

**Revisable Final Draft**

United States  
Department  
of Agriculture

Natural Resources  
Conservation Service

Pacific Basin Area



**MANAGEMENT PLAN  
FOR  
UGUM WATERSHED  
TERRITORY OF GUAM**

**SEPTEMBER 1995**

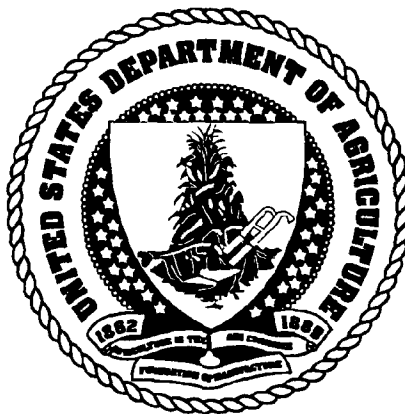
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**TERRITORY OF GUAM**

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**Sponsored by:**

**Southern Guam, Soil and Water Conservation District**

**Guam Bureau of Planning, Coastal Management Program**

**Guam Environmental Protection Agency**

**Prepared by:**

**United States Department of Agriculture  
Natural Resources Conservation Service  
Pacific Basin, Agana, Guam**

**SEPTEMBER 1995**

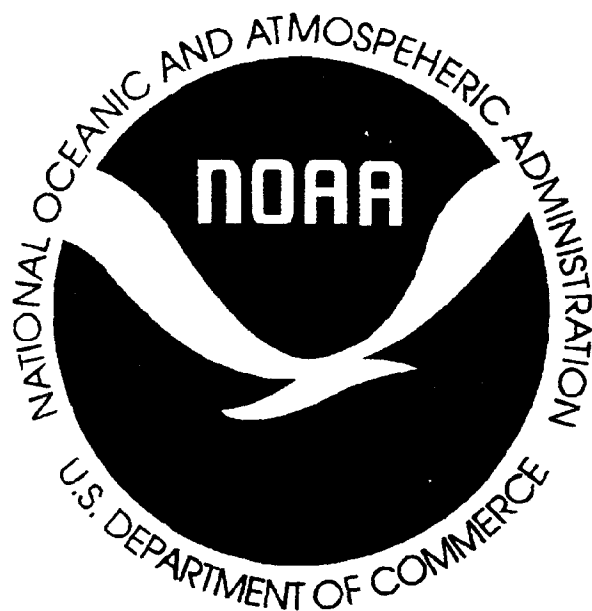
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**REVISABLE FINAL DRAFT**

**MANAGEMENT PLAN FOR  
UGUM WATERSHED  
TERRITORY OF GUAM**

**Sponsored by:**

Southern Guam, Soil and Water Conservation District  
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**Prepared by:**

United States Department of Agriculture  
Natural Resources Conservation Service  
Pacific Basin, Agana, Guam

**September 1995**

**Summary**

This document describes a series of management plans for the Ugum Watershed, Territory of Guam. Four alternative management scenarios were developed during planning, including the Future Without a plan or no action scenario, the Maintenance scenario, the Improvement scenario, and the Reserve scenario. Scenario 2 or 3 are most recommended, the maintenance scenario will implement sufficient reactive controls to maintain the resources at the present level into the future. The improvement scenario has a proactive approach, and looks for prevention of natural and socioeconomic resource problems through the implementation of regulatory controls and conservation practices. The management plans were based on the assumptions for resource needs and future growth in the area. The plans are general in nature and serve as a foundation and recommendations for all future planning and projects in the watershed. The awareness of the need to consider all resources and their interactions forms the background of the management plans, provides the impetus for ecosystem understanding and is the basis of all recommendations. The sponsors' objectives of maintaining water quality while providing for the use of the watershed into the future have been met. The different scenarios fulfill the objectives to different degrees. The most highly recommended plan is the use of proactive control of the problems and solution to maintain and improve the natural resources in the watershed.

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### SUMMARY

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COOPERATIVE AGREEMENT  
BETWEEN THE  
BUREAU OF PLANNING, GUAM COASTAL MANAGEMENT PROGRAM  
AND THE  
UNITED STATES DEPARTMENT OF AGRICULTURE  
NATURAL RESOURCES CONSERVATION SERVICE  
(PACIFIC BASIN AREA OFFICE)

This AGREEMENT is made this 30th day of Dec.,  
19 94, by and between the Bureau of Planning, Guam Coastal Management Program,  
an agency of the Government of Guam, on behalf of the Territory of Guam, (hereinafter  
referred to as "GCMP") and the United States Department of Agriculture, Natural  
Resources Conservation Service(Pacific Basin Area Office), (hereafter referred to as  
"NRCS").

WHEREAS, GCMP intends to engage the professional services of NRCS to provide  
assistance to GCMP; and

WHEREAS, NRCS has communicated an interest in providing such service;

WITNESSETH, GCMP and NRCS deem it mutually advantageous to cooperate in  
this undertaking and in consideration of mutual covenants hereafter set forth, agree as  
follows:

SECTION I. PURPOSE:

- 1.1 To develop a Watershed Management Plan for the Ugum  
Watershed supported by baseline resource information  
which will address the integrity of the Ugum River  
watershed, and the condition of the stream and marine  
systems, with minimal environmental impact from  
development.
- 1.2 The Management Plan will address water quality and  
non-point sources of pollution as well as ecologic  
conditions as outlined in Attachment A - Work Task  
Description.
- 1.3 The final product will be a Management Plan based on  
technical reports and the series of GIS produced maps

Cooperative Agreement between  
GCMP and NRCS

generated during the resource assessment. The final draft of the Management Plan will be provided to the Bureau of Planning, Guam Coastal Management Program by September 30, 1995.

SECTION II. SCOPE OF SERVICES

- 2.1 NRCS intends to fulfill its obligations as stated in this agreement and agrees to perform all of the services in connection with the project as outlined in Attachment A - Work Task Description.

SECTION III. AGREEMENT TERM

- 3.1 The agreement term shall commence upon the signature of the Governor and continue until September 30, 1995.
- 3.2 This agreement may be amended as agreed to in writing by the parties hereto, and shall be executed at least thirty (30) days in advance of the effective date of the amendment.
- 3.3 NRCS cannot make commitments in excess of appropriated funds authorized by law and administratively made available. If NRCS cannot fulfill the obligations because of appropriations, this agreement will automatically terminate and GCMP will proportionally reimburse NRCS for its share of the cost incurred but not billed before the termination.
- 3.4 This agreement may be terminated by either party hereto by written notice to the other party, if it is determined that the project is not being carried out in compliance with the terms of this agreement. Such written notice shall be issued at least forty (40) days in advance of the effective date of the termination.

SECTION IV. COMPENSATION FOR SERVICES

- 4.1 GCMP will compensate NRCS the sum of Forty Seven Thousand Dollars (\$47,000) for services performed as outlined in Attachment A - Work Task Plan.
- 4.2 NRCS shall be compensated by progress payments based upon

Cooperative Agreement between  
GCMP and NRCS

satisfactory performance of services as set forth in the  
Work Task Plan - Attachment A.

- (a) preliminary schedule for completion of increments:

Twelve Thousand dollars (\$12,000.00).

- (b) Upon receipt of second quarterly report and outline of management  
plan:

Twelve Thousand dollars (\$12,000.00).

- (c) Upon receipt of third quarterly report and listing of potential  
conflicts between land- uses currently proposed for the watershed:

Twelve Thousand dollars (\$12,000.00).

- (d) Upon receipt of the final draft Management Plan:

Eleven Thousand dollars (\$11,000.00).

- 4.3 Final payment shall be made upon satisfactory delivery and acceptance  
of all services as herein specified and performed under this Agreement.  
Prior to the final payment, and as a condition precedent thereto, NRCS  
shall execute and deliver to the GCMP a release, in a form approved by the  
Government, of claims against the Government of Guam arising under and  
by virtue of this Agreement.

**SECTION V. NRCS AGREES:**

- A. That there shall be no employee benefits occurring from this agreement,  
such as:

5.1 Insurance coverage provided by the government of Guam;

5.2 Participation in the government of Guam retirement system;

5.3 Accumulation of vacation leave or sick leave.

- B. That there shall be no withholding of taxes by the Government of Guam.

- C. To submit billings on a quarterly basis beginning January 1995 to GCMP on Form NRCS-FNM-15, Bill, for actual costs incurred and the bill shall be sent to the following address:

Bureau of Planning  
Attn: Director  
P.O. Box 2950  
Agana, Guam 96910

**SECTION VI. GCMP AGREES TO PROVIDE THE FOLLOWING SUPPORT SERVICES OR EQUIPMENT:**

- 6.1. To provide assistance in getting participation by other Government of Guam agencies.
- 6.2. To provide NRCS with any mapping, photographic or GIS information resources which exist in GCMP, or which can be obtained by GCMP, necessary for the completion of this project.

**SECTION VII. SCOPE OF AGREEMENT:**

This agreement supersedes any and all other agreements, either oral or in writing, between the parties hereto with respect to the retainment of NRCS by GCMP and contains all of the covenants and agreements between the parties with respect to such retainment in any manner whatsoever. Each party to this agreement acknowledges that no representation, inducements, promises or agreements, orally or otherwise, have been made by any party, or anyone acting on behalf of any party, which are not embodied herein, and that no other agreement, statement, or promise not contained in this agreement shall be valid or binding.

**SECTION VIII. RESPONSIBILITY OF NRCS:**

NRCS shall be responsible for the professional and technical accuracy of all work and materials furnished under this agreement. NRCS shall, without additional cost to GCMP, correct or revise all errors or deficiencies in their work.

**SECTION IX. ASSIGNMENT OF AGREEMENT:**

NRCS may not assign this agreement, or any sum becoming due NRCS under the provisions of this agreement, without the prior written consent of GCMP.



SECTION X. GENERAL COMPLIANCE WITH LAWS:

10.1. GCMP and NRCS shall be required to comply with all Federal and Territorial laws and ordinances applicable to the program or activities conducted under this agreement.

10.2. The program or activities conducted under this agreement will be in compliance with the nondiscrimination provisions contained in Titles VI and VII of the Civil Rights Act of 1964, as amended: the Civil Rights Restoration act of 1987 (Public Law 100-259): and other nondiscrimination statutes: namely, Section 504 of the Rehabilitation Act of 1973, Title IX of the Education Amendments of 1972, and the Age Discrimination act of 1975. The will also be in accordance with regulations of the Secretary of agriculture (7 CFR-15, Subparts A & B), which provide that no person in the United States shall on the grounds of race, color, national origin, age, sex, religion, marital status, or handicap be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving federal financial assistance from the Department of Agriculture or any agency thereof.

10.3. No member of/or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit arising from it. However, this clause does not apply to this agreement to the extent that this agreement is made with a corporation for the corporation's general benefit.

SECTION XI. ACCESS TO RECORDS AND OTHER REVIEW:

11.1. GCMP shall provide NRCS or the Comptroller General or their authorized representatives access to and the right to examine all records, books, papers, or documents related to this agreement.

11.2. NRCS shall maintain all accounting records and other evidence pertaining to costs incurred and to make such materials available at their respective office at all reasonable times during the contract period and for three (3) years from the date of the final payment under the contract, for the inspection by the government of Guam.

SECTION XII. INDEMNITY:

NRCS agrees to save and hold harmless GCMP, its officers, agents, representatives, successors and assignees and other governmental agencies from any and all suits or actions of every nature and kind, which may be brought for or on account of any injury, death, or damage arising or growing out of the acts or omissions of NRCS, NRCS's officers, agents, servants or employees under this agreement.

**SECTION XIII. MODIFICATIONS:**

This agreement may be amended as agreed to in writing by GCMP and NRCS. Any modification of this agreement will be effective only if it is in writing signed by the party to be charged.

**SECTION XIV. TERMINATION:**

Either of the parties hereto, may, by written notice to the other, terminate this agreement in whole or in part at any time, either for convenience or default. Written notice shall be sent at least thirty (30) days in advance of the effective date of the termination. Upon such termination, all briefs, reports, summaries, completed work and work in progress, and such other information and materials as may have been accumulated by NRCS in performing this agreement shall, in the manner and to the extent determined by GCMP, become the property of and be delivered to GCMP. If the contract is terminated by NRCS, or by GCMP for cause, prior to its completion, NRCS will be paid the reasonable value for services performed that are acceptable to GCMP.

**SECTION XV. SEVERABLE PROVISIONS:**

If any provision of this agreement shall be deemed by a court of competent jurisdiction to be invalid, then such provision shall be deemed stricken from the agreement and the agreement shall be enforce according to its valid and subsisting terms and provisions.

**SECTION XVI. GOVERNING LAW:**

The validity of this agreement and of any of its terms or provisions, as well as the rights and duties of the parties to this agreement, shall be governed by the laws of Guam.

**SECTION XVII. EFFECTIVE DATE OF AGREEMENT:**

This agreement shall take effect upon the date it is signed by the Governor of Guam and the date of this agreement shall be the date upon which the Governor affixes his signature.

Page 7 of 7

Cooperative Agreement between  
GCMP and NRCS

IN WITNESS WHEREOF, the parties have entered into this agreement on the  
dates indicated by their respective names.

U.S. DEPARTMENT OF AGRICULTURE  
NATURAL RESOURCES  
CONSERVATION SERVICE:  
(PACIFIC BASIN AREA OFFICE)

Joan B. Perry  
JOAN B. PERRY  
DIRECTOR

DATE: 12/29/94  
AUTHORITY: Soil Conservation Act  
16 U.S.C. §590a-g (1982 & Supp. 1989)

CERTIFIED FUNDS AVAILABLE:

Carmelita C. Blas  
for: CARMELITA C. BLAS  
Certifying Officer

Date: 12/29/94  
Account No.: 5101E50900ZF104-230  
Document No.: C50900009  
Vendor No.: \_\_\_\_\_  
Amount: \$47,000.00

APPROVED AS TO FORM:

Donald L. Paillette  
DONALD PAILLETTE, Acting  
ATTORNEY GENERAL

Date: 12/30/94

BUREAU OF PLANNING  
GOVERNMENT OF GUAM

Michael J. Cruz  
MICHAEL J. CRUZ  
ACTING DIRECTOR

DATE: 12/29/94

CLEARED PER  
BBMR'S REVIEW:  
CLEARED PER BBMR'S REVIEW:

Joseph T. Sgambelluri  
for: GIOVANNI T. SGAMBELLURI  
Director, Bureau Of Budget  
And Management Research (BBMR)

Date: DEC 29 1994

DEPARTMENT OF ADMINISTRATION	
BUDGET & MANAGEMENT RESEARCH	
Registration	<u>1/4/95</u>
Registration	<u>C50660172</u>
Book No.	<u>1</u>
APPROVED	<u>Joseph F. Ada</u>

APPROVED  
Joseph F. Ada  
JOSEPH F. ADA  
GOVERNOR OF GUAM

Date: DEC 30 1994

RECEIVED

DEC 30 1994  
ATTORNEY GENERAL'S OFFICE

**Cooperative Agreement Between Bureau of Planning  
and Natural Resources Conservation Service**

**WATERSHED MANAGEMENT PLAN**

**ATTACHMENT A**

**WORK TASK DESCRIPTION**

**Work Task**

Develop a Watershed Management Plan for the purpose of maintaining the natural resources including water quality in the Ugum Watershed.

**Time Frame:** The Natural Resources Conservation Service will provide to the Bureau of Planning the final draft of the Management Plan by September 30, 1995.

**Background**

The major objective of the project is to provide a watershed management plan supported by baseline resource information which will address the integrity of the Ugum River watershed, and the condition of the stream and marine systems, with minimal environmental impact from development.

The Ugum Watershed Management Plan is a portion of the Ugum Watershed Project. The Ugum Watershed Resource Assessment, will be completed by January 1995. The resource inventory data collected will be incorporated into and be used as the baseline information to develop the Watershed Management Plan.

**Task Procedure**

1. Develop a Plan of Work(POW); detail the assignment of duties and projected dates of completion, the POW is a dynamic planning tool that can be modified as needed.
2. Identify problems; the identification of resource problems in the planning area.
3. Determine objectives; identify and agree on the objectives of the sponsors and land owners to be achieved through the planning process.
4. Inventory resources; planning area is inventoried so the problems and opportunities are defined and current resource conditions are established.

5. Analyze resource data; the resource data from step 4 is analyzed to clearly define the resource conditions and any problems associated with their use.
6. Formulate alternatives; alternatives that will achieve the objectives, solve problems, and take advantage of opportunities to improve or protect resource conditions are formulated.
7. Evaluate alternatives; evaluation of the alternatives to determine their effect in addressing the objectives and resource problems. This step will include an evaluation of the potential effects on social, economic, and environmental concerns.

The Management Plan will address water quality and non-point sources of pollution as well as ecologic conditions including:

Sediment load at infiltration chambers and the water treatment plant on the Ugum River.

Degradation of stream bank and ravine environment.

Erosion of agricultural lands.

Alternative management systems to be used in development of private lands.

Sediment deposition in the lagoon.

Guidelines for chemical uses in the Watershed.

Protection of high value cultural and biological resources.

Public participation.

Treatment of the upper watershed.

Impact of wildfires.

The final product will be a Management Plan based on the technical reports and the series of Geographical Information System (GIS) produced maps generated during the resource assessment. The plan will require an interdisciplinary approach of several areas of expertise to include; work organization and management, hydrology/watershed management, civil engineering, biology, soils, geology, GIS, forestry/agroforestry, erosion control, conservation/agronomy, and economics to evaluate conditions, project risk of various future developments, and recommend management options. Future implementation proposals will be suggested.

## ATTACHMENT B - SPECIAL PROVISIONS

The signatories agree to comply with the following special provisions which are hereby attached to this agreement.

### I. Drug-Free Workplace

By signing this agreement, the sponsors are providing the certification set out below. If it is later determined that the sponsors knowingly rendered a false certification, or otherwise violates the requirements of the Drug-Free Workplace Act, the Service, in addition to any other remedies available to the Federal Government, may take action authorized under the Drug-Free Workplace Act.

Controlled substance means a controlled substance in Schedules I through V of the Controlled Substance Act (21 U.S.C. 812) and as further defined by regulation (21-CFR 1308.11 through 1308.15);

Conviction means a finding of (including a plea of nolo contendere) or imposition of sentence, or both, by any judicial body charged with responsibility to determine violations of the Federal or State criminal drug statutes;

Criminal drug statute means a Federal or non-Federal criminal statute involving the manufacturing, distribution, dispensing, use, or possession of any controlled substance;

Employee means the employee of grantee directly engaged in the performance of work under a grant, including: (i) All direct charge employees; (ii) All indirect charge employees unless their impact or involvement is insignificant to the performance of the grant; and, (iii) Temporary personnel and consultants who are directly engaged in the performance of work under the grant and who are on the grantee's payroll. This definition does not include the workers not on the payroll of the grantee (e.g., volunteers, even if used to meet a matching requirement; consultants or independent contractors not on the grantee's payroll; or employees of subrecipients or subcontractors in covered workplaces).

#### Certification:

A. The sponsors certify that it will or will continue to provide a drug-free workplace by:

(a) Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;

(b) Establishing an ongoing drug-free awareness program to inform employees

about -

- (1) The danger of drug of abuse in the workplace;
- (2) The grantee's policy of maintaining a drug-free workplace;
- (3) Any available drug counseling, rehabilitation, and employee assistance programs; and
- (4) The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace;

(c) Making it a requirement that each employee to be engaged in the performance of the grant be given a copy of the statement required by paragraph (a);

(d) Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will -

- (1) Abide by the terms of the statement; and
- (2) Notifying the employer in writing of his or her conviction for a violation of a criminal drug statute occurring in the workplace no later than five calendar days after such a conviction;

(e) Notifying the Service writing, within ten calendar days after receiving notice under paragraph (d)(2) from an employee or otherwise receiving notice, including position title, to every grant officer or other designee on whose grant activity the convicted employee was working, unless the Federal agency has designated a central point for the receipt of such notices. Notice shall include the identification number(s) of each affected grant;

(f) Taking one of the following actions, within 30 calendar days of receiving notice under paragraph (d)(2), with respect to any employee who is so convicted -

- (1) Taking appropriate personnel action against such an employee, up to and including termination, consistent with the requirements of the Rehabilitation Act of 1973, as amended; or
- (2) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State or local health, law enforcement, or other appropriate agency;

(g) Making a good faith effort to continue to maintain a drug-free workplace

through implementation of paragraphs (a), (b), (c), (d), (e), and (f).

(h) Agencies shall keep the original of all disclosure reports in the official files of the agency.

B. The sponsors may provide a list of the site(s) for the performance of work done connection with a specific project or other agreement.

II. Certification Regarding Lobbying (7) CFR 3018) (Applicable if this agreement exceeds \$100,000) - The sponsors certify to the best of their knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the sponsors, to any person for influencing or attempting to influence an officer or employee of an agency, Member of Congress, and officer or employer of Congress, or a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a member of Congress, an officer or employee of Congress, or an employee of a Member of Congress, in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form - LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The sponsors shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclosure accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction - imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the require certification shall by subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

III. Certification Regarding Debarment, Suspension, and Other Responsibility Matters - Primary Covered Transactions, (7 CFR 3017).

(1) The sponsors certify to the best of its knowledge and belief, that it and its principals:



(a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;

(b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, state or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

(c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and

(d) Have not within a three-year period preceding this application/proposal has one or more public transactions (Federal, State or local) terminated for cause or default.

(2) Where the primary sponsor is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this agreement.

#### IV. Clean Air and Water Certification

(Applicable if this agreement exceeds \$100,000, or a facility to be used has been the subject of a conviction under the Clean Air Act (42 U.S.C. 1857c-8(e)(1)) or the Federal Water Pollution Control Act (33 U.S.C. 1319(C)) and is listed by EPA, or is not otherwise exempt.)

The project sponsoring organization(s) signatory to this agreement certifies as follows:

(a) Any facility to be utilized in the performance of this proposed agreement is \_\_\_\_\_, is not\_\_\_\_\_, listed on the Environmental Protection Agency List of Violating Facilities.

(b) To promptly notify the Assistant State Conservationist (Administration) prior to the signing of this agreement by the Service, of the receipt of any communication from the Director, Office of Federal Activities, U.S. Environmental Protection Agency, indicating that any facility which he proposes to use for the performance of the agreement is under consideration to be listed on the Environmental Protection Agency List of Violating Facilities.

(c) To include substantially this certification, including thus subparagraph (c), in every nonexempt subagreement.

## **CLEAN AIR AND WATER CLAUSE**

(Applicable only if the agreement exceeds \$100,000, or a facility to be used has been the subject of a conviction under the Clean Air Act (42 U.S.C. 1857c-8(c)(1) or the Federal Water Pollution Control Act (33 U.S.C. 1319(c)) and is listed by EPA or the agreement is not otherwise exempt).

A. The project sponsoring organization(s) signatory to this agreement agrees as follows:

(1) To comply with all the requirements of section 114 of the Clean Air Act as amended (42 U.S.C. 1857, et seq., as amended by Public Law 91-604) and section 308 of the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq., as amended by Public Law 92-500), respectively, relating to inspection, monitoring, entry, reports, and information, as well as other requirements specified in section 114 and section 308 of the Air Act and the Water Act, respectively, and all regulations and guidelines issued thereunder before the signing of this agreement by the Service.

(2) That no portion of the work required by this agreement will be performed in a facility listed on the Environmental Protection Agency List of Violating Facilities on the date when this agreement was signed by the Service unless and until the EPA eliminates the name of such facility or facilities from such listing.

(3) To use their best efforts to comply with clean air standards and clean water standards at the facilities in which the agreement is being performed.

(4) To insert the substance of the provisions of this clause in any nonexempt subagreement, including this subparagraphs A. (4).

B. The terms used in this clause have the following meanings:

(1) The term "Air Act" means the Clean Air Act, as amended (42 U.S.C. 1857 et seq., as amended by Public Law 91-604).

(2) The term "Water Act" means Federal Water Pollution Control Act, as amended (33 U.S.C. 1251 et seq., as amended by Public Law 92-500).

(3) The term "clean air standards" means any enforceable rules, regulations, guidelines, standards, limitations, orders, controls, prohibitions or other requirements which are contained in, issued under, or other requirements which are contained in, issued under, or otherwise adopted plan as described in section 110(d) of the Clean Air Act (42 U.S.C. 1857c-5(d)), an approved implementation procedure or plan under section 111(c) or section 111(d), respectively, of the Air Act (42 U.S.C. 1857c-6(c) or (d)), or an approved implementation procedure under section 112(d) of the Air Act

(42 U.S.C. 1857c-7(d)).

(4) The term "clean water standards" means any enforceable limitation, control, condition, prohibition, standard, or other requirement which promulgated pursuant to the Water Act or contained in a permit issued to a discharger by the Environmental Protection Agency or by State under an approved program, as authorized by section 402 of the Water Act (33 U.S.C. 1342), or by a local government to ensure compliance with pretreatment regulations as required by section 307 of the Water Act (33 U.S.C. 1317).

(5) The term "compliance" means compliance with clean air or water standards. Compliances shall also mean compliance with a scheduled or plan ordered or approved by a court of competent jurisdiction, the Environmental Protection Agency or any air or water pollution control issued pursuant thereto.

(6) The term "facility" means any building, plant, installation, structure, mine, vessel or other floating craft, location or site of operations, owned leased, or supervised by a sponsor, to be utilized in the performance of an agreement or subagreement. Where a location or site of operations contains or includes more than one building, plant, installation, or structure, the entire location shall be deemed to be a facility except where the Director, Office of Federal Activities, Environmental Protection Agency, determines that independent facilities are colocated in one geographical area.

#### V. Assurance and Compliance

As a condition of the grant or cooperative agreement, the recipient assures and certifies that is in compliance with and will comply in the course of the agreement with all applicable laws, regulations, Executive Orders and other generally applicable requirements, including those set out in 7 CFR 3015, 3016, 3017 and 3018 which hereby are specifically set forth herein.

#### VI. Examinations of Records

Give the Service or he Comptroller General, through any authorized representative, access to and the right to examine all records, book, papers, or documents related to this agreement. Retain all records related to this agreement for a period of three years after completion of the terms of this agreement in accordance with the applicable OMB Circular.

## INTRODUCTION

### I. INTRODUCTION

#### ***Purpose***

The purpose of the Ugum Watershed Project is to maintain and protect surface and ground water quality on a watershed - wide basis. The project is divided into three phases: 1) the Resource Assessment; 2) the Management Plan; and 3) the implementation of the Demonstration Projects.

The Ugum Watershed Project is a cooperative watershed project sponsored by the Southern Guam Soil and Water Conservation District (SWCD), the Guam Bureau of Planning (BOP) Coastal Management Program, and the Guam Environmental Protection Agency (GEPA) with technical assistance provided by the US. Department of Agriculture, Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS).

This study is the Ugum Watershed Management Plan. The purpose of this Management Plan is to provide management guidelines based on the documentation of the existing condition of the Ugum Watershed compiled in the Resource Assessment, Ugum Watershed, Guam (DeMeo et al., 1995).

The Ugum River is a major source of potable water for southern Guam and in light of proposed development of the area will benefit from a management plan. The Ugum Watershed Management Plan is an interdisciplinary, interagency management plan to address the interrelationship of the resources and maintain the integrity of the Ugum River Watershed. This management plan provides the basis for action necessary to maintain Ugum River water quality and quantity required for operation of the Public Utilities Agency of Guam (PUAG) water facility, and protect or enhance ecosystem values and functions that may be affected by projected commercial, agricultural, and residential development in the watershed. The management plan discusses issues related to surface water quality and quantity, soil erosion, wildfires, and loss of wildlife habitat as well as other ecological conditions and concerns.

The scope of the Ugum Watershed Project is long range and comprehensive. The management plan will project present conditions and problems twenty years into the future and suggest management measures. The total watershed approach will be applied to assess current and potential future conditions, address identified problems, and determine treatment and management needs to protect surface and ground water quality and quantity.

## INTRODUCTION

### ***Study Methodology***

This Management Plan is an interagency plan to control non-point source (NPS) pollution and the natural resource base in the Ugum Watershed. The Management Plan discusses the actions to prevent or reduce NPS water quality problems identified in the Ugum Watershed Resource Assessment. The natural resources studies contained in the Assessment included ground surveys and inventories, field studies, aerial photo interpretation, remote sensing, Geographical Information System (GIS) mapping and analysis, and consultations with area experts and scientists.

### ***Participation***

The Guam Bureau of Planning (BOP) Coastal Management Program has provided leadership in sponsoring the Ugum Watershed Management Plan. The Southern Guam SWCD has also provided leadership in coordinating with USDA - NRCS, which provided technical and planning assistance and prepared the Management Plan document.

An interagency team called the Ecosystem Based Assistance Team (EBAT) provided the technical reports for the management plan. The Ecosystem Based Assistance Team included seven members; from NRCS Pacific Basin, Reed Sims (soils/geology/wildlife), Jay Cobb (engineering), Robert Wescom (forestry/vegetation/wildlife), and Robin DeMeo (planning/coordinator/writing); from Hawaii NRCS Robin White (hydrology); from GEPA Randy Sablan (wetlands); and Dr. John Brown (economics) with the University of Guam. Each member provided technical reports based on the Assessment for this management plan.

The Guam Bureau of Planning, Coastal Management Program is also sponsoring a section 6217 Coastal Nonpoint Source (NPS) pollution project to determine the recommended Best Management Practices (BMP's) or NRCS conservation practices. The recommended BMP's will address resource problems in rural areas of Guam, including the nonpoint source pollution problems found in the Ugum Watershed.

The GEPA is sponsoring a related project of BMP Demonstration Projects implementation in the Ugum Watershed. Demonstrations of up to eighteen USDA NRCS conservation practices will be implemented over the next two and a half years in the Ugum Watershed by the NRCS with the landowners cooperation.

An Ugum Watershed Steering Committee was formed among all sponsors to discuss project progress and to direct the decision making process. The Steering Committee members are the Southern Guam Soil and Water Conservation District, Guam Environmental Protection Agency, the Guam Bureau of Planning, Coastal Management Program and the United States Department of Agriculture, Natural Resources Conservation Service. A Guam Watershed Committee is in the process of being created, and the above agencies have agreed to participate in the larger committee covering the island. The potential for the Guam Watershed Committee is to act as an interagency committee to share project information in cooperative island resource planning.

## INTRODUCTION

Others supporting the watershed planning efforts and providing technical assistance or information included:

Public Utility Agency of Guam (PUAG) - The PUAG is responsible for all public water production and supply on Guam. The PUAG provided access to the Ugum Treatment Plant and technical information about the water in the river and throughout the treatment process.

Guam Department of Agriculture, Division of Forestry and Soil Resources - is generally responsible for urban and rural forestry on Guam and provided support and trees for reforestation and windbreak projects for this project.

Water and Energy Research Institute (WERI) - is a research institute associated with the University of Guam and provided technical support and expertise on the hydrology and geology of the study area.

University of Guam - Marine Lab - Provided information on coral reef life and studies of lagoon sedimentation, and down stream biota.

Guam Department of Agriculture, Division of Aquatics and Wildlife - Provided information on the animal species and the preferred habitat.

United States Geologic Survey (USGS) - Provided historical hydrology information of the Ugum River.

The University of Guam, Guam Department of Land Management, The Territorial Planning Council, the Village Mayors of Talofofo and Inaranjan, the Land Owners, US Army Corps of Engineers, Bureau of Planning, and developers - general project area information.

Within the Ugum Watershed there are other projects, studies and related efforts. The inventory of the wetlands and analysis of the functions and hydrologic effects within the watershed is being conducted by Dr. Galt Siegrist of the Water and Energy Research Institute, University of Guam. Another project has been started by the Guam Department of Agriculture, Division of Forestry and Soil Resources of planting forest trees on the badlands on the public lands within the Ugum Watershed. And another study is being conducted which is gathering baseline data in connection with fresh water resources within the Ugum and other watersheds of southern Guam by Guam Department of Agriculture, Division of Aquatics and Wildlife.

The implementation of the Ugum Watershed Management Plan will depend heavily on the coordinated effort of all Ugum landowners and all local and federal agencies. The landowners have primary responsibility in care and management of the valuable natural resources in the Ugum Watershed. Sustainable development for economic gain and natural resource management for conservation are compatible goals achievable through a united effort.

Several local and federal agencies have responsibilities and jurisdiction over either the development or the natural resource use in the watershed. The following is a brief partial

## INTRODUCTION

listing of some of the agencies and the areas of responsibilities that may effect the future of the Ugum Watershed.

The Guam Environmental Protection Agency has regulatory responsibility over all environmental quality issues including nonpoint and point sources of pollution in the watershed. These responsibilities extent from water quality monitoring and road construction permitting, and from wetland protection to erosion control.

The Guam Bureau of Planning has authority to manage and develop a plan for the territory. The Bureau of Panning, Coastal Management Program is responsible for the coastal waters and reefs, and the Nonpoint Source Pollution Control Program.

The United States Department of Agriculture, Natural Resources Conservation Service has responsibility to provide technical assistance to the landowners on a voluntary bases. As part of this effort there are certain programs available for the specific areas of assistance.

Guam Department of Land Management has responsibility over the ownership and regulation of use of real property. This agency also has authorities on the most appropriate use of land and orderly growth.

United States, Army Corps of Engineers has regulatory responsibilities over for wetlands permitting and determination on non agricultural lands.

Guam Department of Public Works has responsibilities and authorities on the highway and transportation plan for the territory, right of way improvements and requirements, and storm water disposal and drainage systems.

Public Utilities Agency of Guam manages the water resources to ensure safe drinking water for Guam.

