also increase oxygen to mangrove soils and root systems, and create pockets of fertilizer in their burrows as a byproduct of leaf and propagule consumption (K. Ewel, IPIF, personal communication, April 1999). Crabs can also influence mangrove establishment and species composition by consuming propagules of preferred mangrove species, thereby affecting the possible structure of forest stands (Ball et al. 1998).



**Table B.7.1.** Estimated Area of Mangrove Fishing Habitats by State (square miles). Adopted from ROP State of the Environment Report (Maiava and Otobed, 1994).

<u>State</u>	<u>Mangrove Fish Habitat Area (sq. mi)</u>
Kayangel	N/A
Ngerchelong	12.6
Ngaraard	31.3
Ngiwal	3.4
Melekeok	4.4
Ngchesar	4.7
Airai	20.5
Koror	4.1
Aimeliik	7.3
Ngatpang	16.3
Ngeremlengui	10.4
Ngardmau	18.6
Peleliu	12.7
Angaur	N/A
Sonsorol Islands	N/A
Tobi	N/A
<b>TOTAL:</b>	<b>146.3 sq. mi.</b>

N/A = None or nominal mangrove areas.

Juvenile shrimp and mangrove clams (Anodonita alba, A. edulenta, Polmeseda luhwana and Terebralia semestriata) are common in mangroves. Both play important roles in the human food chain. Shrimp are more common in fringe and riverine mangroves, and in more frequently inundated portions of interior mangroves (Ewel et al. 1998a). Clams are found buried in the soils associated with mangroves.

Mangroves also provide habitat for birds, mammals and reptiles. Many birds use mangroves for feeding and/or nesting. Most birds associated with mangroves feed primarily in the canopy and are common in fringe and riverine forests, which are especially important for migrating birds (Ewel et al. 1998a). Palau has documented 141 species of birds, with 91 of the species being migratory. Birds common in Palau mangroves include: Kedam (Fregate minor and E. ariel), Sechou (Egretta sacra), Cherosech (Halcyon cinnamomina), and Esisebasech (Myiagra erythrops).

Mammals using mangroves include two bats: the Palauan Fruit Bat (Pteropus pelewensis) and a small insectivorous bat (Emballonura palauensis). The Polynesian Rat (Rattus exulans) is also found in mangroves.

Few amphibians are found in Palau's mangroves, but crocodiles, snakes and lizards are common. Mangroves provide critical habitat to the Saltwater Crocodile (Crocodylus porosus).



Above. Saltwater crocodile (C. poros) seeks cover among the roots of Urur (S. alba) tree. The Plan recognizes the critical role mangroves provide as habitat for animal populations.



Above. Jakki Trenbath of the Palau Conservation Society, holds a "mangrove snake" (species unknown) found within a stand dominated by old growth Urur (S. alba).

### **B.7.7 Visually Pleasing Environment**

Mangroves, especially large natural or near-natural stands along riverine and fringe mangrove zones, provide recreational opportunities for tourists and Palauan's. Nature-based tourism, such as boardwalks and canoe/kayak trips, provides opportunities for enjoying natural forest settings, wildlife and marine animal observations, solitude and adventure. Generating income and public education are benefits of nature-based tourism.

### **B.7.8 Wood and Plant Products**

Mangroves provide a variety of products, including wood production of lumber, posts, poles and fuelwood, honey, foliage for grazing and stall feeding livestock, roof thatch and tannin (Hamilton and Snedaker, 1984). Different mangrove species are used for different purposes. For example, on Palau, Bngaol (*R. apiculata*) is used for firewood, charcoal, posts, poles and lumber.

In general, the best growth of mangrove trees occurs in riverine forests, where periodic flooding deposits sediments. However, harvesting is most common in interior forests where access makes wood extraction easier and more economical (Ewel et al. 1998a). Commercial production of preferred mangrove species is common, and if managed properly, provides many useful goods and services on a sustained basis.

### **B.7.9 Biodiversity**

Mangrove ecosystems support a variety of life forms, ranging from tree and plant communities, to animal populations, to marine and estuarine food webs. Mangrove, seagrass and coral reef habitats are linked together providing richness and diversity in the natural environment. This diversity is a critical component for sustaining island health and socioeconomic benefits.

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**APPENDIX C**  
**PLAN MANGROVE RESOURCE STANDARDS AND GUIDELINES**

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**C.1 Introduction**

Appendix C, Plan Mangrove Resource Standards and Guidelines, sets the initial conditions designed to assist Palau resource manager's achieve the Desired Future Condition of mangrove resource elements identified in Volume I, Chapter 2.0, Palau Mangrove Management Direction.

Appendix C further defines the desired future condition of mangrove resources. By setting the baseline conditions for carrying out Plan direction, mangrove standards and guidelines represent the minimum levels of management necessary to reach the Desired Future Condition of mangrove resources.

**C.2 Standards and Guidelines Necessary for Achieving the Desired Future Condition of Mangrove Resource Elements**

This section addresses details needed to achieve the expected Desired Future Condition of mangrove resource elements. The Desired Future Condition represents the full achievement of mangrove resource element goals and objectives. That is, how Palauan's visualize the condition of their mangrove resources (such as mangrove fisheries habitat) in the future, whether projected out five or 100 years.

**C.2.1 Mangrove Vegetation Standards and Guidelines**

**The Standards and Guidelines Necessary to Meet the Desired Future Condition of Mangrove Vegetation are:**

- ◆ Maintain, enhance, protect and restore the health and productivity of mangroves for their multiple-use values.
- ◆ A mangrove policy of "no net-loss" is supported and carried out. When needed, mangrove planting projects will be carried out to ensure "no net-loss" of mangroves. Careful consideration will go into site plantability and species selection. Seedling survival will be assured by on-site evaluations.
- ◆ Mangrove areas important for coastal shoreline protection, biodiversity, productivity, critical habitat, and scientific and cultural significance will be specially designated.
- ◆ As needed, silvicultural prescriptions will be prepared to improve mangrove productivity and health. Because of silvicultural treatments, wood byproducts will be made available for subsistence and limited commercial needs. Forest products will be sold as availability, demand and household economic conditions dictate. Mangrove ecosystem health will not be compromised for forest commodity production. Priority will be placed on traditional subsistence use.

- ◆ Mangrove use and exploitation will be monitored and inspected regularly to ensure Plan provisions are met. Provide regulation and law enforcement measures to ensure mangrove conservation.
- ◆ Provide opportunities for public mangrove educational experiences. Human resource programs and volunteer recruitment efforts can help accomplish mangrove work activities (for example, mangrove plantings), while meeting budget constraints.
- ◆ Where opportunities arise, provide for the collection of basic research data on the ecology of mangroves and associated flora.
- ◆ Coordinate mangrove programs with appropriate national and state government levels, traditional leadership, community groups and the public.

### C.2.2 Marine Fisheries and Wildlife Resource Standards and Guidelines

#### **The Standards and Guidelines Necessary to Meet the Desired Future Condition of Marine Fisheries and Wildlife Resources Associated with Mangrove are:**

- ◆ Ensure the sustainability of viable animal (marine fisheries and wildlife) populations by protecting, maintaining and enhancing mangrove critical habitat.
- ◆ Where opportunities arise, provide for the collection of basic research data on the ecology of fish and animals associated with mangroves.
- ◆ Monitor and restrict activities that adversely affect mangrove habitat and productivity, including incompatible activities in upper watersheds.

### C.2.3 Coastal Lands Standards and Guidelines

#### **The Standards and Guidelines Necessary to Meet the Future Desired Condition of Coastal Lands Associated with Mangroves are:**

- ◆ Coastal productivity will be maintained, and if necessary restored, during any land disturbing activities (for example, sand/coral mining, land reclamation, fish ponds, causeways, residential and commercial building, road building, solid and liquid waste sites and drainage alterations) in and next to mangroves.
- ◆ Excessive shoreline and disturbances, resulting in on-site and off-site soil and water deterioration, will be prohibited. Mangrove mitigation measures, rest-periods (buls), moratoriums, citations, penalties and cease and desist orders will be issued, as needed, by appropriate agencies.
- ◆ Activities that can potentially have an adverse or extraordinary effect on mangroves will be assessed by an Environmental Assessment (EA) or Environmental Impact Statement (EIS) process. Activities resulting in significant and adverse impacts, despite land ownership, will be restricted and/or mitigated.
- ◆ Promote sustainable development strategies that protect mangrove ecosystems.

## C.2.4 Watershed Standards and Guidelines

### The Standards and Guidelines Necessary to Meet the Future Desired Condition of Watersheds Associated with Mangroves are:

- ◆ Prohibit and restrict excessive watershed disturbances. Reduce on-site and off-site soil and water deterioration. Watersheds affecting mangrove NHRS areas will be identified, evaluated and monitored. Focus and prioritize management activities in watersheds that have mangrove NHRS areas.
- ◆ Maintain and improve soil productivity/water quality by restoring degraded watersheds.
- ◆ Minimize upper watershed soil disturbances and enhance mangrove wetland productivity by using Best Management Practices (BMP's).



Above: BNRD employees assess a man-made causeway with a poorly functioning culvert on Palau's west-central coastline. The causeway, in combination with the improperly placed culvert, has likely altered natural tidal patterns resulting in the mortality of approximately five acres of mangrove (in the background). Implementing mangrove Best Management Practices will help mitigate the effects of human activities on the mangrove ecosystem

### C.2.5 Recreation Standards and Guidelines

#### **The Standards and Guidelines Necessary to Meet the Future Desired Condition of Recreation Opportunities Associated with Mangroves are:**

- ◆ Recreational settings, experience and opportunity appropriate to each mangrove NHRS area will be maintained. Integrate mangrove recreational planning with state coastal management activities.
- ◆ Promote the development of mangrove nature-based tourism opportunities.
- ◆ If needed, conflicting recreational activities in mangroves will be separated and consistent between similar mangrove land use classifications.
- ◆ Modifications to mangrove land use classifications, for recreational purposes (for example, resorts and marinas) will be based on Plan objectives.

### C.2.6 Natural Heritage Reserve System Standards and Guidelines

#### **The Standards and Guidelines Necessary to Meet the Future Desired Condition of Natural Heritage Reserve System Areas Associated with Mangroves are:**

- ◆ Implement the Palau Natural Heritage Reserves System by designating Mangrove Conservation Areas, Mangrove Preserves, Mangrove Reserves and Mangrove Special Management Areas. Mangrove areas under these classifications must have specific objectives and selection criteria.
- ◆ Management direction focuses on maintaining the natural values that distinguish each mangrove NHRS area. They will be managed to protect these values until they are designated, modified or dropped from further consideration.
- ◆ The MRD will have the authority to modify mangrove NHRS area land classifications, acreage and uses.
- ◆ Land use proposals that are not consistent with mangrove NHRS areas may be authorized when an EA/EIS processes show no adverse affects. When project effects are found to adversely impact mangrove resources, mitigation measures or stop-work-orders will be initiated by appropriate agencies.