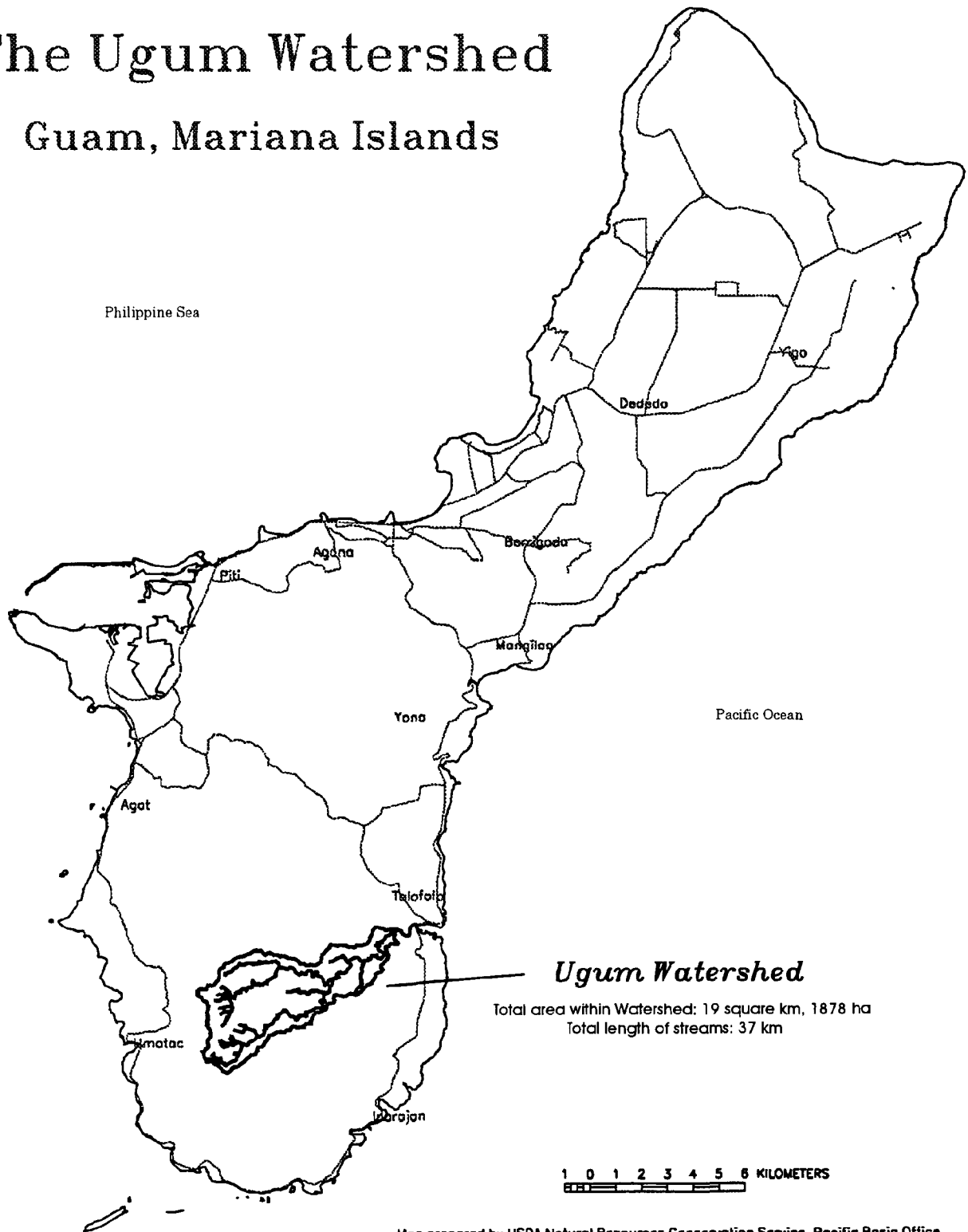
Guam Department of Agriculture has programs to conserve, develop and maintain the agricultural sector. The Division of Aquatics and Wildlife has responsibilities in the conservation of the natural resources and protection of the endangered resident and wildlife species.

The Territorial Land Use Commission is a body appointed by the legislature the reviews requests fro rezoning, wetland permits, and certain development projects.

The Territorial Planning Council heads the territory's comprehensive master planning effort.

# The Ugum Watershed

## Guam, Mariana Islands



Map prepared by USDA Natural Resources Conservation Service, Pacific Basin Office  
Source: USGS Quad Maps of Guam  
Projection: Modified Azimuthal Equidistant  
April, 1995

Figure 1. Ugum Watershed locator map, Guam.



## II. Project Setting

### *Location*

The Territory of Guam is located in the Western Pacific, in the Marianas Islands chain. Guam is the largest and the southernmost of the Marianas Islands. The Island of Guam is approximately 6,100 kilometers west - southwest of Hawaii and 2,600 kilometers east of the Philippines. Guam is located at latitude 13 degrees 28 minutes North and longitude 144 degrees and 45 minutes East (Tracey et al., 1964). The island is about 48 kilometers long and is 6 to 19 kilometers wide, lies generally on a north - south axes. The total area is 54,908 hectares, or about 549 square kilometers.

The Ugum Watershed is located in southern Guam directly south of the Talofoto and Fena Watersheds (Figure 1). The Ugum Watershed stretches from Mount Bolanos that rises to 378.5 meters and forms the western limits of the watershed to the Talofoto River near the Pacific Ocean in the east. Mount Bolanos includes the headwaters of the Atate and Bubulao river systems which flow into the Ugum River.

The Ugum Watershed covers an area of approximately 18.9 square kilometers (7.33 square miles, 4,691 acres) of rolling hills with areas of very steep slopes. The 37 kilometers of rivers and streams in the Ugum Watershed flow from the mountains to sea level where the Ugum River drains into the Talofoto River only 1,303 meters (4,275 feet) inland from the Talofoto Bay.

### *Climate*

The island of Guam has a warm tropical humid climate generally influenced by the northeast trade winds. Precipitation on Guam averages from 2,159 to 2,921 mm (85 to 115 inches) per year. Approximately two-thirds of the annual rainfall occurs during the rainy season, July through November. Approximately 68 - 73 percent of the total annual rainfall, runs directly off into the ocean (Ward et al., 1965). The wet season frequently has periods of short duration heavy rainfall (Bureau of Reclamation, 1985).

The Intertropical Convergence Zone that passes over the island seasonally brings with it disturbances that can become tropical storms or typhoons. The storm frequency during the rainy season is commonly high. The yearly difference in frequency and intensity of typhoons are attributed to El Nino / Southern Oscillation variations (Guard and Lander, 1993). Widespread flooding often follows the heavy rainfall from typhoons and intense local storms. The heavy rainfall and strong winds create severe erosion, land slips and sedimentation of stream and coastal zones.

## PROJECT SETTING

### **Geology**

The Ugum Watershed is located in southern Guam, south of the Talofoto fault zone. The structural province of south Guam, the Bolanos block, is formed by east-dipping Miocene volcanic rocks, of fan-shaped Umatac formation (Tracey et al., 1964). The Ugum Watershed is the drainage system that empties the Ugum and Bubulao Rivers, from Mount Bolanos to the Talofoto River. The Ugum River flows into the Talofoto River approximately 3/4 of a kilometer from Talofoto Bay. The Ugum River valley was created by lineaments stretching from Talofoto Bay to Merizo. Along the lineaments many smaller faults in the volcanic rocks pass into long joint zones (Tracey et al., 1964). The structural lines show as a series of knobs and ridges crossing topographic trends or as fine fissures.

The Ugum Watershed consists of the volcanic uplands of steep dissected slopes east of the mountain summits, and the gently sloping foothills cut by the major streams. The watershed has a small area of limestone on the plateaus over the flood plain near the mouth of the Ugum River, where it joins the Talofoto River.

### **Soils**

The Ugum Watershed includes nine major soil series with 26 different soil phases or mapping units (Figure 2). These mapping units group soils according to properties that affect land use and management, such as slopes (Figure 3). Some map units are made up of two or more major soils; these are soil associations or soil complexes and may include miscellaneous areas such as Badlands. The soils in the Ugum area are represented by the Agfayan, Akina, Atate, Inarajan, Pulantat, Sasalaguan, Togcha, and Ylig Series, sometimes intricately interwoven, and the Badland land type, for further information consult the Soil Survey of Territory of Guam (Young, 1988).

Soils in the Ugum Watershed are derived chiefly from volcanic rock. This rock is a mixture of highly compressed and heated volcanic ash and sand, which weathers down to clay-sized particles as it becomes soil. The parent material, called saprolite, is nearly as erodible by water as the soils that it develops. The soils have high clay content (from 45 to 90 percent) and very low soil pH. These volcanic clays have low bulk density, roughly the same as water, which has a density of 1 gram per cubic centimeter (Young, 1988). The low bulk density of the soils means that they are highly sensitive to water erosion, and that once particles are in suspension, they will remain in suspension indefinitely. When water dislodges and carries the particles, they are not likely to settle out as would, for instance, coral sand particles which are more dense. At the Ugum Water Treatment Plant, a flocculant is required to force the clay particles out of suspension.

The year-round microbial and biological decomposition of soil organic matter provides for rapid depletion of this valuable resource from the soil. Since volcanic soils and minerals are inherently low in nutrient-holding capacity and available water-holding capacity (Sanchez, 1976), soil organic matter is critical to sustained plant growth.

# Ugum Watershed Soils Island of Guam

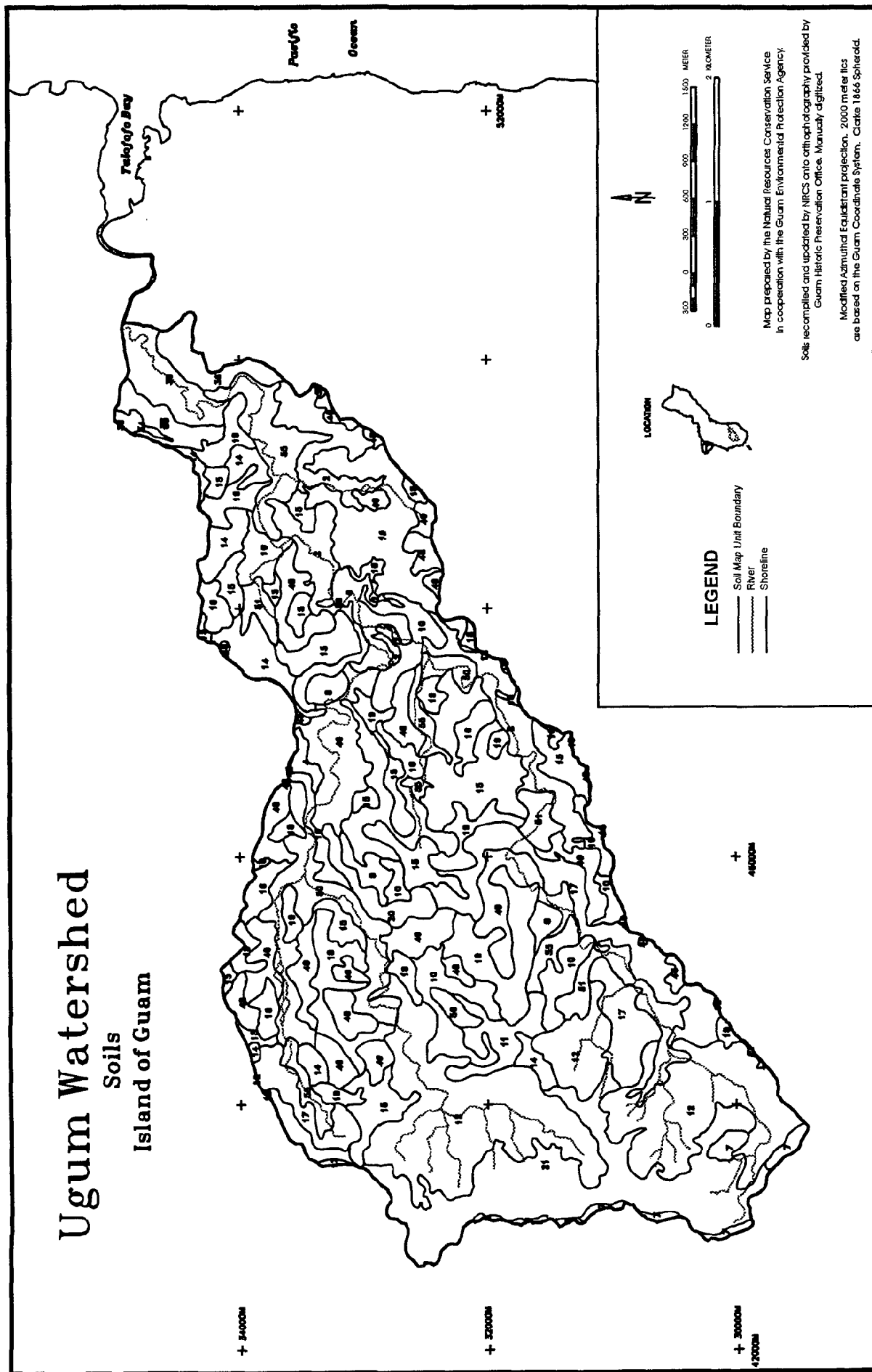


Figure 2. Soils of the Ugum Watershed, Guam.

# Ugum Watershed Slope Classes Island of Guam

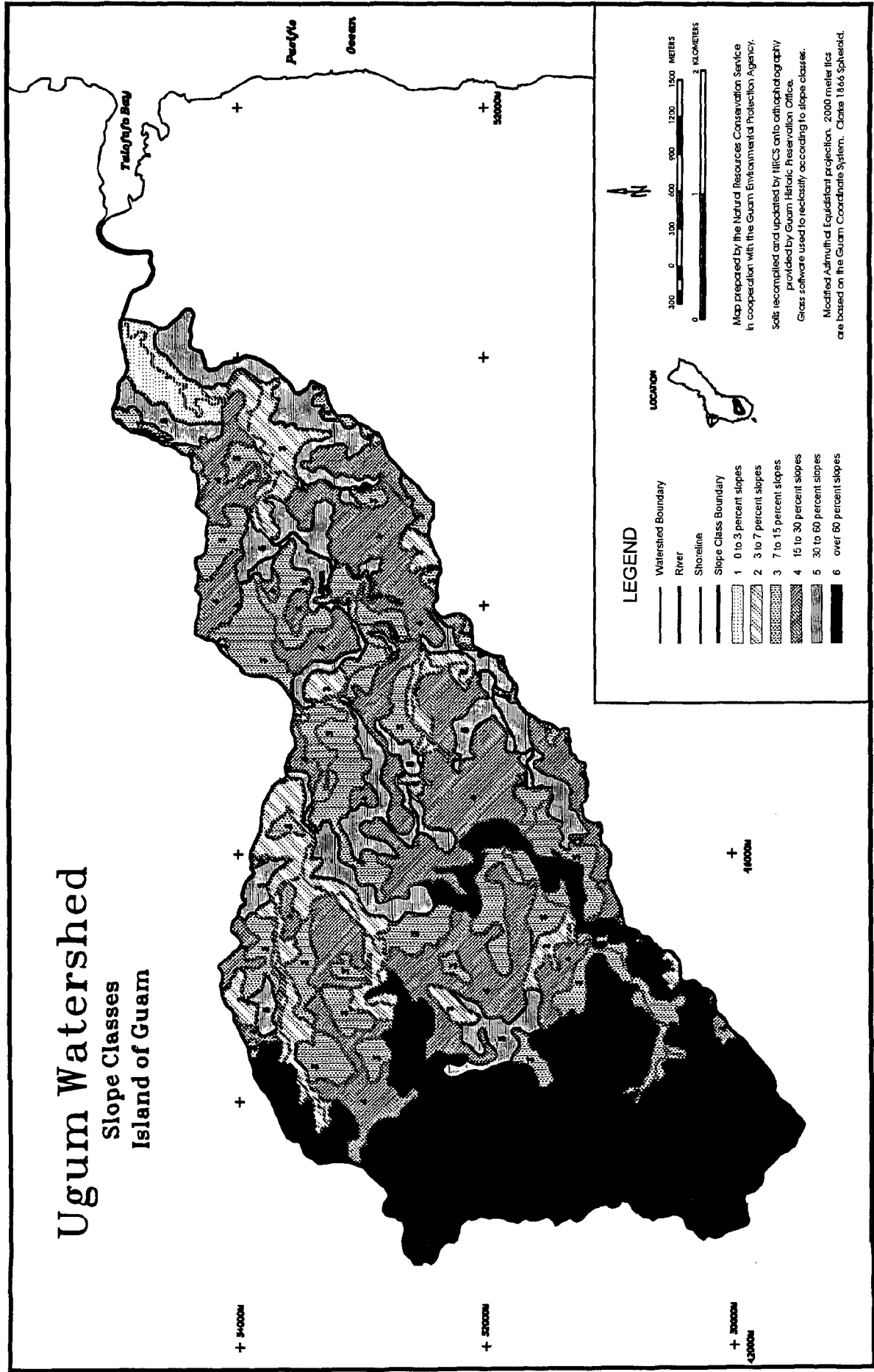


Figure 3. Slope classes, Ugum Watershed, Guam.

## PROJECT SETTING

### ***Water***

The Ugum Watershed has abundant surface water resources and limited ground water resources. The Ugum Watershed has approximately 36.8 kilometers (23 miles) of rivers and streams within the 18.9 square kilometer (7.3 square mile) drainage area. The watershed is made up of volcanic basaltic-andesitic rocks except for a small area near the mouth of the watershed close to the coast which is limestone. The groundwater within the basaltic-andesitic rocks is not easily exploitable with the low hydraulic conductivity of only 0.0432 centimeters per hour (0.034 feet per day) in the Malojloj area. (Mink, 1976). This value is more than a thousand times less than the conductivity of argillaceous limestone (Mink, 1976). The groundwater which does occur within the volcanic soils drains into the streams and rivers through seepage and flows eventually into the ocean. For this reason, surface water is the major source of all water for use in the southern portion of Guam.

The Ugum surface water has been studied for almost 30 years as a source of drinking water for the south and as a supplement to the northern groundwater sources. The PUAG Ugum water facility and treatment plant has been fully operational since November 1992 to tap this important source. The Ugum River water treatment plant is relied upon as the sole source of water for its distribution area. It is currently the primary source of water for the Ipan area of Talofofo village, and all of Inarajan, Merizo and Umatac villages. There are plans to expand the distribution of Ugum River water to include the Talofofo village center and areas along the cross island highway towards Agat to relieve dry season pressure on the Fena reservoir (Personnel communication, Terry Johnson, PUAG). The Ugum water plant can produce a maximum of 4 million gallons of potable water per day (Mgd) in the rainy season.

The Ugum River is not capable of providing for the 4 Mgd diversion at all times. Based on the low flow year of 1983, the diversion of 4 Mgd is possible only 64 percent of the time (GMP, 1989). A minimum downstream flow of 2 cfs is required by GEPA in the permit for the PUAG Ugum River water plant to maintain downstream biota and to minimize the environmental impacts to the levels of the natural low flows of the river.

The Ugum River water plant is currently being used as a sole source instead of the being used as the intermittent source that it was designed to be. This can lead to pressures upon PUAG to violate the minimum conservation streamflow of 2.0 cfs at the Ugum River diversion dam in order to maintain continuous water service to the areas supplied by the Ugum River water plant. These pressures can only increase as the area supplied by the plant are expanded.

### ***Land Ownership***

Land ownership in the watershed is approximately 70 percent (1,329 hectares) private and 30 percent (574 hectares) publicly owned (Figure 4). The public lands are in the headwater areas of the upper Bubulao and Atate River systems and are owned by the Government of Guam (29 percent), and the U.S. Naval Reservation (2 percent). The

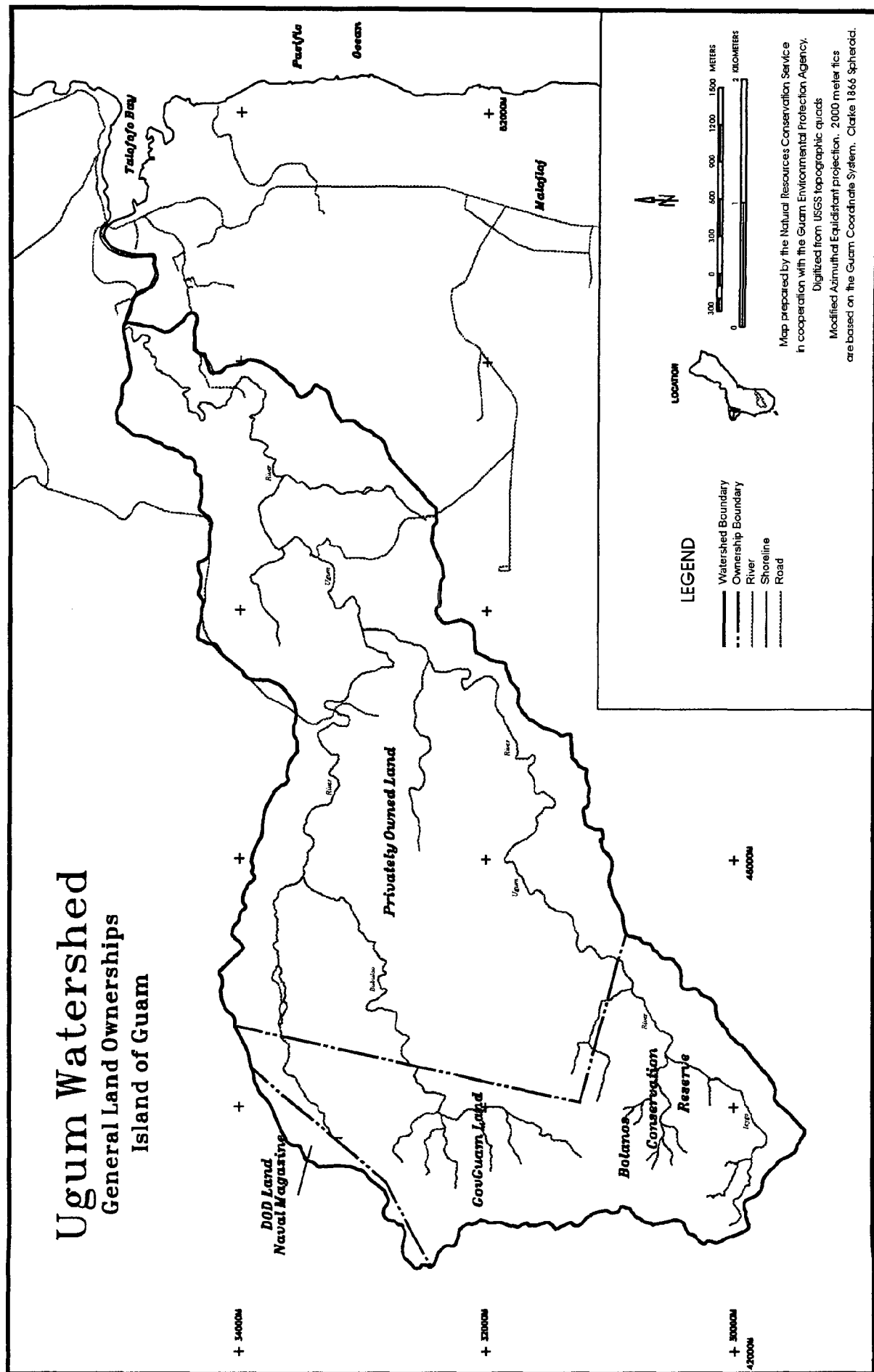


Figure 4. General land ownerships, Ugum Watershed, Guam.

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Bolanos Conservation Reserve makes up a majority of the public land holdings, all of the Government of Guam land, (545 hectares). The U.S. Naval Reservation land is a narrow portion of Fena Reservoir land (only 30 hectares) within the Ugum Watershed boundaries on the northwest corner.

### ***Land Use***

The ownership of the headwater areas by government and the designation as conservation reserves protects these areas and the resources they hold from development, helping to maintain the health of the watershed and water quality. The headwater habitat of the watershed is vital to maintaining water quality and water quantity. The public lands area are generally steep, with slopes greater than 60 percent. The majority of the vegetation is savanna grassland, which covers generally from the mountain tops to the ravine forest along the bottom of the ravine surrounding the streams.

All of the privately owned lands are zoned "Agriculture" at present, or "Intensity 2" under the I Tano'- ta Plan. The exception to this is the "Dan Dan Estates and Country Clubs" land, which is zoned as a "Planned Unit Development" (PUD) for a proposed resort at present or "Intensity 3" under the I Tano'-to Land Use Plan.

The Dan Dan Estates project is in "approved, not constructed" status. The Dan Dan Estates and Country Clubs proposed project plans for three 18 hole golf courses with dwellings, restaurants and supporting structures. Approximately a third of the 213 hectare development project falls within the Ugum Watershed boundaries. The location of this project is in the headwater area in the back of the Ugum Watershed, bordering the south side of the Ugum River and the Bolanos Conservation Reserve. The rest of this project development lies to the south of the Ugum Watershed in the Dan Dan area.

Only 7 hectares of land is presently being actively farmed, as interpreted from the 1993 aerial photos. Field locations are shifted in response to soil productivity. Farming is seasonal, typically in the early dry season. Many land owners have an interest in increasing the amount of agriculture land in production. Presently, there are attempts to subdivide and sell agricultural parcels within the Ugum Watershed. Typical crops include watermelon, beans and cucumber.

The lands within the Ugum Watershed have been more heavily used for agriculture in the near past than at present. During the 1960's and 1970's much of what is known as the Bubulao Ranch was used for grazing cattle and water buffalo (carabao), also pigs were raised. Aquaculture ponds were constructed and freshwater *Macrobrachium* shrimp cultivated for about five years during the same period. Many agricultural crops were grown at the ranch including pineapple, watermelon, beans, taro, cucumber and other melons.

Tourism is also present in the watershed both at Talofofa Falls, on the Ugum River and the jeep tours of the wild lands. The Talofofa Falls has approximately 4,500 visitors a

## PROJECT SETTING

year to this spectacular waterfall. The Jungle River trip has two daily boat tours up the Ugum River from Talofoto Bay to share a taste of "traditional" Chamorro life. The Safari Tours take tourists on jeep trails into the Upper Bubulao area to view the native ravine forests and wildlife of Guam.

There are many other recreational uses of the watershed including hunting wildlife, gathering fruits and betel nut, fishing and swimming. Another recreational use of the watershed is off-road vehicle excursions.

The off-road vehicle use of this area has increased in recent years. The most obvious indicator of this increased is the number of roads in the watershed. From the 1975 aerial photos almost 33.6 kilometers of roads were documented (almost all unimproved) in the watershed. By 1993 the total roads had more than doubled to more than 68.8 kilometers. A large part of the increase is attributed to the off-road recreational use due to the nature of the roads' patterns, which are often in clusters and circular. This activity poses a threat to maintaining the vegetative covered by the increase in erosion from these highly traveled areas.

Fire in the Ugum Watershed is related to human activity. There is evidence (Raulerson, 1978) that the fires which occur in this area are started by hunters. The savanna grassland is burnt so the deer are attracted to the new shoots or as a means to exit an otherwise difficult area to walk. The fire frequency records from the Fire Prevention Division of Forestry Resources at the Department of Agriculture have been utilized with the GIS system to map and record historic burning patterns. The fire frequency for the period record, 1979 through 1985, documented a total of 138 fires in the Ugum.

The fire hot-spots in the Ugum Watershed are the headwaters area of the Atate River with 8 fires, the area between Dan Dan and Talofoto Falls had 24 fires, the south middle Ugum River area west of NASA had 8 fires, and the headwaters of the Bubulao River had 12 fires during the period of record.

Fire has the effect of assisting the savanna grassland to rejuvenate and spread by burning the ravine forest which cannot easily compete with the invading grassland. An increase in soil erosion from newly burnt areas can be expected, especially if rains fall shortly after the fire.

### ***Cultural Resources***

Prehistoric land use of the Ugum River area has been documented by Dye, Price, and Craib, 1978 in Archaeological and Historical Reconnaissance Survey of the Ugum River Valley, Guam, Marianas Islands. The survey of an area approximately 43 hectares (107 acres) surrounding the Ugum and Bubulao Rivers revealed eight areas of prehistoric activity. Historic land use has not been documented for the period from Spanish contact (1521) to World War II. The Ugum Valley was utilized by Japanese soldiers as a place



## PROJECT SETTING

of refuge during and after the War. Shoichi Yokoi, a Japanese sergeant, lived unnoticed for 28 years in the Ugum valley, hiding in a cave near Talofofo Falls.

Other historic and prehistoric sites have been located in the Ugum Watershed as noted by the Government of Guam, State Historic Preservation Office.

### ***Ecosystem Descriptions***

Ecological systems within the Ugum Watershed describe the organization and interactions of communities of living things with their environment. For planning and management purposes the watershed was divided into four ecosystems; Ravine Forest, Savanna/Badlands, Wetlands, and Riparian Areas (Figure 5). The ecosystems each have unique processes and characteristics. The delineation of ecosystem boundaries by dominant vegetation, and hydrology, as well as changes to energy flow and ecological processes as a result of human intervention are indicators of ecological health.

#### **Ravine Forest**

The Ravine Forest Ecosystem comprises areas with a predominance of woody perennial vegetation, and covers 837 hectares or 44% of the Ugum Watershed. Components of this ecosystem are found in both large contiguous blocks as well as isolated batches of forested areas. The ravine forest ecosystem is common along stream channels and all slope classes. The term "ravine forest" refers to its frequent occurrence in ravines and on steep slopes.

Relative to other ecosystems on Guam, the ravine forests are rich with both native and introduced flora. Although relatively low growing, the vertical structure of the ravine forest provide a range of micro-climates that encourage species diversity.

Past human activities have introduced many non-native plant species into the ravine forest ecosystem, including the *Areca catechu*, the betel nut palm. As a result of repeated human-induced and natural disturbances the ravine forest of southern Guam is a secondary forest type as indicated by the widespread presence of *Hibiscus tiliaceus*, *Areca catechu*, and *Cocus nucifera*. The original forest vegetation of southern Guam cannot be discerned.

Where the ravine forest borders savanna grasslands periodic wildland fires affect species composition of the ravine forest. Early secondary vegetation dominate and *Miscanthus floridulus* (swordgrass) is often a dominant species in the understory.

The ravine forests of southern Guam occur on all soil mapping units within the planning area, except Sasalaguan clay. Plant litter on the soil surface absorbs the energy of raindrops and intercepts surface flow. Organic matter and biological activity in the upper soil horizons increases the water holding capacity of the soil and plays an important role in the storage and release of soil water into the Riparian ecosystem and the streams.

**Ugam Watershed**  
Ecosystems  
Island of Guam

**LEGEND**

- Watershed Boundary
- River
- Road
- Trail
- Shoreline
- Ravine Forest
- Savanna Grassland
- Riparian Area
- Wetland and Open Water

Map prepared by the Natural Resources Conservation Service in cooperation with the Guam Environmental Protection Agency. Digitized from USGS topographic quadrants. Modified Universal Transverse Mercator projection. 2000 meter UTM. are based on the Guam Coordinate System. Clarke 1866 Spheroid.

**Figure 5. Ecosystems, Ugum Watershed, Guam.**

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### Savanna Grasslands

The savanna grasslands ecosystem comprises 777 hectares or 41% of the Ugum Watershed with a predominance of grasses and ferns. Highly eroded barren areas that support little to no vegetation (badland complexes) are included in this ecosystem. This ecosystem occurs on all soil mapping units within the planning area, except Pulantat clay. Components of this ecosystem are found in both large contiguous blocks as well as isolated batches of grasslands. The savanna grasslands are common along ridgetops and all slope classes. Periodic wildfires maintain this ecosystem in a early successional state.

The grassland communities are dominated by only a few species including *Miscanthus floridulus* (swordgrass), *Dimeria chloridiformis*, and *Pennisetum polystachyon*. Periodic wildland fires favor grass species that can rapidly resprout and dominant the site before wind disseminated seed becomes established.

If wildland fire is excluded for a few years, woody shrubs and trees, including *Casuarina equisetifolia* may slowly become established in savanna plant communities. The woody component is often destroyed once a wildland fire occurs.

It is generally accepted that the savanna ecosystem is a result of repeated disturbance through land clearing and the periodic burning that has occurred since before the Spanish colonization of Guam. Ecological succession resulting in an orderly process of community development involving changes in species structure and community processes with time is disrupted by the periodic burning, resetting the ecosystem development back to the earliest pioneer stage. Regrowth of the grassland plant community is usually rapid (within months). The cycle of vegetative growth and burning does not permit a stabilizing of the ecosystem processes. High temperatures cause organic matter to be decomposed faster than it is accumulated. Site quality in the savanna has declined as a result of repeated burning. The soil surface has been compacted by rains following the removal of vegetative cover and litter, resulting in a decrease in the rate of water penetration. The ash is susceptible to being wind blown out of the ecosystem, and susceptible to leaching and erosion by rainwater.

The badland scarps associated with the savanna are the result of the extreme effects associated with frequent burning of the savanna and high rainfall. Soils within the scarps are extremely low in pH approximately (4.2), calcium, phosphorous, and organic matter. Even plant species adapted to harsh savanna sites, such as *Miscanthus floridulus*, *Dimeria chloridiformis*, and *Gleichenia linearis*, cannot survive in the extreme conditions found within the badland scarps.

### Riparian Ecosystem

The riparian ecology is closely linked to the watershed morphology in that the associated riparian plant communities follow an organized stream system from the upper watershed to the sea. Riparian ecosystem processes are influenced by the movement of open water in streams as well as subsurface flow from adjacent ecosystems. The riparian ecosystem

## PROJECT SETTING

extends 15 meters on stream orders 2 and 3, and 30 meters on stream orders 4 and 5 to either side of stream channels, and comprises 159 hectares or 9% of the Ugum Watershed. The riparian ecosystem is located along the lower slopes, soils which have eroded from the upper slopes are intercepted by the physical presence of vegetation in the riparian zone. This results in an accumulation of soil in the riparian zone.

The riparian plant communities in the Ugum are longitudinal zoned with plant communities similar to wetland and ravine forest ecosystems found in the higher stream orders near the coast. *Hibiscus tiliaceus*, *Cocus nucifera*, and *Barringtonia racemosa* and other species which are adapted to periodic inundated and waterlogged soil conditions are commonly associated with riparian zones nearer the coast. The width of the riparian ecosystem is widest near the coast where the influence of the stream extends well beyond the stream channel.

In the upper watershed where volume of flow is much less, the savanna grassland vegetation often dominates, and the width of the riparian ecosystem is much narrower.

### Wetland Ecosystem

Wetland ecosystems are those areas that are inundated by surface or ground water with frequency sufficient to support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, mangroves, natural ponds, surface springs, estuaries and similar such areas.

Wetlands are present on 117 hectares or 6% of the watershed within the ravine forest, savanna grasslands, and riparian ecosystems. Wetlands plant communities are dependent upon a constant source of water in their substrate. Within the Ugum watershed, wetlands include marshes, bogs, and springs. For the purpose of this report, running water (lotic) communities associated with streams are included in the wetland ecosystem.

The vegetation of wetland plant communities is strongly influenced by soils which are waterlogged either frequently or seasonally. Plants existing within this ecosystem are adapted to cope with waterlogged conditions. The wetland communities associated with savannas are often dominated by a few grass and sedge species, including *Panicum maximum*, *Phragmites karka*, and *Rhynchospora* spp. In the ravine forest, wetland flora may include woody trees including *Hibiscus tiliaceus* and *Barringtonia racemosa*.

Wetland ecosystems serve as a highly productive interface between terrestrial and open aquatic systems, providing beneficial functions to both, and facilitating the flow of energy, water and nutrients between them.

Wetland ecosystems that are surrounded by savanna plant communities can be affected by wildland fires during drought periods. The higher moisture content with the wetland plant communities usually result in lower combustion of above ground biomass and

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rarely does a wildland fire completely consume the wetland plants. The net result of these energy exchanges is that large quantities of energy is stored as soil organic matter and in plant biomass (above and below ground).

Nutrient cycling in a wetland ecosystem differs from both the ravine forest and savanna. Nutrients can enter the wetland ecosystem as either eroded sediment or as dissolved minerals in subsurface flow from ecosystems above the wetland. Because of the hydric nature of the soils, anaerobic soil conditions exist during periods of saturation which may result in slow decomposition of organic matter, and higher levels of organic matter in the soil than either the ravine forest or savanna ecosystems. The organic matter can serve as a storage of nutrients.

### ***SocioEconomic***

The population of the Territory of Guam has grown at a high rate in the last twenty years. Guam's resident population in 1990 was 133,152. The annual rate of growth over the last census interval (1980 to 1990) was 2.27 percent. This was up from a growth rate of 2.2 percent during the 1970 to 1980 census interval (Guam Business News, 1994).

If the population growth rate of 2.27 percent per year is projected, the 1995 population is approximately 145,660 residents. The population in 2015, the end of the projected planning period, would be an estimated 233,400 island residents.

The projected growth rate of the island, as stated in the I Tano-ta, The Land Use Plan for Guam by the Territorial Planning Council, is an estimated 2.85 percent annual growth rate over the next twenty years. This would result in a total population of approximately 263,000 permanent residents in the year 2015 (Flores et al., 1993).

Currently, Guam's economy is driven by tourism, the most important source of the island's outside income. The U.S. military is the second most important source of outside income and a major source of employment. Non-military Federal expenditure also provides significant amounts of off-island income.

Investment from off-island is another important source of income. Construction, often driven by outside investors is a highly variable component it tends to be the most cyclical component of the economy. Transportation and shipping also contribute to off-island income.

In December 1994, the total island employment was 66,460 persons. The private sector employed 46,100 persons or 69.4 percent of the filled jobs on-island. Government employed 20,360 persons or 30.6 percent of the filled jobs on-island. The breakdown of the public sector employment was: 6,930 persons in Federal Government employment and 13,430 persons in Territorial Government employment. The Government of Guam is by far the largest single employer on the island (Department of Labor, 1995).

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Private sector employment was divided into eight categories. The largest private sector category is retail trade. It employed 12,930 persons or 19.4 percent of the island's payroll. The second largest category was services with an employment of 12,380 or 18.6 percent of the island's payroll. The service sector was dominated by hotel employment. The sixth largest category was wholesale trade. It employed 2,060 persons or 3.1 percent. Government, services, retail and wholesale trade together accounted for 71.8 percent of the island's payroll. Thus, the importance of government, including the military, tourism and trade are clearly evident.

The third largest employment category in the private sector was construction. In December, 1994, construction provided employment for 8,820 persons or 13.3 percent of the jobs on-island. Construction is the most cyclical component of Guam's economy. Employment in the construction industry peaked in 1991 at 12,060 persons. At that time, it accounted for 18.2 percent of the island's employment. Many of the construction workers on Guam are H-2, temporary workers from Asia, but the economic activity generated by off-island investment and its associated construction activities plus military construction projects has strong influences on the overall boom and bust cycles on Guam.

The fourth largest category was transportation and public utilities with 4,980 jobs or 7.5 percent of payroll. This reflects Guam's active tourism trade and its role as a regional transportation center. The fifth largest category of private sector employment was finance, insurance and real estate with 2,760 persons employed or 4.1 percent of payroll. Manufacturing, primarily food preparation and printing, employed 1,910 persons or 2.9 percent of the island's payroll. Finally, the smallest component of the private sector was Agriculture. It employed 260 persons or about 0.4 percent of the island's jobs (Department of Labor, 1995).

### III. WATERSHED PROBLEMS AND OPPORTUNITIES

The Ugum Watershed is in a fairly undisturbed state at present with no or few permanent structures and little activity in the watershed. Even with this low level of disturbance and the near pristine nature of the watershed there are natural resource problems. The major problems and opportunities prioritized in public meetings, reported in the Ugum Watershed Resource Assessment, and defined by the Ugum Ecosystem Based Assistance Team, include:

- \* Soil Erosion - Loss of productivity and deterioration of the soil resource base due to excessive erosion, often from roads.
- \* Fire - Loss of vegetative cover and increased erosion due to frequent wildfire in the savanna grassland.
- \* Water Quality and Quantity - Decrease in surface water quality due to the increased sedimentation in the streams and near shore waters. Decrease in available water quantity in the Ugum river due to changing vegetative cover and possible changes in the hydrologic cycles.
- \* Fish and Wildlife Habitat Protection - Decrease in wildlife habitat due to the changing vegetative cover in the watershed, changing land use and wildfire.

#### ***Existing Problems***

##### **Soil Erosion**

Soil erosion is the major problem to be dealt with in the watershed. It is the primary factor affecting sedimentation and water quality in the Ugum River and its tributaries. Erosion occurs naturally on all soils, and at accelerated rates on tropical volcanic soils. Young (1988) describes typical erosion rates that can be expected on each of the soil types (series) on Guam. It should be noted that the erosion rates described are not necessarily natural, but reflect historical human influences on the particular soils.

The term erosion is defined as the detachment of soil and rock particles by water, wind and gravity. Erosion is occurring throughout the drainage area of Ugum Watershed. The degree of erosion varies greatly from place to place and varies with vegetative cover. The erosion rates are greatly influenced by human activities.

Soil erosion in the Ugum Watershed effects the productivity of the land and also negatively impacts the quality of the water in the stream and the coastal areas. According to the extensive soil erosion study, compiled in the Ugum Watershed

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Resource Assessment, DeMeo et al., 1995, the soil erosion levels on the savanna grassland, badlands, and unimproved roads are excessive.

The major sources of erosion recognized in the Ugum Watershed Resource Assessment are: (1) sheet and rill, (2) road surface, and (3) stream channel. Sheet and rill erosion and road surface erosion account for a majority of the total erosion in the watershed. The sloped road surface erosion rate is reported as 27 times that of the ravine forest, this is the highest rate within the watershed (DeMeo et al., 1995). The badland erosion is the second highest at 20 times the erosion of the ravine forest. However, the greatest total amount of erosion is from the savanna grassland, 48 percent of the total erosion in the watershed due to the high rate and the large area (42 percent of the watershed) in grassland (DeMeo et al., 1995).

Roads in the Ugum Watershed and its surrounding watersheds are usually found along the ridges, with steep connecting roads that cross the streams between. The Akina soil series occupies many of these ridges. Young (1988) reported a sustainable soil loss rate of 6.8 metric tonnes per hectare per year for this soil; the sustainable rate is low because the soil is generally less than 100 centimeters deep. This rate was determined for the Akina series under grassland vegetative cover. DeMeo et al. (1995) used the Universal Soil Loss Equation (Wischmeier and Smith, 1965) to estimate a current erosion rate of 70 tonnes per hectare per year occurring in the Savanna Grassland ecosystem; this estimate shows that some degradation of the soil and the ecosystem is already occurring. One hectare of road surface, exposing bare soil or saprolite (highly weathered volcanic sedimentary rock), and running up and down a slope in the watershed was estimated to erode at a rate of 729 tonnes per year. If the current trend of doubling the steep road surface area within the watershed during the period 1975-1993 continues for the next 20 years, sediment yield to the Ugum River from this source will be over 15,000 tonnes per year by 2015, as compared with the 1993 level of 7560 tonnes. The roads connect naturally occurring badlands, exposing these areas to accelerated erosion. Uncontrolled use of the roads and badlands for recreational driving purposes accelerates erosion rates and prevents revegetation of sensitive areas. Many of the recreational vehicle drivers are unaware of the consequences of their actions, and prefer starting new trails to following existing ones.

Roads that currently follow the contour and thus do not provide channels for flowing water nevertheless erode at a rate much higher than soil with vegetative cover. DeMeo, et al (1995) estimated erosion from one hectare of level road surface to be 169 tonnes per year, as opposed to 70 tonnes for grasslands and 27 tonnes for typical areas of ravine forest. None of the roads observed in the watershed included drainage ditches or other water-redirection devices. There is no master road plan for the watershed, and without proper planning and design, similar statistics will be generated for future road expansion.

Agricultural clearing currently accounts for 25 to 40 hectares per year within the Ugum Watershed. These fields are on slopes of less than 7 percent. Residue is left on the surface, and weed control is accomplished by light use of chemicals such as the product



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Roundup®. Plowing does not follow the contours. At an estimated 45 tonnes per hectare per year, the soil lost from agricultural fields is currently 1,100 to 1,800 tonnes. We project that 200 to 500 agricultural homestead lots will be developed within the next 20 years, and that all of the land on these half-hectare lots will be cleared for cropping, with small areas set aside for home development. These lots will probably be set up in areas with less than 15 percent slopes. Potential erosion from agriculture could increase to 60 tonnes per hectare per year given the likelihood of steeper slopes on some of the lots. If 200 lots are settled and cleared, the amount of soil eroded from agricultural land will increase to 6000 tonnes per year, a three-fold increase from current estimates. Water quality will show corresponding degradation in the Ugum subwatershed, where the lots are most likely to go in.

During golf course and residential subdivision construction, large areas of disturbed soils are exposed, usually for short periods, during which soil erosion increases to levels similar to those for level and sloping roads. The volume of sediment carried to wetlands and open water is greatly increased during each rain event, resulting in plugs which damage stream habitat and wildlife populations. It is common for construction sites on Guam to stand bare for extended periods due to funding shortages, sudden downturns in the Asian economy, infrastructure delays or equipment breakdown. Some sites are abandoned for months or years. By Guam law, attention is given to erosion prevention during active construction with such measures as silt fencing. However, these measures require periodic maintenance. Abandoned sites do not receive this maintenance, and erosion will increase before volunteer vegetative cover can stabilize the soil. The silt fencing observed in the past three years at construction sites by the authors has been improperly installed in most cases, and has not been an effective barrier.

One result of erosion is biomass loss due to root loss. In every hectare of soil in the top 15 centimeters, there are 22.5 metric tonnes of organic matter for each percentage point of reported organic matter content. This would amount to 180 tonnes for each hectare of Akina soil with a healthy grassland cover, assuming 8 percent organic matter, the middle of Akina's range. By contrast, a hectare of badland or severely eroded Akina soil might contain just over 1 percent organic matter, or 23 tonnes, a difference of more than 150 tonnes per hectare. Disturbed savanna soils lose organic matter by about 5 percent per year in tropical Africa (Sanchez, 1976). Burning or clearing the vegetation removes the replenishment source, and soil organic matter content will decline. Often, clearing operations remove the upper layer of soil, accelerating organic matter loss.

If we consider that badlands or exposed soils in the watershed erode at an average rate of 547 tonnes per hectare per year - about 5 centimeters off the surface by sheet erosion - and that the top layer of soil has the highest percentage of organic matter, 10 to 40 tonnes can be lost each year from each hectare of this ecosystem if adequate grass cover is not maintained.

Local residents have noted an increase in sedimentation of the river, the bay and the coral reef over the years because of NPS pollution. When the soil becomes unproductive due

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to erosion the vegetation type changes often from forest to savanna grassland, or from savanna grassland to badlands. The ecology of the land changes also with less species diversity and wildlife habitat is often negatively impacted. In stream aquatic habitat is changed, the coastal reef can be smothered, and fish population decline (Rogers, 1990).

Sedimentation of the coastal reefs affects the corals photosynthetically, physically, and chemically. The reduction in quantity and quality of solar radiation will affect the growth and distribution of the corals (Richmond, 1993).

The affects of erosion and sedimentation are accumulative in that over time the impacts from these processes are magnified and continue to worsen.

### Fire

The wild land fire problem relates to other problems such as changes in vegetative types, loss of soil organic matter, lessening of soil productivity, loss of forest lands, loss of wildlife habitat, increased erosion, increased sedimentation and changes in aquatic life of the rivers.

Fires are a growing problem in the Ugum Watershed. Wild land fires in the watershed are largely intentionally started, whether for hunting and food-gathering access or from carelessness or recreation. The sum of all fires within each square kilometer in the watershed for the period 1979 through 1985 (see Figure 6, data from Government of Guam, Department of Agriculture's, Fire Prevention) shows clear "hot spots" where road access is easiest, especially near the Dandan area in the Ugum and Upper Ugum subwatersheds. The historic data indicates an average fire frequency of 160 hectares (400 acres) per year, or an approximate burning of all the savanna grassland within the watershed every five years.

The total kilometers in unimproved roads increased by more than 100 percent in the 18 year period from 1975 till 1993 in the watershed. There were 33.6 kilometers of unimproved roads in 1975, and 63.4 kilometers of unimproved roads in 1993 in the watershed.

Wild land fires usually occur in the Savanna Grassland ecosystem. The ecosystem is dominated by bunchgrasses. These areas are fire-prone during the dry season from February to May; during late dry-season fires, the leaf litter that protects the soil surface is usually burned off. The clay particles of these soils, derived from highly weathered volcanic tuff (sandstone) parent material, typically aggregate into silt- or sand-sized particles. At the soil surface, these particles are easily lifted and transported by storm runoff. Water channels through burned-over areas were clearly visible several weeks after a fire in 1995, along the ridge separating the Bubulao and Ugum Rivers. The slope at the observation site was less than 7 percent. Steeper slopes could lose a portion of the surviving vegetation simply through scouring, because the water channels are not interrupted or blocked by vegetative or other barriers. The photos (Figures 7 a,b,c,d)

**Ugam Watershed**  
Cumulative Fires, 1979-1985  
Island of Guam

**LEGEND**

- Watershed Boundary
- River
- Road
- Shoreline

Each block shows the number of fires within one square kilometer over period of record.

Map prepared by the Natural Resources Conservation Service  
in cooperation with the Guam Department of Agriculture,  
Division of Forestry

Digitized from USGS topographic quads  
Modified Azimuthal Equal-area projection, 2000 meter UTM  
are based on the Guam Coordinate System, Clarke 1866 Spheroid.

**Figure 6. Fires within the Ugom Watershed, Guam, 1979-1985.**

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show the ground cover one day, one month, two months, and five months after fires in 1995 in Southern Guam. The rills and water channels were relatively clear even five months after a fire; no recent erosion was evident at time of observation, nor was there any evidence that the soil would be stabilized before onset of the wet season two to four weeks later. The only protection pioneer grasses afforded the site was 60-75 percent protection from raindrop impact.

The swordgrass-dominated savanna vegetation is a fast growing pioneer community. Because of the high rate of soil erosion under this vegetative cover, the ravine forest late-successional community does not easily reestablish. When fires occur near the edge of the ravine forest, some of the fringe plants are destroyed, creating a transitional edge effect which is maintained by a conservatively estimated fire repeat cycle of 5 years. The ravine forest cannot be expected to expand without the exclusion of fire.

### *Opportunities*

#### **Water Quality and Quantity**

The water resources within the Ugum River Watershed are sufficient in quantity and quality to provide for partial fulfillment of our island's needs. Water quality and quantity are affected by the increase in sedimentation and decrease in vegetative cover in the watershed. The watershed acts as a catchment basin which funnels most of the precipitation that falls in the area to the mouth of the watershed. The construction of the treatment plant has allowed for utilization of some of these water resources. The maintenance and preservation of the water quality and quantity into the future is the stated objective of the sponsors and the aim of this study.

Water quality is critical on an island since resources are limited. The Government of Guam and GEPA have placed a high priority on protecting the islands water quality at the source (Flores/Barrett, 1993). The surface water quality of Guam is of generally high quality. The parameters of concern for the Ugum River are mainly the turbidity of the water and the presence of harmful microorganisms. After storms the high turbidity of the surface water is the biggest problem facing treatment plants on Guam. Turbidity is a measure of the clarity of the water and an indicator of the presence of suspended organic and inorganic soil particles or sediment. The PUAG Ugum River water treatment plant laboratory results for raw water turbidity averaged about 5 nephelometric turbidity units (NTU) for the first three months of 1994.

The other area of general concern for water quality is microorganism contamination, the past water samples from the Ugum River have very low levels of fecal coliform bacteria (GMP, 1989). The amount of fecal coliform is used as an indicator for the presence of potentially harmful bacteria.

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Housing or road construction, overgrazing by livestock and other human activities form breaks in the riparian buffers. This creates undesirable paths which can channel storm runoff laden with sediment directly into the Wetland and Open Water Ecosystem without the benefit of vegetative filtering and particle capture. The soils throughout the Ugum Watershed have at least 40 percent clay content, and once suspended in moving water, clay particles are too light to settle out. A break in the riparian buffer is, therefore, a direct sediment conduit from the highly eroding roads, badlands and burned-over grasslands to Talofofo Bay and the surrounding coral reefs.

An opportunity exists with the implementation of this plan, to halt the degradation to the watershed, start restoring the damaged ecosystems, and minimize future effects of human activities. Thus insuring the continued high water quality, and a possible increase in water supply for future generations.

### **Fish and Wildlife Habitat Protection**

Wildlife habitat is impacted by fires, erosion and changes in vegetative cover. The objectives of this section are to describe the wildlife habitats based on the various vegetation types and plant communities. The possible existence and distribution of the different wildlife species within the watershed in relation to the ecosystems and habitats will be discussed. The value and importance of the existing wildlife and habitats to the maintenance of water quality will be examined. Possible management recommendations for the Best Management Practices for the wildlife and the habitats are examined for future management of the watershed.

The ecological importance of the various ecosystems and habitats to the maintenance of the wildlife populations and the health of the watershed are well understood. However, there have been few comprehensive studies of wildlife or biology in the Ugum study area. These include Raulerson et al. (1978), Biological Study of the Potential Ugum Dam Site, and the Division of Aquatic and Wildlife Resources of the Department of Agriculture has various studies of the specific wildlife of this area. At present there is an ongoing study by the Marine Lab, University of Guam (UOG), on the impacts to aquatic organisms by the installation of the Public Utilities Agency of Guam (PUAG) Treatment Plant on the Ugum River. The Raulerson et al. (1978) study inventoried the aquatic organisms and terrestrial flora and fauna of the Ugum River and the Bubulao River area.

The two dominant wildlife habitats in the watershed are ravine forest and savanna grassland ecosystems (Fosberg, 1960). Within these two dominant habitats are two more specialized areas, those of the aquatic habitats (Figure 9) and agricultural land.

Historically there were few native species on Guam due to its natural isolation from other land masses. The introduction of animal and plant species by people has, through competition and predation, diminished the native species in number and variety. The introduced brown tree snake has had a devastating impact on the native bird and bat populations.

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The wildlife sighted during ground surveys within the Ugum Watershed include pigs, eel in the rivers, shrimp and fish, as well as the birds: Black Francolin, the island swiftlet, and Blue-breasted Quail. Deer and water buffalo signs were also identified. There were numerous invertebrates and skinks sighted.

The Ugum Watershed can be considered one of the remaining relatively pristine undisturbed areas on the island of Guam. At present there are no permanent structures in the watershed except at Talofofo Falls and at the Public Utilities Agency of Guam, Ugum River Water Treatment Plant. The ravine forest is large and contiguous, supplying potential habitat to many threatened and endangered species. The wetlands are prime habitat for the Common Moorhen.

A specialist from the Division of Aquatic and Wildlife Resources, Department of Agriculture stated that the habitat is ideal for many of the wildlife species on Guam and probably home to some of the uncommon or rare species (Wiles, 1994).

The Marine Lab at UOG is conducting a study of the in-stream biota to determine variations in species from before and after the PUAG treatment plant operations started in November 1992. The results are as yet inconclusive; however there are some indications that the species diversity has changed. There appears to be more brackish water species living below the PUAG weir now (Smith, 1994). The reduced downstream flow volume may be causing a change to a more brackish aquatic habitat.

The possible impacts to the coastal marine habitat and species is another area of concern. The sediment plume into Talofofo Bay is often visible and is well known. The plume deposits sediment and nutrients on the fringing reef, inhibiting coral growth and zooxanthallae activity. Under these conditions, coral colonies fail.

The watershed acts as an interrelating ecosystem in which ecological activities and human interventions affect the watershed environment and quality. Virtually every change that occurs benefits some wildlife species and harms others (Wenger, 1984). Often the ecological impacts are far reaching. For example, fire on the upland savanna will promote new growth of the grassland encouraging deer and carabao grazing. Another effect of fires is the increased susceptibility to soil erosion, which adds to sedimentation in the rivers and streams, possibly covering the coastal reef with silt. The importance of the ravine forest and riparian ecosystem as wildlife habitat and as a stabilizing agent within the watershed cannot be over-stated. The ravine forest acts as a filter for rain, erosion, sediment and chemicals, diminishing nonpoint source pollution.

#### IV. SCOPING OF CONCERNS

The scoping process to identify the significant issues to be addressed or considered in the development of the Ugum Watershed Management Plan was begun soon after the planning commenced and continues through the planning process. Comments were obtained from government agencies and from interested groups and individuals. The scoping process included meetings with individuals, telephone contacts, correspondence, and group meetings.

The inventory and forecasting phases of this study identified a broad range of socioeconomic and environmental factors that were of primary concern in the watershed. During the initial stages of the planning, in the Resource Assessment, the data was gathered on the status of these resource concerns. Two public and agency meetings were held to afford the affected publics the opportunity to participate in the planning and scoping process. Twenty-six environmental, economic, social, and cultural concerns were expressed during these meetings. The nominal group technique was used at the public meeting to prioritize the concerns. A complete listing of the prioritized concerns is given in the Appendix A of this plan.

The following, Table A, Evaluation of Identified Concerns, lists all the resource concerns identified during the public meeting scoping process, the sponsors concerns and the problems identified by the EBAT planning team, and their degree of concern and significance to decision making for the project.

Potential effects on the four major concerns as defined by the Ecosystem Based Assistance Team are discussed during the development of the alternative scenarios and in the effects section of this report. The remaining concerns are evaluated only generally for impacts from the potential future scenarios. Many of the concerns overlap and are closely related, therefore most of the concerns are dealt with to some degree in the scenario description and effects sections. The remaining concerns are briefly defined and discussed as to impacts from the project area.

## SCOPING OF CONCERNS

**TABLE A - EVALUATION OF IDENTIFIED CONCERNS**

Environmental, Economic, Social and Cultural Concerns	Degree of Concern and Significance to Decision Making
Soil Erosion	High
Fires	High
Water Quality and Quantity	High
Fish and Wildlife Habitat Protection	High
Off Road Vehicle Impact	High
Sedimentation of Streams	High
Sedimentation of Coastal Waters and Reef	High
Pesticides and Fertilizer Use	High
Development of Agricultural Use	High
Impact of Development	High
Land Use Conflicts	High
Infrastructure Development Needs	High
Road Building and Grading	High
Wetland Protection	Medium
Threatened and Endangered Species	Medium
Cultural Resources	Medium
Water Rights	Medium
Water Pressure	Medium
Security of PUAG Intake Facility	Medium
Access to Public Lands	Medium
Interagency Coordination	Medium
Suitable Commercial Activities	Medium
Capturing Excess Water	Medium
Beautification of Watershed	Low
Regulation for Protecting the Resources	Low
Access to Private Land	Low
Health Effects of Cattle Grazing	Low
Water Availability for Agriculture	Low
Flooding	Low
Illegal Fishing and Hunting	Low
Affect of Recreation on Water Quality	Low
Monitoring Development in Dan Dan Area	Low

High - Considered in the analysis of alternatives.

Medium - Affected by some alternative solutions.

Low - Consider, but not significant.



## SCOPING OF CONCERNS

The first four concerns from the Evaluation of Identified Concerns - Table A, are defined and discussed at length in the scenario descriptions and the effects section, these four major concerns have been the focus of this report, and include many of these other concerns. It is recognized that all of the natural resources and socioeconomic resources interact and should be addressed as a whole. It is beyond the scope of this management plan to solve in detail many of the concerns, however as much as possible from the general natural resource conservation context of this plan each concern is addressed.

### Off road vehicle impact - high

The off road vehicle impact in the watershed is considered high due to the fact that one of the highest rates of erosion is from the fast expanding kilometers of unimproved roads. The increase in recent years of the number and use of off road vehicles contributes to the erosion and sedimentation problems, the fire problem and the destruction of the wildlife and their habitat. All of these impacts are associated with the water quality.

### Sedimentation of streams, coastal waters and reefs - high

The sedimentation of the streams, coastal waters and reefs is of high concern and has been discussed in detail under the soil erosion problem and with the water quality opportunity.

### Pesticide and fertilizer use - high

The potential effects of using pesticides and fertilizers on environmental quality is of high concern in the watershed. At present levels of use there has not been a problem. In the future the potential for increased agricultural use of the land will necessitate the need of conservation practices such as agrochemical mixing stations.

### Development of agriculture use - high

The development of agriculture and its economical viability within the Ugum Watershed is of high concern to the land owners. Several factors are involved in support of agriculture development is the agriculture zoning in the watershed, however this may change. Other areas of needed development are the use of water and a road system to get in and out of the watershed.

### Impact of development - high

The impact and potential adverse effects of rapid development of hotels, golf courses, and condominiums within the Ugum Watershed to agricultural use is of concern to land owners. The potential loss of the area for agriculture use if rezoning is allowed, could change the agricultural lands into commercial development. This is not only of concern from the land owners and farmers but from a resource conservation and water quality perspective, also.

### Land use conflicts - high

The potential land use conflicts within the Ugum watershed include many aspects. The conflicts between preservation and exploitation of land use are present. Conflicts of access to land parcels and use of water also need to be resolved.

## SCOPING OF CONCERNS

### Infrastructure development needs - high

The infrastructure development needs (roads, water, sewer, electrical, etc.) within the Ugum Watershed will need to be addressed. Without planning of infrastructure it is more likely to result in uncontrolled growth and possible pollution of the waters in the Ugum.

### Road building and grading - high

The adverse effects of road building and grading within the Ugum Watershed are of concern for the water quality. The road maintenance (grading) meets with restrictions from EPA, this leads to less maintenance being completed. Properly designed roads with drainage systems and covered surfaces for minimizing the erosion is the preferred method. The planning and development of a complete road system in the Ugum would help to solve these problems and allow for the revegetation of some of the highly erosive roads which are not utilized.

### Wetland protection - medium

Wetland protection is a major resource concern not only because of the protected status of this resource, but also due to the potential hydrologic effects in the watershed. Wetlands are water storage areas for the slow release of water into the river system when times of drought. The wetlands are also the wildlife habitat of many threatened and endangered species. Wetlands are federally and locally protected areas.

### Threatened and endangered species - medium

The threatened and endangered species in the watershed are of concern partly due to the lack of information on what species are present in the watershed. It is recommended that the further studies be conducted on the existence of the threatened and endangered species in the watershed, and that surveys for these species be a part of every development effort and included in a detailed EIS.

### Cultural resources - medium

Historic cultural resources are present in the watershed and the few studies which have been completed in parts of the watershed have been recorded and mapped. Most areas have not been studied, and a detail survey for cultural resources is recommended as part of every development effort and a detailed EIS.

### Water pressure - medium

Water pressure for domestic and agricultural use is a concern due to the low pressure of the past. At times of low rain fall the supply of water into and out of the Ugum treatment plant drops, this in turn lowers water pressure. As the demand for water rises with population increases the need for larger water storage facilities, more intake from the river when the water is at high enough levels, or a water reservoir may need investigation.

### Security of the PUAG intake facility - medium

Maintaining the security of the water intake site at the PUAG Ugum treatment plant is of concern. The water from this plant provides water for most of southern Guam. The plant itself is closely monitored and therefore poses very little threat of contamination.

### Access to public lands - medium

Access to public lands within the Ugum watershed is a concern found in the scoping process. The back third of the watershed is Government of Guam, Conservation Reserve. The access to the public lands is the same as all of the watershed there is no improved road infrastructure and access is limited due to crossing of private lands.

## SCOPING OF CONCERNS

### Interagency coordination - medium

Coordination amongst government agencies for the implementation of the Ugum Watershed Project is of major concern. It is recognized that the work of managing the watershed resources will take the involvement and commitment of many Government of Guam and Feral agencies. The structure of coordination and willingness of the agencies to participate are areas of future need.

### Suitable commercial activities - medium

Commercial activities that are suitable within the Ugum Watershed must be determined in the context of the management plan and the infrastructure and natural resource needs.

### Capturing excess water - medium

The potential for capturing excess water in the Ugum Watershed in the form of a reservoir or larger and more holding tanks is the concern as the water need increases in the future of the area.

### Beautification of the watershed - low

How can the island beautification program be extended to the Ugum watershed. This concern was brought up at one of the public meetings. The idea of creating a park like atmosphere and beautifying the watershed with planting of trees and flowering plants would help to promote this area as a tourist and recreation destination.

### Regulation for the protecting the resources - low

Special land use regulations are needed to protect the natural resources and values of the Ugum watershed. The public is concerned for the protection of the resources and realizes that regulations may posse the best options.

### Access to private land - low

Many land owners in the watershed are concerned with the access to isolated parcels of private land. This concern would be address with the installation of a master for road and the establishment of right of ways to land locked parcels.

### Health effects of cattle grazing - low

The effects of grazing cattle in the watershed are of concern to the health risk of Giardia being introduced to the drinking water. The present level of grazing in the watershed is minimal and mostly from wildlife so there is little health hazard. However as the use of the watershed increases close monitoring of the water quality and possible restrictions on location and control of cattle grazing may be needed.

### Water availability for agriculture - low

The water for agriculture use in the watershed needs to be made available with minimum restrictions. The majority of the private land is zoned agriculture in the watershed and farmers need water to provide the economic gains of crop production.

### Flooding - low

Flooding does occur in the watershed in the lower section in times of heavy rains. The level of flooding and the flashiness of the floods pose little concern at present. The factors in the watershed that could lead to flooding problems are loss of life or property due to construction in the flood prone areas.

### Illegal fishing and hunting - low

Illegal fishing and hunting is of concern in the watershed and needs to be controlled. There are several factors which combined to define this problem, the illegal hunting is

## SCOPING OF CONCERNS

done without permission of the land owners, hunters often set fires which destroy ecosystems and harm biodiversity, and the vehicles uses for access into the watershed cause erosion.

### Affect of recreation on water quality - low

The activities in the watershed that have an adverse affect on recreation water quality are of concern. The use of off road vehicles increases the erosion in the watershed and the crossing the river repeatedly can cause streambank erosion.

### Monitoring development in the Dan Dan area - low

Monitoring of all development in the watershed will be necessary to maintain and fulfill the objectives of the land owners and sponsors of this project. The development activity and housing planned in the Dan Dan area should be monitored under the Ugum Watershed Project.

## V. FORMULATION OF SCENARIOS

Alternative scenarios were formulated to address the maintenance and protection of the water quality and other natural resources in the Ugum Watershed. Each scenario is an outline or synopsis of the potential outcome or effects of a possible set of future actions within the watershed. This section describes the formulation process of the four scenarios for the future conditions of the watershed.

### ***Formulation Process***

The formulation process began by developing and evaluating the forecasted conditions within the watershed without the implementation of a management plan. The Ecosystem Based Assistance Team (EBAT) formulated the four future scenarios based on four intensifying levels of management of the watershed. The future without management or No Action scenario conditions serve as the basis for evaluating the effects of the alternative future scenarios.

The time scale of the twenty year period from 1995 till 2015 is the scope of the Management Plan for the Ugum Watershed. The general forecasting and assumptions of the projected future of the Ugum Watershed follow the current trends of population growth, increased land use development, increased demand for water, increased expansion of the unimproved roads, increased fire and increased agricultural use expected on Guam. The projected parameters for this project are based on the population growth and the land owners desire to develop their land in the Ugum Watershed. With the increase in total population for the island the pressure and need to develop this undeveloped watershed will be increasingly greater.

### ***Forecasting / Assumptions***

The EBAT planning team assumed certain development within the watershed based on the present zoning for land use in the watershed. It is assumed that in the next twenty years the "Planned Unit Development" called the "Dan Dan Estates and Country Club" will be constructed, and 80 to 200 hectares (200 to 500 acres) of land will be developed into "Agricultural Lots". The Dan Dan Estates project is a 213 hectare (522 acres) development including 54 holes of golf and supporting structures. Approximately a third of the 213 hectare development project falls within the Ugum Watershed boundaries. The location of this project is in the headwater area in the back of the Ugum Watershed, bordering the south side of the Ugum River and the Bolanos Conservation Reserve. The rest of this project development lies to the south of the Ugum Watershed in the Dan Dan area (see Figure 8). Under the Agricultural Lots zoning each one acre of agricultural land may have up to four residential houses built, with no requirement for roads, water, or other infrastructure under agricultural zoning. Due to the relatively isolated nature of the watershed and the present lack of road access the EBAT team assumed only the above development.

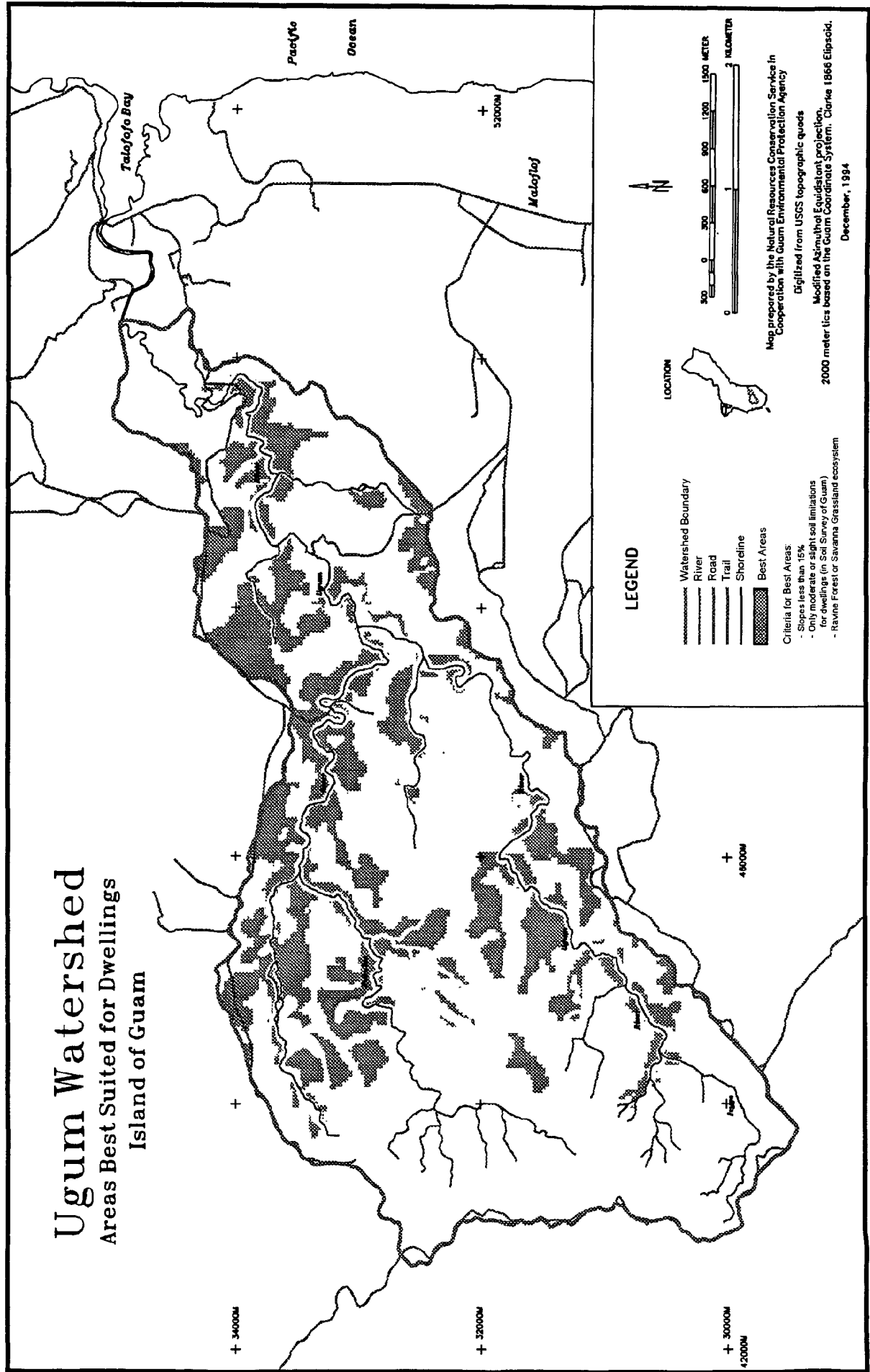


Figure 8. Areas best suited for dwellings within the Uguu Watershed, Guam.