### C.2.7 Mangrove Resource Law and Regulation Standards and Guidelines

#### **The Standards and Guidelines Necessary to Meet the Future Desired Condition of Areas of Mangrove Resource Law and Regulation Enforcement are:**

- ◆ Mangrove legislation, regulation and enforcement processes will be conducted in a way that preserves the rights, expectations and traditional uses of mangroves, and are consistent for all those violating such laws, rules and regulations.
- ◆ Primary emphasis will be on the prevention of activities that degrade mangrove resources.
- ◆ Public education and forestry extension programs will be the primary means of informing

the public on national and state mangrove policy.

- ◆ Laws and regulations will be developed in cooperation with state government, customary leaders and the public.
- ◆ All mangrove resource laws, plans, permits, regulations and other instruments of management will be updated and revised, as needed, to be consistent with the developing Plan and related environmental documents.
- ◆ Provide law enforcement and monitoring duties as dictated or needed to ensure perpetuation of mangroves ecosystems.
- ◆ Use mangrove enforcement processes such as citations, bond forfeiture, cease and desist orders, penalties, rewards, and orders to repair damage for activities that degrade mangrove resources.

### C.2.8 Cultural and Historic Resource Standards and Guidelines

#### **The Standards and Guidelines Necessary to Meet the Future Desired Condition of Cultural and Historic Resources Associated with Mangroves are:**

- ◆ All project-related activities in mangroves will be assessed, and, if necessary, project sites will be inventoried to allow for identification, protection and mitigation of any significant cultural or historic properties.
- ◆ Confidentiality of cultural resources in or next to mangroves will be maintained, where applicable.
- ◆ Public education and interpretation will be used to increase public awareness of heritage resources.

### C.3 Palau Mangrove Best Management Practices

The following Best Management Practices (BMP's) were identified during Plan development. They are based on Palau mangrove conditions and several sources, notably Hamilton and Snedaker (1984), Devoe (1992), Ewel (personal communications, 1999), Ewel et al. (1998a), Lal (1989) and Taylor and Valencia (1988). They are designed to support the productivity and sustainability of Palau's mangrove resources.

#### Environmental Quality Reviews:

- BMP #1: Before any land disturbing undertakings occur within mangroves, use EA/EIS processes to decide the environmental and socioeconomic consequences of the proposed action.

#### Mangrove Management:

- BMP #2: Recognize the management distinctions between fringe, riverine and interior



mangrove zones, and promote their wise use based on these understandings.

#### Mangrove Conservation:

- BMP #3: Use moratoriums, cease-and-desist orders and "rest-periods" for degraded or over-exploited mangrove areas. These conservation strategies are designed to restrict mangrove conversion activities within specific areas over predetermined time periods.
- BMP #4: Incorporate "buffer-zones" around core mangrove NHRS areas to ensure they are not jeopardized by incompatible human activities. Buffer-zones should encircle core mangrove areas and be large enough to guarantee NHRS integrity.
- BMP #5: Promote sustainable development schemes that are compatible with specific mangrove areas and mitigate environmental impacts.

#### Water and Soil Resources

- BMP #6: Under all but the most compelling reasons, the restriction or increase of lagoon circulation and the diversion of water reaching mangroves because of roads, dikes, drainage structures and channelization activities are not permitted. Promote the maximum use of culverts in causeway designs.
- BMP #7: Erosion and sediment causing activities (for example, land fills, timber treatments, upper watershed disturbances) should be strictly regulated to mitigate excessive soil displacement and sedimentation.
- BMP #8: Do not use interior mangroves zones where crabs and other food sources are collected for wastewater treatment areas.
- BMP #9: All upland disturbances need to be assessed for their potential impacts on mangroves. Watershed analysis and cumulative watershed impacts must be assessed.

#### Marine and Wildlife Resources:

- BMP #10: Fisheries, marine and wildlife habitat requirements are largely unknown for Palau's mangroves. For all mangrove disturbing activities, develop plans that protect and mitigate impacts to natural habitat types.
- BMP #11: Seek information on mangrove habitat needs for fisheries, marine and wildlife by promoting interdisciplinary resource projects and increased collaboration with other offices and agencies.

BMP #12: Ensure fresh water resources are not consumed, diverted, or experience changes in timing of water delivery, in a manner that can adversely affect mangrove ecosystems.

Agriculture:

BMP #13: Minimize mangrove conversions for agricultural purposes. Soil testing and land assessments should precede conversion activities. Pesticides, fertilizers and acid sulphate conditions can adversely impact nearshore waters.

BMP #14: Minimize conversion of freshwater swamps and marches next to mangroves to maintain ecological functions and processes.



Above: The failure of a constructed roadbed along the Tabecheding River has resulted in soil erosion and mangrove mortality adjacent to the Ngaremeduu Mangrove Preserve and Ngaremeduu Mangrove Reserve.

### Road Engineering:

- BMP #15: Minimize interference with water flows. Whenever possible, roads and access should be parallel to surface flow patterns, including tides, and not perpendicular.
- BMP #16: Culverts should hold fifty year flood levels and fit as closely as possible to the original flows.
- BMP #17: Consider road mitigation measure by planting road embankment margins with mangroves to provide stability, reduce erosion and protect exposed inner mangrove systems.
- BMP #18: In demucking and grouting operations, waste muck and clays should not be discharged into mangrove areas or flow into nearshore corals.

### Mangrove Harvesting:

- BMP #19: Mangrove harvest activities should be confined to interior (mid-stand to landward edge) mangrove zones. No harvest activities should be conducted in fringe and riverine mangrove zones.
- BMP #20: No mangrove harvest activities should occur within 100.0 feet of mangrove channels and rivers.
- BMP #21: No mangrove harvesting should occur within 100.0 feet of the outermost seaward mangrove fringe.
- BMP #22: Use small patch cuts as a technique for harvesting mangrove trees. A patch cut refers to taking one to three trees from a specific site. Move to another location if more trees are to be harvested. This technique, has the benefit of creating only small gaps in the forest canopy.
- BMP #23: No patch cuts along lagoon-side mangrove fringes less than 650.0 feet in width.
- BMP #24: No mangrove harvesting activities will occur between inter-islet channels.
- BMP #25: Mangrove conversion activities should not be permitted along coastal areas with high erosion potential.
- BMP #26: Any loss of mangroves wetlands for any purpose, should result in the establishment of an equal area of mangrove in predetermined locations ("no net-loss").
- BMP #27: Stand specific silvicultural prescriptions will be prepared before any harvest

activity is scheduled. This will assure management objectives and stand conditions are compatible with proposed treatments.

- BMP #28: New channel construction for timber harvest operations is prohibited under all circumstances.
- BMP #29: Keep stump heights under 24.0 inches to improve utilization standards.
- BMP #30: Use directional felling operations to reduce tree hang ups and environmental impacts during harvest activities. Train local harvesters in directional felling.

Mangroves and Mariculture/Aquaculture:

- BMP #31: All mariculture uses proposed in mangrove areas must be reviewed using EA/EIS processes. Loss of mangroves, for fish and shrimp farms, is not an appropriate land use. Under all but the most compelling reasons, clearing mangrove areas for fish or shrimp pond development is prohibited. Promote mariculture systems such as trapping and holding, or where mangrove coexists in ponds with shrimp or fish.
- BMP #32: Fish or shrimp pond construction within or next to mangrove areas must be carefully planned. Activities must be designed to reduce impacts on mangrove resources.
- BMP #33: Beware of mangrove areas which are suitable for mariculture because of tidal range, land elevation and soils. Acid sulphate soils are common with fish/shrimp pond activities. Acid sulphate soils reduce mangrove system productivity and threaten water quality when liming and flushing are used to control soil conditions.
- BMP #34: If mariculture enterprises are going to be started, use degraded or severely damaged mangrove stands first, before using undisturbed mangroves.
- BMP #35: Always plant the outer banks of mariculture ponds with mangroves to improve bank stability and to compensate for mangrove losses.
- BMP #36: If ponds (and causeways) are abandoned, the dikes should be breached to allow renewed natural flushing and mangrove recolonization.
- BMP #37: If shrimp ponds are initiated, distributing effluent from shrimp ponds into interior mangrove forest areas may limit impacts to water quality and may increase mangrove growth rates.

## Residential and Urban Developments

- BMP #38: Provide at least a 60.0 foot construction setback from the landward edge of mangroves.
- BMP #39: Minimize water flow interference. Avoid filling areas to meet grade specifications. Build homes and facilities on stilts, posts and pilings to allow continued surface water circulation and normal sediment movement.
- BMP #40: Mangrove conversions tend to create habitats favorable for biting insects. Plant mangroves as new landscape and to help control insect problems and make development more attractive.
- BMP #41: At a minimum, foreshore conversion activities will be prohibited within 100.0 feet of the outermost seaward edge of mangrove fringes to reduce potential erosion processes.

## Recreation:

- BMP #42: When constructing boardwalks with mangrove wood products, cut materials away from the boardwalk area so that the area around the boardwalk has a high natural appearing quality.



Above: Areas along the landward edge of mangrove stands are often converted to solid waste land fills.

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**APPENDIX D**  
**PALAU NATURAL HERITAGE RESERVE SYSTEM: MANGROVE MANAGEMENT**  
**DIRECTION**

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**D.1 Introduction**

Appendix D provides detail on proposed mangrove NHRS area guidelines, specific NHRS mangrove area management direction and boundary locations, mangrove NHRS area selection criteria, and specific mangrove NHRS area conditions and vegetation classifications.

**D.2 Natural Heritage Reserve System Guidelines for Mangroves**

**Boundaries**

1. Mangrove Preserve, Mangrove Reserve and Mangrove Special Management Area should have recognizable boundaries. A boundary can be easily identified by a geographic land feature (for example, channel, causeway, harbor, bridge, road, mud/sand flat, coral reef, point, high tide mark), and by boundary signage, such as buoys in waterways and signs along landward edges. Proposed mangrove NHRS area locations and boundaries could change significantly with continuing Plan development.

2. Mangrove NHRS area boundaries should be kept simple. However, not all mangrove NHRS areas will have easily recognized boundaries due to their shapes and protective buffer zones. The high tide water mark is used as the most landward boundary. The high tide water mark is chosen because it closely parallels the landward edge of mangrove wetlands, primarily represents state government property and some private property, while avoiding substantial private land holdings. Size of a mangrove NHRS area is not overly important, they can very small or very large areas, but must be large enough to secure site integrity.

**Buffer Zones**

3. Where applicable, mangrove NHRS areas will include protective buffer zones. Mangrove NHRS area protection and integrity can be enhanced either by protective buffer zone's around core preserve areas and/or by appropriate uses of adjacent lands (including upper watersheds) and waters. Often, adjacent coastal waters (for example, seagrass beds and reefs) and uplands (for example, fresh water swamps and marshes) act as buffer zones around mangrove NHRS areas. These areas should support mangrove NHRS areas and have complementary use designations when possible.

**National, State and Local Government Collaboration**

4. Mangrove NHRS areas can be managed jointly by national and state government levels.

State governments, with their exclusive ownership of mangrove resources, must be fully involved in Plan implementation and NHRS area administration. Plan success is dependant on the development of a strong partnership with State and local/customary leaders. If States and local communities support and endorse the Plan, then the long-term protection and enforcement of mangrove NHRS area can be guaranteed. State and local government mangrove initiatives need to be encouraged and supported by BNRD. NGO mangrove initiatives also require support and collaboration with BNRD.