## FORMULATION OF SCENARIOS

This stated level of development is not an endorsement for development in the watershed or a limitation on the development in the watershed. The actual level and nature of future development and natural resource use in the watershed may differ, and will be determined by the land owners and the regulatory agencies.

The demand on the surface water resources as a source of drinking water and for agricultural development use inside and outside the watershed will also increase. The kilometers of unimproved roads in the watershed is expected to double in the next twenty years, from more than 63 kilometers in 1993 to 140 in the year 2015. The increased access will add to the frequency of fires in the watershed, fires occur more often in areas where there is the highest frequency of off-road vehicular traffic. The fire frequency has historically been at an average rate of approximately 160 hectares per year, or if this is extrapolated out, the total savanna grassland (approximately 800 hectares) burns every five years. In the twenty year planning period all of the grassland is expected to burn four times.

### ***Methodology for Planning / Philosophy***

The methodology and philosophy for the planning applied the above facts and assumptions to four planning scenarios. The first scenario or No Action Scenario would be the result of the natural progression of the development of the watershed without planning. The second scenario or the Maintenance Scenario defines the minimum management level necessary to maintain ecosystem functions, water quality and the other natural resources at the present level while planning for the above stated development. The third scenario or Improvement Scenario builds on the second scenario, adding more conservation practices and focuses on improving the ecosystem functions and water quality where possible. The fourth scenario or Watershed Reserve scenario reflects maximum management of the watershed for preserving the ecosystems for a water resource into the future.

## VI. SCENARIO DESCRIPTIONS

This section describes, in general terms, the state of the watershed under the four various levels of management. Four proposed management scenarios were developed by the Ecosystem Based Assistance Team to be considered for the Ugum Watershed Management Plan. Each scenario takes into consideration the land use trends that may develop within the watershed over the 20 year planning period, from the date of this plan to the year 2015. The following are descriptions of the scenarios which cover the assumed overall development levels and the agricultural and housing placements, and the main resource problems of the overall water quality and quantity, the soil erosion, roads, fires, riparian buffers, and wildlife habitats defined under each scenario. The next section will review the scenarios effects on all the resources and compare the scenarios to each other.

### ***No Action Scenario***

The No Action Scenario or Future Without Scenario draws a picture of the estimated likely outcome of not implementing an organized management plan in the Ugum Watershed. The No Action Scenario assumes that existing island wide trends for development, resource use, the general overall management and land uses will continue unabated in the watershed into the future. Under this scenario there is no plan for mitigation measures and the watershed will continue to degrade at the present rate and accelerate as development occurs.

Under the No Action Scenario, there would be no unified governmental policy towards the management of the Ugum River Watershed. No additional environmental protections would be undertaken within the watershed. No mitigation recommendations will be offered under this scenario unless federal or Government of Guam laws are broken. Often, the government reaction will occur too late for the local ecosystems to benefit, and mitigation efforts may not be monitored. Riparian areas will suffer the most, since water is a limited resource in the watershed, and water access may be sought for each development effort independently.

It is important to note that the No Action Scenario does not mean that efforts to protect ecosystems such as wetlands will cease or that resources such as wildlife and water quality will receive less attention. It only assumes that a management plan will not generally guide land uses and land use practices. In the absence of a formal Watershed Management Plan it is hoped government agencies will create working relationships to address the minimal protection standards for drinking water quality, however government will play a largely regulatory role under this scenario in the watershed.

Without a watershed management plan, there will be no overall planning of any mitigation required of developers that are allowed to use and fill wetlands within the



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watershed. Nor will there be an overall plan for the maintenance of water quality within the watershed.

On the other hand, the No Action Scenario would not place any additional restrictions upon the owners of private lands within the watershed. They would be free to place their property into any currently conforming use that would maximize their economic benefits.

The outcome of this scenario is to minimize the cost of government intervention in island land use change and policy. This will encourage Guam's historical patterns of development to continue. It is assumed under this scenario that current public education efforts adequately prepare individuals for sound environmental decision making; that the water quality of the Ugum River is sufficient for current uses and will remain so indefinitely; and that there is no need to control wildfires in the Ugum Watershed or elsewhere on the island.

### **Development**

Without a watershed management plan, there will be no guidance for the government in the planning of infrastructure construction in the watershed. Roads, power lines and waterlines will be built as demanded by political and economic pressures without regard to the overall effect of the induced development upon the environment of the watershed. This may lead to the more sensitive areas of the watershed receiving more development or more intensive development than would be desired.

Under the No Action Scenario the housing / agricultural development of 200 hectares (500 acres) will be placed without consideration for the ecosystems and overall environmental effects. Under this scenario the land owners will build homes and place their agricultural lots where ever is most convenient without regard for the over all watershed or the water quality problems created. The outcome of this development maybe housing and agriculture along or near the rivers and streams, and in areas of steep slopes. The present zoning of most of the watershed, "Agriculture One", allows for up to four houses per acre without infrastructure. The 200 hectares developed may result in 20,000 houses in the watershed possibly without sewer lines, improved roads, power or water. Agricultural development that will accompany the housing development will be implemented with only present levels of restrictions or controls. This is limited to voluntary cooperation of individual land owners for the implementation of the conservation practices on agricultural and other lands.

### **Resort Development**

It is assumed that the "Dan Dan Estates and Country Club" resort development will be installed in the back of the watershed as planned some time in the next twenty years. The golf courses may be constructed next to or near the Upper Ugum River.

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### **Water Quality and Quantity**

The No Action scenario conditions would potentially decrease the overall quality and quantity of water in the streams and rivers. The coastal waters and reefs may also be impacted by greater amounts of sedimentation from the Ugum River due to the increased erosion in the watershed. Under these conditions in the watershed the usefulness of the Ugum River as a drinking water source would be greatly diminished.

### **Soil Erosion / Sedimentation**

The level of soil erosion in the watershed would continue to increase with the new uncontrolled development, increased unimproved road surface and increase fires frequency and area burnt.

Without a watershed management plan, there would be no response to increased recreational pressures on the watershed. It should be expected that recreational use of the watershed would greatly increase over the next twenty years. This would lead to an increase in the frequency and size of grass fires and an increase in the rate of conversion of savanna grasslands to badlands, of ravine forests to savanna grasslands and an increase in the sediment loading current upon wetlands and streams. Increased recreational use of the watershed would lead to an increase in the number and mileage of unplanned jeep trails in the watershed. Both the grass fires and the jeep trails will lead to higher rates of soil erosion within the watershed and a loss of wetland functionality.

### **Roads**

The total unimproved road miles within the watershed will at least double at current construction standards based on the previous eighteen year expansion of roads already documented. The current unimproved road construction has no road surface finishing, or drainage, and are placement is without regard for slope or grade causing erosion damage.

### **Fires**

The estimated fire frequency under the No Action scenario will increase by 25 percent in area burnt from the average historic 160 hectares (400 acres) per year to 200 hectares (500 acres) per year. The savanna grassland (777 hectares or 41 percent of watershed) would continue to be the main ecosystem effected, however the ravine forest (837 hectares or 44 percent of the watershed) would continue to be impacted by fire encroachment on the edge of the forest.

### **Riparian Buffers**

The riparian buffer zone (presently 159 hectares or 9 percent of the watershed) along the streams and rivers would be impacted by fire, agriculture, roads and development. The level of erosion in the watershed would increase and the sedimentation into the streams and rivers increase. With the decrease of area in ravine forest and riparian buffer strips the overall quantity and quality of the wildlife habitat would decrease further threatening the endangered and threatened wildlife species in the Ugum Watershed. The riparian

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areas will suffer misuse from development and agriculture over the next 20 years, the encroachment into these areas will damage the sediment and water filtering capabilities of these buffers.

### **Wildlife Habitat / Wetlands**

The wetland areas (presently 117 hectares or 6 percent of the watershed) would continue to be protected in the No Action scenario under the present regulations and permitting. The increases in fire frequency, increases in erosion rates and the decreases in ravine forest and riparian areas would have negative effects on the wildlife habitat and wetlands. The impact would be a reduction or damaging of the wildlife habitat and wetlands either through direct loss of vegetation or by increase sedimentation of the wetlands.

### ***Maintenance Scenario***

The Maintenance Scenario is a watershed management plan that aims to maintain the current levels of functionality of the watershed. The goal of the Maintenance Scenario is to preserve the functions and benefits of the ravine forest, riparian areas, and wetland ecosystems at existing levels, with no future loss in area or benefits. This is based on the assumptions that the development will include needed conservation and environmental protection measures aimed at maintaining watershed conditions and water quality at current levels.

Under this scenario, we recognize that though imperfect, the Ugum Watershed is functioning well at present and provides water of adequate quality to the citizens served by the Ugum River Treatment Plant. A program of continuous water quality monitoring in the lower Ugum River is necessary to fulfill the goal of maintaining the current standard as development begins. It is also recommended that developers be encouraged to monitor their own ground and surface water, so that problems can be pinpointed and solved quickly.

A no net change in resource qualities is planned, yet only limited retrofitting for existing problems will occur. This would mean that there be no increase in the rate of soil erosion over present rates. There would be no loss of functionality of the wetlands present in the watershed. There would be no decrease in the present utility of wildlife habitat in the watershed. And finally, there would be no decrease in the water quality of the rivers within the watershed.

### **Development**

The 200 hectares of housing / agricultural development would be installed in areas of the watershed which would have minimum impact on the ecosystem functions and overall health of the watershed under this scenario. The development would be concentrated in areas of lesser slope and easier access to diminish the possibility of erosion and degradation (see Figure 8). The figure, "Areas Best Suited for Dwellings", is based on land of less than or equal to 15% slope, soil types designated with slight to moderate

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limitations for building dwellings, and within the ravine forest or savanna grassland ecosystems, this avoids building dwellings in the more sensitive riparian areas and wetlands ecosystems. Most of the development over the next 20 years will probably be concentrated in the savanna grassland ecosystem, so we expect relatively minor changes in the functions performed by ravine forests. The ravine forest ecosystem is slated to remain static in area under the Maintenance Scenario. The objective of agriculture under this scenario is to promote sustainable agriculture through proper site location and adoption of conservation practices. Government of Guam, through the Soil and Water Conservation Districts, would actively support conservation planning on all agriculture lands within the watershed. Zoning and land use policy would limit agriculture activities to specific soils and slopes. A conservation plan would be required and practices designed to protect and enhance wildlife habitat would be encouraged. Generally agriculture fields would be located within the savanna grassland ecosystems on flat or only gentle slopes.

### **Agricultural**

The agricultural development under the Maintenance Scenario will include voluntary implementation of necessary conservation practices. The total area in agriculture will increase over present levels, however the impact to the watershed would not increase due to the mitigation of any erosion or negative effects. Conservation plans would consider the following practices:

- Streambank and shoreline protection (580)

- Tree planting (612)

- Water- and sediment control basin (638)

- Wildlife upland habitat management (645)

- Wildlife wetland habitat management (644)

### **Resort Development**

The “Dan Dan Estates and Country Club” resort development will be completed within the planning period. Under this scenario there would be no increase in negative impacts due to the construction or maintenance of this development. The final design, location and construction of the project will reflect the appropriate conservation practices and mitigation of impacts to maintain the ecosystem functions, and preserve water quality.

### **Water Quality and Quantity**

The water quality would be maintained at present levels through mitigation of all projects or effects which would affect the water quality. This would include mitigation of agricultural chemicals, non point source pollution from roads and construction sites, and sedimentation control.

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An educational program would be developed for land owners and farmers in the watershed to teach them the importance of protecting the water quality. Before construction permits are granted for any golf-courses or development in the watershed, a water quality management plan specific to the development should be in place.

Water availability will continue to be highly seasonal, as in the No Action Scenario, although may not worsen since Maintenance is the keyword here. Demand for the water supplied by the Ugum will increase, bringing pressure for short-term solutions.

### **Soil Erosion / Sedimentation**

This plan would identify practices that could be used to control both on and off-site erosion of farmland and other land uses. Erosion control and sediment plans are an integral part of any commercial or residential development and must be followed according to Guam law. These plans will prevent eroded soils from leaving the construction sites or farmland and will reduce off-site sedimentation problems and stream turbidity.

### **Roads**

The roads under the Maintenance Scenario would be maintained at present overall total length or impact on the watershed. There would be new or different roads constructed within the planning time, to accomplish the overall no change in road impact a plan would be needed. A plan to control and mitigate the unimproved roads in the watershed would be a part of the Maintenance Scenario. This would need to either limit the creation and location of new roads and / or control the amount of soil erosion from the actual mileage of unimproved roads within the watershed. The location of the roads would need to avoid flood plains, steep slopes and river valleys whenever possible.

### **Fires**

The fire frequency and location within the watershed would be controlled and maintained at no worse than present levels. This level of fire would allow for no more than the 160 hectares (400 acres) per year burnt as is the present yearly average. A fire control program would need to be implemented as a part of the plan. The fire control would be based upon maintaining the current frequency and distribution of fires to retain the four ecosystems and maintaining the current rate of soil erosion within the watershed.

A policy of curtailing expansion of the savanna grassland ecosystem within this scenario does not require fire eradication, but does involve intervention and control whenever the grassland fires encroach on human habitation or other ecosystems. The public education campaign, repeated during dry years, may cut fire frequency. However, the fire damage is expected to be remained at the same level, about 160 hectares per year burned each year within the watershed.

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### **Riparian Buffers**

The riparian buffers under the Maintenance Scenario will focus on maintaining the present level of functionality of these areas as critical wildlife habitat and protection for threatened and endangered species. The existing procedures by Government of Guam agencies include specifying a buffer strip of 3 to 8 meters along stream banks. The Ecosystem Based Assistance Team has designated larger riparian buffer strips to insure the integrity of the streams, the wildlife habitat and the sediment filtration function these areas serve. The riparian buffer strips on stream orders 2 and 3 are 15 meters on both sides of the stream, and stream orders 4 and 5 have buffers of 30 meters on each side of the streams (see Figure 5, the Ugum Watershed Ecosystems). To maintain the present level of riparian buffer strip benefits for the watershed all impacts to this area will need to be mitigated.

### **Wildlife Habitat / Wetlands**

The wetland component of a management for maintenance level watershed plan would focus on maintaining the water storage capacity of the wetlands in the short-run and maintaining the habitat functionality of the wetlands in the long-run. Wetlands are particularly valuable wildlife habitat, the watershed management plan may provide an extra level of protection for these areas.

Wildlife habitat is now described by ecologists, not only in terms of total area, but also according to its shape with respect to the landscape and its fragmentation.

### **Conclusion**

A maintenance level management plan will require at least: 1) a road management component, 2) a fire control and education plan, 3) an infrastructure plan, 4) a wetlands and wildlife habitat management component and 5) a water quality management component.

The approach within this scenario is one whereby agencies and landowners recognize ecological problems and processes and react to environmental degradation within the traditional bounds of their activities or program oversight.

### ***Improvement Scenario***

The Improvement Scenario for management of the Ugum Watershed is named for the goal of improving the ecosystem functions and minimizing the present problems in the watershed. This plan provides the next level of protection and the highest level of active participation for the owners and various agencies in the watershed management. This scenario adds to the management measures of the maintenance scenario.

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The primary differences between the maintenance and the improvement alternative scenarios is the focus on the minimizing and control of soil erosion, control of fires, protection of wetland functionality and improving wildlife habitat in the watershed.

The Improvement Scenario would allow for the implementation of a number of mandatory conservation practices and best management practices (BMP's) as well as impose restrictions for land uses. This scenario also would strongly encourage a number of conservation programs to be developed and implemented over the long term. Resource and land management entities would play a critical and often determining role in land use development and future policy making decisions. The watershed and all of the ecological-components would be systematically monitored and evaluated for preventative and remedial resource actions where resource agencies have clearly identified duties (roles) and real time response modes to address any significant issues. Selection of this management scenario would require that clients either direct the ultimate implementation of the scenario prescriptions or seek a lead agency to accept the primary stewardship role for watershed protection and conservation.

A necessary attribute of any plan to improve the different ecosystem functions in the watershed is that such a plan would have to be proactive instead of reactive in its approach. Under this scenario agencies and landowners would take aggressive actions to protect and enhance ecological processes within the watershed. Active steps would have to be undertaken in each of the primary areas of concern in order to improve the parameter of interest.

### **Development**

Development should be limited to areas with suitable soils and slope. A map of suitable areas for development based on soils and slope is shown in Figure 8. Erosion control and sedimentation plans must be developed and maintained for any construction activity.

The Government of Guam has some control over the majority of development in the watershed by controlling the pattern of infrastructure installation in the watershed. If a potential developer wants power, water, and telephone lines, then the government can use its control of these utilities to leverage the developer into conforming with the watershed management plan in place.

### **Agriculture**

Agricultural lands will be required to have a resource management system such as a conservation plan under this scenario. The use of buffer strips and filter strips around fields to catch sediment and run off would be strictly enforced. Confined animal facilities developed in the watershed would be required to have an approved waste utilization plan. This plan would include the proper handling, storage and application of waste. Agrochemical handling facilities would also be developed for each farm to provide proper storage and prevent accidental spillage of chemicals and fertilizers.

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A Farmstead Assessment System would be implemented to help farmers to recognize the potential for ground or surface water contamination on their farm. The program uses step-by-step worksheets that rank each farmstead activity or structure that could cause surface or ground water contamination. The assessment rates soils and geologic and hydrologic features of the farmstead to give an overall picture of potential and actual water quality problems.

### **Resort**

The "Dan Dan Estates and Country Club" resort development will be constructed with every consideration for the conservation of the watershed and preservation of the water quality. The developers will be responsible for developing and maintaining a conservation plan in order to not only minimize negative impacts of the construction but to improve on the present level of watershed problems. One possible beneficial impact of construction of this project could be the improvement and expansion of the riparian buffer zone in this very steep and sensitive area in the upper watershed.

### **Water Quality**

The water quality under this scenario is to be improved over present levels through mitigation of all projects and retrofitting to diminish the present erosion and sedimentation levels for improved water quality. This would include mitigation of all activities in the watershed including construction of all kinds, agriculture and the use agricultural chemicals, and road construction, repair and re-vegetation.

### **Soil Erosion / Sedimentation**

The Improvement Scenario would build on the practices identified in the Maintenance Scenario to control both on site and off site erosion and sedimentation, and lessen the present level of non point source pollution in the watershed. The erosion control and sediment control plans developed for all activities will need to be strictly adhere to and enforced. One possible means of obtaining a greater degree of protection of the watershed and diminishing the erosion is by governmental incentive programs offered to all those who input effective erosion control plans.

### **Roads**

Abandoned roads should be closed and future road development restricted as identified in Maintenance Scenario. In addition, new roads must be designed and approved prior to installation. GEPA would be the regulating agency. The designs must take into consideration the need for appropriate surface water drainage and the re-vegetating of disturbed areas.

One alternative for improving the number and placement of roads is to limit access or control access by the construction of improved roads. These could be designed so that they would not erode as badly as the present ad-hoc network. This would also provide access for constructing fire-breaks and for fire fighting equipment. This alternative would not be inexpensive.



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### **Fires**

Under the Improvement Scenario fire would be actively controlled. It is understood that total control of fires would be unlikely, therefore the planning level calls for a reduction in fires by 25 percent of the present level. The goal would be for only 121 hectares (300 acres) per year burnt instead of the 161 hectares (400 acres) per year at present. In the management of fires, an active effort to limit the number and scope of fires in the watershed would have to be undertaken. Access would be provided for appropriate fire protection. The construction of a network of improved roads would allow for more active fire fighting than is possible at present. It would involve constructing and maintaining access roads, constructing and maintaining fire-breaks and patrolling for fire prevention. These roads must be carefully located and meet the design criteria for the roads mentioned above. The need to restrict access to the roads is critical to prevent the encouragement of fires in remote areas and the development of spur roads for recreational purposes.

Since almost all of the fires are deliberately set, one approach might be to limit access into the watershed. This approach would also solve the problem of the increasing number of unimproved roads in the watershed. If adopted, it would be the least expensive method of decreasing the number of fires and the mileage of unimproved roads. The Government of Guam could accomplish this through a combination of direct action in the conservation reserve and a set of property tax incentives for the private land owners in the watershed.

Habitat loss from fires conversion of forest into grasslands would be minimized under a plan of limiting access into the watershed. Additional habitat could be created by planting the badlands on both government and private lands. The private landowners would likely be more cooperative if there were a cost sharing by the government.

### **Riparian Buffers**

Under the Improvement Scenario the establishment and maintenance of the riparian buffer strips would be very important. The riparian buffers strips of 15 meters on both sides of stream orders 2 and 3 in the upper watershed and 30 meters on either side of the stream orders 4 and 5 in the lower watershed are recommended. To establish maximum benefit from the riparian ecosystem the forest buffer will need to be reinforced and widened in areas.

### **Wildlife Habitat and Wetlands**

In addition to prevention of loss of wetland functionality in the watershed, the plan would require an improvement in the number and functioning of wetlands in the watershed. In all likelihood, this could only be achieved on private lands at the time that the owners sought permits to develop their properties. Otherwise, the deliberate creation of wetlands on private property would involve future restrictions on the owners' land use options that the owners would not likely allow.

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Wetlands could be created in the conservation preserve without worry about future land use concerns and options by the government. Creation of wetlands or planting the badlands in the conservation preserve would be a very expensive endeavor because of the inaccessibility of the area. Additionally, it would require the creation of access trails into the area. However, the expense could be paid for by establishing a plan where wetlands were to be created by developers who wanted to develop wetlands elsewhere on the island, but who had no available alternative site upon which to create mitigation wetlands.

### **Conclusion**

The combined effort of these practices, if implemented would effectively shelter existing ecosystems and enhance their processes and thereby maintain or improve existing water quality levels. The management of the different elements is critical. If one element is allowed to degrade several ecosystems within the watershed will be impacted.

The goals in this scenario are to: reduce the cost of ecosystem maintenance through elimination of redundancy and work scheduling conflicts; increase forest cover in the watershed; bring the entire public of Guam to a higher level of understanding of this most pristine watershed, and thereby reduce the public impact on its ecological functions; to provide a template for coordinated conservation projects, and assess their applicability in other, more degraded watersheds.

In this scenario, the Ugum Watershed is viewed as a potential model ecosystem against which watersheds across the island and throughout the Marianas can be compared. It is planned that subsets of the conservation measures could be exported to other areas, with better predictions for success. A clear hierarchy of functions and values for the entire watershed will be developed by consensus, one that the watershed's managers can consult as they contemplate the benefits of new activities.

Under this scenario, we recognize that the ecosystems represented within the watershed are not as healthy as they could be, that through coordinated efforts by many individuals and by effective use of funds, greater benefits can be derived from the watershed than are currently possible.

### ***Watershed Reserve***

The Watershed Reserve scenario is offered as a means for comparison to the other scenarios. The true benefit and cost of maintaining or improving the ecological quality of the watershed may be most clearly seen in comparison to the cost of total governmental control of the watershed.

The Watershed Reserve scenario would call for the purchase of all the private lands in the watershed by the Government of Guam, so the watershed may be controlled for producing water. There are 1329 hectares of privately owned land in the watershed. The

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estimated present value for unimproved land in southern Guam from between \$0.50 to \$6.00 per square meter. At these figures per square meter each hectare would cost between \$5,000.00 to \$60,000.00 dollars, the total 1329 hectares of private land would cost from \$6,645,000. to \$79,740,000. dollars. These figures are only a rough estimate, the true value depends on many factors such as the availability of utilities and infrastructure, and the land owners willingness to sell.

Under this scenario the land in the Ugum Watershed would be treated with the highest degree of non active management of all the scenarios. No development or land disturbance would be allowed. Controlled hunting and recreational use may be the only activities. No road access would limit the erosion from the roads and diminish the frequency of fire and the need to fight them. The Ugum Watershed may be managed as a park like area, allowing non destructive access in per determined areas such as on walking trails only.

The benefits to this approach to management of the watershed would be many, including the increase water quality, increase rate of low flow, decrease peck flows and an increase amount of water available for use. Increase in wildlife habitat, increase in wetland functions, increased in vegetative cover, decrease in the amount of erosion and sedimentation of the rivers and streams.

## VII. SCENARIO EFFECTS ON THE ECOSYSTEMS AND RESOURCES

### *Comparison of Scenarios*

This section describes the economic, environmental, and social effects of each alternative scenario. The focus is on those factors which have been determined in the scoping process as the major concerns and opportunities for the Ugum Watershed. The intent of this section is to provide the analytical basis for the comparisons of the scenarios. The resource and environmental concerns discussed at length below include the problems of soil erosion along with Table B, Soil Erosion Comparison of Scenarios, and fires in the watershed, and the opportunities of maintaining water quality and quantity, and the loss of wildlife habitat. In addition to these comparisons there is Table C, Summary and Comparison of Alternative Scenarios, which briefly addresses all of the high concerns identified in the scoping process.

### *Soil Erosion*

The soil erosion in the Ugum Watershed under present conditions and in each of the four possible scenarios taken into consideration in this management plan is summarized in the Table B, Soil Erosion - Comparison of Scenarios, below. In the table the hectares of each ecosystem and rates of erosion for each scenario are given.

### *Existing Conditions - Soil Erosion*

The existing condition of the soil erosion in the watershed have been discussed at length in the Watershed Problems and Opportunities section of this document. Soil erosion is a problem in the watershed in terms of the effect of diminishing water quality and lessening the potential productivity of the land. In general terms the majority of the present problem with soil erosion in the Ugum Watershed is isolated to a few specific human activities and types of vegetative cover.

The extensive study of the soil erosion in the watershed, compiled in the Ugum Watershed Resource Assessment, revealed that the savanna grassland, badlands, and unimproved roads have excessively high rates of erosion. The highest rate of erosion in the watershed comes from the sloped unimproved roads, at 729 tonnes per hectare per year. The rate of erosion from sloped and level roads taken together is approximately 448 tonnes per hectare per year. The total area covered with unimproved roads more than doubled in the last eighteen years in the watershed. Of the present human activity in the watershed, which is minimal, the creation and use of unimproved roads has the greatest impact in the creation of the soil erosion.

The second highest rate of erosion in the watershed is from the badlands, the rate of 544 tonnes per hectare per year make these critically eroded areas a major contributor to

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erosion. The greatest overall contributor to total erosion and sedimentation in the watershed is the savanna grassland. The grassland erodes at a lower rate than the other major sources, however it covers 41 % of the watershed and therefore contributes the majority of erosion in the watershed. Fire causes a temporary increase in savanna grassland erosion at a rate of 1.6 times the normal erosion from grassland each year.

### **Future Without - Scenario 1 - Soil Erosion**

The future without scenario infers minimal action and lack of public and governmental coordination, we would expect the soil resource to degrade as development occurs. Clearing for road construction, road design, water withdrawals for irrigation and riparian area usage will all be determined by developers as dictated by the needs and goals of their projects.

The future without a management plan will generally result in an increase in erosion rates and larger areas at higher erosion rates. As the agricultural and housing development occurs in a random manner there will be an increase in overall erosion in the watershed and greater sedimentation in the streams and rivers, as well as the coastal areas. It is assumed that the unimproved road areas will increase at the historic rate, and more than double in the next twenty years within the watershed. Also the rate of erosion of the roads will increase by 25 percent to 560 tonnes per hectare. The easier access into the watershed from the doubling of roads will increase the fire rate and area burnt by an estimated 25 percent (to 200 hectares) over this planning period. The erosion rate from fire will increase by 1.8 percent the rate of the savanna grassland erosion. The savanna grassland will increase in area an estimated 25 percent as the fires continue uncontrolled burning into the ravine forest and riparian areas.

The stream bank erosion will increase by approximately 10 percent over the present rate due to the increase in overall unimproved roads which will increase the number of stream crossings. Another possible effect of the increase in road access and off road vehicles traffic is the increase in erosion rate from the badland area (to 680 tonnes per hectare) which are often frequented by such vehicles.

### **Maintenance - Scenario 2 - Soil Erosion**

The problems of soil erosion and sedimentation of the water ways under the second scenario are to be maintained at present levels through the restriction of activities and development to areas which are most appropriate. In addition, the implementation of identified practices for conservation of soil in agriculture and construction of buildings and roads will be aimed at maintenance of the watershed at present levels of quality. The level of soil erosion will be maintained at present levels by mitigating any significant effect on site and off site caused by the agricultural development and the resort development in the watershed. The lands going into agricultural development and the resort development will come mostly from savanna grassland and to a lesser extent from ravine forest areas. Under this scenario the ravine forest area will decrease from the present hectares by a small amount (30 hectares). The savanna grassland will decrease

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from the present level by 250 hectares with this area being used for the agricultural development along with the 30 hectares from the ravine forest. All other ecosystems would stay the same in area.

Roads are expected to double under this scenario as under all the scenarios. The noteworthy difference is the use of road design and construction techniques to balance the increased road area with erosion control measures such as road gullies, road surfacing and road building along the contour. Other beneficial practices as putting the unused roads or the highly eroding roads away will decrease the total erosion from the roads. In this manner the increased total roads will not have an increased impact on the total erosion. The erosion rate on the roads is projected to remain the same as present at approximately 448 tonnes per hectare. All effects will be mitigated to the present level of total erosion and sedimentation in the watershed.

### **Improvement - Scenario 3 - Soil Erosion**

The improvement scenario will decrease the erosion and sedimentation due to a high level of active management and mitigation for all negative impacts in the watershed. Under the improvement scenario the area in the ravine forest ecosystem will increase by 81 hectares over the present even with the planned implementation of the agricultural / development. The agricultural / development will be constructed in the areas best suited for dwellings, see Figure 8, these areas correspond with fairly level land with soil suited for building. The savanna grassland area will decrease by 361 hectares from the present to 416 hectares in grassland, this will be accomplished by the conversion of grassland to agricultural use and revegetation of grassland to forested lands. The agricultural lands will produce less erosion per hectare, lowering the rate of erosion of this land to 33.6 tonnes per hectare by use of conservation practices and conservation plans. The erosion rate for roads will be lower by 25 percent from the present level, producing less total erosion by use of improved construction and mitigation. The badland erosion rate also will be lowered under this scenario by the improvement in the management of these critically eroding areas. The erosion rate for the badlands will be 25 percent less than at present, to a rate of 408 tonnes per hectare per year. The fire will also have a restricted impact under this scenario due to the increase in active management of the fires and public education campaign. The area burnt will be less by 25 percent less (only 121 hectares per year).

### **Reserve - Scenario 4 - Soil Erosion**

The reserve scenario will have an overall decrease in erosion due to the restricted use and land disturbance in the watershed. The restricted access into the watershed under this scenario will diminish expansion the roads and hold the total roads to approximately the present level. The restricted access will help control the number of fires and total area burnt. The ravine forest will begin the process of expansion into the savanna grassland, the area in ravine forest will increase to approximately 916 hectares, while the savanna grassland will decrease in area to 696 hectares. The development would not be allowed

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under this scenario, there will be a great decrease in erosion with the lack of development.

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**TABLE B - SOIL EROSION - COMPARISON OF SCENARIOS**

**Ecosystem or land type by area and erosion rate per scenario.**

		<b>Present</b>	<b>Scen. 1</b>	<b>Scen. 2</b>	<b>Scen. 3</b>	<b>Scen. 4</b>
<b>Ravine Forest</b>	Hectares	837	707	807	918	918
	Erosion	26.8	26.8	26.8	26.8	26.8
<b>Savanna Grassland</b>	Hectares	777	627	527	416	696
	Erosion	71.7	71.7	71.7	71.7	71.7
<b>Riparian Ecosystem</b>	Hectares	159	159	159	159	159
	Erosion	26.8	26.8	26.8	26.8	26.8
<b>Wetlands Ecosystem</b>	Hectares	117	117	117	117	117
	Erosion	0	0	0	0	0
<b>Agriculture/ Developmt</b>	Hectares	20	280	280	280	0
	Erosion	44.8	143	44.8	33.6	0
<b>Roads</b>	Hectares	19	38	38	38	19
	Erosion	448	560	448	336	336
<b>Badlands in SG area</b>	Hectares	44	44	44	44	44
	Erosion	544	680	571	408	436
<b>Fire in SG area</b>	Hectares	161	200	161	121	80
	Change in Rate of SG Erosion	1.6 times	1.8 times	1.6 times	1.4 times	1.3 times
<b>Streams in Wetland Ecosystem</b>	Kilometers	37	37	37	37	37
	Erosion (28 T/Km)	1036	1139	1036	1036	1036
<b>Total Erosion</b>	Tonnes / Year	150,210	196,508	142,074	111,785	120,342
<b>Total Sediment</b>	Tonnes / Year	69,847	91,376	66,064	51,980	55,959

Note; Ecosystems as defined in Figure 5, with areas in hectares and erosion rates in metric Tonnes / Hectare / Year. The total watershed area is 1890 hectares. The badlands areas are mapped as part of the savanna grassland ecosystem, the area effected by fire is part of the savanna grassland and is shown in rate change per area burnt of the savanna grassland, and the stream areas are included in the wetland ecosystem.



### **Fire**

The effects of fire in the Ugum Watershed under the existing conditions and in each of the four possible scenarios for this management plan is summarized below. In general, fire poses one of the greatest threats to the long term maintenance of the bio-diversity and the ecosystems within the Ugum Watershed. The habitat destruction from fire is not only a problem for the plant and animal species which may parish, but also a large contributor to the water quality problems due to the increases in erosion.

#### **Existing Conditions - Fire**

The existing conditions of fire in the watershed have been covered in the Watershed Problems and Opportunities section. Fire is a problem in the Ugum Watershed on many accounts. In most cases fire is intentionally set and therefore may be controlled or eliminated. Fire causes temporary loss of vegetative cover, this in turn causes soil erosion on the areas burnt, loss of wildlife habitat and potentially lessen the productivity of the land.

Loss of vegetative cover from fire establishes a cycle of savanna grass burning and regrowing. The fires limit species diversity to only those species which compete with the highly competitive sword grass under these conditions.

The loss of cover also leaves bare the soil which causes accelerated soil erosion and sedimentation. Approximately 160 hectares are burnt per year within the watershed. The rate of erosion has been determined to be approximately 1.6 times greater on burn areas compared to the normal average savanna grassland erosion. This accounts for more than 42 tonnes / hectare / year over the already high savanna grassland rate of 717 tonnes / hectare / year.

The loss of wildlife habitat due to fire impacts all of the ecosystems in the watershed. The savanna grassland is where the largest impacts are felt, but also the edge of the ravine forest and riparian areas are burnt. The wetlands are also impacted by fires near these sensitive areas by the change in vegetation cover and the increased sedimentation into the wetlands.