5. BNRD mangrove awareness programs are targeted at communities next to mangrove NHRS areas. Promote the wise use of mangroves by assisting local communities in their management for traditional subsistence mangrove wood and nonwood needs. Identifying specific areas for the public to harvest trees, with an opportunity to educate and promote sustainable harvest guidelines, is a primary program area.

### **D.3 Site-Specific NHRS Mangrove Management Direction**

#### **D.3.1 Ngaremeduu Mangrove Preserve**

The Ngaremeduu Mangrove Preserve is of unique character with high in biological diversity and implied productivity. Some of the oldest and least disturbed mangrove stands are found in this area providing exceptional amenity values. The Ngaremeduu Mangrove Preserve supports and compliments the Ngaremeduu Conservation Area established by Aimeliik, Ngetpang and Ngeremlengui States.

This Mangrove Preserve is vital to Palau's west-central aquatic habitat and water quality. There is a need to plan carefully and regulate human activities within and adjacent to this Mangrove Preserve. Upland conversion activities for agriculture, residential and infrastructure developments are on the increase. Combined with unregulated mangrove harvesting, these activities have the potential to degrade Mangrove Preserve water quality and aquatic habitats. Routine monitoring of human activities that affect mangroves within and next to this Mangrove Preserve is essential.

Mangrove conservation strategies along the Tabecheding (2.5 miles) and Ngetpang (2.1 miles) are important for filtering and trapping waterborne sediments and buffering nutrients outwelling from these river systems. Conservation of approximately 94.0 acres (38.0 hectares) of freshwater swamp immediately inland is an important consideration for sustaining ecological processes linked to mangrove health. Promotion of sustainable development schemes in the upper watershed are vigorously encouraged.

The Ngaremeduu Mangrove Preserve is aligned between the Ngetpang River to the north and the Tabecheding River to the south. Within the Mangrove Preserve, emphasis is on the protection and preservation of mangrove wetlands. Regulation of human activities to maintain preserve integrity is an important focus. Expansions of residential and agriculture encroachments,

beyond any existing, are considered inappropriate land uses. Promoting the protection and preservation of Palauan traditional village and terrace sites, located within and next to the MCA is also an important consideration.

Ngaremeduu Mangrove Preserve area and vegetation classifications total approximately 579.0 acres (234.0 hectares), representing MN0H = 14.0 acres, MN0H.R = 43.0 acres, MN1H = 459.0 acres, MN1L = 7.0 acres and MN2H = 56.0 acres. The Ngaremeduu Mangrove Preserve is bounded on the north by Ngaremeduu Bay and the Ngetpang River, on the east by the high water mark on the landward edge, on the south and west by Ngaremeduu Bay and the Tabecheding River.

### **D.3.2 Rock Islands Mangrove Preserve**

The Rock Islands Mangrove Preserve has exceptional amenity values. Although very small populations of mangrove occur in the Rock Islands, some of the most unique and least disturbed mangroves are found in small protected coves and channels, and in depressions or lakes within the interior of some Rock Islands. During Plan field checks, some of the largest Denges (B. gymnorhiza) were observed in depressions within the interior of select islets.

Within the Rock Island Mangrove Preserve area, management emphasis is on the protection and preservation of mangroves. Regulation of human activities and maintaining preserve integrity are important considerations. Access is regulated. Subsistence wood cutting is not permitted. Only subsistence non-wood product gathering is allowed within the mangrove areas, if appropriate and authorized. Educating the public to preserve these unique mangrove stands is a key task.

Rock Island Mangrove Preserve area and vegetation classifications are estimated (by select visual observations) at approximately 100.0 acres (40.0 hectares), representing: MN0H.R = 10.0 acres, MN1H = 85.0 acres, and MN2H = 5.0 acres.

### **D.3.1 Ngaremeduu Mangrove Reserve**

The Ngaremeduu Mangrove Reserve is of unique character, high in biological diversity and implied productivity, with exceptional amenity values. Some of the oldest and least disturbed mangrove stands are found in this area. The Ngaremeduu Mangrove Reserve supports and complements the Ngaremeduu Conservation Area established by Aimeliik, Ngetpang and Ngeremlengui States, and serves as a buffer zone around the Ngaremeduu Mangrove Preserve.

This Mangrove Reserve is vital to Palau's west-central aquatic habitat and water quality. There is a need to monitor and regulate human activities within and adjacent to this Mangrove Reserve. Upland conversion activities for agriculture, mineral extraction, residential and infrastructure developments are on the increase. Combined with unregulated mangrove harvesting, these activities have the potential to degrade Ngaremeduu Bay water quality and



aquatic habitats.

Mangrove conservation strategies along the Tabecheding (2.5 miles), Ngetpang (2.1 miles), Nkebeduul (2.9 miles) and Ngeremeskang (4.8 miles) are important for filtering and trapping waterborne sediments and buffering nutrients outwelling from these river systems. Conservation of over 131.0 acres (53.0 hectares) of freshwater swamp immediately inland is an important consideration for sustaining ecological processes linked to mangrove health. Promotion of sustainable development schemes in the upper watershed are vigorously encouraged.

The Ngaremeduu Mangrove Reserve is aligned north and south of the Ngarmeduu Mangrove Preserve, serving as a key buffer zone around the core mangrove preserve area. Within the Ngaremeduu Mangrove Reserve, management activities focus on maintaining natural processes and starting community forestry programs. Supporting subsistence wood cutting programs within interior mangrove stands, educating the public not to cut mangroves within fringe and riverine forest zones, and providing mangrove awareness programs in the communities of Ngerebkus, Ngkebeduul, Ngerekimadel, and Ngeremeskang will be important tasks. Promoting the protection and preservation of Palauan traditional village and terrace sites, located within and next to the MCA is also an important consideration.

Ngaremeduu Mangrove Reserve area and vegetation classifications total 1,070.0 acres (433.0 hectares), representing: MN0H = 50.0 acres, MN0H.R = 17.0 acres, MN1H = 1,003.0 acres. The Ngaremeduu Mangrove Reserve is bounded on the north, east and south (inland) sides by the high water mark on the landward edge and on the west (ocean) side by Omeduaol Island and, where appropriate, the high water mark.

#### **D.3.4 Ngemai-Imolech Mangrove Reserve**

The Ngemai-Imolech Mangrove Reserve, is high in biological diversity and implied productivity. Some of the oldest and largest Urur (*S. alba*) trees, with exceptional amenity values (gnarled and decayed old-growth character trees), are found in this area. The Ngemai-Imolech Mangrove Reserve supports and compliments the Ngemai Conservation Area established by Ngiwal State.

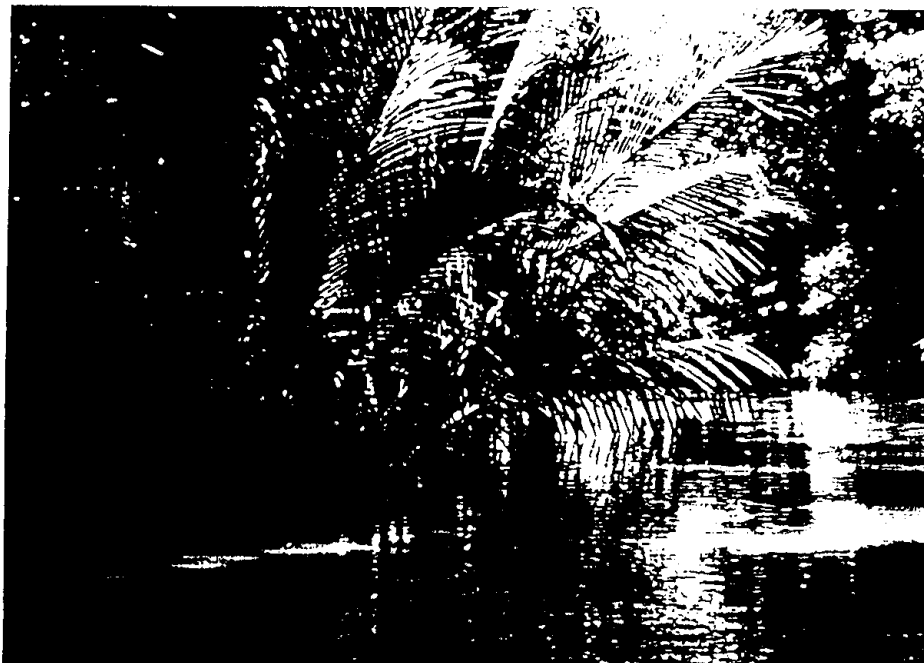
The Ngemai-Imolech Mangrove Reserve emphasis is on protecting near-shore coral reefs, water quality and aquatic habitat from excessive sedimentation, nutrient and salinity changes. Overall, management direction focuses on regulating land conversion activities within the Mangrove Reserve area. Mangrove conservation along Ngeredekuu River and several un-named mangrove channels in the Imolch area is important for trapping waterborne sediments and buffering nutrients to protect near-shore resource elements from excessive sedimentation, nutrient and salinity changes. The conservation of more than 580.0 acres (235.0 hectares) of adjacent freshwater swamp and marsh (particularly in the Ngeredekuu River drainage) for sustaining ecological linkages and wildlife habitats, is also an important consideration.

Within the Mangrove Reserve, management activities focus on maintaining natural processes and community forestry programs. Supporting subsistence wood programs within interior mangrove zones is an important management objective. Promoting the preservation of one historic property and several traditional village sites, providing mangrove awareness programs in the communities of Ngercheluuk, Ngermechau, Ngeburch and Ngeruling, and supporting sustainable development schemes are program components.

Ngemai-Imolech Mangrove Reserve area and vegetation classifications total 599.0 acres (243.0 hectares), representing: MN1H = 573.0 acres, and MN2H = 26.0 acres. The Ngemai-Imolech Mangrove Reserve is bounded on the north, south and west (inland) sides by the high water mark and on the east (ocean) side by Ngemal Reef.

#### **D.3.5 Airai Bay Mangrove Reserve**

The Airai Bay Mangrove Reserve, is particularly important as a mangrove filtering mechanism, protecting lagoon-like habitat and near-shore coral reefs from sediment pulses caused by many upland soil disturbing activities (for example, national airport, roads, agriculture, wildfire, and infrastructure development). Excellent mangrove habitat for the endangered saltwater crocodile is found around Airai Bay. This Mangrove Reserve supports and compliments the Airai State Mangrove Conservation Area (Bill No. 2-25-11R, 02/03/97), and provides an opportunity for further national and state mangrove collaboration.



Above: Riverine mangrove zone within the Taoch Ngerdorch-Taperngesang Mangrove Reserve. Nypa palm (*N. fruticans*), photo center, is common in the middle interiors of mangrove stands and landward edges of mangrove channels in Palau.

Overall, management direction focuses on regulating land conversion activities within and next to the Mangrove Reserve. Closeness to large urban areas and local communities, coupled with easy boat access, lead to high mangrove exploitation and degradation potential. Current and anticipated levels of upland and mangrove resource exploitation could potentially disrupt ecological processes. Subsistence wood and nonwood product harvesting is common. Harvesting of wood products should be restricted to interior (landward edge) mangrove stands.

In order to protect near-shore resource elements from excessive sedimentation, nutrient and salinity changes, mangrove conservation along Taoch Ngerikiil is an important objective. Additionally, mangrove conservation strategies along the historic Tngebard and Taoch re Kali (manmade mangrove channels), several traditional villages, and a dock are also important for preserving historic resources and providing potential eco-tourism opportunities. Mangrove harvesting, especially along fringe and riverine zones, requires monitoring and regulation. Providing mangrove educational programs in the communities of Oikull, Airai, Yelch, Ngerusar and Ngeruluobel will be key tasks. Community forest emphasis is on supporting subsistence wood and nonwood needs.

Airai Bay Mangrove Reserve area and vegetation classifications total 1,137.0 acres (460.0 hectares), representing MNOH = 4.0 acres, MNOH.R = 154.0 acres, MN1H = 938.0 acres, MN1L = 6.0 acres, MN1H.D (D=Disturbance), and MN2H = 33.0 acres. The USDA - Forest Service maintains one (1) - permanent growth and yield research plot (#58) within the Reserve area. The Airai Bay Mangrove Reserve is bounded on the north (inland) side by the high water mark, on the east by the western channel entrance to Taoch re Kali, on the south by near-shore corals, and on the west by Ngeream Island and an unnamed channel leading north to the village of Ngerusar.

#### **D.3.6 Taoch Ngerdorch-Taperngesang Mangrove Reserve**

The Taoch Ngerdorch-Taperngesang Mangrove Reserve, is of unique character, high in biological diversity and implied productivity, and has exception amenity values. This Mangrove Reserve compliments the Melekeok State Lake Ngardok Nature Reserve (MSPL 4-21) and the Airai State Mangrove Conservation Area (Bill No. 2-04-2R, 08/17/94). The mangroves of Taoch Ngerdorch provide excellent habitat for the endangered saltwater crocodile. This river corridor leads to Lake Ngardok, one of Palau's most important crocodile breeding habitats.

Mangrove conservation along Taoch Ngerdorch is important for filtering and trapping waterborne sediments and buffering nutrients outwelling from one of Palau's longest river systems. Protecting near-shore resource elements from excessive sedimentation, nutrient and salinity changes and conservation of a unique freshwater swamp/marsh, representing approximately 116.0 acres (47.0 hectares), are important considerations. Overall, management direction focuses on monitoring and regulating land conversion activities within and next to the Mangrove Reserve area. Providing mangrove awareness programs within the communities of Ngerdiol, Rrai, and Ngerngesan are an important task.

Taoch Ngerdorch-Taperngesang Mangrove Reserve area and vegetation classifications total 367.0 acres (149.0 hectares), representing: MN0H.R = 284.0 acres and MN1H = 83.0 acres. The Taoch Ngerdorch-Taperngesang Mangrove Reserve is bounded on the north by Taprengesang Point, on the east by near-shore corals, on the south by the Merong area, and on the west (inland) side by the high water mark.

#### **D.3.7 Diongradid Mangrove Reserve**

The Diongradid Mangrove Reserve is vital to Palau's west, northwest aquatic habitat and water quality. There is a need to carefully plan and regulate human activities within and next to this area. Upland conversion activities for agriculture, residential and infrastructure developments, coupled with unregulated mangrove harvesting, have the potential to degrade water quality and aquatic habitats. Expansions of residential and agriculture encroachments into mangroves, beyond any existing, are considered inappropriate land uses. The Diongradid Mangrove Reserve supports and compliments the Ngaraard State Mangrove Conservation Area (State Law, NSPL 4-4, 1994) and the proposed Ngaraard State Conservation Act of 1998 (KN Bill No. 4-28-98), and provides opportunities for further national and state mangrove management collaboration.

Within the Mangrove Reserve area, emphasis is on the protection and conservation of mangrove wetlands. Management activities focus on maintaining natural processes and community forestry programs. Mangrove conservation strategies along Taoch ra Iwekel, Diongradid River, Ngoslsang channel, Ouang channel, Desengong channel, Taoch ra Klebeang channel and several unnamed channels are an important management objective. Additionally, mangrove conservation next to two traditional villages near Urdmang and Kioultaoch are important for maintaining and preserving historic resources. Promotion of sustainable development schemes that reduce the effects of human habitation on mangrove ecosystems is vigorously encouraged.

Community forest emphasis is on supporting traditional subsistence wood and nonwood needs. Providing mangrove awareness programs in the communities Ngebuked, Klebeang, Urdmang, Ngerutoi and Ngetbong will be a key task.

Diongradid Mangrove Reserve area and vegetation classifications total 935.0 acres (379.0 hectares), representing: MN0H = 54.0 acres, MN0H.R = 124.0 acres, MN1H = 738.0 acres, and MN2H = 19.0 acres. The USDA - Forest Service maintains one (1) - permanent growth and yield research plot (#5) within the Reserve area. The Diongradid Mangrove Reserve is bounded on the north (ocean) side by near-shore corals, on the east side by the Ungellel point area, on the south (inland) side by the high water mark and on the west side by Iuellandg (rock point).

#### **D.3.8 Taoch ra Imeong Mangrove Reserve**

The Taoch ra Imeong Mangrove Reserve is important to Palau's west-central aquatic

habitats and water quality. Mangrove conservation strategies along Taoch ra Imeong, Taoch ra Ngerutecher and Chometubet are important for trapping waterborne sediments and buffering nutrients. Upland conversion activities, coupled with unregulated mangrove harvesting, have the potential to degrade this watershed. The Taoch ra Imeong Mangrove Reserve is a component of the Ngaremeduu Conservation Area. The conservation of more than 400.0 acres (161.0 hectares) of adjacent freshwater swamp is important for sustaining ecological processes.

Within the Mangrove Reserve, management activities focus on maintaining natural processes and community forestry programs. Programs support subsistence wood gathering within interior mangrove stands and the maintenance of eight traditional villages and one terrace sites. Providing mangrove awareness programs in the communities of Imeong, Orull, Uluang and Ngermetengel will be a key task.

Taoch ra Imeong Mangrove Reserve area and vegetation classifications total 626.0 acres (253.0 hectares), representing: MN0H = 129.0 acres, MN0H.R = 11.0 acres, and MN1H = 486.0 acres. The USDA - Forest Service maintains one (1) - permanent growth and yield research plot (#22) within the Reserve area. The Taoch ra Imeong Mangrove Reserve is bounded on the north by Itebang Mienui, on the east (inland) side by the high water mark, on the south by Usas Point, and on the west (ocean) side by near-shore corals.

#### **D.3.9 Aimeliik-Airai Mangrove Reserve**

The Aimeliik-Airai Mangrove Reserve is high in biological diversity and implied productivity, and supports one of the Palau's largest continuous mangrove fringes. This Mangrove Reserve is vital for maintaining Babeldaob's southwestern aquatic habitats and water quality. Mangrove conservation along the Ngerderar and several un-named channels is important for trapping sediments and buffering nutrients from adjacent uplands.

Monitoring and regulation of human activities is an important focus. Expansions of residential, urban and agriculture encroachments, beyond any existing are considered inappropriate land uses. Management activities focus on maintaining natural processes and promoting sustainable development schemes. Community forest emphasis is on supporting subsistence wood needs. Directing harvest activities to interior mangrove zones or other pre-determined areas is an important management task. Providing mangrove awareness programs in the communities of Elechui, Ngerkeai, Imul and Ngetkib will be a key consideration.

With the proposed Compact Road running immediately inland of this Mangrove Reserve, frequent monitoring will be required. Upland conversion activities for agriculture, residential, urban and infrastructure developments have the potential to degrade water quality and aquatic habitats.

Aimeliik-Airai Mangrove Reserve area and vegetation classifications total 694.00 acres (280.0 hectares), representing: MN0H.R = 16.0 acres, MN1H = 635.0 acres, and MN2H = 43.0

acres. The Aimeliik-Airai Mangrove Reserve is bounded on the north by Bkul Rengesukl, east (inland) side by the high water mark, on the south by an un-named point along the coastline, approximately 0.7 miles north of K-B Bridge, and on the west (ocean) side by near-shore corals.

#### **D.3.10 Northern Babeldaob Peninsula Mangrove Reserve**

The Northern Babeldaob Mangrove Reserve serves as critical marine and fisheries habitat for one of Palau's most productive reef and lagoon systems. Some of Palau's least disturbed mangroves are found in this area.

The Northern Babeldaob Mangrove Reserve is vital for maintaining Palau's northern aquatic habitats and water quality. Mangrove conservation strategies along Taoch ra Klebeang and four un-named mangrove channels are important for trapping sediments and buffering nutrients.

Within the Mangrove Reserve, management activities focus on maintaining natural processes. Expansions of residential and agriculture encroachments into mangroves, beyond any existing, are considered inappropriate land uses. Supporting subsistence wood and nonwood programs and protecting approximately nine traditional villages, one terrace, three taro gardens and one dock are important program considerations.

Providing mangrove awareness programs in the communities and schools of Iungel, Ollei, Ngatmei, Ngerbau, Iebukel, Ngebei, Mengellang, Ngerchelong School, Ngruil, Chol, Chol School, Ngebuked and Chelab, will be important tasks.

Northern Babeldaob Mangrove Reserve area and vegetation classifications total 928.0 acres (375.0 hectares), representing: MN0H = 19.0 acres, MN0H.R = 68.0 acres, MN1H = 622.0 acres, MN1H.R = 102.0 acres and MN2H = 117.0 acres. The Northern Babeldaob Mangrove Reserve is bounded on the north, east and west by near-shore corals on the ocean side and the high tide water mark on the landward sides, on the southwest by Taoch ra Klebeang channel and on the southeast by Uluchel.

#### **D.3.11 Peleliu Mangrove Reserve**

The Peleliu Mangrove Reserve, is of unique character in Palau, with mangroves adapted to more carbonate and coralline soils associated with low lying limestone atolls. When compared with the more developed mangroves on Babeldaob, Palau's high volcanic island, these mangroves appear smaller with fewer trees per acre.

The Peleliu Mangrove Reserve is vital for maintaining Palau's southern island aquatic habitats and water quality. This Mangrove Reserve provides critical habitat to the endangered saltwater crocodile. Routine monitoring and regulation of human activities within and next to the Peleliu Mangrove Reserve is an important task. Providing mangrove awareness programs in the

communities of Kloulklubed, Ongeuidel and Imelechol will be a key consideration.

Peleliu Mangrove Reserve area and vegetation classifications total 1,174.0 acres (475.0 hectares), representing: MN0L/SV = 11.0, MN0H = 30.0 acres, MN1H.R = 19.0 acres, MN1L.SW = 22.0 acres, MN1L.D acres = 6.0, MN1L = 145.0 acres, MN1H.N = 4.0 acres, MN1H = 765.0 acres, MN2M.AT = 42.0 acres, MN2M = 89.0 acres, and MN2H = 41.0 acres. These areas reflect mangrove acreage and vegetation types associated with the adjacent rock islets of Ngebad, Ngedbus, Ngurungor, Olngueal, Ruriid, and Tingabard. The Peleliu Mangrove Reserve is bounded on the landward edges by the high tide water mark, and on the ocean side by near shore corals.