#### **Future Without - Scenario 1 - Fire**

The future without a management plan in the Ugum Watershed is likely to see the present trends continue and accelerate as the pressure on the watershed resources increase with population growth. Under this scenario, it is estimated that the area impacted by fire will increase as access from more unimproved roads increases and population pressure increases. Over the twenty year planning period an increase in fire frequency and area burnt is expected. The estimate of 200 hectares burnt every year for a total of all the savanna grassland burnt every four years. These fires would not just effect the grassland, but would increasingly expand the grassland into more fragile ecosystems. The fire would encroach into the ravine forest, riparian buffers and wetland areas. The results of the increase of fire will mean a decrease in wildlife habitat, increase in erosion

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by 1.8 times the savanna grassland rate, decrease in soil productivity and decrease in water quality over time.

### **Maintenance - Scenario 2 - Fire**

The maintenance scenario would have to balance the increasing tendency toward more fires by an educational program and fire control to maintain the present level of area burnt. The maintenance of the fire at present levels would result in 160 hectares burnt each year adding 1.6 times the present rate of erosion to the savanna grassland burnt. Under this scenario the effects of fire over the twenty year planning period would be counteracted by an ever increasing campaign to maintain the fires at the present levels.

### **Improvement - Scenario 3 - Fire**

The improvement scenario would entail an active campaign to minimize fire to a level lower than the present. It is recognized that fire would continue in the watershed due to the activities of hunters and others who may set fire intentionally. An estimate of 120 hectares will be burnt each year under this scenario, this is a decrease of about twenty five percent of the present level, and this will mean an increase of the savanna grassland erosion rate to only 1.4 times the present rate. A public education program to address the protection of the watershed and outline the problems caused by the fire will be necessary. A active fire protection and prevention plan should be implemented, this may include fire fighting, installation of living fire breaks, and the use of improved roads for access to burning areas for fire fighting.

### **Reserve - Scenario 4 - Fire**

The reserve scenario would minimize access into the watershed and thereby decrease fire to a rate of only 80 hectares burnt each year. The erosion rate increase would be 1.3 times that of the savanna grassland erosion. Under this scenario an active program of fire fighting and public education would be required. The objective of this scenario, of reserving the watershed for water quality and other natural resource protection, could only be obtained with the suppression of fire.

## ***Water Quality and Quantity***

The water quality and quantity in the Ugum Watershed under the existing conditions and in each of the four possible scenarios for the management plan are summarized briefly below. In general terms water is not presently considered a problem in the watershed but poses an opportunity for the resource agencies and landowners to maintain the quality and quantity of water in the watershed in the face of likely development and impacts of the future.

### **Existing Conditions**

The existing conditions of the water quality and quantity have been discussed at length in the project setting section of this document and in the Ugum Watershed Resource

## SCENARIO EFFECTS ON THE ECOSYSTEMS AND RESOURCES

Assessment (DeMeo, et al., 1995). The water quality meets the present standards excepts in the area of sediment which must be flocculated out at the Ugum Treatment Plant. There is little or no water quality problem in connection to excessive chemicals in the water due to either agricultural or naturally occurring chemicals. The level of agriculture is minimal in the watershed at present and the high cost of agrochemicals reduces the use and threat of these chemicals to water quality.

### **Future Without - Scenario 1 - Water Quality and Quantity**

The future of the water quality and water quantity in the Ugum Watershed can be projected to decrease as use of the watershed increase. Under the future without a management plan the lack of controls on use and prevention of contamination of the water will result in lower water quality and possible water quantity in the future. As development occurs without the use of sufficient erosion control the level of sedimentation of the water ways will increase. Furthermore, the possible wide spread construction of homes and other building would add to the flashiness of the runoff in times of heavy rains. The estimated outcome of this would be flooding and rapid runoff of waters lowering the permutation of the water into the soils.

### **Maintenance - Scenario 2 - Water Quality and Quantity**

Under the maintenance scenario the erosion and sedimentation controls necessary to maintain the present level of water quality and quantity would be incorporated into any project potentially effecting these resources. What this would mean for the future projects in the watershed would vary according to the nature and problems caused by the project. However under this scenario the managing agencies would create the mechanism necessary to implement erosion control and other pollutant controls as needed.

### **Improvement - Scenario 3 - Water Quality and Quantity**

The improvement scenario for water quality and quantity recognizes the potential for improving the water resources through proactive management in the watershed. Potential methods of improving water quality include the expansion of the riparian buffers around all water ways including rivers, streams, wetlands and head waters. Other practices which will improve water quality include the use of filter strips along agricultural fields and the planting of deep rooted trees over larger areas. The establishment of more water reserves in the form of wetlands, ponds or reservoirs would tend to feed the water more slowly through the ground and potentially increase the water quantity in low rainfall months.

### **Reserve - Scenario 4 - Water Quality and Quantity**

The reserve scenario would not actively change water quality or quantity in the watershed. The water resources would remain similar to the present level. The lack of development under this scenario and the park like management of the watershed would maintain the present conditions in the watershed.

### ***Fish and Wildlife Habitat Protection***

The fish and wildlife habitat under the present conditions and the four potential future management scenarios in the watershed are discussed below in general terms. The resources of the fish and wildlife habitat have not been thoroughly studied, though several past studies have been valuable and the present studies of species and habitat will add to the bank of knowledge, generally there are many assumptions on the species content and potential for threatened and endangered species in the watershed. Even with this understanding it is widely thought among both plant and wildlife specialist that the habitat does exist in the Ugum to provide for many threatened and endangered species in the watershed. The Ugum Watershed is presently in a fairly pristine state and posses one of the best potentials of maintaining the habitat and bio-diversity of species for southern Guam.

#### **Existing Conditions**

The existing conditions of the fish and wildlife habitat in the Ugum are fairly undisturbed. Many fresh water species exist in the clean waters of the Ugum river system, however, present studies are pointing to the possible changes in the species compassion. Likewise with the continual threat from introduces species both native plant and animal species are struggling to maintain their niches in the various ecosystems. Uncontrolled agriculture and other types of development pose a threat to these areas. The existing conditions allow for development or land use without regard for wildlife or habitat. In fact much of the off-road traffic is contributed to the illegal hunting of carabao and deer in the watershed.

#### **Future Without - Scenario 1 - Fish and Wildlife Habitat Protection**

The future without a management plan in the Ugum Watershed will see the continuation of the present trends of resource use and ever greater threat to the fish and wildlife habitat. The estimated gradual destruction the ravine forest and riparian areas can be expected without active planning and controls. Under this scenario the fish and wildlife habitat will be negatively impacted, resulting in a loss of habitat and possible species.

#### **Maintenance - Scenario 2 - Fish and Wildlife Habitat Protection**

The fish and wildlife habitat will be protected to some degree under the maintenance scenario. The effects on these habitats will be minimal due to the implementation of sufficient controls to maintain the wildlife habitat at present levels while allowing agricultural development in savanna grassland ecosystems where fewer impacts will be felt.

#### **Improvement - Scenario 3 - Fish and Wildlife Habitat Protection**

The improvement scenario will take a proactive approach to maintaining and improving the fish and wildlife habitat. Many conservation practices and proper planning will assist in the habitat protection while allowing for wise use of the agricultural and development lands in the watershed. An active campaign for the protection of the valuable fish and

## SCENARIO EFFECTS ON THE ECOSYSTEMS AND RESOURCES

wildlife habitats including wetlands will be needed in the watershed to achieve the goal of the improvement scenario.

### **Reserve - Scenario 4 - Fish and Wildlife Habitat Protection**

In the reserve scenario the fish and wildlife habitats will remain protected due to the lack of disturbance allowed in the watershed. It can be expected that the forest habitat will increase as the fires become less frequent with the restricted access into the watershed. Likewise the riparian and wetland areas would remain at present levels without the destruction that development may bring or the expansion that active conservation implementation would bring.

The following table (Table C) summarizes the general effects and comparisons expected under each scenario. The various ecosystems along with the major natural resource concerns, problems and opportunities are compared. Several of the planning and management measures are also listed for comparison.

# SCENARIO EFFECTS ON THE ECOSYSTEMS AND RESOURCES

**TABLE C - SUMMARY AND COMPARISON OF ALTERNATIVE SCENARIOS**  
**UGUM WATERSHED MANAGEMENT PLAN**

<b>Effects</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>	<b>Scenario 4</b>
<b>Cost</b>	None	Voluntary	Voluntary, local and federal programs, and incentive programs.	Gov. Guam 6 - 80 Million
<b>Ravine Forest Ecosystem</b>	707 hectares and less diversity	807 hectares and maintain diversity	918 hectares and improve diversity	918 hectares and maintain diversity
<b>Savanna Grassland Ecosystem</b>	627 hectares	527 hectares	416 hectares	696 hectares
<b>Riparian Buffer Ecosystem</b>	impacted by ag and development	159 hectares maintained	159 hectares improved	159 hectares
<b>Wetland/Stream Ecosystem</b>	impacted by fire and erosion	maintained at present levels	improved with protection	improve with less disturbance
<b>Soil Erosion</b>	196,508 Tonnes/Year	142,074 Tonnes/Year	111,785 Tonnes/Year	120,342 Tonnes/Year
<b>Sedimentation</b>	91,376 Tonnes/Year	66,064 Tonnes/Year	51,980 Tonnes/Year	55,959 Tonnes/Year
<b>Fires</b>	200 hectares	161 hectares	121 hectares	80 hectares
<b>Water Quality</b>	Adverse effect	No effect	Improve	No effect or improve
<b>Wildlife Habitat and Wetlands</b>	Negatively impacted	Maintained	Improved	Reserved, improved
<b>Roads</b>	140 kilometers, with no design or controls	140 kilometers, with minimal design	140 kilometers, with improved designed	63 kilometers, no new roads

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<b>Public Education</b>	none	Program for fire retention	Program for fire control and habitat protection, etc.	Program for fire control and habitat protection
<b>Measures</b>	None	Minimum land treatment	Land treatment	Land treatment
		Water quality monitoring	Pest and nutrient management	Revegetation of unused roads
		Minimum wetland and wildlife habitat protection	Waste management systems	Maintenance of trails
		Erosion and sediment control systems	Road surface and ditch stabilization	
			Erosion and sediment control systems	
			Riparian buffer management	
			Fire management	
			Water quality monitoring	
			Wetland and wildlife habitat protection	
<b>Agriculture and Development</b>	280 hectares, uncontrolled location, major impacts on all natural resources	280 hectares, limited to areas Best suited for Dwellings	280 hectares, limited to areas Best suited for Dwellings	Non allowed No effect
		Minimum impacts	Resource Management Systems	
			Conservation Plans	
			Farmstead Assessment System	

## SCENARIO EFFECTS ON THE ECOSYSTEMS AND RESOURCES

### ***Risk and Uncertainty***

Throughout the planning process the best available data was obtained and used in order to minimize risks and uncertainties. When risk and uncertainty occur the projected future and the cost and benefits may not be actualized as estimated. The major areas of risk and uncertainty with regard to the project are discussed below.

### **Projected Future**

The projected future of the conditions in the watershed are based on assumptions about the population growth and economic need for the development of the Ugum Watershed. The growth rate and pattern of development of the past twenty years on the island of Guam are the model used to project both the population pressures and the economic necessity to develop the watershed.

### **Assumptions**

The assumptions of the costs and benefits of the implementation of the various management plans are based on the best available data and information. Many years of research have produced the resource assessment and the conservation management techniques suggested in this report. The projection of the interaction and benefits of the conservation practices have been performed in other location but have yet to be demonstrated in the Ugum Watershed.



## VIII. RECOMMENDATIONS

The recommendations for the Ugum Watershed from the technical team the Ecosystem Based Assistance Team are general in nature. The Maintenance Scenario 2, and Improvement Scenario 3 are best suited for the goals of the sponsors and the landowners. Scenario 4, the Reserve Scenario, while maintaining watershed quality would remove control of the land from the present owners and cost the Government of Guam, this planned scenario is not recommended. The purposes of the watershed plan, to maintain water quality and watershed protection while maintaining productive agricultural land and opportunity for development, will be met under either scenario 2 or 3 to various degrees. The general recommendation follow the problems and concerns discussed in this watershed management plan.

The implementation of the management measures would insure continued water quality and maintain the ecosystems of the ravine forest, riparian buffer areas and wetlands that are fundamental to the health of the watershed.

The project will make the area a better place to live by improving health and safety, esthetics, and the economy. Properly constructed roads will improve traffic safety, last longer, and need less maintenance. Erosion control should increase productivity and incomes on farms, and decrease sedimentation of the water ways. Fire control and prevention will minimize the damage and promote productivity of the land and encourage the flourishing of wild plant and animal species. Water quality improvements will make water treatment less expensive and insure continued production of this important water supply for southern Guam. The proper development of the area will insure economic benefits to the land owners and the entire area while maintaining the valuable natural resources for future generations.

The general recommendations for management measures are followed by a related section on supporting programs for conservation planning and activities. The listing of possible funding and incentive programs which could be utilized to fund various activities or projects in the Ugum Watershed is given. And the regulatory framework which supports the watershed protection and enhancement activities are discussed in Appendix 1.

### ***Management Measures***

For each of the management plan scenarios, except the No Action scenario, the recommended management measures include both preventive mitigation and corrective mitigation measures. The intensity of the mitigation measures increase as the level of ecosystem protection increases. The following management measures support the intent of the Ugum Watershed Management Plan and are provided to assist land owners and agencies in the future decision making processes for the watershed.

## RECOMMENDATIONS

Owners Association - The implementation of the watershed protection and enhancement activities is strongly encouraged on a voluntary basis for all Ugum Watershed land owners. The association of the Ugum land owners for the coordination of the conservation and development activities would assist in the implementation of management measures and the securing of local and federal assistance. Cooperative agreements could be made with land owners, lease tenants, and responsible individuals with special interests in the Ugum Watershed. This management measure should be implemented either as an overlay to existing or new management measures or if nothing else is accomplished mutual assistance in protecting the more sensitive ecosystems and private property interests. Issues that could be addressed by a cooperative agreement include, notification of resource damage (protocol), a process to involve resource agencies in development planning, technical assistance for development design, wetland determinations, technical advise, and many others as needed. This management should be the basis for managing development and conservation activities in the watershed and all parties involved need to agree to the general guidance provided.

Conservation Plans - The implementation of soil and water conservation plans that reduce the loss of nutrients and fine soil particles will maintain and improve the soil resource base and associated productivity. Reduction in on farm erosion will increase farm productivity and decrease sedimentation of the water system. Erosion control for new development and construction projects should necessarily be strict. The long term conversion of badlands to savanna or forest ecosystems will provide positive impacts with regard to efforts to limit soil erosion and sedimentation.

Fire Protection - The enactment of an active fire fighting plan for fire retardation and prevention would reduce the erosion, help maintain water quality and protect wildlife habitat from destruction. A plan for fire prevention and active protection of the more sensitive areas should be considered for ravine forest, riparian areas and wetlands as well as development areas.

Roads - A master plan for roads in the Ugum Watershed for road development and maintenance would potentially lower the over-all erosion in the watershed. In as much as possible, a master plan for roads should guide road development away from steep slopes, rivers and wetlands. A road system that provides adequate access to various private lands in the watershed while minimizing the roads and jeep trails that represent a duplication of utility, will help guide development and reduce the current uncontrolled road and trail development in the watershed. Various roads that are poorly planned in that they cross rivers, streams and wetlands at multiple locations could be eliminated. Seldom used roads that only serve or encourage access to poachers should also be eliminated and restored to natural conditions. Any effort to reduce the sheer number of roads in the watershed should greatly contribute to erosion control.

Wildlife Habitat- Consideration for wildlife habitat within all the planning is highly recommended for the Ugum Watershed. The protection of wildlife habitat including

## RECOMMENDATIONS

ravine forest and riparian areas will result in the added protection for the native, endangered and threatened species. The riparian wetlands are important habitat areas for the maintenance of stream flows, water quality, stream water temperature regulation, the important leaf, woody debris, and other organic material for downstream productivity and habitat. Riparian habitat protection has developed substantially in other parts of the world as a field of study and unique ecosystem component providing benefits to both terrestrial and aquatic wildlife systems as well as for water quality maintenance. The protection of riparian areas and riparian wetlands in the Ugum Watershed will ensure that a natural buffer exists between upland activities and aquatic systems, including the ultimate fate of fresh water (quality) in the estuarine and marine environments. The regulatory mechanism for protecting riparian wetlands is already in place through the Federal Clean Water Act, however in those cases where riparian areas are not wetlands, the rules on buffers must be adopted through the mandates and authority of the Watershed Management Plan.

Monitoring - Long term monitoring of stream flows, water quality, sedimentation and potential pollutants should be implemented as early as possible in order to attain quality background data for future watershed assessments. In addition, qualitative and quantitative aspects of ecosystem and wildlife habitat health should be monitored.

Zoning - No unplanned zoning/land use changes for the watershed. All land use decision making efforts should include watershed protection and management concerns and constraints. The Ugum Watershed Management Plan should be formally presented to the Territorial Land Use Commission, Territorial Seashore Protection Commission, Chamorro Land Trust Commission, Territorial Planning Commission, the Guam Legislature, and the Governor. In addition, resource agencies such as the Department of Commerce must be made aware of the plan since they promote the research and development of potentially impacting aquaculture industries. It is very likely that several if not all of these land management entities will acknowledge the plan as vital to land use decision making including the wetland management and protection practices specified.

Public Education - One of the primary and proactive recommendations for watershed management and natural resources protection overall is public education about resource management and conservation. Conservation education should be a critical component of a larger public education and landowner education effort for the Ugum Watershed.

Education curriculum for conservation should be centered on ecosystem functions for water quality protection, habitat protection, flood control, economic benefits, etc. as well as the legal and economic consequences and costs of destroying (filling, dredging, clearing, polluting) wetlands and water ways and other natural resources. When landowners and the general public are aware of ecosystem functions that provide for a certain "quality of life" they will then begin to form personal and community values about the treatment, conservation and use of resources in the Ugum Watershed. Watershed management/protection concepts formalized with this plan will provide the broad based multiple use and functional benefit framework for understanding.

## RECOMMENDATIONS

Environmental Impact Statements - The Environmental Impact Statement (EIS) and Environmental Assessment (EA) are the basic planning tools for environmental land-use planning. EIS's are required by Guam Executive Order 90-10 and by the National Environmental Policy Act, 1969 (NEPA) for federal projects and expenditures. EIS's provide the basis for decisions, document the significant constraints to development and mitigation necessary to minimize environmental impacts. It is strongly recommended that an EIS be utilized for all major land use projects in the Ugum Watershed.

Low Impact Land Use - Low impact and compatible land uses in or adjacent to sensitive areas such as riparian areas and wetlands may provide viable development options if planned for and implemented considering the ecosystem sensitivities. Ecotourism may be promoted in Guam as a major marketing idea with the concept that tourism must be integrated with natural ecosystems for long term sustainable yield. Nature tours and wilderness appreciation are significant ingredients in the existing off-road touring enterprise, however the tours cannot be considered as compatible with resource protection due to unplanned and uncontrolled off-road impacts which are believed to cause significant erosion.

Golf Courses - Golf course development if planned appropriately and managed with environmental protection in mind could be considered a low impact use. Exceptions to this view are related to undesirable impacts of pesticide and fertilizer use, temporary construction impacts, and the loss of native forest and other resources. A golf course, in order to be considered compatible or as having low impact on resources would have to incorporate most the following design and operational features:

- be located almost entirely on existing badlands or savanna grasslands
- involve no loss of native wetlands or only minor modifications
- involve little if any irrigation from deep ground water and appropriate surface sources
- should be managed pesticide and fertilizer free
- constructed in small incremental phases to reduce construction impacts

Ecotourism - Ecotourism and what might be considered Ecogolf are just two examples of land uses that may feasibly be designed as compatible with sensitive ecosystems and other resource systems. Some level of development will eventually be realized in the watershed, therefore those uses that derive financial benefits to landowners yet only passively consume resources while applying sustainable use management concepts, or convert less desirable and stable ecosystems to stable ones should be emphasized.

## RECOMMENDATIONS

### ***Supporting Programs***

#### **Incentive Programs**

The development of specific tax and conservation incentives or an incentive package that addresses a variety of ecosystem protection and conservation programs should be explored fully. Land owners and developers would be encouraged to conserve resources if there were economic incentives to support the land use policies and regulations. Opportunities for protection legislation should also include similar legislative efforts to require a method of funding and compensating other affected parties.

The following programs include local and Federal sources which could or are being utilized to fund various activities or programs to improve or protect natural resources on Guam.

Agricultural Conservation Program offers cost sharing for soil, water and forestry practices of long term benefit. The USDA Natural Resources Conservation Service must approve the practice prior to funding, applications should be made to USDA Farm Service Agency. The Farm Service Agency will pay up to 65% of the cost of soil, water and forestry conservation practices to a \$3500 annual maximum.

Clean Water Act Nonpoint (319(h)) Source Grants are available from the Guam Environmental Protection Agency for nonpoint source management projects. Grants are awarded for projects that demonstrate new, innovative, or fundamentally different best management practices (BMPs) or other approaches to address nonpoint sources of pollution. Funds for educational activities and cost sharing for farmers and ranchers may also be provided.

Conservation Easements is provided for in Public Law 12-25, the Guam Land Conservation Act. In most cases conservation easements are proposed as a form of mitigation for environmental and natural resource impacts that occur as a result of development. The dedication of a Conservation Easement in many ways provides a legal and binding commitment to conserve land resources in exchange for otherwise undesirable environmental impacts.

Conservation Reserve Program is available for cost sharing for creating or improving permanent wildlife habitat, shallow water areas for wildlife, vegetative filter strips, or any other practice that benefits fish and wildlife. The US Fish and Wildlife Service can provide up to half the cost of practices which may result in little or no cash outlay for cooperators. The landowner match for the cost share can be provided in labor, materials or cash.

Guam Bureau of Planning operates the Guam Coastal Management Program which has section 6217 funding for nonpoint source pollution control projects.

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Guam Department of Agriculture has a revolving fund program for small loans to farmers and fisherman in support of these enterprises. The Division of Aquatic and Wildlife Resources advises on habitat and wetlands issues and species.

Guam Economic and Development Agency has a agricultural loan package available to land owners for development and support of agricultural projects.

Forest Stewardship Incentive Program is available from Guam Department of Agriculture, Division of Forestry and Soil Resources to private landowners with no more than 1000 acres of land with existing tree cover, or land suitable for growing such vegetation. Land owners must have an approved Forest Stewardship Plan. Ten practices have been approved for cost-sharing, including soil and water protection and improvement, riparian and wetland protection and improvement, fisheries and wildlife habitat enhancement, and rare, threatened and endangered species protection.

Property tax incentives may prove to be a viable method for relief from strict legal requirements which limit land uses in wetlands, and a valuable method for promoting conservation of riparian buffer areas. Special conditions must be incorporated in order to receive tax credits (reductions) that are only available if wetlands and other sensitive areas remain undisturbed and loss of credit if these areas are proposed to be damaged, permitted, or otherwise. In addition, the federal tax code allows for tax deductions when gifts of conservation lands are made to either private conservation groups or government agencies in the form of conservation easements or wildlife preserves (US EPA 1992).

Soil and Water Loans are available to qualified applicants who are unable to obtain sufficient credit elsewhere from USDA Farm Service Agency, at reasonable rates and terms. Loans and technical management assistance is available to farmers and ranchers for developing and conserving their land and water resources. Fund uses can include establishing approved forestry practices and building erosion control structures.

Watershed Loans are available to local watershed organizations from the USDA Rural Economic and Community Development agency in connection with the Natural Resources Conservation Service approval. The purpose of the loans are to carry out plans to protect, develop and utilize the land and water resources in small watersheds. Loans and advances are made only to finance the local share of costs of improvements in watershed projects approved under the Watershed Protection and Flood Prevention Act or in connection with the 11 watershed improvement programs authorized by the Flood Control Act of 1944.

Wetland Mitigation Banking involves the setting aside of wetland and upland areas for enhancement mitigation and resource protection in exchange for permitted impacts at other sites. The banking requires several key components; availability of land for conservation in perpetuity, an established exchange rate and mechanism (rules), and government assistance in the banking system. Resource managers find that banking offers benefits where substantial commitments are made in a protected environment to restore,

## RECOMMENDATIONS

enhance and provide for wildlife habitat. Large landowners in the Ugum Watershed might be interested in banking wetlands for profit and tax incentives.

Wetlands Reserve Program is a Natural Resources Conservation Service program for the purchase of easements from land owners with eligible agricultural land who voluntarily agree to restore and protect the wetlands. The protection functions include improvement of wildlife habitat, protection and improvement of water quality, and environmental education.

Existing incentive programs and regulatory controls provide the supporting framework for the protection of the natural resources in the Ugum Watershed, however the availability of programs and effectiveness of regulation maybe limited. The legal mechanisms are in place, but an enforcement and regulatory approach to management will not necessarily ensure proper planning and consideration for the natural resources and the ecosystems, instead public education and awareness, as well as planning assistance must be provided.

Best Management Practices that address project and site specific construction and operation environmental protection during development will directly and indirectly result in resource protection and reduced impacts. The management situation supported here is that when modifications are proposed, resource agencies are involved in the guidance and planning process, whereby the final outcome justifies minimal modification as the only practical alternative for sound development.

## **IX. CONSULTATION AND PUBLIC PARTICIPATION**

The purpose of this section is to document the opportunities provided for public participation throughout the process of the preparation of the management plan. During the process of the preparation of the Ugum Water Resource Assessment numerous local and federal experts and references were consulted, as well as land owners and farmers in the watershed. The State Historic Preservation Officer was consulted regarding cultural resources in the watershed, maps were generated but not included for the protection of these resources. The Guam Division of Aquatics and Wildlife was consulted regarding the threatened and endangered species in the watershed, a listing of potential species is provided in the Resource Assessment. The general public was informed and consulted in the two public meeting and numerous informational articles and displays about the project.

On the 17<sup>th</sup> of March 1994, the first public meeting was held at the Inarajan Community Center, with 21 people in attendance from both the public and private sector. The purpose was to introduce the project and determine public concerns in the watershed. A second public meeting was held on August 18<sup>th</sup>, 1994 at the Talofoto Elementary School, to report technical information and prioritize the public concerns (see Appendix B). A total of 13 participants attended the second meeting. The concerns and planning objectives were identified from returned scoping response sheets and the first public meeting. The list of concerns were prioritized with the "nominal group method" in the second public meeting, and placed in order of importance with seven major concerns for the areas resources defined (see Appendix A). Public notification of both meetings was made in the local newspaper, the Pacific Daily News (PDN), and all land owners were notified by written letter.

An Ugum Watershed Steering Committee has been formed among all sponsors and meets regularly to discuss project progress and to direct the decision making process. The Steering Committee is made up of the Southern Guam Soil and Water Conservation District, Guam Environmental Protection Agency, the Guam Bureau of Planning, Coastal Management Program and the United States Department of Agriculture, Natural Resources Conservation Service. The Steering Committee is expanding to include other interested agencies and individuals as the project grows.

The Ecosystem Based Assistance Team was formed among technical staff from the USDA Natural Resources Conservation Service (NRCS) in the Pacific Basin, USDA NRCS in Hawaii, Guam Environmental Protection Agency and the University Of Guam. This team provided the technical background information used as a bases of the management plan. The team was selected for the broad experience and expertise each member could bring to this project.



## CONSULTATION AND PUBLIC PARTICIPATION

This section will provide a summary and responses to significant written comments on this management plan

# LIST OF PREPARES

## LIST OF PREPARERS

Name	Present Position (years)	Education Degree-Subject	Previous Positions (years)	Other Qualifications
Dr. John W. Brown	UOG - Associate Professor Ag. Economics (6)	BS-Biology PhD-Economics	Sea Grant/National Marine Fishery (3)	
Jay B. Cobb	NRCS - Guam Conservation Engineer (3)	BS-Ag. Eng. MS-Civil Eng.	Ag. Eng. (6) Civil Eng. (3)	PE-Civil Eng. WY, GU
Robin A. DeMeo	NRCS - Guam Watershed Planner (2)	BS-Tropical Ag.	Nur. Manager (4) PC (2)	
Randel L. Sablan	GEPA - Planner (5)	BS-Forestry		Wetland Delin., EIA
Z. Reed Sims	NRCS - Guam Soil Scientist (9)	BA-Aquatic Biology BS-Fish & Wildlife Mgmt. MS-Soil Science	Fish & Wildlife Biologist (1)	
Robert W. Wescom	NRCS - Guam Forester (5)	BS-Natural Resources Mgmt. MS-Natural Resources - Forestry	Silviculturist (16)	Regis. Prof. Forester, Cert. Silviculturist
Robin White	NRCS - Hawaii Planning Geologist (3)	BS-Geology MS-Geoscience	Planning Geologist (7) Physl Sci Tech (1) Geophysical Tech/Supvr/Mgr(4)	RG - NC

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## APPENDIX - A

### UGUM WATERSHED PROJECT LIST OF PUBLIC CONCERNS

Prioritized at the second public meeting on August 18, 1994, held at the Talofoto Elementary School.  
Listed in order of rating, highest concern to lowest.

1. What activities in the watershed can have an adverse affect on drinking water quality? 34/7
2. What are the potential effects of using pesticides and fertilizers on environmental quality? 34/6
3. How can the water resources within the Ugum Watershed Project be protected? 22/4
4. How can agriculture remain an economically viable activity within the Ugum watershed? 21/4
5. What activities in the watershed can have an adverse affect on marine life and reefs? 18/5
6. What are the potential adverse effects of rapid development within the Ugum watershed to agricultural use. 17/5
7. What are the potential effects of the development of hotels, golf courses, and condominiums in the Ugum watershed? 16/4
8. How can the potential land use conflicts within the Ugum watershed be resolved? 15/4
9. What are the infrastructure development needs (roads, water, sewer, electrical, etc.) within the Ugum watershed? 14/4
10. Who has the water rights within the Ugum Watershed Project? 14/4
11. How can water pressure for domestic and agricultural use be maintained at acceptable levels? 14/3
12. How will the Ugum Watershed Project affect security of the water intake site at the Ugum PUAG site? 14/2
13. How can access to public lands within the Ugum watershed be enhanced? 10/2
14. How can coordination amongst government agencies be enhanced by the Ugum Watershed Project? 9/3
15. How can the adverse impacts of off-road vehicle use be minimized? 8/2
16. What commercial activities are suitable within the Ugum Watershed Project? 8/2
17. What activities in the watershed can result in soil erosion? 8/2
18. What is the potential for capturing excess water in the Ugum Watershed? 6/3
19. How can island beautification program be extended to the Ugum watershed? 5/2
20. What are the adverse effects of road building and grading within the Ugum watershed? 5/2

## APPENDIX - A

21. What special land use regulations are needed to protect the resource values of the Ugum watershed? 4/1
22. How can access to isolated parcels of private land be enhanced? 4/1
23. How does the Ugum Watershed Project relate to coastal water use planning? 4/1
24. What is the risk of Giardia being introduced to the drinking water derived from the Ugum watershed as a result of cattle grazing? 1/1
25. How can water for agriculture use be made available with minimum restrictions? 1/1
26. What factors in the watershed could lead to flooding? 1/1

The following public concerns were listed and voted for at previous public meetings or surveys, however did not receive any votes at this meeting.

How can illegal fishing and hunting be controlled within the watershed?

What activities in the watershed can have an adverse affect on recreation water quality?

How can the development activity and housing plan in the Dandan area be monitored under the Ugum Watershed Project?

How can road maintenance (grading) be completed with minimum EPA restrictions?

APPENDIX - B

UGUM WATERSHED PROJECT

PUBLIC MEETING MINUTES

TALOFOFO ELEMENTARY SCHOOL

AUGUST 18, 1994 7:00PM

- I. Mayor Vicente S. Taitague of Talofofo opened the meeting and welcomed the participants.
- II. Benny P. San Nicolas, Chairman of the Southern Guam Soil and Water Conservation District introduced all the speakers and reviewed the meetings agenda.
- III. Robin DeMeo, the Ugum Watershed Project Coordinator from the Pacific Basin office of the Soil Conservation Service spoke about the overall objective of the Ugum Watershed Project. The objective is to address non-point source pollution as a means to maintain quality drinking water and conservation of the natural resources in the area. An explanation of the responsibility of each participating agency was given, GEPA is providing financial support for Phase I, the Resource Assessment, the Coastal Management Program is providing partial funding for Phase II, the Management Plan, and the Soil Conservation Service is providing the technical expertise. Robin explained the purpose of the project is to preserve the valuable resources of the area through implementation of conservation practices for control of the nonpoint source pollution in the Ugum Watershed. The location of the Ugum Watershed is just south of the Talofofo Watershed, and includes both the Ugum River and the Bubulao Rivers and their tributaries, and stretches from the top of Mount Bolanos to the mouth of the Ugum River where it meets the Talofofo River. The Ugum Watershed is approximately 7.3 square miles or 4694 acres, with 23 miles of rivers and streams. The land ownership within the Ugum is about 1/3 government and the remainder is privately owned. The Resource Assessment, or Phase I of the Ugum Project is half completed, the ground surveys for determining the present state of the natural resources are finished. We are examining the general areas of; geology, soils, water quality and quantity, erosion and sedimentation, vegetation types, and wildlife, as well as present and past landuse.

## APPENDIX - B

The slides gave an overview of the watershed, potential problem areas, and solutions. Robin discussed the different vegetation types present in the watershed. The potential problem areas discussed were the badlands, road cuts and fire damage that showed signs of erosion and may contribute to the sediment load and water pollution. Robin suggested possibilities to control the erosion such as reforestation.

Questions were entertained from the participants. Rogue Aguon, of the PDN, a participant from the Talofofo area, discussed his experiences of seeing severe soil erosion that occurs within the Ugum area.

- III. Colleen Simpson, the Plant Material Specialist with the USDA Soil Conservation Service, explained some of the techniques with plant materials that may be used as solutions to control the soil erosion problem. Colleen explained the wattling techniques and the type of plant material that is used for wattling with the visual aid of the slide show. Then Colleen got into details on the actual installation of wattles with a live size wattle bundle to show the participants.

Questions regarding the funding of the labor to install the wattles were asked. Bob Wescom explained a little more on the sites and steps that the plant material would be concentrated on.

- IV. Mark Stacey, the Nonpoint Source Specialist with the Guam Coastal Management Program, explained nonpoint source pollution. The possibility of creating regulations that would minimize the contribution of nonpoint source pollution was discussed. Mark explained the importance of vegetating the area. Some of the pollution is endangering health and life, and that soil is itself a pollutant in fresh water and ocean water. He also touched on the lack of septic tank testing and the danger to ground water purity.
- V. Terry Kocsis, the GIS Specialist with the USDA Soil Conservation Service, explained the functions of the GIS Program using projectional pictures. She explained the data that is needed for the GIS Program. Terry explained the process and methods of using GIS. She also mention how and what type of data GIS could analyze. Terry presented computer generated maps that were done with GIS system. The maps showed the types of soils, vegetation and so forth that will be used for this project.



## APPENDIX - B

VI. Robert Wescom, Agroforester and Facilitator with the Pacific Basin Area USDA Soil Conservation Service, discussed his participation with the Ugum Watershed Project, and the Nominal Group Process of prioritizing the public concerns. He posted and explained 29 public concerns generated from the previous public meeting and a survey dealing with the Ugum Watershed that were generated over the last 9 months period. Bob then asked the participants to select the highest 7 of the 29 concerns which they hold as priority and to order them from highest to lowest concern. After the participants were done posting their priority concerns, Bob reviewed the total votes and prioritized the concerns by majority.