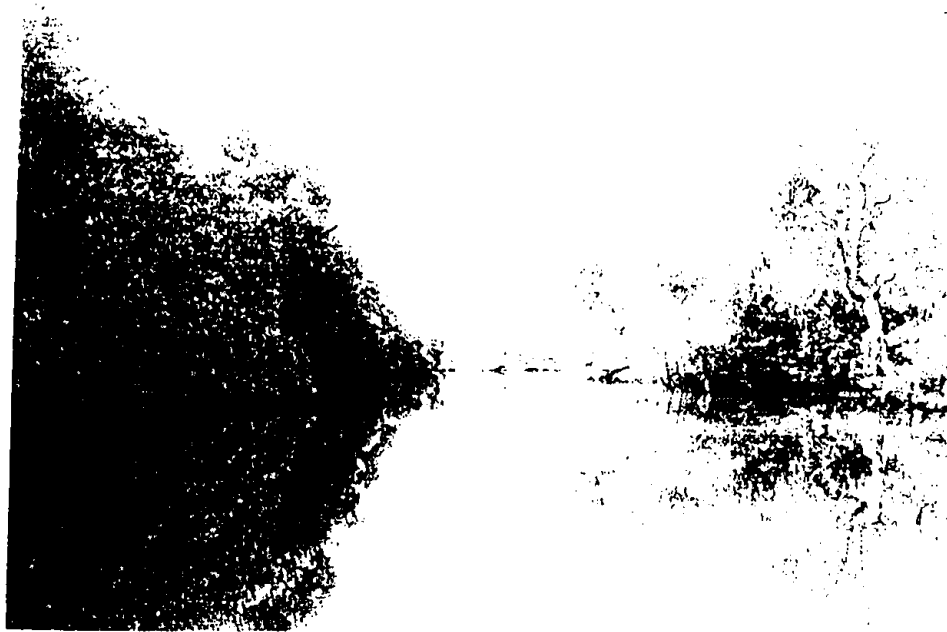
#### **D.3.12 Koror Mangrove Special Management Area (MSMA)**

The Koror MSMA is essential for maintaining Koror's aquatic habitats and water quality. There is a need to plan carefully and regulate human activities within and next to the mangroves in this area. Mangrove conversion activities for residential, urban and infrastructure developments have the potential to degrade water quality and hasten shoreline erosion in this highly urbanized and populated setting.

Within the Koror MSMA, mangrove conservation is the management emphasis. Conservation strategies, especially along Taochel Mid and Llebuchel channels, are important for shoreline protection. The mangroves east of Nberbeched, and south of Ikelau and Ngerkeseuaol, are important for filtering sediments and buffering nutrients.

Promotion of sustainable development schemes in Koror's upland areas is strongly encouraged. Expansions of residential and urban encroachments into Koror mangroves, beyond any existing, are considered inappropriate land uses. Management activities focus on mangrove educational awareness programs, especially for the populated communities adjacent to Koror.

Koror MSMA area and vegetation classifications total 478.0 acres (193.0 hectares), representing: MN0H.R = 18.0 acres, MN1L.D = 1.0 acres, MN1M = 36.0 acres, MN1H = 395.0 acres, MN2M = 13.0 acres, and MN2H = 15.0 acres. The Koror MSMA is bounded on the north, east, south and west by near-shore corals on the ocean side and by the high water mark on the landward sides.



Above: Bngaol (*R. apiculata*) and Urur (*S. alba*) dominate this riverine mangrove zone within the Ngaremeduu Mangrove Reserve.

#### D.4 Selection Criteria for Mangrove NHRS Areas

**Mangrove Preserve Selection Criteria Include:**

- ◆ Unique, limited, or outstanding examples of dynamic mangrove ecosystems based on productivity, genetics, integrity, health, variation and diversity of vegetation and animals.
- ◆ Human activity has been minimal or conditions warrant preserve designation for the good of Palauan society.
- ◆ Candidate preserve areas are in natural or near-natural states with ecosystem processes uninterrupted by human activities.
- ◆ National, State and customary jurisdictions must guarantee the protection and enforcement of Mangrove Preserve areas. Ensure ecological processes and integrity are not sacrificed by exploitation or occupancy; and the ability to guarantee the protection of upper watersheds and groundwater sources affecting Mangrove Preserve areas.



**Mangrove Reserve Selection Criteria Include:**

- ◆ Candidate mangrove areas are in natural or near-natural state.
- ◆ Natural, cultural or scenic areas of national and international significance which must be protected for scientific, historic, recreational and educational interests.
- ◆ Areas needed for shoreline and water quality protection.
- ◆ Areas that have high productivity potential.
- ◆ National, state and traditional jurisdictions must guarantee protection, and enforce regulations and policy's to ensure ecological processes and amenity values are not degraded.

**Mangrove Special Management Area Selection Criteria Include:**

- ◆ Areas that have been traditionally used for residential and commercial uses.
- ◆ Areas reasonably accessible to the public.
- ◆ Areas exploited for forest products and/or in need of management.

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## APPENDIX E

### PALAU MANGROVE TIMBER MANAGEMENT PROGRAM

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#### E.1 Introduction

The proposed mangrove timber program that follows acts as a guide for Palau resource managers in developing a wood commodities enterprise. This element focuses on initiating experimental, research-designed silvicultural programs. Developing sustainable subsistence wood programs and identifying basic mangrove timber management questions are key program objectives.

Change in mangrove stands is inevitable, whether by natural or human processes. This mangrove vegetation program is flexible and may be adjusted to fit changes and conditions over time. Controlling the establishment and development of mangrove stands through silvicultural treatments is preferable to the erratic and sometimes disastrous events that can take place without a comprehensive vegetation program.

#### E.2 Palau Mangrove Timber Management Direction

The goals of the mangrove timber program are designed to assist in the achievement of the Desired Future Condition of mangrove wetlands.

**The overall aim of the Plan mangrove timber program is to support the following goals:**

- ◆ Provide sustainable forest products (for example, fuelwood, posts, poles, sawlogs, handicrafts) from silvicultural treatments which promote forest productivity and health. Emphasize harvesting activities on the interior (middle to landward edge) zone of developed mangrove stands, not in mangrove fringe or riverine zones.
- ◆ Set up a mangrove program of "no-net loss" through reforestation/afforestation projects.
- ◆ Develop consistent national/state mangrove marketing processes that support traditional and limited commercial needs.
- ◆ Promote mangrove wetland biological productivity and diversity, thus providing for variety of life and enhanced ecological processes.
- ◆ Provide marine and fisheries habitat by protecting the food rich mangrove nursery.
- ◆ Provide and protect mangrove wildlife habitat for sensitive, threatened, rare and endangered species.
- ◆ Maintain mangroves that provide shoreline and low-lying coastal area protection, thus reducing the potential for the loss of land and property.
- ◆ Provide interpretive services that foster public understanding of mangrove ecosystems.
- ◆ Support vegetation management education and training opportunities for Forestry Unit personnel.



Above: Palauan's transport harvested Medulokebong (*X. granatum*) within the Taoch Ngerdorch-Taperngesang Mangrove Reserve. Posts were reportedly harvested for house building purposes.

### **E.3 Potential Palau Mangrove Silvicultural Systems**

Starting experimental silvicultural treatments will provide needed information about managing Palau's mangrove vegetation. The often destructive effects of unregulated mangrove harvesting can be reduced with prescribed treatments. Regulating mangrove harvesting can provide sustainable yields of subsistence and commercial wood products.

#### **E.3.1 Silvicultural Activities: Location and Mangrove Size Classes**

Palau mangrove harvest and silvicultural treatments should be done in the interior zone (middle to landward edge) of developed mangrove stands. Harvest activities should not occur in the fringe and riverine zones because of greater water movement, higher environmental stressors and high erosion potential. The interior zone is more flexible for management activities because of less water movement and erosion potential (Katherine Ewel, IPIF, personal communication, April 1999).

Initially, Stratum MN1 (emphasis on high density classes) will be targeted for silvicultural treatments. For MN1 stand locations, refer to Vegetation Survey of the Republic of Palau maps,

Resource Bulletin PSW-22. (Cole et al. 1987). These stratum, due to their inferred productivity and area representation, provide the greatest opportunity for sustainable timber activities.

Selection criterion for identifying site-specific MNI harvest areas include: 1) proximity to local communities, 2) timber accessibility, 3) subsistence and commercial needs, 4) traditional harvest areas, 5) stands virtually undisturbed by human activities, and 6) stands needing regulation due to over-exploitation.

### E.3.2 Types of Potential Palau Silvicultural Systems

Several silvicultural systems could be applied to Palau's mangrove forests. These systems include the following (or variants of): 1) Selection, 2) Clear-felling, and 3) Shelterwood. Managed silvicultural treatments can convert selected stands into more productive and manageable states, reducing environmental impacts associated with unregulated timber harvesting. These treatments will be designed to promote the regeneration and growth of desirable mangrove species and size classes.

Initially, controlled research will be critical to all silvicultural prescriptions. Due to stand response uncertainties (for example, growth and yield and successional development), silvicultural treatments need to be experimental and small-scale.



Above Stand of Urur (*S. alba*) heavily utilized for post and pole materials by adjacent communities. Urur tree in foreground displays recent cutting of main bole.

The following silvicultural systems and guidelines were assembled in part from several sources, notably "Micronesian Mangroves, Harvesting and Caring for our Mangrove Forest" (IPIF Video, 1998), Hamilton and Snedaker (1984) and FAO Forestry Paper 117 (1994). These references should be referred to for further information.

The Selection system closely resembles traditional Palauan harvest techniques. In its purest form, selection management is a single tree management practice used in Palau for hundreds of years. It is environmentally low-impact and is easy to initiate with basic timber management skills. This system requires the removal of various size classes (by species, if applicable) creating a stand condition that regulates size class distribution and stocking levels. The selection system provides excellent site protection. Variations of single tree selection can, however, create small group selection cuts (canopy openings in scattered gaps). Group selection cuts can develop and maintain very small even-aged groups of trees.

Selection management provides the Palau forest manager with an excellent system to reduce unregulated harvest activities, increase mangrove stand productivity, protect coastal resources, and meet subsistence and limited commercial mangrove wood needs without full-scale timber production activities. The selection management approach provides opportunities to regulate size class distributions, stocking levels and promote advanced regeneration in the seedling size class.

**The Preferred Palau Silvicultural Treatment is the Selection System based on the following benefits:**

- ◆ Meets the present subsistence mangrove product demand, using a harvest technique similar to traditional practices.
- ◆ Maintains a continuous forest cover, an important requirement for natural forest regeneration, wildlife resources, coastal protection and recreation/aesthetic values.
- ◆ Creates small gaps, rather than large gaps, in the forest canopy, an important consideration for natural regeneration. Uses small patch cuts, removing of one to three trees per site.
- ◆ Environmental disturbances from treatment operations are not concentrated and relatively easy to cleanup.
- ◆ Will improve general forest health and vigor by thinning overstocked stands, thereby improving individual tree and stand productivity.
- ◆ Supports Forestry Unit employee timber management skill development.

The Clear-felling system is an area-based treatment where all trees are removed in a single operation. This system would likely be the easiest to carry out because its relatively simple and inexpensive to carry out, is suitable for stands under initial treatments, and requires fewer timber management skills than other systems. However, when compared with other silvicultural systems, the clear-felling system increases the risk of site deterioration and reduces the aesthetic and amenity values associated with mangrove wetlands. Without adequate natural regeneration or mangrove planting success, clear-felling can leave large gaps in forest canopies.