The meeting was closed with a few words from Benny San Nicolas and Robin DeMeo.

## APPENDIX - C REGULATORY FRAMEWORK

### Regulatory Framework

The following is a summary of the Guam and Federal laws relevant to comprehensive planning and environmental protection. This is not an inclusive list, but provides the structural foundation and framework from which watershed protection and conservation activities function.

Bureau of Planning, Public Law 12-200 as amended by P.L. 20-147

Created the Bureau of Planning as a staff agency of the office of the Governor and is responsible for developing plans, coordinating planning activities, and providing recommendations to the Governor.

Coastal Zone Management Act, U.S. Public Law 92-583, as amended by P.L. 94-370

The Guam Coastal Management Program (GCMP) carries out mandates and programs of its federal counterpart through Federal Consistency reviews, activities requiring federal permits and assistance. Much of the program is focused on coastal planning and protection through the programs, and enforceable development and resource policies.

Federal Water Pollution Control Act (commonly referred to as Clean Water Act), U.S. Public Law 92-500 as amended through 1992

The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Established broad and comprehensive rules, regulations, and authority for the protection, maintenance, and improvement of water quality for all waters of the United States and specifics actions (investigation, research, comprehensive programs, grants, etc.) necessary to address past, current and future water pollution prevention efforts by Federal and state government.

Guam Code Annotated Title 10, Chapter 45 Guam Environmental Protection Agency Act (P.L. 11-191)

Establishes the Guam Environmental Protection Agency, the purpose of which is to provide a united, integrated, and comprehensive program of environmental protection of land, water, and air resources for public health, safety and welfare of our island.

Guam Code Annotated Title 10, Chapter 46 Water Resources Conservation Act Requires the conservation and beneficial use of all surface and underground water resources, management of such resources to prevent over pumping, and the maintenance, operation modification, abandonment, destruction, and contamination of water wells (resources) as a result of extraction and establishment of all water resources as property of the people of Guam.

Guam Code Annotated Title 10, Chapter 47 Water Pollution Control Act

Requires that the government of Guam conserve, protect, maintain, and improve the quality and potability of public water supplies for the propagation of wildlife, fish and aquatic life, and for agricultural, industrial, recreational and other beneficial uses through the prevention, abatement and control of new or existing water pollution sources.

Guam Code Annotated Title 10, Chapter 53 Guam Safe Drinking Water Act Requires the protection of drinking water for public consumption in order to protect human health and safety to the greatest degree practical.

Guam Executive Order 90-13 Protection of Wetlands

Declares that the official, interim wetland map for Guam shall be the National wetlands Inventory map, US Fish and Wildlife Service, and that all government agencies shall utilizes the map in review of

## APPENDIX - C REGULATORY FRAMEWORK

physical development projects. The appropriate government agencies, including the Guam Environmental Protection Agency, Department of Agriculture, Bureau of Planning complete a study of wetlands, prepare public information, draft necessary legislation, rules and regulations or executive order for protection of wetland resources, including water quality and wildlife habitat.

### Public Law 20-147 Process for Comprehensive Development Planning in Guam

Section 1 R/R GC, Chapter II, Title LXV, Comprehensive Planning

Section 2 R/R GC Section 13200, Chapter III, Title XIV, Territorial Land Use Commission

Section 3 R/R GC, Chapter I, Title XLV, Section 48002(a), Territorial Land Use Commission

Requires the government of Guam, through existing and newly established planning authorities, to develop comprehensive land use plan(s) for the Territory of Guam and for the implementation, administration, and enforcement of such plans.

### Subdivision Law, Public Law 6-134 (21 GCA, Chapter 62)

Establishes certain minimum regulations and standards to control and regulate the development and / or subdivision of any land for any purpose whatsoever.

### Territorial Seashore Protection Act, Public Law 12-108, 1974

Declared that the Territorial Seashore Reserve is a distinct and valuable natural resource existing as a delicately balanced ecosystem; that the permanent protection of natural, scenic, and historical resources of the reserve is paramount. To this end the Act specifies that four (4) primary things must be accomplished: (1) study the seashore reserve to determine ecological planning principals to ensure conservation, (2) prepare a comprehensive and enforceable plan based on the study for long-range conservation, management, and development of the reserve, (3) to ensure interim development will be consistent with this law, (4) that the board of Directors, Territorial Seashore Protection Commission is mandated to implement the provisions of the law.

### Zoning Law of the Territory of Guam, Public Law 1-88, 1952 (21 GCA, Chapter 61)

Establishes certain minimum regulations for the protection of public safety, health and welfare whereby such regulations encourage the most appropriate use of land, open space, air, light and prevent undue concentration of population, and ensure adequate provisions for community services such as water, schools parks and other public requirements.

## TECHNICAL REPORTS

The following technical reports have been provided by the Ecosystem Based Assistance Team, the interagency interdisciplinary group of specialists. The Ecosystem Based Assistance Team included seven members; from NRCS Pacific Basin, Reed Sims (soils/geology/wildlife), Jay Cobb (engineering), Robert Wescom (forestry/vegetation/wildlife), and Robin DeMeo (planning/coordinator/writing); from Hawaii NRCS Robin White (hydrology); from GEPA Randy Sablan (wetlands); and Dr. John Brown (economics) with the University of Guam.

The reports are provided here for completeness, and to enable the process of finalizing this document. It is hoped that the detailed background information in these reports will assist in the process of editing and coming to consensus on the content and context of this document. The final draft of the Ugum Watershed Management Plan will include these technical reports depending on the comments in the technical review.

**ECONOMICS BACKGROUND TECHNICAL REPORT**  
**FOR THE**  
**UGAM RIVER WATERSHED MANAGEMENT PLAN**

June 2, 1995

Prepared by:  
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Prepared for:  
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## **1.0 Introduction:**

Guam is an island in the Western Pacific Ocean. It is approximately 6,100 kilometers west-southwest of Honolulu and 2,500 kilometers south-southeast of Tokyo. It has a population of 133,152 (US Bureau of the Census, 1990) living on a land mass of 549 square kilometers (NRCS, 1995).

The island is totally dependent on its own resources for fresh water as the distance to continental water sources precludes the economic importation of water. Generally, this is not a problem as the island receives an average of 2,486 mm of rain per year (NOAA, 1992). Fresh water is stored in a limestone based aquifer under the Northern half of the island and in the soils of the southern half of the island where it flows to the ocean as surface water. The only surface water impoundment is the Fena Valley Reservoir. The reservoir is located on the Maagas River which is a tributary of the Talofofo River.

The Northern water lens is the primary source of fresh water for the island. Its water is of very high quality, and the water is pumped directly into the distribution system needing only chlorination and fluoridation to render it suitable for public consumption. The ability to distribute water from the northern water lens without processing it, provides a very cheap water source for the island. Costs of the water are primarily associated with drilling the wells, pumping the water and building and maintaining the distribution system. Thus, the northern water lens has become the primary source of water for the northern and central population centers of the island.

There are two other primary, utilized alternative sources of fresh water on the island. The first alternative source is the Fena Valley Reservoir which supplies the west coast areas of Agat, Santa Rita and the Apra Harbor Naval Reservation. The second alternative source is the Ugam River which supplies the east and southern coastal regions from Ipan, Talofofo to Umatac.

The three sources of water, the northern water lens, the Fena Reservoir and the Ugam River define what are basically three separate water distribution systems. The systems are at best weakly connected and the current ability to transfer water from one system to another is greatly limited (Pers. comm., T. Johnson, PUAG).

There is no impoundment of the Ugam River, and its dry season flow is maintained by the limited rains during this period and by the natural water storage ability of the watershed. (Generally, the dry season is defined to be February to April with November to January and May to June being considered transition periods from and to the rainy season of August to October (see Figure 1)). During drought years, streamflow in the Ugam River has historically reached a minimum during the months of May through July (see Figure 2).

The Guam water authority, Public Utilities Agency of Guam (PUAG), has built a water treatment plant on the Ugam River. This plant was sized to produce a maximum of 4 million gallons per day (MGD) of water from the river. One condition of PUAG's permit for the Ugam River plant is the maintenance of a minimum streamflow of 2 cubic feet per second (CFS) (Pers. comm., T. Johnson, PUAG). PUAG's ability to extract water during drought years from the river will eventually be limited by its requirement to maintain the minimum streamflow.

## **2.0 Purpose:**

The purpose of this report is to provide economic background to a proposed management plan for the Ugam River Watershed. The management plan is to be written by the staff of the Natural Resources Conservation Service of the US Department of Agriculture under sponsorship of the Southern Guam Soil and Water Conservation District, the Guam Environmental Protection Agency and the Guam Bureau of Planning, Coastal Management Program.

## **3.0 Guam's Economy, Population and Water:**

This sections first reviews the development of Guam's economy and the rate of population growth on the island. It then uses these to examine the current water situation and to forecast the current water situation into the future.

### **3.1 Guam's Economy:**

Prior to the Second World War, Guam primarily had an agricultural based economy. There was a small military presence and a colonial government. In the nineteen thirties, Guam became a stop on the Pan American seaplane route to Asia. Most of the cash entering the economy came from the payrolls of the military and the colonial government and from exports of copra (Thompson, 1947).

The Japanese invasion in December 1941 brought an abrupt end to this period. From December 1941 to July 1944, the Island was under Japanese control. The US liberated the Island in July 1944 and used it as a staging base for the anticipated invasion of the Japanese mainland. The buildup for the planned invasion of the Japanese mainland resulted in two immediate actions effecting Guam. The first was the stationing of over 200,000 Allied troops on the island. The second was the appropriation of large areas of land on the island on which to base the troops and their equipment. With the dramatic increase in military activity, there was a drastic increase in the demand for local civilian labor. Almost any person who wanted a wage paying job on island could obtain employment. Concurrently, the loss of large areas of private land to the US military meant that for many farming was no longer a viable option. Thus, much of the local labor pool left the farms and entered the local wage economy.

After the end of the Second World War, Guam's strategic location meant that it continued to be an important outpost for the United States military. The colonial Naval Government continued, and the military continued to be the primary source of income for the island's economy (see Figure 3) along with US government aid. Government employment, both Federal and Territorial was the primary source of civilian employment. The creation of the civilian Government on Guam in 1950 as a result of the passage of the Organic Act added additional civilian employment to the economy.

In 1962, President Kennedy ended the military's control of civilian travel to and from the island. Tourism became a possibility, it and started to develop a few years latter (see Figure 4). Currently, Guam's economy is driven by tourism and it is the most important source of the island's outside income. The US military is the second most important source of outside income and it is a major source of employment. Non-military Federal expenditure also provides significant amounts of off-island income.

Investment from off-island is another important source of off-island income. Construction, often driven by outside investors is a highly variable component it tends be the most cyclical component of the economy (see Figure 5). Transportation and shipping are contribute to off-island income.

In December 1994, total island employment was 66,460. The private sector employed 46,100 persons or 69.4 percent of the filled jobs on-island. Government employed 20,360 persons or 30.6 percent of the filled jobs on-island. The breakdown of the public sector employment was: 6,930 persons in Federal Government employment and 13,430 persons in Territorial Government employment. The Government of Guam is by far the largest single employer on the island (Department of Labor, 1995).

Private sector employment was divided into eight categories. The largest private sector category is retail trade. It employed 12,930 persons or 19.4 percent of the island's payroll. The second largest category was services with an employment of 12,380 or 18.6 percent of the island's payroll. The service sector was dominated by hotel employment. The sixth largest category was wholesale trade. It employed 2,060 persons or 3.1 percent. Government, services, retail and wholesale trade together accounted for 71.8 percent of the island's payroll. Thus, the importance of government, including the military, tourism and trade are clearly evident.

The third largest category in the private sector was construction. In December, 1994, it provided employment for 8,820 persons or 13.3 percent of the jobs on-island. Construction is the most cyclical component of Guam's economy. Employment in the construction industry peaked in 1991 at 12,060 persons. At that time, it accounted for 18.2 percent of the island's employment. Many of the construction workers on Guam are H-2, temporary workers from Asia, but the economic activity generated by off-island investment and its associated construction activities plus military construction projects has strong influences on the overall boom and bust cycles on Guam.

The fourth largest category was transportation and public utilities with 4,980 jobs or 7.5 percent of payroll. This reflects Guam's active tourism trade and its role as a regional transportation center. The fifth largest category of private sector employment was finance, insurance and real estate with 2,760 persons employed or 4.1 percent of payroll. Manufacturing, primarily food preparation and printing, employed 1,910 persons or 2.9 percent of the island's payroll. Finally, the smallest component of the private sector was Agriculture. It employed 260 persons or about 0.4 percent of the island's jobs (Department of Labor, 1995).

### **3.2 Guam's Population Growth:**

Guam's population in 1990 was 133,152. The annual rate of growth over the last census interval (1980 to 1990) was 2.27 percent. This was up from a growth rate of 2.2 percent during the 1970 to 1980 census interval (Guam Business News, 1994).

If this trend rate of 2.27 percent per year is projected, the 1995 population is 145,660, and the population will reach 166,700 in the year 2000. The estimated population in 2015, the end of the projections for this report would be 233,400. These estimates are for the resident population of the island and do not include the transient, tourist population, on the island at any given time.

### **3.3 Guam's Water Situation:**

The vast majority of the island's population lives in the northern two-thirds of the island in the area serviced with water from the Northern Water Lens. The current estimate of the sustainable yield (from the Northern Guam Lens Study of 1982) of the Northern Water Lens is approximately 60 MGD. Because of the topology of the Northern Guam Water Lens, the wells must be spread in their geographical distribution, and it is impossible to fully utilize the full potential of the lens without a complete geographical distribution of the wells.

A large part of the Northern Water Lens lies under Anderson Air Force Base. In order to access the 17 MGD of the lens potential that lies under the base, PUAG would require the Air Force's permission to drill on its property. PUAG currently does not have this permission. There is currently an agreement between the Air Force and PUAG for PUAG to purchase water from the Air Force at a minimum rate of 250 gallons per minute (0.36 MGD). Thus, the actual quantity of water that PUAG currently has access to from the lens is 43 MGD, plus its purchases from the US Air Force.

Table 1. shows the total island-wide supply of water for Guam in 1989. A rough update of this table for 1995 would be and increase in PUAG's supply from drilled deep wells by approximately 2 MGD per year for the six years between 1989 and 1995. Plus, PUAG is currently obtaining about 2.1 MGD from the Ugam River diversion. Thus, PUAG's supply in 1995 is roughly 24 MGD from wells, 7 MGD purchased from the Navy, 2.2 MGD from surface water, 1 MGD from springs and 1.3 MGD purchased from the Air Force or roughly 36 MGD total.



Table 1. **Water supplies on Guam in 1989**

		Wells	Springs	Surface	Total
PUAG	18.33	0.71		0.07	19.11
US Air Force	5.19	---		---	5.19
US Navy		0.70	1.0		12.0
Private	2.82	---		---	2.82
Total		27.54	1.71		12.07
					41.32

Source: Water facilities master plan update. Barrett Consulting Group, 1992.

Table 2. **Projected Average Total Water Demand in Maximum Month**

Year	MGD	Year	MGD
1990	30	2005	81
1993	55	2010	88
2000	72	2015	95

Source: Water facilities master plan update. Barrett Consulting Group, 1992, extended to 2015 by the author.

Total water withdrawn from the Northern Water Lens might approximate 33 to 36 MGD in 1995. Additional wells have been drilled into the lens at a rate of about 2 MGD/year in recent years. If this trend continues, PUAG will be extracting roughly 34 MGD in the year 2000, and 44 MGD in the year 2005. Thus, It is an open question as to the ability of the Northern Water Lens to support the water needs of the island's population centers beyond the period from 2005 to 2010. Table 2 shows the most recent estimates of island-wide water demand that the author was able to obtain.

Sometime in the interval between 2000 and 2015 (most likely between 2005 and 2010 the exact estimate of timing depend on growth rates, estimates of the lens capacity and predictions of PUGA ability to reduce it the quantity of water lost from its distribution system), Guam will need to develop water supplies in addition to the Northern Water Lens.

Table 3. **Estimated alternative water source development costs**  
(1991 costs per 1,000 gallons of production)

	Interest & Amortization	Operation Maintenance & Replacement	Total
Deep drilled wells	0.25	0.24	0.49
Surface water diversion	1.88	0.40	2.28
Dam and reservoir	2.60	0.36	2.96

Source: Water facilities master plan update. Barrett Consulting Group, 1992.

Table 3 shows the estimates of costs for the two most likely (and least expensive) additional sources water supplies for the island, surface water diversions and surface water impoundments. These surface water sources only occur in the southern half of the island. The quantities of water that will be needed early in the twenty-first century basically preclude the use of surface water diversions, and thus the Government of Guam will be forced to build one and maybe two impoundments in the southern half of the island. The Ugam River is, in the author's opinion, the most likely site for such a dam to be built. The actual location will depend upon the availability of land for the site, the hydraulics of the system, the infrastructure costs and its placement in PUAG's distribution system among other factors. PUAG is currently studying its options among the different possible locations available (Pers. comm., S Khosrowpanah, WERI).

#### 4.0 Southern Water Supplies and the Ugam River:

The Talofofo River system is the largest potential source of water in the southern end of Guam. It is currently being utilized by both the Fena Valley Reservoir plant and Ugam River diversion water plant.

The Fena Valley Reservoir is being used at its dry season capacity and there has been a recent history of dry season water shortages in its service area. There is a project to add capacity to the current Fena water system, but this will be only a temporary measure in the long term goal of meeting the island's water needs.

The Ugam River Water Plant is being relied upon as the sole source of water for its distribution area, because of the present design of the PUAG distribution system. It is currently the primary source of water for the Ipan area of Talofofo Village, and all of Inarajan, Merizo and Umatac Villages. Also, there are short-term plans to expand the distribution of Ugam River water to include the Talofofo village center and areas along the Cross Island Highway towards Agat. This is being considered to relieve dry season pressure on the Fena Valley reservoir (Pers. comm., T. Johnson, PUAG). However, this relief is likely to be unreliable during those dry seasons when problems occur with the Fina Reservoir supply for the reasons already discussed.

The Ugam River water plant was designed as an intermittent water source that was not expected to be able to produce its full 4.0 MGD design capacity of water in drought years (see Figure 2). The permit for the Ugam River Plant requires a minimum dry season conservation stream flow of 2.0 CFS downstream of the diversion and allows for a maximum pumping of 7.0 CFS in the rainy season.

The historic minimum average monthly flow of the Ugam River was 3.2 CFS in May 1966 (NRCS, 1995). When the conservation flow of 2.0 CFS is subtracted from this, the remaining water legally available to PUAG would be 1.2 CFS or approximately 1 MGD. Even without the conservation flow, 3.2 CFS is only 2.0 MGD.

In order for PUAG to average 2.0 MGD per day of water withdrawal while allowing for a 2.0 CFS conservation flow over a month would require an average of 5.1 CFS of streamflow for the month. Table 4 shows the historic flows for the Ugam River as measured by a USGS gage near the present diversion dam. There are 18 years of

record displayed in the table. In 11 months occurring in 5 different years, the measured streamflow dropped below the 5.1 CFS required for PUAG to legally utilize the Ugam River Plant at a 2.0 MGD level.

The Ugam River Water Plant is currently being used as a sole source instead of the being used as the intermittent source that it was designed to be. This can lead to pressures upon PUAG to violate the minimum conservation streamflow of 2.0 CFS at the Ugam River diversion dam in order to maintain continuous water service to the areas supplied by the Ugam River Water Plant. These pressures can only increase as the area supplied by the plant are expanded.

#### **4.1 Water Demand in the Ugam River Plant's Current Service Area:**

Our estimate of the current demand for the water from the Ugam River is based on the population of the four villages that it serves (see Figure 6). The population of the four villages totaled 7,418 in 1990.

At a generous estimated household use rate of 150 gallons per person per day, the 1995 household water demand for the four villages currently serviced by the Ugam River Water Plant would be approximately 1.14 MGD. Water demand for governmental, commercial, and agricultural and irrigation uses might increase this to approximately 1.5 MGD or approximately 2.3 CFS of Ugam river flow. Total water demand in the four villages is then about 200 gallons per capita per day. Assuming that 30 percent of the water pumped into the distribution system is not delivered to the consumers, then approximately 2.1 MGD (3.25 CFS) will needed to be supplied by the Ugam River Plant. Estimates of current production by the Ugam River Plant is in the range of 2.1 to 2.2 MGD (Pers. comm., T. Gamboa, PUAG).

The population of Guam has previously been estimated to be 233,400 by the year 2015. The population in the four villages served by the Ugam River currently comprises about 5.6 per of the total population of the island. This has been decreasing by about 0.75 percentage points every 10 years over the past 30 years. Thus, an estimate of the population of the four villages in the year 2015 is 8,700.

The total water demand in the four villages would be approximately 1.74 MGD or approximately 2.7 CFS of river flow in the year 2015. If PUAG can improve it loss rate of its distribution system, then all of the projected growth in demand can be supplied from this recovered water and current river withdrawals would normally be sufficient to cover future, forecast demand from the four villages.

In summary, once the minimum downstream conservation flow required by PUAG's permit is taken into consideration, the estimated 1995 water demand of 1.5 MGD has already begun to push the limit of surplus water available from the Ugam River during a drought year dry season. The Ugam diversion should not be expected to be a fully reliable water source for the southern villages.

If the majority of water transmission losses are eliminated, then the Ugam River, normally, should be able to supply the majority of the needs of its current service area through the year 2015. It is not expected that the Ugam River diversion will be able to reliably supply areas other than its current service area in the future particularly during drought years. In order to reliably provide water to other parts of PUAG's distribution system, the Ugam River will need to be impounded. The most likely time-frame for this impoundment, if it occurs, is from 2005 to 2010.

#### **5.0 Economic Activities Associated with the Ugam River Watershed:**

Economic activities associated with the watershed are divided into two parts, current activities and projections about future activities.

These activities are and will continue to be controlled by the limited access into the Ugam River Watershed. Access from the north is via a dirt road off of Route 4A just north of Talofoto Village proper. This road is normally passable only by 4-wheel drive vehicles. It is blocked to casual access at the Talofoto River by a private landowner's gate. Access from the south is from Malojloj via the NASA Tracking Station Road and a dirt road

that leads to Talofofu Falls. Access from the east is via the Ugam River diversion road and access is limited by first the PUAG gate and then at the Ugam River by a private land owner's gate. This is the only paved road into the watershed and the only intrusion of electrical power lines into the watershed. There are no known PUAG water distribution lines entering the watershed. All other access into the watershed is by jeep trails.

There are no permanent residencies in the watershed. Construction in the watershed has so far been limited to the infrastructure required for the diversion dam and pumping station at the lowest part of the river, the road leading to Talofofu Falls and a few temporary farm sheds in the Babulao district.

### **5.1 Current Activities:**

The primary current benefit in terms of economic activities from the Ugam River Watershed is the provision of water for the four southern villages as discussed in the last section. Water is priced by PUAG in units of one thousand gallons. The PUAG retail water price is \$1.17 per unit. If PUAG is supplying 1.5 MGD of water from the Ugam River, the retail value of this water would be at most only \$640,000 per year. From Table 3, the cost of water from a river diversion was \$2.28 per 1,000 gallons at 1991 costs. If we value the water at what PUAG spent in obtaining it, the 2.1 MGD of water that the Ugam River Plant supplies is approximately \$1.75 million at 1991 costs, or at 1995 costs, the operating budget alone for the Ugam River Water Plant exceeds \$2 million per year (pers. comm., T. Gamboa, PUAG).

Tourism related activities are the second most important economic activity occurring in the Ugam River Watershed. There are three known tourist related enterprises that occur at least partially in the watershed. The Jungle River Cruise occurs primarily on the Talofofu River, but it enters the lower portion of the Ugam River during part of the trip. This tour normally carries between 70 to 100 passengers per day. An estimate of a mean number of passengers would be 80 (unnamed boat captain, pers. comm.). An estimate of the gross sales associated with this activity would be 28,800 passengers per year at a retail price of \$59.00 each or \$1.7 million per year.

The second most valuable tourist related activity is the jungle jeep tours operated by Safari Tours. The jungle tours occur primarily in the highlands between the Babulao River and the Saraasa River, but again a portion of the tour does occur in the Ugam River Watershed. The tour averages approximately 20 passengers per day. At a retail price of \$55.00 per passenger, the gross receipts from the tour would be \$400,000 per year (Manager, Safari Tours, pers. comm.).

The third most valuable tourist related activity occurs entirely within the watershed. It is visiting the Talofofu Waterfalls. An estimated 58 people per day or roughly 21,000 per year visit the attraction. The cost per visitor is \$4.00. Total admission receipts would be \$84,000 per year. Additional sales might approximate \$37,000 per year based on an average concession expenditure of \$1.75 per person.

The total retail value of tourist related activities occurring at least partially in the watershed would then approximate \$2.22 million per year.

Local recreational and harvesting activities in the watershed are important. Unfortunately, there is no method of quantifying the economic value associated with them for this report. The harvesting of a variety of plant materials would be included under the recreational activities heading. Among the items sought would be bettlenut, wild yams, coconuts, breadfruit, mangos, guavas, cycads, pandanus leaves and nuts, wild anonas, hot peppers, bamboo and piut. Much of the wild bettlenut harvested is sold. If an estimate of the quantities harvested could be made, the retail price has recently ranged for \$0.20 to \$0.50 per nut.

Hunting of both deer and wild pigs is another recreational activity in the uninhabited portions of the island. Harvesting freshwater shrimp is a popular activity in the upper portions of the rivers of Guam. Often this occurs in conjunction with swimming in the river. Fishing and crabbing also occurs in the lower portion of the Talofofu River below the confluence of the Ugam River. Two popular methods for valuing recreational hunting and fishing activities are the expenditure method and the travel cost method.

Off-road driving of 4-wheel drive vehicles is a popular activity in the Ugam River Watershed. With many of the other activities mentioned above, bettlenut gathering, hunting and shrimping, access is made into the watershed by 4-wheel drive vehicles. But, there is also a recreational activity of simply driving through the boonies in a jeep. Most frequently this activity occurs in the dry season, however there is a rainy season component where the primary purpose seems to be to test the vehicle against the mud.

Talofofo Bay is the mouth of the Talofofo River and it is where the water from the Ugam River reaches the sea. This bay is the most popular surfing location on the island. It is not unusual to see nearly 40 surfers in the water on a weekend afternoon during the dry season when the surf is up. A rough estimate of the average number of surfers was made by the author by counting the number of surfers each day on the way home from work during the latter part of this study. On average 8-10 surfers were observed. If the true daily count is twice this and the surfing season is 180 days long, then the bay is receiving approximately 3,000 visitor days from surfers. The bay is occasionally used by windsurfers and jetskiers. No estimates of their numbers can be made. Very little scuba diving occurs in the bay or in nearby waters because of the turbidity and the high dry season waves of the east coast. Finally, the author has seldom seen any salt water fishing occurring in the bay, although this activity does occur on the reef margins just north of the bay.

## **5.2 Future Activities:**

The primary factor guiding future activities in the Ugam Watershed will be the development of access and of infrastructure. Currently, access into the watershed is extremely limited as was discussed in section 5.0. This lack of infrastructure provides the Government of Guam with a method of controlling and guiding the future course of development in the watershed. Basically where there is access and infrastructure, development will follow.

This can be seen along the Ugam River diversion access road. The Government of Guam built a paved road from Route 4 at Talofofo Bay to the Ugam River diversion dam site, and an electric line was installed to power the pumps. A bridge was built over the diversion dam allowing access to the private lands on the other side of the river. There is now residential construction occurring along this road and some of these houses will become the first permanent residences in the watershed. This road may also provide the access needed to develop the lowest reaches of the watershed in the area most proximate to the pumping station.

This is also the most attractive part of the watershed for residential development in terms of having the shortest travel time to the population centers of the island. It seems reasonable to expect that this part of the watershed will be the first part developed as a residential area. This area contains largest areas of relatively flat floodplains in the watershed and may be particularly "ecologically sensitive" to development. Particular care should be taken in reviewing plans and guidelines for prospective development in this area of the watershed. Development in this area is likely to occur in the reasonably near future (within the next five years).

There is an approved Planned Unit Development (PUD), Dan Dan Estates and Country Club, sited on 213 hectares in the Dan Dan area of Inarajan. Approximately one-third of this PUD is located in the Ugam Watershed (NRCS, 1995). The potential construction of this project would have two effects. The first effect is the direct impact of the project upon the watershed. This would normally be well regulated as a part of the permitting process and it should be reasonably well controlled. The second impact of the project is that the construction of access roads and infrastructure for the project will open-up a part of the watershed to development that had been relatively inaccessible. It will also provide the 4-wheel drive vehicles greater recreational access to the upper parts of the watershed and in particular to the Government lands in the conservation district. The author considers it unlikely that construction of this PUD will begin in the short or intermediate term, but its existing approval does represent a loss of control of development in the watershed.

Earlier, it was predicted that the Government of Guam would construct a dam and impoundment on the Ugam River. This project will most likely be accessed from the Dan Dan area of Inarajan. Construction of the dam and water treatment plant will mean the construction of access roads and the installation of electric power lines into the watershed. The most like timing of the initiation of the project was considered to be the intermediate term

(2005 - 2010). The construction of this project could decrease the cost of bringing infrastructure to the Dan Dan Estates project, and thus, increase the probability of the Dan Dan Estates project being built. It will also open a new area of the watershed to the construction of residential housing.

The third access route into the watershed is the northern route. Although this is currently the second most actively used access, after Talofof Falls, it is in many ways likely to be the last route into the watershed to be developed with the infrastructure necessary for permanent residencies. The most likely near term development to occur using this route is the development of agricultural subdivisions and it is unlikely that many of these small farms will support residential structures. For the near and intermediate terms, the agricultural development that occurs in the northern part of the watershed will likely remain "day farms" where the farmer lives elsewhere and only occasionally stays overnight on the ranch, because of the current lack of infrastructure. In the long term, if the Government of Guam subsidizes the installation to the necessary infrastructure, then there will be some residential development in this area, but for the next 10 to 15 years, it is likely to remain a lightly used farming district.

Finally, as access improves into the watershed, there will be an increase in the recreational use of the area for hunting, fishing and gathering activities as well as for recreational 4-wheel vehicle activities. These activities are likely to spread into areas of the watershed that until now have seen very little use pressure.

#### **6.0 Current and Future Management Issues in the Watershed:**

The four southern villages are fortunate to have access to a water supply from a watershed in as pristine condition as the current Ugam River Watershed. There are currently minimum human activities occurring in the watershed and it is providing water of the highest possible quality.

The primary human activities affecting water quality are related to the recreational use of the watershed. There are two related problems with the current recreational pattern of use of the watershed. The first is that the use of off-road vehicles for access into the watershed is creating additional jeep trails at a rate that doubles their mileage every 20 years (NCRS, 1995). These jeep trails are being formed in an uncontrolled manner and their formation leads to higher rates of soil erosion in the watershed. Additional soil erosion is also created when recreational users of the watershed burn the grasslands for hunting and ease of access. The burning of the grasslands can have an additional effect of reducing the quantities of other more desirable ecosystems within the watershed. Both off-road vehicle use and grassfires can contribute to the formation of the badland areas that are prevalent in southern Guam.

Soil erosion creates or contributes to five problems in the watershed. The first of these is the loss of soil fertility. This problem is most acute on agricultural lands, but also, a second problem is created when the soil loss leads to loss of habitat from vegetation changes. The third problem with soil erosion is the loss of water storage capacity in the watershed. As the amount of topsoil diminishes in the watershed, there is simply less storage capacity available to provide dry season streamflow. The fourth and fifth problems arise from the physical entrainment of soil particles in the rivers of the watershed. The increased sediment load in the water creates additional water processing costs for PUAG at its treatment plant. Plus, the additional sediment load settles out of the water when the fresh river water enters the ocean. The siltation can diminish coral populations and lead to lower fish populations in the area effected by the silt.

In addition to directly leading to increased rates of soil erosion, grass fires can lead to habitat loss by converting savanna grasslands to badlands, and by converting ravine forests to grassland. These habitat changes will reduce the utility of the watershed for both wildlife and human use. They can also increase the rates of soil erosion and directly and indirectly decrease the water storage capacity of the watershed.

If the Ugam River Watershed could be maintained in its current state, then the vast majority of the watershed management issues could be solved by dealing with the recreational users of the area. However, uses of watershed will change with time and additional issues will arise in the future. Recreational use of the watershed will intensify. Residential construction will occur, and current farming efforts will expand. Most likely, PUAG

will construct a dam and impound the river. The installation of the infrastructure of the water project will accelerate the first three uses of the watershed and may encourage the construction of PUDs in the watershed.

Increased recreational use of the watershed will intensify current problems associated with grass fires and off-road vehicle use. No additional types of management issues should arise with intensified recreational use of the watershed.

Residential and PUD construction will introduce new management issues to the watershed. Primary among the concerns will be the disposal of human and animal waste, loss of habitat and possibly loss of wetlands or loss of their functionality, and road and site construction erosion. If residential construction occurs in flood prone area, then flood control will become an additional watershed management issue for the first time.

Currently, farming in the watershed is limited to about 14 hectares or 0.7 percent of the total area of the watershed. This is not enough land area to affect the watershed in any significant manner. Farming activities are likely to increase in the future. However, unless the nature of the farming activities changes from the cultivation of crops to moderate to large scale animal husbandry, either on land or as aquaculture, the scale of farming is likely to remain insignificant in the overall management of the watershed. Soil erosion from farmed areas would play a minor role in the overall sediment load in the rivers of the Ugam Watershed. Leaching of plant nutrients or biocides is not likely to significantly affect water quality.

Finally, construction of a PUAG water project will change the focus on the effect of soil erosion from one concentrating on damage to the coral reefs and their fish populations to a focus on the effect of sediment loads upon the usefully life of the impoundment and its water storage capacity. Construction of the impoundment also will diminish the importance of the water storage capacity of the soils and wetlands in the watershed for maintaining minimum streamflows for dry season water supplies.

## **7.0 Three Proposed Management Scenarios:**

The technical committee proposed three alternative levels of management to be considered for the Ugam Watershed Management Plan. The first of these was called the no action plan. The second was called the maintenance plan and the third was called the improvement plan. Each of these will be briefly reviewed.

### **7.1 The No Action Plan:**

The first alternative management plan for the Ugam River was called the No Action Plan (NAP). It basically stipulates that no watershed management plan specific to the Ugam River Watershed be adopted by the Government of Guam. This does not mean that there should be no environmental management exercised in the Ugam River Watershed, but rather that the environmental protections presently in place on Guam may be adequate to protect the functions of the watershed.

Under the NAP, there would be no unified governmental policy towards the management of the Ugam River Watershed. No additional environmental protections would be undertaken within the watershed. Without a watershed management plan, there would be no response to increased recreational pressures on the watershed. It should be expected that recreational use of the watershed would greatly increase over the next twenty years. This would lead to an increase in the frequency and size of grassfires and an increase in the rate of conversion of savanna grasslands to badlands, of ravine forests to savanna grasslands and an increase in the sediment loadings current upon wetlands. Increased recreational use of the watershed would lead to an increase in the number and mileage of unplanned jeep trails in the watershed. Both the grassfires and the jeep trails will lead to higher rates of soil erosion within the watershed and a loss of wetland functionality.

Without a watershed management plan, there will be no guidance for the government in the planning of infrastructure construction in the watershed. Roads, power lines and waterlines will be built as demanded by political and economic pressures without regard to the overall effect of the induced development upon the environment of the watershed. This may lead to the more sensitive areas of the watershed receiving more development or more intensive development than would be desired.

Without a watershed management plan, there will be no overall planning of any mitigation required of developers that are allowed to use of fill wetlands within the watershed. Nor will there be an overall plan for the maintenance of water quality within the watershed.

On the other hand, the NAP would not place any additional restrictions upon the owners of private lands within the watershed. They would be free to place their property into any currently conforming use that would maximize their economic benefits. It should be expected that any watershed management plan that the present land owners in the watershed see as placing undue or unreasonable burdens upon them will be strongly opposed in the political process of adjudicating the proposed plan.

## **7.2 Management for Maintenance of Current Levels of Watershed Functionality:**

The second alternative proposed by the technical committee was a watershed management plan that explicitly sought to maintain the current levels of functionality of the watershed. This was called the management for maintenance (MFM) plan. This would mean that there should be no increase in the rate of soil erosion. There should be no loss of functionality of the wetlands present in the watershed. There should be no decrease in the present utility of habitat in the watershed. And finally, there should be no decrease in the water quality of the rivers within the watershed.

The first element of a MFM plan would have to deal with controlling the impacts of recreational activities within the watershed. This would have to have two components. First, a fire control program would need to be implemented as a part of the plan. The target level of fire control would be based upon maintaining the current distribution of the four ecosystems within the watershed or it would be based upon maintaining the current rate of soil erosion within the watershed. The level would be set by whichever goal required the most fire control. The second element dealing with recreational impacts would be a jeep trail control/mitigation plan. It would need to either limit the creation of new jeep trails or limit the amount of soil erosion from the actual mileage of jeep trails created within the watershed.

The second element of a management for maintenance level watershed management plan would be an infrastructure installation master plan. It could be as simple as a requirement that any infrastructure installed or subsidized by the Government of Guam be placed on the ridgelines separating the river valleys. It would require that roads and electric lines avoid floodplains and river valleys whenever possible and that consideration of the effects of induced development be made when the PUAG dam and impoundment site is being planned.

The wetland component of a management for maintenance level watershed plan should focus on maintaining the water storage capacity of the wetlands in the short-run and maintaining the habitat functionality of the wetlands in the long-run. A set of guidelines as to where in the watershed the environmental planners are willing to allow wetlands to be impacted and where they are not willing to allow adverse impacts. The guideline should provide suggestions as to where mitigation or restoration efforts should be located, if such efforts are allowed in exchange for damage to wetlands in other parts of the watershed. Wetlands that are particularly valuable habitat should be delineated, and the watershed management plan should provide whatever extra level of protection that is possible to these areas.

Finally, the watershed management plan should have a water quality protection component. The primary reason for developing the Ugam River Watershed Management Plan is to protect the Ugam River as a source of safe drinking water for the people of Guam. Turbidity from soil erosion is only one component of water quality. When consideration is being given to drinking water standards, turbidity is only of minor importance as it is easily dealt with by modern water treatment plants. In water source management, the primary concern is the protection of the water source from contamination with toxic chemicals. These may come from many human activities. All activities except agriculture that use any form of toxic compound should be carefully evaluated before permits are granted to allow them into the watershed. Crop production and golf courses are already permitted or present in the watershed. A education program should be developed for farmers in the watershed to teach them the importance of protecting this particular body of water. Before construction permits are granted for any golf-



courses or PUDs in the watershed, a water quality management plan specific to the development should be in place.

Human and animal waste can introduce both infectious agents and nutrients into a water source. It is not likely that sanitary sewers will be installed as part of the watershed's infrastructure in the foreseeable future except as a part of the development of a large PUD. Small PUDs, individual residences and animal husbandry operations will require septic systems for the processing of their sanitary wastes. A necessary part of the water quality component will be specifications for septic systems and their siting within the watershed.

Thus, a maintenance level watershed management plan will require at least the following: 1.) a recreational impact component, 2.) an infrastructure plan, 3.) a wetlands management component and 4.) a water quality management component.

### **7.3 Management for Improvement of Current Levels of Watershed Functionality:**

The highest level of protection considered by the technical committee was called the management of improvement (MFI) alternative watershed management plan. The primary differences between the maintenance and the improvement alternatives focused on the control of soil erosion, control of grassfires, loss of wetland functionality and improving habitat in the watershed.

A necessary attribute of any plan to improve the different ecosystem functionalities in the watershed is that such a plan would have to be proactive instead of reactive in its approach. Active steps would have to be undertaken in each of the primary areas of concern in order to improve the parameter of interest.

In the management of grassfires, an active effort to limit the number and scope of grassfires in the watershed would have to be undertaken. Since almost all of the grassfires in uninhabited parts of southern Guam are deliberately set, one approach might be to limit access into the watershed. This approach would also solve the problem of the increasing number of jeep trails in the watershed. However, it would be politically unpopular and difficult to enforce on Government of Guam lands and nearly as unpopular and difficult to enforce on those private lands where there has been historic public access. If adopted, it would be the least expensive method of decreasing the number of grassfires and the mileage of jeep trails. The Government of Guam could accomplish this through a combination of direct action in its conservation reserve and a set of property tax incentives for the private land owners in the watershed.

An alternative to limiting access is controlling access by the construction of jeep trails. These could be designed so that they would not erode as badly as the present ad-hoc network. This would also provide access for constructing fire-breaks and for fire fighting equipment. This alternative would not be inexpensive. It would involve constructing and maintaining fire-breaks, constructing and maintaining access via jeep trails and patrolling for fire prevention and for enforcement of jeep trail use. Before this alternative could be initiated, the issue of easements into the watershed would have to be clarified.

In addition to prevention of loss of wetland functionality in the watershed, the MFI plan would require an improvement in the number and functioning of wetlands in the watershed. In all likelihood, this could only be achieved on private lands at the time that the owners sought permits to develop their properties. Otherwise, the deliberate creation of wetlands on private property would involve future restrictions on the owners' land use options that the owners would not likely allow.

Wetlands could be created in the conservation preserve without worry about future land use options, if the government were to choose to do so. Creation of wetlands or planting the badlands in the conservation preserve would be a very expensive endeavor because of the inaccessibility of the area. Additionally, it would require the creation of access trails into the area. However, the expense could be paid for by establishing a plan where

wetlands were to be created by developers who wanted to develop wetlands elsewhere on the island, but who had no available alternative site upon which to create mitigation wetlands.

Habitat loss from fires conversion of forest into grasslands would be minimized under a plan of limiting access into the watershed. Additional habitat could be created by planting the badlands on both government and private lands. As long as the plantings were not to be wetlands, the private landowners would likely be more cooperative if there were a cost sharing by the government.

Finally, if the MFI alternative were to be chosen, the Government of Guam can control the vast majority of development in the watershed by controlling the pattern of infrastructure installation in the watershed. If a potential developer wants power, water, and telephone lines, then the government can use its control of these utilities to leverage the developer into conforming with whatever watershed management plan that is in place.

### **8.0 Evaluating Changes in the Watershed:**

Changes in the watershed are most easily assigned an economic value when they can be linked to changes in an output of the watershed upon which society places a direct value. Any gain in fish harvests from decreased sediment loads on the coral reefs would have as a minimum value, the value of the fish in the market.

Similarly, if an acre of wetlands in the watershed retains an acre-foot of water from the rainy season and releases it as additional river flow in the dry season, and if this acre-foot of water allows PUAG avoid the cost of developing an alternative water source, then the economic benefit of the wetland as a water storage device would be the cost avoided over the planning period of the analysis.

In both cases, the information necessary to perform the analysis is not available. We do not know how the addition or subtraction of an acre of wetlands changes the dry season flow patterns in the watershed. Nor do we know how much a ton less of soil would increase the fish harvested from the waters of and surrounding Talofofo Bay.

The loss of soil fertility from agricultural lands can be valued by estimates of changes in the productive capacity of the soil. However, loss of fertility of un-farmed lands must be calculated by more indirect measures. One measure would be the amount that people willing to pay both to prevent the loss of habitat value from any induced vegetation changes and to preserve the value of the land as a potential agricultural area for future generations.

If the water treatment plant can deal with changes in water quality, then the cost of a decrease in water quality is the additional treatment costs to process it. Unavoidable decreases in water quality cannot be valued directly. Since decreases in water quality are not traded in a market, we need an indirect estimate of how much the consumers would have to be paid to leave them indifferent between the old, clean water and the new dirty water. Both indirect and direct measurement procedures have been developed in the economics literature. An excellent summary of these is provided in "The Benefits of Protecting Rural Water Quality: An Empirical Analysis" by Crutchfield et al. (1995).

If the services associated with a particular change in land use such as creating a wetland are jointly produced, as would be the water storage, flood control, prevention of soil erosion, and habitat services, then the social values associated with all of the services are additive. Additive valuation means that the failure to assess a value for any one of the multiple services rendered by the wetland would produce an under estimate of the benefits gain from creating or preserving the wetland. This would bias the valuation process, and in general, lead to less wetlands being created or preserved than would be socially desirable.

Overall there is no readily available information that would allow the estimation of the differences in benefits and costs between the three management plans. Some of the estimates could be made with a considerable expenditure of time and money. Once the plans are fully developed, then the first step would be to quantify the effects on each plan upon the parameters of interest. Once the changes in the parameter were specified, the evaluation

process could begin. However, the reality is that neither the time, money or information on the effects of the three plans is available.

## **9.0 Recommendations:**

The author realizes that his participation in the technical committee was solicited with the expectation that he would be able to provide some quantitative valuations that could be used to make choices between the different management options under consideration. In light of his failure to provide this information, he would like to offer some recommendations of an intuitive nature. They are based more on opinion and profession judgement than anything else. The recommendations are as follows:

### **1. Neither the management for improvement plan or the no action plan should be adapted.**

The watershed is providing water of excellent quality and any attempt to improve the quality is likely to prove overly expensive for the gains made. The Talofofo Bay system has been coping with high sediment loads in the rainy season for a long time. Additionally, sediment loading is not a major problem for the water treatment plant. However, a comprehensive management plan for the watershed is needed. It may not need a plan that allows for no degradation of any of the aspects of the watershed as the management for maintenance plan does, and no degradation may well be wishful thinking under any scenario for the future, but an overall watershed management plan should be put into place.

### **2. Explicit consideration should be given to possibility of a PUAG impoundment in any plan formulated.**

It is the author's opinion that a water storage impoundment will be built in the Ugam River watershed within the next twenty years. It should be a part of any watershed management plan put into place for the Ugam River Watershed.

### **3. The management plan should provide the Government of Guam clear guidance as to the installation of public infrastructure into the watershed.**

The pattern of public infrastructure that is built in the watershed will determine the pattern of development that occurs in the watershed for all but the very largest developments. Since the author feels that it is unlikely that any large scale PUDs will be built in the watershed in the near future, virtually all development in the watershed will be controlled by the availability of public utilities and roads.

### **4. Serious consideration should be given to limiting access by recreational off-road vehicles into the watershed.**

The possibility of providing the private land owners in the watershed with property tax breaks in exchange for their limiting (not eliminating) the use of recreational off-road vehicles on their property should be considered. The proliferation of fires and jeep trails would be eliminated at a minimum cost. If this program was voluntary, there would be no imposition upon the right of the involved land owners.

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**Figure Headings:**

Figure 1.

Mean monthly rainfall on Guam. Source: NOAA 1993.

Figure 2.

Ugam River streamflow as measured at USGS Gage 8550 from October 1952 to September 1970. The data from this gage was used because its location is closest to the current Ugam River Diversion. Median and minimum observations are shown along with lines for two levels of water extraction by the Ugam River Diversion. These lines include a 2 CFS downstream flow as required by the PUAG permit. Source: NRCS, 1995.

Figure 3.

Total, and active duty military workforce on Guam in the post WWII period. The overall percentage of the local workforce on active duty has been steadily decreasing since the Second World War. Source: Brooks, 1994.

Figure 4.

Total visitor arrivals on Guam and the number of hotel rooms on-island. The Growth of tourism and hotel rooms on Guam has been fairly steady over the past 23 years and it is expected to remain in a pattern of strong growth for the foreseeable future. Source: GVB, Various; Department of Commerce,. Various; Economic Development and Planning Division. 1994.

Figure 5.

Construction permits issued each year on Guam. The total value of all permits and the number of residential permits are shown. Source: Department of Commerce,. Various.

Figure 6.

The population of Guam has been growing steadily during the post-war period as can be seen from the overall population bars. However while the population in the four southern villages serviced by the Ugam River Water Plant also has been growing over the same period, it has not been growing at a rate equal to the overall growth rate of the island's population, and the proportion of the population living in these four villages has decreased since the 1960 census. Source: Bureau of the Census. 1991; Department of Commerce. Various.

## **Technical Report - Ugum Watershed Plan**

Ecologically-Based Assistance Team - Engineering Discipline

### **1.0 Watershed Resources and Values: Ecosystem Descriptions**

The purpose of this report is to identify those activities occurring within the Ugum Watershed, how they may change over time, and how they affect existing resources. To understand how different resources are impacted in the watershed requires a knowledge of its' physical characteristics and interaction with ecological systems.

#### **1.1 Ecosystem Descriptions**

The watershed is divided into four ecosystems which describe the organization and interactions of communities of living things with their environment. Each ecosystem is characterized by its own unique processes. The ecosystems for the Ugum Watershed are divided as follows: Ravine Forest, Savanna/Badlands, Wetlands, and Riparian Areas. "The Ravine Forest Ecosystem comprises areas with a predominance of woody perennial vegetation of low stature. Components of this ecosystem are found in both large contiguous blocks as well as isolated batches of forested areas. Understory vegetation is tolerant to low light microenvironmental conditions. This ecosystem occurs on all soil mapping units within the planning area, except Sasalaguan clay. The Ravine Forest Ecosystem is common along stream channels and all slope classes." Wescom

"The Savanna Grasslands Ecosystem comprises areas with a predominance of grasses and ferns. Inclusions of highly eroded barren areas that support little to no vegetation (bad-land complexes) are included in this ecosystem. This ecosystem occurs on all soil mapping units within the planning area, except Pulantat clay. Components of this ecosystem are found in both large contiguous blocks as well as isolated batches of grasslands. The Savanna Grasslands are common along ridgetops and all slope classes. Periodic wildfires maintain this ecosystem in a early successional state." Wescom

"The Riparian Ecosystem extends to either side of stream channels. As with other ecosystems, solar energy is the primary energy source to the ecosystem and the ecological processes within the riparian zone is similar to those described for the other ecosystems. Because the riparian ecosystem is located along the lower slopes, soils which have eroded from the upper slopes are intercepted by the physical presence of vegetation in the riparian zone. This results in an accumulation of soil in the riparian zone." Wescom

Wetland Ecosystem - "Those areas that are inundated by surface or ground water with frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, mangroves, natural ponds, surface springs, estuaries and similar such areas." Ref. ?

#### **1.2 Watershed Physical Characteristics**

There are several different watershed characteristics that must be identified and analyzed to determine the suitability of different materials for development and their susceptibility to degradation. The geology, soils, and hydrology of the watershed will be reviewed to provide baseline information for determining the impacts of existing and future activities in the watershed.

#### 1.2.1 Geology

The Ugum Watershed and the southern part of Guam in general consists of mountains and hills of dissected volcanic rocks. These rocks are highly weathered and relatively impermeable. The area is predominately underlaid by the Bolans pyroclastic member. The highest part of this watershed is Mount Bolanos at an elevation of 379 meters above mean sea level.

#### 1.2.2 Soils

The understanding of soils is necessary to determine appropriate land use. Foundations, crops grown, septic systems and road beds are all effected by underlying soils. A thorough knowledge of soil mechanics associated with land use practices is necessary to protect against soil failure. The USDA Soil Conservation Service has developed a Soil Survey of the Territory of Guam which provides important information on the physical and chemical characteristics of soils for the island. The soils identified in the Ugum Watershed are represented by the following Series: Agfayan, Akina, Atate, Inarajan, Pulantat, Sasalaguan, Togcha, and Ylig.

The **Agfayan, Akina,** and soils are located on ridgetops and sideslopes and are shallow and well drained. It was formed from residuum derived from marine deposits of tuffaceous sandstone. These soils are poorly suited to agricultural and urban use. The steepness of slope and erosional hazard are its main limiting features. Improperly designed roads are quickly eroded. Fires are also a problem for these soils as they expose it to the erosive effects of rainfall. Fires also increase the rate of runoff accelerating erosion.

The soils are located on valley bottoms and are deep soils that are poorly drained. These soils are clay throughout and are derived from volcanic material and marine sediment. This soil is suited for cropland, homesites, urban development and wetland wildlife habitat.

The soils are gently sloping to steep soils that are well drained, shallow and found on dissected plateaus and hills. This soil is made up of clays and silty clays throughout and is underlaid with limestone at a depth of 25 to 51 centimeters. Agriculture is limited by the shallow depth of the soil and its' steep slope. However, the soil may be appropriate for low density homesite development, recreational development, limited agriculture, and wildlife habitat.

soils are well drained and located on volcanic uplands. It is strongly acid to slightly acid and has a slow permeability. These soils are mainly used for subsistence and commercial farming. This soil is also poorly suited for homesite development due to its' high shrink swell potential.

The Togcha soils are usually found on the lower sides of slopes. They are silty clay soils that are very deep and well drained. The permeability is very slow to moderate. It is moderately well suited for subsistence farming, commercial farming, grazing, and homesites.

The Ylig soil is clay that is commonly found in valley bottoms and depressional areas. It is very deep and somewhat poorly drained with a moderately slow permeability. This soil is also moderately suited for subsistence farming, commercial farming and grazing. It is also poorly suited for homesite development because of its high shrink-swell potential and seasonally high watertable.

#### 1.2.3 Hydrology

The Ugum Watershed is located in Southern Guam and covers an area of approximately 11.8 square kilometers (7.33 square miles, 4691 acres). It is characterized by rolling hills and areas of very steep slopes. The Ugum Watershed has 37 kilometers of streams and rivers that spread from the mountains to sea level. DeMeo Ugum Resource Assessment

Surface water hydrology is the study of the distribution, properties and effects of water on the earth's surface. Several factors influence the hydrologic cycle and surface water flow. Water holding elements of this cycle include, but are not limited to the following: vegetation, land surface (slope), soil, atmosphere, streams, and aquifers. (Engineering Hydrology by Ponce, pp1-2). Changes in activities or land use in the Ugum Watershed has an effect on the timing and the amount of water that is released through the river system.

The USGS had one gaging station operating near the outlet of the Ugum Watershed. This gage, number 8850, was in operation from 1953 to 1970. The following frequency table using a Log Person Type III distribution was generated from this data:

#### PEAK FLOW RATES (CFS)

		Return	Period (years)		
2	5	10	25	50	100
436	707	935	1,285	1,598	1,959

Changes in peak flow rates may occur from increased activities in the Ugum Watershed. Surface water that is normally intercepted by vegetation and absorbed by the soil will quickly runoff should vegetation be removed. This could accelerate and increase surface water flows from precipitation events. Severe erosion could result from a combination of exposed soil and increased flow rates. Flooding may also become a potential problem from increased flows. Additionally, the loss of detention storage resulting from cleared land could reduce the volume of water in the Ugum River during dry periods.

### 2.0 Resources Consequences

This section will identify the various activities occurring in the watershed, the resource problems associated with those activities and estimate future impacts associated with expansion of these activities.

#### 2.1 Agriculture

It is estimated that approximately 25 to 40 hectares (ha) are being cleared per year for agriculture. Presently, the farm land is located in two areas. One is near the mouth of the Ugum River and the other is in the center of the watershed. Both of these areas are located in Ravine Forest Ecosystem.

The typical crops grown in the watershed include watermelon, bittermelon, cucumber, beans and eggplant. These crops are grown during the dry season and require irrigation. Typically a pump and pipeline system are used to uniformly distribute water over the fields. A drip line is used to apply irrigation water directly to the crops.

Problems associated with agriculture include clearing of land, irrigation, and chemical applications. Clearing large areas exposes soil to degradation from erosion. During high intensity precipitation events sheet and rill erosion can greatly reduce topsoil on farmed areas. Sloped areas have the greatest potential for erosion. Additionally, cleared areas reduce habitat for various species of wildlife. Presently, the number of acres cleared per year is minimal and has little impact on sediment loading to the Ugum River.



Approximately 1324 ha are zoned for agriculture development in the watershed. It is estimated that over a 20 year span between 250 and 500 homestead lots will be developed. It is assumed that only 50 percent of this area will be cleared and utilized for agriculture. This will increase the total acres in production from 40 ha to 662 ha. It is estimated that erosion on agricultural land may be increased by as much as 6000 tonnes.

Chemical applications by their very nature are a concern and will continue to be so as agricultural activities occur in the watershed. The amount and type of chemicals currently used to control weeds and pests and fertilize is minimal. If used properly, these chemicals pose little threat to the environment and may be used safely. No current problems have been identified in the watershed related to agricultural chemical use.

## 2.2 Recreation

There are several different recreational activities that take place in the Ugum Watershed. These include tourism, hunting, hiking, and recreational vehicle use.

Talofofo Falls relies on tourism and is the only commercial recreational area within the Ugum Watershed Boundary. It has a complete infrastructure including, a road, power, water, and septic waste disposal. Both the water and power are provided by the Government of Guam. The falls are located just below the confluence of the Bubulao and Ugum River.

Another commercial activity in the watershed is Safari Tours. This business transports tourists on a four wheel drive adventure through different ecosystems within the watershed. Often they make trails that are in poor locations, poorly drained, and not maintained. This has created severe erosion problems on many roads and ultimately led to their abandonment. These activities will only increase over time. The Safari Tours operation will continue to increase the number of roads in the watershed which will ultimately increase soil erosion and off-site effects of sedimentation.

The hunting of wild pigs and deer occurs throughout the watershed. This activity along with hiking are not directly detrimental to the physical environment but are responsible for the development of small jeep trails that are used for access to remote areas. These are often located in areas of severe slope and poor soils and are extremely susceptible to erosion since no provision is made to control surface water. If provisions are not made to limit the number of roads this activity will probably continue.

Talofofo Falls will see and increase in tourism but will not directly affect the resources in the watershed unless additional areas are cleared and the operation expanded. Indirect effects may be residential development activities that are not part of Talofofo Falls operation but benefit from its' infrastructure.

Another future activity that could materialize in the next 20 years is the development of the Dan Dan Resort and golf course. It is estimated that 152 acres of the Upper Ugum subwatershed will be developed. This will also increase future use by providing access and infrastructure for development.

Private recreational activities, all terrain vehicles, are and will continue to be a problem in the watershed. Typically, this activity is limited to the badlands where little or no vegetation exists. The constant use of vehicles in these areas creates roads or paths where water is quickly channelized. The concentrated flows erode surfaces to form gullies which continue to degrade and transport sediment to low lying areas. This affects water quality, turbidity, and ecosystem processes. As access is improved into these areas the use will increase prompting increased erosion.

## 2.3 Fires

Fires in the Ugum Watershed usually occur during the dry season from February to May. Nearly all the fires are intentionally set either out of carelessness or to facilitate hunting activities. These fires predominately occur in the Savana/Badland Ecosystem where climate conditions and fuel are favorable for burning.

Fires are responsible for removing vegetation from large areas and making them more susceptible to soil erosion. It may also affect the surface hydrology of the area by increasing surface runoff. This could in turn accelerate erosion of the exposed areas and deposit sediment in the Ugum River increasing turbidity levels. The future will probably not see an increase in fires but will also not see a decrease unless actions are taken to prevent or protect against them. The development of the area for residential or commercial purposes including agriculture will facilitate the need to protect against fires in the future.

## 2.4 Development

Developments can be divided into several areas including, resorts, residential, municipal, and roads. Resorts were covered in the section on recreation, and roads, due to their large impact, will be addressed in the following section.

Residential development is limited to only a few homesites located in the lower watershed. These have been developed only after the completion of the Public Utility Agency of Guam water treatment facility for the Ugum River. The installation of the treatment facility provided the infrastructure for the development of these homes. In the future, as infrastructure is expanded within the watershed, new home sites will be constructed.

There are several problems associated with home or residential construction that impact the watershed. These include: clearing of land, soil erosion, storm water management, and infrastructure development. The clearing of land, soil erosion, and storm water management are all closely related. Whenever home sites are selected and cleared for development it exposes the disturbed area to potential erosion and increases storm water runoff.

The influence of infrastructure is a more systemic problem that affects future development of the watershed and thereby indirectly affects the amount of erosion occurring. The construction of water and sewer lines may directly affect erosion rates if proper erosion control measures are not implemented during construction.

## 2.5 Roads

Roads are one of the major areas where active soil erosion is occurring. There are presently approximately 69 kilometers of roads in the Ugum Watershed. Of this total, approximately 32 kilometers are on level ground and 37 kilometers on sloping ground. DeMeo "Resource Assessment". The roads tend to transect each ecosystem in an effort to access remote areas for hunting or for recreational purposes. Few of the roads were installed to any type of standard and there has been little attempt to control surface water. All roads in the watershed except for the road leading to the entrance of the pump station for the water treatment facility have untreated road surfaces that cut through existing soil strata and may or may not have a base course of crushed coral.

The greatest problem associated with roads in the Ugum Watershed is erosion. Without proper water control roads are quickly eroded to the point they are not passable without grading. Often many of these roads are abandoned after the first year due to deep gullying. Another problem is with the displaced sediment from eroded roads that are deposited in streams and rivers. It causes increased turbidity in the rivers reducing water quality and increasing water treatment costs.

## 3.0 Summary

### Summary of Resource Problems

Description	Impacted Ecosystem	Savanna Badland	Riparian Areas	Wetland
Agriculture				
Clearing	X	X	X	
Erosion	X	X	X	X
Chemical	X	X	X	X
Use				
Development				
Erosion	X	X	X	X
Storm	X	X	X	X
Water Runoff				
Fires				
Control	X	X	X	
(access to)				
Erosion	X	X	X	X
Roads				
Erosion	X	X	X	X
Off Road				
Vehicle Use				
Erosion	X	X	X	X

#### 4.0 Recommended Mitigation Measures and Their Impacts

The following is a description of practices that may be used to correct or prevent the problems described above. It is important to realize that a particular practice may not be adequate in itself to solve a specific resource problem, but may require the implementation of an entire system of practices. Vegetation is also an integral part of most engineering practices involving erosion control and should be incorporated as part of a complete erosion control system.

##### 4.1 Erosion Control

Soil erosion and its impact to water quality are the greatest concerns for the Ugum Watershed. Accelerated water erosion from roads, development, agriculture and as a result of fires are the significant contributors. Several practices have been developed and may be implemented to control or prevent soil erosion from occurring. The following is a list of practices developed by the NRCS that may be used to address erosion concerns:

##### PRACTICE NAME

Access Roads  
Sediment Basin  
Diversion

Grade Stabilization Structure  
Land Grading  
Heavy-Use Area Treatment  
Grassed/lined Waterways  
Hillside Ditch  
Structure for Water Control  
Critical Area Planting  
Vegetative Filter strip  
Mulching  
Firebreak

It is important to recognize that no one practice will usually solve soil erosion problems but requires a combination of practices integrated into an overall management system.

Agricultural lands should have a Resource Management Plan developed that would help to identify resource concerns and possible preventive or corrective measures. The management plan would should show a landowner's property, existing and proposed activities, and would list future actions that are needed to protect his livelihood and the natural resources. If confined animal facilities are developed within the watershed they must have appropriate waste management systems that would also be integrated into the Resource Management Plan for the farm.

All other development needs an erosion control plan for preventing erosion both before and after construction. Components of the erosion control plan should include a description of the project, site plan, construction schedule, stormwater drainage system, temporary erosion and sedimentation control measures, permanent erosion and sedimentation control measures, and erosion and sedimentation facilities maintenance procedures. Guam Soil Erosion and Sedimentation Control Manual, GEPA, 1986.

#### 4.2 Roads

Roads require special consideration since they require more than just erosion control measures. Consideration needs to be given to slope, obstacles, grade, buffer strips, soils, drainage, stream crossings, seasonal construction limitations, and maintenance. Road Building Guide For Small Private Roads by Robert A. Dellberg. Proper designs, incorporating the considerations mentioned above, are needed to prevent serious erosion problems from occurring on existing or newly constructed roads.

The importance of road drainage can not be over stressed. Provisions must be made for appropriate road drainage with the water conveyed to a safe outlet. Many techniques have been developed for controlling water on roads and include outsloping, insloping, crowning, pipe culverts, dips, and open culverts.

#### 4.3 Chemical Use

Presently, there is very little chemical use in the watershed. This will change with increased agricultural activity and development. The need for proper application and storage of chemicals, as new agricultural land is brought into production, is critical to protecting surface waters. Agrichemical handling facilities may be used to properly store chemicals and to prevent accidental spillage. The Natural Resources Conservation Service can provide assistance in the design of these facilities.

### **5.0 SCENARIOS AND ECOSYSTEM MANAGEMENT: RECOMMENDED MITIGATION MEASURES**

#### 5.1 Scenario I: No Action

This scenario assumes that no mitigation measures will be installed and the watershed will continue to degrade at its present rate.

### 5.2 Scenario II: Maintenance, Current Zoning

Under this scenario current ecosystem functions will be maintained for existing water quality under current development trends.

Agricultural lands will be maintained by developing a Resource Management System Plan for each farm. This plan would identify practices that could be used to control both on and off-site erosion on farmland. A properly applied RMS (farm plan) will ensure the sustainability of the farm and reduce or prevent erosion from occurring. Filter or buffer strips should also be considered when farmed areas are near or adjacent to surface waters. A minimum buffer area of 30 meters should be used on 4th and 5th ordered streams in the lower watershed and 15 meters on 2nd and 3rd ordered streams in the upper watershed. This will help prevent the movement of any surface water chemicals, fertilizers or pesticides/herbicides, from entering the water systems. These practices will improve surface water quality by reducing stream turbidity and chemical contamination.

Erosion control and sediment plans are an integral part of any commercial or residential development and must be followed according to Guam law. These plans will prevent eroded soils from leaving the construction site and will reduce off-site sedimentation problems and stream turbidity problems.

Abandoned roads should be closed off and future road development curtailed by restricting access and working with local off-road vehicle groups to find more appropriate areas for their activities. If this can be accomplished a decrease in denuded areas should become evident over time as native vegetation is allowed reclaim those disturbed roads. The greatest benefit, however, will be the prevention of future road expansion which will greatly reduce soil erosion in the watershed and impacts to wetlands and river systems created by ford crossings and culverts.

The overall benefit from the implementation of these engineering practices would be the maintaining of existing ecological processes. Ugum River turbidity levels would be maintained along with existing identified wetlands.

### 5.3 Scenario III: Improve Ecosystem Functions to Improve Water Quality

Under this scenario agencies and landowners would take aggressive actions to protect and enhance ecological processes within the watershed.

Agricultural lands will be required to have a Resource Management System as described in Scenario I. The use of buffer strips and filter strips would be strictly enforced. The minimum criteria used above would also be applied. Confined animal facilities developed in the watershed would be required to have an approved waste utilization plan. This plan would include the proper handling, storage and application of waste. Agrichemical handling facilities would also be developed for each farm to provide proper storage and prevent accidental spillage of chemicals and fertilizers.

A Farmstead Assessment System would be implemented to help farmers to recognize the potential for ground or surface water contamination on their farm. The program uses step-by-step worksheets that rank each farmstead activity or structure that could cause surface or groundwater contamination. The assessment rates soils and geologic and hydrologic features of the farmstead to give an overall picture of potential and actual water quality problems.

Development should be limited to areas with suitable soils and slope. A map of suitable areas for development based on soils and slope is shown in Figure 1. Additionally, erosion control and sedimentation plans must be developed as identified above in Scenario II for any non agricultural construction activity.

Abandoned roads should be closed and future road development restricted as identified in Scenario II. In addition, new roads must be designed and approved prior to installation. GEPA would be the regulating agency. The designs must take into consideration the need for appropriate surface water drainage and the Re-vegetating of disturbed areas.

Access would be provided for appropriate fire protection. These roads must be carefully located and meet the design criteria for the roads mentioned above. The need to restrict access to the roads is critical to prevent the encouragement of fires in remote areas and the development of spur roads for recreational purposes.

The combined effort of these practices, if implemented would effectively shelter existing ecosystems and enhance their processes and thereby maintain or improve existing water quality levels. The management of the different elements is critical. If one element is allowed to degrade several ecosystems within the watershed will be impacted.

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Hydrology Technical Report

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A sensitivity analysis for the Ugum Watershed was completed using the computer program described in Technical Release 20 (TR20) for project formulation hydrology.

**Purpose:** The sensitivity analysis was performed to ascertain whether land use changes in subwatersheds would effect peak discharge for the entire watershed.

**Methodology:** The existing conditions for each subwatershed was simulated. The Bubulao Subwatershed was further subdivided into Upper, Middle and Lower subdivisions. The Upper Bubulao reflects the steep upland area, the Middle Bubulao is upstream of the confluence with the North Bubulao Subwatershed, and the Lower Bubulao is downstream of the confluence with the Northern Bubulao drainage area.

Runoff from the subwatersheds was approximated by using land use or vegetative cover acreages and their curve numbers to achieve a weighted curve number for the entire subwatershed.

The TR20 computer program was utilized to simulate flow through the Ugum River watershed. Channel bottom widths, sideslopes and Manning's roughness coefficient were adjusted until the peak discharge for various storm frequencies at the mouth of the Ugum River was within ten percent of the peak discharge for the same storm frequencies from the USGS stream gage data.

The calibrated model was run for the 2-, 5-, 10-, 20-, 50- and 100-year storm frequencies. Also to see the effect of practices on flows below the 2-year storm, the model was run for the 1-, 2-, 3-, 4-, 5- and 6-inch 24-hour rainfall. The results were compared to the present condition to determine the significance of the change.

**Assumptions:** The representative channel cross-sections were assumed to be trapezoidal with no low flow channel. The channel flow was assumed to be out of channel after the flow was one foot deep. This was done to ease the calculation of channel flow cross-sectional area for different flow rates.

Rainfall was considered to be the same over the entire watershed.

The roughness coefficient for the channel (Manning's n) was adjusted from 0.06 to 0.1. This reflects both the channel and the increase of roughness during out of bank flow.

Future conditions are unpredictable due to the many factors. The scenarios investigated in the sensitivity analysis were:

The Dan Dan Golf Course utilizes 152 acres in the Upper Ugum subwatershed (94 ac Ravine Forest and 58 ac Savannah).

The Dan Dan Golf Course and 200 acres of houses on 1/4 acre lots with infrastructure included on 175 acres of Savannah and 25 acres of Ravine Forest in the Lower Ugum subwatershed.

The Dan Dan Golf Course and 500 acres of houses on 1/4 acre lots with infrastructure included on 350 acres of Savannah and 150 acres of Ravine Forest in the Lower Ugum subwatershed.