The Clear-felling system provides opportunities to create even-aged regulated stands in one rotation. Clear-felling operations are suitable only for mangrove species which can withstand open stand conditions. Variations in the clear-felling system (group, strip and alternative strip) can enhance natural regeneration opportunities and reduce visual impacts associated with clear-felling systems.

The Shelterwood system promotes the establishment of a younger crop of trees under an existing mature stand of trees that are periodically harvested. This timber management approach also provides opportunities to regulate size class distributions, stocking levels and promote advanced regeneration in the seedling size class. The shelterwood system requires the removal of larger, older trees, creating a stand condition which provides a supportive environment for the regeneration and growth of younger trees. This treatment also provides excellent site protection. When compared with the Selection system, the Shelterwood system is more difficult to carry out.

#### **E.4 Silvicultural Considerations and Guidelines**

##### **General**

- ◆ Initially, the development of silvicultural treatment areas will be derived from: 1) Palau vegetation type maps (Cole et al. 1987) which identify Stratum MN1 mangrove vegetation classifications. These mangrove classifications will be prioritized for initial treatments based on: 1) proximity to wood consuming communities, 2) site-specific information such as high density classes, 3) mangrove stands are easily accessible, 4) stands supportive of research-based treatments, and 5) mangrove forest growth and yield data as it becomes available.

##### **Stocking Guidelines**

- ◆ Initially, during experimental thinning operations, no more than 33% of standing basal area should be removed unless for research purposes. For example, if a stand has 220.0 square feet of basal area per acre, removal of 73.0 square feet (33% of 220 sq.ft.) of basal area will leave 147.0 square feet of residual basal area. This will serve as a protective measure to ensure the development of stand wind firmness and help maintain acceptable stocking levels.

##### **Potential Rotation Lengths by Species and Utilization Standards**

- ◆ Initially, setting rotation cycles for Palau mangrove timber programs will be experimental. In general, the Forestry Unit will be looking at a range of rotation ages for different species and utilization standards. Rotation lengths could range between 30 and 190 years depending on species and utilization standards. Long-term sustained yield cutting cycles could be estimated from overall FSM species mean annual increment and eventually by site-specific growth rates.

**Table E.4.1.** FSM Predicted Rotation Lengths (years) by species and product (adopted from Devoe and Cole, 1998).

Species	Fuelwood (10cm dbh)	Pole Timber (25cm dbh)	Sawtimber (35cm dbh)	Saw Timber (50cm dbh)
B. gymnorrhiza				
All trees	52	94	*	147
R. apiculata				
All trees	55	106	131	**
R. mucronata				
All trees	31	71	110	**
S. alba				
All trees	36	102	*	167
X. granatum				
All trees	28	54	*	193

\* = No trees in size class sampled.

\*\* = Species does not normally attain this diameter in FSM.

## E.5 Harvest Considerations and Guidelines

### Harvest Treatment Areas

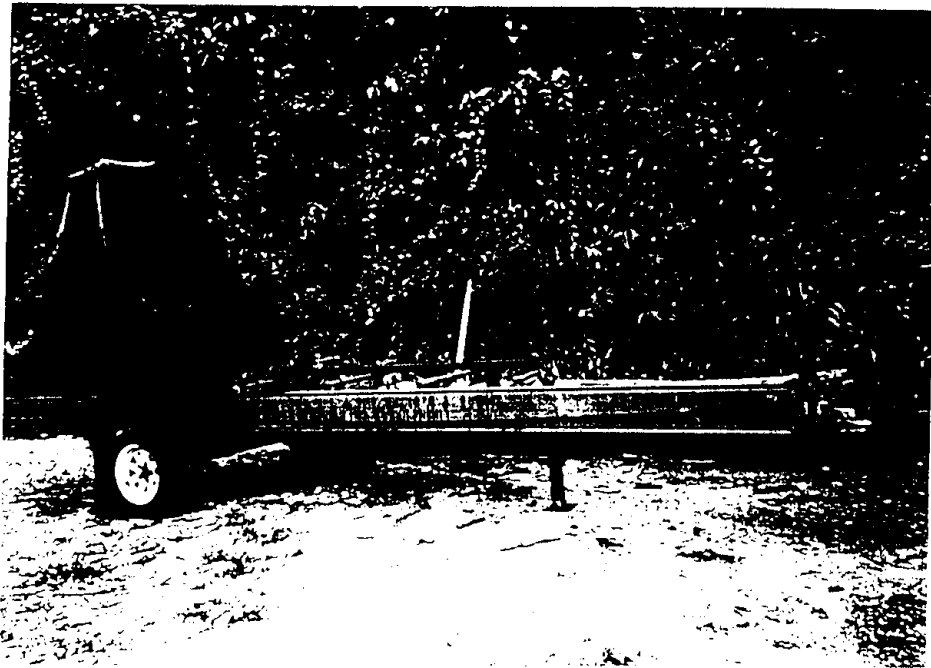
- ◆ Separate public subsistence cutting areas and commercial timber sale areas. Subsistence and commercial timber sale areas will likely have different objectives and prescribed silvicultural treatments.
- ◆ Public cutting areas can be designed to meet community subsistence and limited commercial wood needs. Forestry Unit personnel assist State governments prepare cutting areas by marking trees to be cut and removed by the public in site-specific areas. Trees targeted for removal include: 1) preferred traditional size classes, 2) trees in surplus diameter classes; 3) suppressed trees; 4) trees of poor form or health; and 5) insect or diseased trees.

### Conventional Harvest Methods and Operations

- ◆ In general, trees will be removed by silvicultural treatments which improve residual stand health and vigor, in turn providing wood byproducts for subsistence and limited commercial uses. Wood byproducts should be disposed of according to their highest potential use and value. The methods used to accomplish timber treatments will vary by the size of the trees to be removed, access, and environmental constraints such as tidal inundation, soil, aesthetics and wildlife.
- ◆ Harvesting of mangrove stands will be based on site-specific silvicultural prescriptions and

harvest schedules. All harvest activities will be based on sound sustained-yield management prescriptions which reduce site disturbances and provided suitable conditions for natural or artificial regeneration.

- ◆ Smaller diameter size classes (up to approximately 8.0 inch d.b.h.) will be used for posts, poles, beams, firewood, handicrafts, planting sticks. Larger diameter (8.0 inch d.b.h. and above) green trees of commercial species will be "appraised and sold as sawlogs" although the purchaser may use them in any way they chose.
- ◆ Commercial harvest activities should be accomplished by the public through special-use permits or by private contractors using timber sale contracts. Sometimes, harvest activities may be done by Forestry Unit personnel. This practice should be confined to small or scattered projects (research, training or priority management needs) as it is usually less cost effective.
- ◆ Careful planning is required to ensure that felling and extraction sequences reduce damage to residual trees and soil disturbances. Minimum site disturbances promote replacement stand development and protect coastal and marine resources for excessive sedimentation and erosion.



Above: One of several mobile saw mills currently used on Palau.



- ◆ Buffer strips will be incorporated into all harvest treatment activities providing a minimum width for protection. No harvest cutting will occur within 100.0 feet of the outermost seaward edge of shorelines (fringe), tidal channels and rivers (riverine) preventing adverse soil erosion and water quality impacts. This width is determined by taking the average tidal range between low and high tide and multiplying that number by 15 (Snedaker and Getter, 1985). For Palau, the tidal inundation range is estimated at approximately 6.0 feet.

#### **Extraction of Harvest Materials**

- ◆ Design timber extraction procedures to reduce impacts to mangrove wetlands and nearby ecosystems. To minimize disturbances, small wood materials should be removed by boats along existing channels or manually carried out. Larger timbers should be transported along designated channels and skid trails (preferably by suspended cable systems) to strategically located log deck areas.
- ◆ Timber extraction by channel is the preferred removal method. To help this it may be necessary to perform channel clearing and maintenance activities in some localities. Channel clearing can also benefit eco-tourism opportunities.

#### **Slash Treatments**

- ◆ Slash (branches, limbs and prop roots), left on the site from harvest activities, could be used successfully as subsistence or commercial fuelwood areas. Experimentation with slash treatments, under controlled settings, could provide useful information regarding mangrove seed dispersal processes.

### **E.6 Mangrove Establishment Considerations and Guidelines**

Shoreline protection, wetland restoration and sustainable wood products make a mangrove planting program an important consideration for the Forestry Unit. The Forestry Unit currently has the technology, workforce and skills to start a small scale mangrove establishment program. With concerns over eroding shorelines, raising sea-levels, unregulated harvesting and degraded wetlands, mangrove establishment activities provide an opportunity to sustain mangrove ecosystems. Establishment of younger stands can help assure a continuous supply of these important trees for Palauan society.

The mangrove establishment component focuses on planting treatments. As needed, during the first five-year period, up to two acres per year of plantings could be done in degraded mangrove areas, areas of coastal erosion concern, areas with inadequate levels of natural regeneration and within areas identified as "opportunity plantings" (for example, harvest areas, wastewater treatment sites and wetland restoration sites).

The following section provides basic considerations and guidelines designed for helping in the management of Palau's mangrove vegetation program:

- ◆ Conduct pre-establishment site surveys to decide priority planting areas, planting objectives (for example, coastal protection, causeway protection, subsistence/commercial wood needs, fisheries habitat, restoration of degraded areas, wastewater treatments, etc.) and site suitability for seedling survival and establishment. Sites should be checked for natural mangrove establishment, as this will likely show what species, if any, will grow best on the site. Initially, mangrove plantings should occur in small areas (0.1 to 0.5 acres). For larger areas, natural regeneration may be best due to cost and workforce constraints.
- ◆ Planting sites need to be selected carefully. Coastal processes and human habitation have significant effects on the success of mangrove establishment. Natural processes such as succession and sand buildup can render sites unsuitable for planting. Infrastructure developments such as causeways and seawalls change lagoon circulation, sand movement, tidal inundation, near shore currents and salinity levels can render sites unsuitable for mangrove establishment.
- ◆ The selection of a mangrove species for a specific site will be based on species biology, substrate, tidal inundation, wave exposure, elevation and salinity tolerances. For utilization purposes, consideration also needs to be given to preferred Palau mangrove species.
- ◆ In general, when compared with other mangrove species, Rhizophora and Bruguiera species are more tolerant of handling and planting. Rhizophora and Sonneratia species are more tolerant to tidal inundations and should be planted along the seaward edge. Lumnitzera and Cerriops species tolerate drier areas with infrequent tidal inundations and should be planted on the landward edge. Bruguiera species prefer a zone between Rhizophora and Lumnitzera. Xylocarpus species prefer upper channels and landward edges within the normal high tide zone.
- ◆ Initiate Mekekad (Lumnitzera littorea), Biut (Cerriops tagal), and Ebebech (Heritiera littoralis) establishment operations. As three of Palau's most preferred timber species, nursery tending and planting projects provide an important Forestry Unit (DAMR) management component. Biut and Ebebech are believed to be scarce possibly due to over-exploitation and/or stand successional dynamics.
- ◆ Rhizophora species propagule collection is one of the easiest and most efficient methods of securing mangrove seedlings. During Plan development (May 1999), site visits indicated large quantities of developing propagules for most of Palau's mangrove species.
- ◆ Only ripe propagules should be collected for establishment purposes. Mature propagules

are greenish brown to purplish in color, large and fully developed with a well-formed radical and are easily detached from the tree. Propagules should be collected from trees of good form and vigor. Avoid the collection of propagules from trees of poor health or which have multiple stems or forks. Propagules blemished by insects or which are malformed or damaged should also be avoided. Propagules can be collected directly from the parent tree or from newly fallen propagules on the ground or in the water. Propagules can be stored for up to three weeks if kept from excessive heat and exposure. Slightly wilted propagules can discourage crab predation on planting sites.

- ◆ Avoid planting areas with moderate to high energy shorelines as seedlings are susceptible to tidal uprooting. Planting will likely be more successful behind a protective barrier of established mangrove trees or other structural feature where low energy tidal zones occur. Propagules should be planted just deep enough to prevent them from falling over. In general, propagules should be gently pushed about 2.0 to 4.0 inches into a soft substrate. Do not plant propagules too deeply. Encircling mangrove propagules with coral fragments, "anchored" tires and other materials can help protect propagules from tidal surge and predation, improving survival success.
- ◆ Propagules should not be planted in dense groupings. Densely planted propagules result in excessive competition between seedlings which in turn lowers seedling growth rates. In general, Rhizophora spacings between 1.5 and 4.0 feet are recommended.
- ◆ To ensure germination success, it may be best to initiate small scale nursery operations. It is not known whether the seeds of these species require germination pretreatment (for example, stored in seed beds and watered regularly). Controlled experimentation and research will be essential requirements for nursery operations. Seedlings raised in seedbeds or plastic containers are easily out planted.
- ◆ Mangrove plantings can be coordinated with coastal protection engineering solutions (for example, seawalls, groynes, breakwaters) and causeways. Coastal protection structures, in combination with mangrove plantings, provide excellent coastal protection strategies. There may be an excellent opportunity to investigate the role of mangroves as a coastal protection structure.
- ◆ To enhance mangrove survival and establishment success, engineering structures should permit low energy tidal circulation that allows for the movement and deposition of silt/sediment on the landward edge. This will help develop favorable planting sites for mangrove establishment. Coastal protection designs made from porous coral and rock materials provide a feasible and economical structure that would help support mangrove establishment efforts.
- ◆ The mangrove establishment component must have an evaluation process in place to assess planting success. This program, based on seedling stocking and survival

examinations, provides information on species establishment and growth rates. Damaging agents (physical and biological) to seedlings and planting can also be assessed. Seedling survival exams are carried out using "fixed-plots" within planting sites. Exams would collect information on the number of live/dead seedlings, seedling height and diameter growth and site conditions. Survival exams should occur after the first and third years of growth.

- ◆ A mangrove wetland policy of "no-net loss" will be initiated by the BNRD. Afforestation activities will emphasize the planting of mangroves (where site conditions are suitable) in an attempt to stabilize and reduce shoreline and channel erosion along high risk areas. The mangrove production component provides preliminary direction for subsistence and limited commercial wood production.



Above: Kashgar Rengulbai, Palauan Forester, examines an area cleared of trees adjacent to a mangrove stand on the landward edge of the proposed Ngemai-Imolech Mangrove Reserve. Note: poor utilization standards.

## **E.7 Mangrove Vegetation Program Technical and Research Needs**

Palau's mangrove ecosystems are not well understood. Various levels of technical assistance and scientific research will be required to formalize sound silvicultural prescriptions. Many sources of technical and research assistance are available to the Forestry Unit. Partnerships need to be developed with donor agencies and ngo's. Further Plan development will require financial and workforce related support. Areas of consideration include:

- ◆ Re-inventory and maintain five (5) permanent yield and growth inventory plots established by IPIF in 1987. Analyze growth and yield data. Report trends. Develop long-term research programs.
- ◆ Initiate basic research programs that address mangrove biology, ecological processes, stand dynamics, goods and services valuation, and disturbance responses.
- ◆ Investigate swamp forest and marsh vegetation types. Assess stand components, ecological dynamics and benefits/services provided. Develop long-term research programs.
- ◆ Assist in the development of strategies that integrate national, state and cultural mangrove strategies into laws and policies. Assess social-economic values of Palau mangroves.
- ◆ Assist national forest managers develop silvicultural prescriptions and general timber management activities.
- ◆ Assist national/state forest managers improve utilization standards during harvest operations. Training in harvest cutting techniques.

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## APPENDIX F PLAN ANALYSIS AREA

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### F.1 Introduction

This summary of the Palau Mangrove Management Plan (Plan) analysis area focuses on socioeconomic and environmental conditions affecting Palau mangrove resources. Where applicable, this section addresses how these resources are expected to respond to Plan implementation. Section F.2 briefly describes the socioeconomic settings and influences on mangrove forest resources. Section F.3 briefly describes select physical-biological conditions and influences on the mangrove resource.

### F.2 Social Settings and Influences on Mangrove Ecosystems

#### F.2.1 Traditional, Current and Future Uses

Historically, Palauans have used mangrove for subsistence purposes. Mangroves provide fuelwood, timber for construction (examples include boats, houses, fences, and other structural needs) and wood for artisan crafts. Mangroves provide habitat for a variety of marine, fish and wildlife species, many of which are consumed by Palauans. During periods of influence by Spain (up to 1899), Germany (1899 to 1914), Japan (1914 to 1945) and the United States (from 1945 to 1994), mangroves were selectively harvested for various purposes.



Above: Palauan's transport Medulokebong (*X. granatum*) posts along the Taoch Ngerdorh.

To this day, mangroves still play critical roles in the daily subsistence needs of Palauans. Examples include fish and mangrove crabs, fuelwood, and building materials. In addition to subsistence uses, commercial uses (primarily mangrove non-forest products) have become more prevalent with Palau's increasing population and tourism industry. Mangrove conversion activities (for example, coral, sand and gravel mining, tourism developments, road construction, agricultural expansion and residential development) are also becoming more prevalent. Commercial mangrove harvesting, although currently limited, is likely to intensify in the future.

It is anticipated, that mangroves throughout Palau will be under considerable pressure as tourism increases, population centers shift, watershed and coastal land developments expand, and phenomena such as rising sea-levels affect low lying coastal areas. With a growing population, more people will be consuming and producing, putting additional pressures on mangrove Resources. The demand for mangrove commodities and land could change quickly resulting in over-exploitation of this invaluable resource.

Plan implementation will have a variety of effects on mangrove ecosystems. Most notably, subsistence mangrove use will essentially continue unimpeded over the first five to ten years. In particular localities, subsistence use will be monitored and regulated. Some areas may require restrictions to prevent mangrove over-exploitation. The supply of subsistence and commercial wood products will increase through silvicultural treatments that emphasize forest productivity and health.

## **F.2.2 Population Setting**

Palau mangrove uses are determined chiefly by "population centers" located along flat, low-lying coastal areas. In 1990, Palau's total population was 15,220 people (Palau Master National Development Plan, 1996). The population of Palau proper resides in sixteen (16) states. Residential populations (1990) for these states are: Kayangel (137), Ngerchelong (354), Ngaraard (310), Ngiwal (234), Melekeok (244), Ngchesar (287), Airai (1,234), Koror (10,501), Aimeliik (439), Ngatpang (62), Ngeremlengui (281) Ngardmau (149), Peleliu (601), Angaur (206), Sonsorol Islands (61) and Tobi (22). Overall population growth within Palau is estimated at 2.78% per year (Otobed and Maiava, 1994). Population projections estimate population growth at 2.6% in 2000 (20,314 persons) and 1.5 percent in 2020 (30,300 persons). The real population growth rate is low, primarily due to declining birth rates and continued emigration of Palauans seeking employment and education (Palau National Master Development Plan, 1996).

With most of Palau's population residing next to mangrove wetlands, population stresses such as residential house construction, industrial developments, boat facilities, road building, agriculture, upper watershed land conversions, piggeries, fresh water diversions, solid and liquid waste dumps, and unregulated forest product use will have mostly adverse affects on mangrove.

The Plan is not expected to have impacts on population dynamics in the short-term. However, possible wood product industries and eco-tourism enterprises arising from the Plan may

contribute to population distributions over the long-term.

### **F.2.3 Socioeconomic Setting**

Communities and social groups living next to mangrove wetlands provide the context within which they are managed. Few mangrove management activities are without a social dimension.

Palau's Gross Domestic Product per capita was over US\$5,000 in 1992 (Palau National Master Development Plan, 1996). In 1980, 39% of the potential Palauan workforce was in the labor force, with 61% in subsistence activities. By 1990, Palauan participation in the workforce increased to 53 percent and is projected to reach 62 percent by 2000. Foreign workers have an 80 percent workforce participation rate, which is expected to increase. Palauan employment rates are projected to reach 13 percent by 2000 (Palau National Master Development Plan, 1996). Palau has a market and subsistence economy. Though the market economy is more important, households in Palau have a high consumption of local subsistence products.

Presently, the mangrove forest products industry is practically nonexistent on Palau. Small cottage industries, such as local sawmill operators, local construction businesses and wood crafters use nominal amounts of mangrove. Mangrove use levels for subsistence cooking and structural materials are unknown.

During Plan development, up to four portable sawmills and two stationary sawmills were in operation. Production figures for rough milling are not available. One mill operator indicated cutting mangrove periodically for local construction purposes. However, as noted in the past, this could change on an almost daily basis.

Mangrove influence in the State economy is small on a wood commodity or production level. However, the mangrove resource fulfills a vital economic influence at the subsistence level, especially for fish and crab products. Foremost, mangroves exhibit a virtually priceless economic influence when related to ecological services, values, and benefits. Plan use could have noticeable impacts on the tourism and forest product sectors. Sustainable nature-based tourism and timber production opportunities will likely increase. These economic sectors promote job opportunities and improved environmental quality.

### **F.2.4 Infrastructure Development Setting**

With Palau's increasing population, the need for infrastructure development is a primary national and state government goal. Infrastructure developments, if not properly planned, could have adverse affects on mangroves.

Palau infrastructure projects in the planning and developmental phases include: Compact Road construction, community access roads, improvement of state docking facilities, national



airport runway and facility expansion, state airport facility construction and expansion, wastewater treatment facilities, shoreline engineering, mariculture enterprises, agricultural land expansion, tourism and boat facilities, and industrial developments. These infrastructure developments are important for improving Palauan quality of life. Over time, many of the projects listed above will be carried out. With careful foresight and appropriate technologies, many of infrastructure developments can coexist with mangrove wetlands. Plan implementation is intended to encourage sustainable development within the public and private sectors.

#### **F.2.5 Palau Government Planning and Development Strategy Setting**

Palau has three major planning levels: national, state and traditional. State and traditional influence at the community level is a critical consideration in overall Plan planning. Without information sharing, cooperation, and consistent environmental policies between these planning levels, portions of the Plan will be seriously compromised. Aspects of the Plan need to be incorporated into all planning levels.



Above. In the background, a diesel power plant rises above a mangrove fringe on the southwest coast of Babeldaob Island. Infrastructure improvements, if not carefully planned, can place considerable pressures on mangrove ecosystems.

Currently, the Ministry of Resources and Development, has several levels of studies involving marine, coastal and watershed resources. These partnerships provide invaluable information, support and funding to mangrove management. Fostering of such programs and relationships is vital to Plan implementation.

Palau State planning and development strategies will play a vital role in mangrove conservation. State planning programs need to address issues that affect or have the potential to affect mangrove resources. Multi-disciplinary coordination between divisions, offices and ngo's is essential. Without adequate representation, mangroves are often considered expendable when compared with the demands of state and local interests.

Under Palau's land tenure system, mangrove is considered public domain. The public domain is controlled in most cases by the "Klobak" (village council), but there are cases where control was exercised by a District Council or group of villages within a district. In public domain areas, members of a village could enter and harvest resources such as timber without prior approval of the Council. Other villages need to get approval of the Council or make a payment of Palau money before exploiting Resources.

Plan implementation will ideally have an impact on state planning schemes. Addressing mangrove conservation with responsible agencies will improve sustainable development efforts. The Plan should be incorporated into all state coastal planning efforts.

#### **F.2.6 State and Traditional Institutionalism**

In Palau, under a Constitutional provision, the states have exclusive ownership of their living and non-living land and sea resources out to 12 nautical miles (Article I, Section 2, ROP Constitution). States are responsible for the management and development of resources within these boundaries.

State and traditional government level cooperation is essential for ensuring Plan success. Community level recognition and support are also key for managing mangroves. National, state and traditional levels must work together in managing mangrove resources. State and traditional government levels must also recognize national government guidance and support to ensure Plan success. Carrying out the Plan will provide benefits, such as uniform laws and regulations, marketing schemes and improved environmental quality to state and local government levels.

**Table F.2.1. Mangrove Areas by States, Republic of Palau.** Adopted from Vegetation Survey Maps of the Republic of Palau (Cole et al. 1987) and approximate State Boundary Lines from the Indicative Landownership Map of Babeldaob Island, Bureau of Lands and Survey, Ministry of State (1999).

<u>State</u>	<u>Mangrove Area (Acres)</u>
Kayangel	N/A
Ngerchelong	725.0
Ngaraard	1,018.0
Ngiwal	459.0
Melekeok	273.0
Ngchesar	680.0
Airai	2,131.0
Koror (includes Rock Islands)	529.0
Aimeliik	1,083.0
Ngatpang	1,281.0
Ngeremlengui	1,331.0
Ngardmau	949.0
Peleliu	1,174.0
Angaur	N/A
Sonsorol Islands	N/A
Tobi	N/A
<b>TOTAL:</b>	<b>11,633.0 Acres</b>

N/A = none or nominal mangrove areas.

### **F.2.7 Plan Relationship to Laws, Planning Levels and Studies**

This section briefly discusses Palauan Environmental Law with a focus on policies that affect or potential to affect mangroves. This information is summarized from the Palau Environmental Legislation Review (Pulea, 1994).

#### **1. Constitutional Provisions**

The Palau Constitution specifically references environmental responsibilities under Article VI, which states that the “national government shall take positive action to attain these national objectives and implement these national policies: conservation of a beautiful, healthful and resourceful natural environment.” The Preamble to the Constitution reaffirms the dedication of Palauans to preserve and enhance their traditional heritage. In general, the Constitution ranks as the supreme law of Palau.

#### **2. National Laws, State Laws and Customary Laws**

The Republic of Palau recognizes sixteen State Governments. State legislatures have the

power to make laws as provided under their State Constitutions, which is the supreme law of the State. Unless State Constitutions are subject to the National Constitution (for example, Aimeliik State, Airai State, and Ngchesar State), then it is unclear how the relationship between the National Government and other State Government's would be resolved for environmental matters.

Under the Constitution of Palau (Article V), statutes and customary law are to be equally authoritative. In situations where conflict arises between statutes and customary law, the statute can prevail only to the extent that is not in conflict with the underlining principles of traditional law. However, this conflict is resolved in favor of written law through a provision (Section 302, Title 1 of the Palau National Code) which recognizes the full force and effect of customary law as long as such is not in conflict with such legal authority.

Customary practices, entitled "buls," provide traditional laws and regulations which ban hunting, fishing, or wood cutting activities in specific areas or for specific fish, animal and plant species. Today, these traditional bans are still widely used. Traditional chiefs, make announcements called "subed," concerning seasonal or species closures. Under Palau's customary land tenure system, mangrove was considered public domain.

### 3. Environmental Quality Protection Act (RPPL-1-58,s.102 PNC Title 24)

This act recognizes the profound impact of human activity on the natural environment and the use of all practicable means and measures, to create and maintain conditions under which humankind and nature can coexist in productive harmony, while fulfilling other requirements (for example, economic growth and environmental protection) of present and future generations of Palau.

### 4. Other Laws of Palau

The Palau National Code (1985) provides a mixture of adopted laws, for example the Clean Water Act. Under the Compact of Free Association with the United States, Article VI (s. 161) promotes efforts to prevent and eliminate damage to the environment and biosphere and to enrich understanding of Palau natural resources. Additionally, environmental standards are mutually agreed to for carrying out Compact policy (s. 162).

## **F.3 Physical-Environmental Setting and Influences on Mangrove Ecosystems**

### **F.3.1 Geography and Geology**

Palau (approximately 7 degrees, 20 minutes north latitude and 134 degrees, 28 minutes east longitude) consists of four high volcanic islands and many coral limestone islands in the Western Caroline Islands. Palau is about 500 statute miles (800 kilometers) east of the Philippines, north of Papua New Guinea and southwest of Guam. Palau is approximately 188.0

square miles (334.0 square kilometers) in land area. Four (4) volcanic islands (Babeldaob, Meiuns, Malakal and Koror) comprise most of the land mass. Roughly seven reef islands and 300 plus high limestone islands occur within the barrier reef surrounding Palau. At 700 feet above seal level, Mt. Ngerechelehuus, is Palau's highest elevational landmark. Coastal areas contain many coves, while the interior consists of rugged, steep ridges with associated deep valleys. Most of Palau's islands are surrounded by an outer barrier reef (approximately 70.0 miles in length and up to 20.0 miles wide). The barrier reef forms a large lagoon, approximately 560 square miles (1,455.0 square kilometers) around the islands (Cassell and Otobed, 1992).

Geologically, Palau is part of a large oceanic shield volcano formed during the Miocene and Pleistocene. Tectonic activity along the Palau ridge over millions of years built a volcanic mountain islands of Palau. The reef and atoll islands have formed in more recent times from uplifting and/or subsiding of reef structures. Over time, weathering has created a landscape of rugged character and beauty (Cassell and Otobed, 1992).

### **F.3.2 Climate**

The climate of Palau is maritime tropical rainy, with very high annual rain fall. Average annual rainfall is approximately 150 inches per year. Temperatures vary little with an average annual temperature of 81 degrees. Average daily maximum and minimum temperatures range within seven to 12 degrees. Relative humidity averages at 80%. Prevailing trade winds come from the northeast and east from November to May and from June to September, southwest winds dominate. Typhoons generally track to the north of Palau, with occasional typhoons passing through the islands in an east-west direction. Flood and accelerated erosion producing storms can occur during any part of the year.

### **F.3.3 Soils**

Mangrove habitat types on Palau occur primarily on one soil type: Llchetomel soil series. The Llchetomel soil series, represents about 10,200 acres (4,130 hectares) or 10% of Palau's bottom land soils along most of the intertidal zone next to the shoreline of volcanic islands. The vegetation on this series is mainly mangrove forest. The Llchetomel soil series is about 80 percent llchetomel soils and 20 percent components of minor extent. The Chia-Insak soil series makes up a minor extent in this unit, near the lagoon and mucky silt loam soils.

The Llchetomel soil series consists of very deep and very poorly drained soils. Slopes range from zero to 1 percent. Taxonomic classification is euic, isohyperthermic Typic Sulphhemists. PH ranges from medium to slightly acid (Ph 5.6 to 6.0 in 1:1 water). Soil depth ranges from zero to 59.0 inches. The Llchetomel soil series is not suited for agricultural crop production. The woodland management and productivity classifications show severe equipment limitations, moderate seedling mortality, slight windthrow hazard and slight plant competition ratings. Soil properties are unfavorable for recreation activities such as camping, picnicking, playground development, hiking and golfing. Building site and sanitary facilities are unfavorable.

Engineering uses have to be assessed at each site and for each proposed use.

#### **F.3.4 Watershed Components**

Palau's upland forest, in combination with swamp forest, mangrove forest, atoll forest, casuarina forest, limestone forest, rock island forest, plantation forest, palm forest and secondary vegetation, make up the core watershed vegetation components. Upper watersheds play a vital role in island ecological processes by maintaining water yields and quality, providing erosion and sedimentation control, storing and buffering nutrients, and many other biological and physical functions.

#### **F.3.5 Mangrove Wetland Area**

Palau's limited mangrove area (approximately 15% of the total land area of Palau proper) and location along the ocean fringe make mangroves very accessible. Level topography and seaward/landward access, predispose mangroves to a variety of commercial, residential and subsistence stresses. Considerable pressures are being placed on Palau's mangrove ecosystems. These pressures and stresses include:

##### Activities:

- Unregulated conversion and harvesting of mangroves for subsistence and commercial uses.
- Expansion of residential homes, agricultural lands and port facilities.
- Construction of airports and public/tourist service facilities.
- Construction and expansion of roads, channels, causeways and reef/sand mining.
- Construction of solid and liquid waste land fills.

##### Stresses:

- Mechanical damage to trees trunks and limbs resulting from unregulated cutting activities, tropical storms and vandalism.
- Damage to roots and hampered physiological processes caused by excessive sedimentation, siltation and pollution.
- Natural drainage pattern alterations resulting in localized changes in fresh water flow, water temperature and salinity levels.
- Addition of toxic compounds into the environment.

##### Small Mangrove Areas

Palau has many small, separated mangrove areas. The areas, ranging from a single tree or clump of mangrove to mangrove patches, provide important value for their small size. Small mangrove areas are under the same stresses as large mangrove areas. Each small mangrove area

contributes to the diversity of Palau's coastal environment, providing isolated critical habitat to visually appealing solitary mangrove trees along the coastline. Efforts to conserve, even the smallest mangrove areas, are important.

### **F.3.6 Associated Mangrove Vegetation**

A limited variety of understory and epiphytic plant species can be found in Palau's mangroves. Understory species are generally found along the landward edge where tidal inundation is shallow and brief. Epiphytes are found growing on trees above mean high tide levels. Any undertakings within mangroves, should ensure that vegetative diversity is protected.

No Palau mangrove plant or associated plant species are listed as Sensitive, Threatened, Rare, or Endangered, under the U.S. Endangered Species Act.

### **F.3.7 Associated Fauna**

Palau's mangroves provide habitat for fish, birds, molluscs, shellfish, amphibians, and to a lesser extent mammals and reptiles. Old growth mangroves, especially Urur (*S. alba*), provide excellent habitat for a variety of bats and sea birds. Under the U.S. Endangered Species Act, the Saltwater Crocodile (*Crocodylus porosus*) is the only endangered animal on Palau that is associated with mangrove habitats.



Above: The Taoch ra Klai Channel, proposed Airai Bay Mangrove Reserve, Airai State. This man-made mangrove channel represents a significant Palauan cultural resource and continues to serve as a boat route in Palau's transportation network.

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**APPENDIX G**  
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