Fifty percent of the Savannah would be improved to the equivalent of a meadow in good condition for all subwatersheds except the Upper Bubulao and the Atate.

**Results:** Rainfall less than 2 inches produced minimum flow.

Improvement of 50% of the Savannah had the most dramatic effect. Peak flow decreased by 9 to 20% for the less than 2-year storms and ranged from 2 to 7% for the 2- to 100-year storms.

For the scenarios of the Dan Dan Golf Course in the Upper Ugum subwatershed alone or with 200 or 500 acres of houses in the Lower Ugum subwatershed, the increase in peak discharge was from less than 1% to 20% of the present condition. The greatest percentage increases were in the less than 2-year storm events which have the lowest flows.

Further analysis of the golf course scenarios was accomplished by comparing the housing projects with the golf course to the golf course alone scenario. The increase in peak discharge ranged from 2 to 16%. The greatest percentage increases were in the less than 2-year storm events which have the lowest flows.

**Conclusions:** Significant changes to the majority of the subwatersheds must be made to greatly effect the peak discharge of the higher storm frequency events at the mouth of the Ugum River. Conversely, significant changes can occur in the smaller rainfall events or within individual subwatersheds.

**Investigation Reliability:** This analysis was made for planning purposes only and many liberties were taken to quickly simulate the Ugum watershed. Therefore the model and results should be only used to determine a trend of various conditions on the watershed and not as an exact numerical model of the watershed.



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as of 2 May 1995Ecologically-Based Assistance Team - Soils Discipline  
Client: Guam Coastal Zone Management Program

Soils in the Ugum Watershed are derived chiefly from volcanic rock. This rock is a mixture of highly compressed and heated volcanic ash and sand, which weathers down to clay-sized particles as it becomes soil. Because of the particular minerals present in the mixture, the colors of the weathered material can be quite spectacular. Areas which have eroded down to this weathered bedrock often show a swirled red and white or gray pattern. This material is called saprolite and it is nearly as erodible by water as the soils that develop from it. The soils have high clay content (from 45 to 90 percent); these volcanic clays have low bulk density, roughly the same as water, which has a density of 1 gram per cubic centimeter (Table 12, Young, 1988).

There are small areas of limestone-derived soils (map units 34, 36 in the Soil Survey) on ridges bordering the Ugum River where it joins the Talofofo River. The ridges are the remnants of an uplifted coral reef. Their influence on the watershed is minor. Runoff from these soils carries less clay, and is better pH-buffered than the water in the Ugum River due to its content of dissolved carbonates. The stretch of river that receives the runoff is also influenced by tidal fluctuation, further diluting the effects of these soils.

Water quality in the Ugum River is relatively high because there are intact riparian areas and wetlands which intercept and filter the soil particles out before storm runoff reaches river channels. These biological filters are even more important in the watersheds of volcanic islands than their counterparts in temperate zones, for several reasons:

- the low bulk density of the soils means that they are highly sensitive to water erosion, and that once particles are in suspension, they will stay so indefinitely. Thus, when water dislodges and carries the particles, they are not likely to settle out as would, for instance, coral sand particles which are more dense. Settling ponds are most effective when soil particles are of somewhat higher bulk density than water. At the Ugum Water Treatment Plant, a flocculant is required to force the clay particles out of suspension (personal communication).
- the amount of precipitation is high, averaging 2500 millimeters in the upper subwatersheds.
- the warm tropical climate provides year-round stimulus for the microbial and biological decomposition of soil organic matter: once exposed, this material is rapidly depleted from the soil. Since volcanic soils and minerals are inherently low in nutrient-holding capacity and available water-holding capacity (Sanchez, 1976), soil organic matter is critical to sustained plant growth. When a wetland or riparian area is cleared or altered, reestablishment of its plant community and its functions are difficult and costly. It costs about twenty dollars to restore each square meter of wetland on Guam (information from Dames and Moore, Leo Palace Resort, Guam). Creating new or mitigation wetlands costs roughly the same.

## Ravine Forest

The biomass in a healthy, multi-story tropical ecosystem such as the Ugum Watershed's Ravine Forest proffers numerous water quality benefits. It provides temperature buffering, raindrop impact protection, a complex wildlife habitat with many distinct niches, and a constant source for the replenishment of soil organic matter. Rapid decomposition of the leaf litter keeps this layer sparse in the Ugum Watershed as compared with rainforest floors on islands such as Pohnpei, which receives 2 to 3 times this watershed's precipitation with a corollary increase in biomass production and leaf litter accumulation. In some areas, wild pigs scratch many square meters of the forest floor bare. Soils in the Ravine Forest Ecosystem have a moderate to high organic matter content (4 to 8 percent).

Infrastructure is limited in this ecosystem to roads connecting ridges, or leading from the ridgetops (Savanna Grassland Ecosystem) to stream banks and river crossings. Guam's water, sewer and power networks do not serve this ecosystem within the Ugum Watershed. Thirty-one percent of the watershed's roads (mapped from 1993 aerial photos) network occurs in this watershed, but only 23 percent of the paved roads.

### **Savanna Grassland**

Soils in the Savanna Grassland Ecosystem also have a high organic matter content (6 to 10 percent for Akina soils) where the vegetation is dominated by grasses. This is due to the rapid biomass production, mortality and turnover typical of grasslands. Fine and very fine roots fill the soil profile to a greater extent than is typical in forest ecosystems. Because of this, the primary biomass storehouse in an area of Savanna Grassland is the soil. Fires reduce the amount of organic matter added to the system each year, and can burn off past years' accumulation. Soil temperatures in burned-over areas are elevated, promoting more rapid organic matter decomposition. Bare soils are subject to over-saturation by water, erosional undercutting of steeper slopes by gullies, and slumping. The resultant badland areas do not readily revegetate.

This ecosystem is crisscrossed by established and new jeep trails, which follow each ridgeline. Some of these are historic carabao cart trails. Sixty-four percent of the watershed's roads (mapped from 1993 aerial photos) are in this ecosystem. Most of the paved road length (67 percent) is also found here.

### **Riparian Areas**

This team has identified a Riparian Area as a habitat and ecosystem which is heavily influenced by the open water or wetlands it is adjacent to. Likewise, the quality of the water and its ecology are determined in part by the health and composition of the adjacent lands. There are many ways to determine the width of the riparian buffer. We designed the recommended buffers around terrain, sensitivity of the ecosystem to disturbance, and the projected intensity of activity in the area. We have chosen to use 15 meters (looking straight down on the landscape) along the upper watershed streams, where the topography drops steeply from the Savanna Grassland or Ravine Forest Ecosystems to the waterside. In these areas, the vegetation does not change appreciably from that of the Ravine Forest Ecosystem. Where streams converge, widen and drop more sediment to form a floodplain, we designated a 100 m riparian buffer. The vegetation canopy is more complex than that in upper watershed riparian areas. There is a corresponding increase in habitat complexity and diversity in the lower watershed. Human influences are more likely to occur here due to its greater accessibility.

The complex vegetation canopy shades the water, keeping its daily temperature relatively constant. The canopy also provides protection for wildlife that live near or visit the streams and wetlands. Storm runoff and groundwater enter the riverine system at the riparian interface, so land disturbance here has the most profound effect on water quality within the Ugum Watershed. The dense vegetation, leaf litter, and active soil fauna in the Riparian Area Ecosystem provide an effective filtering mechanism for sediment and organic debris suspended in storm runoff from the Ravine Forest and Savanna Grassland Ecosystems. Erosion increases after grassland wildfires (especially during the first hard rains signalling the wet season's onset), and the riparian vegetation is the only filtering system protecting the Wetland and Open Water Ecosystem from the resultant sediment load. Wetlands also function as a biofilter; however, their functions are impaired by excessive sedimentation. Their conversion to drier marshes would reduce potential habitat for the Marianas Common Moorhen, an Endangered Species on Guam.

The soils within the Riparian Area Ecosystem are similar to those in the Ravine Forest and Savanna Grassland Ecosystems. However, nearly half of this ecosystem is composed of very deep alluvial soils - these are areas where eroding sediments from the steep slopes above have accumulated. The water table is less than 100 cm below the surface in the Ylig soil, much of which occurs in depressional positions

along the banks of the larger, order 4 and 5 streams. Togcha soils are often found intermixed with the Ylig soils, and occupy more upland positions. In the steeper, eroding headwaters areas, where one finds Akina and Agfayan soils, the water table is more than 100 cm down. The topsoil in all of these soils contains the greatest percentage of organic matter. When this layer is removed by erosion, the organic matter's buffering function is lost, with a corresponding reduction of soil pH. Low-pH (more acidic) soils are a harsh substrate for revegetation. The most acidic substance is the saprolite parent material. When this is exposed in the badland areas by erosion of the entire soil profile, its pH can be as low as 4. This is 100 times more acidic than the alluvial Togcha and Ylig soils, whose surface layer pH is between 5.1 and 6. The difference can be attributed mainly to the presence of organic matter in these soils.

The cumulative nature of the riparian soils, combined with their proximity to abundant water creates the basis for a richer, more diverse ecological community than the surrounding upland ecosystems.

The Ugum Water Treatment Plant intake structures and pipes are serviced in this ecosystem. A paved road leads down from a more developed area of Savanna Grassland to the site. Several dirt roads lead through other riparian areas to stream crossings. Riparian areas contain only seven percent of the watershed's road network. No other infrastructure exists in this ecosystem.

### **Organic Matter**

Soil organic matter provides the following functions and benefits to the ecosystem:

- provides binding sites for soil nutrients and nonpoint source contaminants like pesticides
- supplies most of the plant nutrients available to the vegetative cover, in a readily available form (Sanchez, 1976), and provides a steady supply of dissolved organic substances to the adjacent aquatic systems
- maintains a healthy microbial and macrobiotic population within the soil
- increases the water-retention properties of the soil (though not as much difference as sandy soils would display)
- buffers the pH of the upper layers of soil
- improves infiltration of rainwater
- increases permeability and therefore groundwater storage and transmittal
- improves tilth for agriculture
- provides significant carbon storage to buffer global climate change
- binds soil particles together to prevent erosion and absorb water drop impact (a "glue" effect)
- undecomposed root fiber networks knit large soil masses together and keep them from slumping on steep slopes, which is the beginning of badland formation (a "rebar" effect)

The potential plant community that can be established or selected for depends greatly on the quality and stability of the soil. This resource is integral to the health of the ecosystem. "In many cases, the total nature and longevity of the aboveground aspects of an ecosystem are controlled by the chemical, biological and physical properties of the soil organic matter pool" (Tate, 1987).

The soil resource in the Ugum Watershed could be mined as a source of fill dirt for the large areas of Guam which have very shallow soils. However, the resultant exposed parent material would share the problems inherent in existing badland areas within the watershed. The cost to the local ecosystem's health would be prohibitive, as described below.

### **Watershed Activities and Their Consequences**

Soil erosion is the major problem to be dealt with in the watershed. It is the primary factor affecting sedimentation and water quality in the Ugum River and its tributaries. Erosion occurs naturally on all

soils, and at accelerated rates on tropical volcanic soils. Young (1988) describes typical erosion rates that can be expected on each of the soil types (series) on Guam. It should be noted that the erosion rates described are not necessarily natural, but reflect historical human influences on the particular soils; the erosion rate given is the maximum that can be sustained over time without degradation of the soil resource and the ecosystem.

Erosion can be described more narrowly as a cause of biomass loss. In every hectare of soil in the top 15 centimeters, there are 22.5 metric tonnes of organic matter for each percentage point of reported organic matter content. This would amount to 180 tonnes for each hectare of Akina soil with a healthy grassland cover, assuming 8 percent organic matter, the middle of Akina's range. By contrast, a hectare of badland or severely eroded Akina soil might contain just over 1 percent organic matter, or 23 tonnes, a difference of more than 150 tonnes per hectare. Disturbed savanna soils lose organic matter by about 5 percent per year in tropical Africa (Sanchez, 1976). Burning or clearing the vegetation removes the replenishment source, and soil organic matter content will decline. Often, clearing operations remove the upper layer of soil, accelerating organic matter loss.

If we consider that badlands or exposed soils in the watershed erode at an average rate of 547 tonnes per hectare per year - about 5 centimeters off the surface by sheet erosion - and that the top layer of soil has the highest percentage of organic matter, 10 to 40 tonnes can be lost each year from each hectare of this ecosystem if adequate grass cover is not maintained.

Roads in the Ugum Watershed and its surrounding watersheds are usually found along ridgetops, with steep connecting roads that cross the streams between. The Akina soil series occupies many of these ridges. Young (1988) reported a sustainable soil loss rate of 6.8 metric tonnes per hectare per year for this soil; the sustainable rate is low because the soil is generally less than 100 centimeters deep. This rate was determined for the Akina series under grassland vegetative cover. DeMeo (1995) used the Universal Soil Loss Equation (Wischmeier and Smith, 1965) to estimate a current erosion rate of 70 tonnes per hectare per year occurring in the Savanna Grassland ecosystem; this estimate shows that some degradation of the soil and the ecosystem is already occurring. One hectare of road surface, exposing bare soil or saprolite (highly weathered volcanic sedimentary rock), and running up and down a slope in the watershed was estimated to erode at a rate of 729 tonnes per year. If the current trend of doubling the steep road surface area within the watershed during the period 1975-1993 continues for the next 20 years, sediment yield to the Ugum River from this source will be over 15,000 tonnes per year by 2015, as compared with the 1993 level of 7560 tonnes. The roads connect naturally occurring badlands, exposing these areas to accelerated erosion. Uncontrolled use of the roads and badlands for recreational driving purposes accelerates erosion rates and prevents revegetation of sensitive areas. Many of the recreational vehicle drivers are unaware of the consequences of their actions, and prefer starting new trails to following existing ones.

Roads that currently follow the contour and thus do not provide channels for flowing water nevertheless erode at a rate much higher than soil with vegetative cover. DeMeo, *et al* (1995) *estimated erosion from one hectare of level road surface to be 169 tonnes per year, as opposed to 70 tonnes for grasslands and 27 tonnes for typical areas of ravine forest. None of the roads observed in the watershed included drainage ditches or other water-redirection devices. There is no master road plan for the watershed, and without proper planning and design, similar statistics will be generated for future road expansion.*

Agricultural clearing currently accounts for 25 to 40 hectares per year within the Ugum Watershed. These fields are on slopes of less than 7 percent. Residue is left on the surface, and weed control is accomplished by light use of chemicals such as the product Roundup. Plowing does not follow the contours. At an estimated 45 tonnes per hectare per year, the soil lost from agricultural fields is currently 1,100 to 1,800 tonnes. We project that 200 to 500 agricultural homestead lots will be developed within the next 20 years, and that all of the land on these half-hectare lots will be cleared for cropping, with small areas set aside for home development. These lots will probably be set up in areas

with less than 15 percent slopes. Potential erosion from agriculture could increase to 60 tonnes per hectare per year given the likelihood of steeper slopes on some of the lots. If 200 lots are settled and cleared, the amount of soil eroded from agricultural land will increase to 6000 tonnes per year, a three-fold increase from current estimates. Water quality will show corresponding degradation in the Ugum subwatershed, where the lots are most likely to go in.

During golf course and residential subdivision construction, large areas of disturbed soils are exposed, usually for short periods, during which soil erosion increases to levels similar to those for level and sloping roads. The volume of sediment carried to wetlands and open water is greatly increased during each rain event, resulting in plugs which damage stream habitat and wildlife populations. It is common for construction sites on Guam to stand bare for extended periods due to funding shortages, sudden downturns in the Asian economy, infrastructure delays or equipment breakdown. Some sites are abandoned for months or years. By Guam law, attention is given to erosion prevention during active construction with such measures as silt fencing. *However, these measures require periodic maintenance. Abandoned sites do not receive this maintenance, and erosion will increase before volunteer vegetative cover can stabilize the soil. The silt fencing observed in the past three years at construction sites by the authors has been improperly installed in most cases, and has not been an effective barrier.*

#### Wildland fires

Wildland fires in the watershed are largely intentionally started, whether for hunting and food-gathering access or from carelessness or recreation. The sum of all fires within each square kilometer in the watershed for the period 1979 through 1985 (*see Figure \_\_\_\_\_, data from Government of Guam Department of Agriculture's Forestry Division*) shows clear "hot spots" where road access is easiest, especially near the Dandan area in the Ugum and Upper Ugum subwatersheds.

Wildland fires usually occur in the Savanna Grassland ecosystem. The ecosystem is dominated by bunchgrasses. These areas are fire-prone during the dry season from February to May; during late dry-season fires, the leaf litter that protects the soil surface usually burns off. The clay particles of these soils, derived from highly weathered volcanic tuff (sandstone) parent material, typically aggregate into silt- or sand-sized particles. At the soil surface, these particles are easily lifted and transported by storm runoff. In fact, water channels through burned-over areas were clearly visible several weeks after a fire in 1995, along the ridge separating the Bubulao and Ugum Rivers. The slope at the observation site was less than 7 percent. Steeper slopes could lose a portion of the surviving vegetation simply through scouring of plant tissue at the base by suspended soil particles, because the water channels are not interrupted or blocked by vegetative or other barriers. *(Figures xxxx - ) show the ground cover one day, one month, two months, and five months after fires in 1995 in Southern Guam. The rills and water channels were relatively clear even five months after a fire; no recent erosion was evident at time of observation, nor was there any evidence that the soil would be stabilized before onset of the wet season two to four weeks later. The only protection pioneer grasses afforded the site was 60-75 percent protection from raindrop impact.*

The swordgrass-dominated savanna vegetation is a pioneer community, fast-growing. Because of the effects of soil erosion under this vegetative cover, the ravine forest late-successional community does not easily reestablish. When fires occur near the edge of the ravine forest, some of the fringe plants are destroyed, creating a transitional edge effect which is maintained by a conservatively estimated fire repeat cycle of 5 years. The ravine forest cannot be expected to expand without the exclusion of fire.

#### Riparian Buffer Removal

Housing or road construction, overgrazing by livestock and other human activities form breaks in the riparian buffers. This creates undesirable paths which can channel storm runoff laden with sediment directly into the Wetland and Open Water Ecosystem without the benefit of vegetative filtering and

particle capture. The soils throughout the Ugum Watershed have at least 40 percent clay content, and once suspended in moving water, clay particles are too light to settle out. A hole in the riparian buffer is, therefore, a direct sediment conduit from the highly eroding roads, badlands and burned-over grasslands to Talofoto Bay and the surrounding coral reefs.

#### Organic Mulch Surface Treatment

Purpose: to provide a blanket of less erosive organic cover for bare areas such as badlands

Expected Outcome: up to 25 percent reduction in the erosion rate where applied, enhanced seedling germination success, replenishment of soil organic compounds; may be combined most effectively with contour wattling.

#### The Wetland Reserve Program

Purpose: U.S. Government program to lease private land that has beneficial hydrogeomorphic functions in order to preserve these functions, rather than allow development or other disturbance.

Expected Outcome: A set of protected wetland areas which maintain water quality and provide flood control and wildlife habitat in the local ecosystem; stretch the water yield to the river system out over a greater time period, with lesser peak flows; land owner is paid for the functions this land provides, winds up managing for highest use. Owner-initiated protection of 60 percent of Ugum Watershed wetlands is possible.

#### Wetland Mitigation Bank

Purpose: a government program to fund the creation of mitigation sites which compensate for wetland conversion elsewhere on the island.

Expected Outcome: Enhancement of local wetland functions and habitat with compensation for the land owner; maintenance of Guam's overall wetland area vs. development, possible to provide 15 hectares of new wetland (based on soil map unit inclusion area), and 80 hectares of improved existing wetland (75 percent of the 117 existing wetland hectares).

#### Contour Wattling

Purpose: To provide a physical barrier to sheet and rill erosion, to force formation of terraces, to provide seed germination beds on bare slopes

Expected Outcome: Conversion of badland areas to land with stable, terraced vegetative cover. Reduction of erosion by 50 percent on treated badlands.

#### Road Ditching

Purpose: To design upslope-side ditches to be installed on new roads, with proper culvert placement

Expected Outcome: Redirection of storm runoff water away from bare soil surfaces such as rural roads, which have the highest erosion rate of any land surface in the Ugum Watershed.

Expected reduction of erosion from roads by 25 percent (180 tonnes per hectare of protected steep-slope road surface per year, or 42 tonnes per hectare of protected level road surface per year) .

#### Lumber Drainage Interceptors

Purpose: To divert water that is running down steep road surfaces into grassed roadside areas that dissipate its energy

Expected Outcome: Improved water quality; 25 percent reduction in road surface gullyng.

#### Access Road Specification

Purpose: To provide designs for new roads which apply ecological principles and protect the health of the ecosystems they pass through

Expected Outcome: A 50 percent reduction in erosion from new road surfaces; old roads will be retired and can revegetate to accomplish a 25 percent reduction in erosion from older roads.

**Streambank Protection**

Purpose: To improve the stability of steep or impaired banks of streams of all sizes

Expected Outcome: Improved water quality, reduced sediment loads reaching the Water Treatment Plant, Talofofo Bay and the coral reefs.

**Critical Area Planting**

Purpose: to provide stabilizing root masses in areas with excessive erosion; to provide shade for improved germination and growth of native or beneficial species

Expected Outcome: Localized plantings will stop the advance of gully erosion; more stable seed beds for establishment of sustained vegetative cover; filled gaps in riparian buffers around streams and wetlands; stabilized streambanks; multistoried wildlife habitat where it once was depauperate.

**Grassed Waterway or Outlet**

Purpose: to provide a channel where runoff water energy can be dissipated over a broad area

Expected Outcome: a 25% decrease in gully formation from road runoff.

**Crop Residue Use**

Purpose: to keep the soil covered in agricultural areas when crops are started and during fallow periods

Expected Outcome: a 30% reduction in erosion from agricultural fields; improved water quality in the Wetland and Open Water Ecosystem

**Tax Breaks and Economic Incentives for Conservation**

Purpose: To reward private landowners in the Ugum Watershed for initiating conservation practices and participating in the oversight and planning operations

Expected Outcome: Painless landowner buy-in and education on conservation matters; Full consensus on Watershed-wide decisionmaking

**Public Information Campaign**

Purpose: To provide information to target audiences such as water customers, off-road vehicle operators, government employees, development contractors and watershed residents about the functions of the Ugum's ecosystems, the benefits these people derive from those functions, and suggestions on how they can adjust their behavior to protect these ecosystems.

Expected Outcome: A large group of people who are aware of the Ugum Watershed and its value to themselves and other island residents; grass-roots watershed clean-up groups who apply the lessons learned in the Ugum to their own ecosystems.

**Public Education Campaign**

Purpose: To provide classroom kits and lesson plans for teachers at different levels (primary, secondary and college) to use; to provide field trip opportunities for government and school groups

Expected Outcome: An island that views its most pristine watershed as a jewel that should be polished and protected; widespread use of the lesson plans for many years by teachers desperate for locally important scientific education opportunities; a general knowledge of the effects of wildfires on the ecosystem and on citizens' lives; the knowledge that nearly all wildfires on Guam are started by humans.

**Scenarios and Ecosystem Management: Recommended Mitigation Measures****Scenario I: No Action**

The goal of this scenario is to minimize the cost of government intervention in island land use change and policy. This will encourage Guam's historical patterns of development to continue. It is felt under this scenario that current public education efforts adequately prepare individuals for sound environmental decisionmaking; that the water quality of the Ugum River is sufficient for current uses and will remain so indefinitely; and that there is no need to control wildfires in the Ugum Watershed or elsewhere on the island.

#### *Recommended Mitigation Measures*

(None)

#### *Results*

Because the scenario infers minimal action and lack of public and governmental coordination, we would expect the soil resource to degrade as development occurs. Clearing for road construction, road design, water withdrawals for irrigation and Riparian Area usage will all be determined by developers as dictated by the needs and goals of their projects. It is expected under all three scenarios that road length within the watershed will double within the next 20 years.

No mitigation recommendations will be offered under this scenario unless federal or GovGuam laws are broken. Often, the government reaction will occur too late for the local ecosystems to benefit, and mitigation efforts may not be monitored. Riparian Areas will suffer the most, since water is a limited resource in the watershed, and water access may be sought for each development effort independently.

There will be no assistance from the public or from any of the groups that routinely use or benefit from the Ugum Watershed. Government of Guam agencies will cover the entire cost of any environmental improvement efforts they deem necessary to counter for the decline in water quality caused by development or recreation activities over the 20-year planning cycle.

Wildfires would increase by 25 percent under this scenario, to 200 hectares per year, mainly due to the increased access caused by an estimated doubling of road length within the watershed.

The climate on Guam is characterized by short rain events and occasional typhoons. Streams in the upper subwatersheds are intermittent rather than perennial. Heavy rain events usually input more water than the low infiltration rates of the Ugum Watershed's clayey soils can absorb. The result is that rapid storm runoff is the norm, especially on burned-over lands. The peak flows of the river exceed the Ugum Water Treatment Plant's maximum harvest rate. Less water is stored in the watershed's soils; during the dry season the river level decreases significantly, sometimes falling below the minimum flow required by law to maintain habitat. This flooding-drought cycle will continue to be highly seasonal. Water demand throughout the Plant's service area, however, will steadily increase during the next 20 years as Southern Guam's population increases. These trends will prompt or encourage politically-motivated decisions, such as to ignore the minimum flow requirements, or to initiate a dam/reservoir project in the Ugum Watershed. Under the No Action Scenario, this kind of project could be approved before all agencies knew of it or could review its ramifications.

#### **Scenario II: Maintenance, Current Zoning**

The approach within this scenario is one whereby agencies and landowners recognize ecological problems and processes and react to environmental degradation within the traditional bounds of their activities or program oversight. However, the best use of each part of the Watershed is not agreed upon and parties do not cooperate to abate or prevent subtle environmental degradation.

This scenario has a goal to preserve the functions and benefits of the Ravine Forest, Riparian Areas, and Wetland and Open Water Ecosystems at existing levels, with no future loss in area. Under this



scenario, we recognize that though imperfect, the Ugum Watershed is functioning well and provides water of adequate quality to the citizens served by the Ugum Treatment Plant. Further effort that would improve wildlife habitat and water quality is seen as unnecessary expense. A program of continuous water quality monitoring in the lower Ugum River is necessary to fulfill the goal of maintaining the current standard as development begins. It is also recommended that developers be encouraged to monitor their own ground and surface water, so that problems can be pinpointed and solved quickly.

#### *Recommended Mitigation Measures*

- Contour Ditches
- Contour Wattling
  - Use on Badlands and on new road cuts or banks. Concentrate application in the areas with most bare soil and recreational roads: Savanna Grassland Ecosystem in the Ugum Subwatershed area near Talofoto Falls, the Upper Ugum Subwatershed, and the Bubulao Subwatershed.
- Mulching
  - Apply 3-inch layer of compost, shredded paper or combination on gullying or steep road banks.
- Access Road Specification
  - Pass legislation that in this watershed, the specifications shall be met for all new roads.
  - Publish specifications and give to each developer pro-actively before construction begins.
- Fire Control
  - Use near human habitation and businesses.
- Erosion Control Legislation
  - At the time of this Management Study, there are laws on the books which require erosion control during the construction phase of projects. Further legislation is recommended to require close inspection of these control measures throughout the construction phase for projects within the Ugum Watershed. We also recommend that laws be enacted to require continued erosion control and stabilization of the property after the construction phase is completed.
- Erosion Control Seminars
  - Pass legislation that these are required for construction crews working in Ugum Watershed.
- Lumber Drainage Interceptors
  - This practice will be most effective if the best or most necessary roads are retained and improved, while other, unnecessary roads are retired and blockaded - do roads and trails on hilltops or ridgelines first. There is no provision in this scenario, however, for a Master Plan for roads in the watershed. Choices will be made by each party installing practices according to their own list of priorities, if such a list exists.

#### **Results**

##### **Savanna Grassland Ecosystem**

Although the swordgrass-dominated vegetation in this ecosystem provides more than 100 percent cover to intercept raindrops and prevent soil disturbance by their impact, the flora is primarily bunchgrasses which leave part of the soil surface unprotected from runoff waters. This situation will continue in the Maintenance Scenario.

The projected level of development will not impair water quality much further than currently exists in this scenario, since the goal of the scenario is to implement all necessary educational and conservation practices to ensure the maintenance of current water quality standards. With legislation in place, at least 50 percent of new roads will be designed and built with conservation measures. The Water Quality Monitoring Program will fill in the data gaps and give government and non-profit organizations clues as to where the greatest sediment-load problems are, so that mitigation costs are minimized.

A policy of curtailing expansion of the Savanna Grassland Ecosystem within this scenario does not require fire eradication, but does involve intervention and control whenever the grassland fires encroach on human habitation or businessplaces. The public education campaign, repeated during dry years, may cut fire frequency in other areas by a few percent through citizen efforts. However, the fire damage is expected to remain the same at about 160 hectares per year within the watershed. Soil erosion will diminish in those areas where fires are controlled for more than one year, since leaf litter is the primary agent retarding sheet erosion. Planning Team members visited and photographed the soil and landscape at sites in southern Guam where fires had occurred the previous day, and one, two and five months before time of assessment (*Figs. xxxx -* ). *Seeding was extensive after 5 months (see Fig. xxxx); however, germination did not begin until onset of the wet season, and about half of the soil surface between new plants was still without leaf litter. Most rills were clear of detritus, ready to erode with the first heavy rains. There is a description of the effects of wildfire on soil erosion processes in the "Watershed Activities and Their Consequences" section of this report.*

#### Ravine Forest Ecosystem

This ecosystem is slated to remain static in area under the Maintenance Scenario. Most of the development over the next 20 years will probably be concentrated in the Savanna Grassland Ecosystem, so we expect relatively minor changes in the energy flow and functions performed by Ravine Forests. Where development coincides with this ecosystem, the recommended legislation will force, but may not enforce, mitigation on nearby lands. *Sites within the Savanna Grassland Ecosystem in the Ugum Watershed will be chosen for mitigation, to further the goal of zero net loss of ravine forests.*

#### Riparian Areas Ecosystem

There is no consensus on riparian buffers under this scenario. The focus will be on critical wildlife habitat identification and protection for threatened and endangered species. Insofar as riparian areas are critical habitat, they may be included in this realm and thus protected. Also, existing procedures by GovGuam agencies include specifying a buffer strip of 3 to 8 meters along streambanks. Many organizations do not consider Riparian Areas important in their discussions of habitat or ecology. The Riparian Areas Ecosystem will suffer misuse from development and agriculture over the next 20 years; there are only 159 hectares in the Ugum Watershed as we have identified it (8 percent of the watershed), so any losses will be significant.

Wildlife habitat is now described by ecologists, not only in terms of total area, but also according to its shape with respect to the landscape and its fragmentation.

Water availability will continue to be highly seasonal, as in the No Action Scenario, although may not worsen since Maintenance is the keyword here. Demand for the water supplied by the Ugum will increase, bringing political pressures to bear for short-term solutions.

#### Scenario III: Improvement; Adjusted Zoning and Land Use Policy

The goals in this scenario are to: reduce the cost of ecosystem maintenance through elimination of redundancy and work scheduling conflicts; increase forest cover in the watershed; bring the entire public of Guam to a high level of understanding of this most pristine watershed, and thereby reduce the public impact on its ecological functions; to provide a testbed for coordinated conservation projects, and assess their applicability in other, more degraded watersheds.

In this scenario, the Ugum Watershed is viewed as a potential model ecosystem against which watersheds across the island and throughout the Marianas can be compared. It is planned that subsets of the conservation measures could be exported to other areas, with better predictions for success. A

clear hierarchy of functions and values for the entire watershed will be developed by consensus, one that the watershed's managers can consult as they contemplate the benefits of new activities there.

Under this scenario, we recognize that the ecosystems represented within the watershed are not as healthy as they could be, that through coordinated efforts by many individuals and by effective use of set-aside funds, greater benefits can be derived from the watershed than are currently possible.

*Recommended Mitigation Measures*

The measures mentioned in the Maintenance Scenario are a basic set which should be applied under the Improvement Scenario also. Their implementation will be coordinated among agencies. The key difference is that in this scenario, an ecosystem perspective prevails. The entire watershed will be treated and protected, as opposed to protecting individual agencies' priorities and ongoing programs. Most practices will require consensus to implement properly, and new conservation practices are introduced.

- Grade Stabilization Structures

On roads with steep embankments where embankment cannot be graded back and road cannot be closed.

- Roadside Ditching

On steepest roads first, in areas where large runoff drainage is intercepted

- Contour Wattling

Use as in Maintenance Scenario on new road cuts or banks, but combine with other road conservation designs and practices for a multi-stage approach to ensure greater success. Initiate a schedule to apply this practice in combination with Mulching and Tree Planting to badlands which are nearest to the Riparian Areas and Wetland and Open Water Ecosystems and present the greatest water quality problems. Begin on the Savanna Grassland Ecosystem in the Ugum Subwatershed area near Talofofa Falls, the Upper Ugum Subwatershed, and the Bubulao Subwatershed.

- Mulching

Use in conjunction with contour wattling first (behind wattles)  
Apply 3-inch layer of compost, shredded paper or combination on gullying or steep road banks

- Lumber Drainage Interceptors

Use in combination with other retrofit activities in areas where road gullying is obvious. The benefits are immediate and extensive. Start high on the slope.

- Ugum Roads Master Plan

A Plan should be agreed upon by a number of agencies and non-profit conservation groups, with explicit criteria for improvement or retrofit of selected existing roads, closing of poor or redundant roads, and design for new roads as needed for access to development sites. These criteria should include as a minimum the specifications described in the Field Office Technical Guide, Section IV (1977).

- Wetland Mitigation Bank

The relatively small acreage of wetlands in the Ugum Watershed could be designated part of the island-wide Mitigation Bank to accomplish two goals: improvement of

- Wetland Reserve Program

- Streambank and Shoreline Protection

Use in Riparian Areas Ecosystem. Require developers to use these practices when designing and building new projects or stream access facilities. Provide economic incentives for landowners to fix old degrade streambanks .

- Recreational Off-Road Vehicle Use Specification

Pass legislation that prohibits Off-Road Vehicle use except in areas that private and government parties agree to designate. The operators' preference for rough terrain could

be satisfied by building features into designated roads which provide a jouncy ride and perceived risks, while incorporating extensive environmental protection measures.

- Water Quality Monitoring Program

Use at the outlet of each subwatershed in the Ugum to get baseline data on current water quality so that mitigation efforts can be focused appropriately and tailored, to minimize costs.

- Tax Breaks and Economic Incentives for Conservation

Start with property tax cuts for: participation in the Watershed Conservation Plan; adherence to the Plan. Focus Wetland Reserve advertising on these landowners, try to get some to sign up if eligible. Grants to Off-Road Vehicle clubs or operators for conservation practice installation and participation in the education campaign. Grants to landowners for improving streambanks on their property according to specifications.

### *Results*

Far more will be accomplished to maintain ecosystem health and improve it with this scenario's approach. Most of the practices listed for the Maintenance Scenario will still be adviseable. However, the cooperating agencies and private individuals will be coordinating their efforts to accomplish more. Each cooperator would choose a niche to fill within the Ugum Roads Master Plan, for instance. They would share tools and resources with others to accomplish the agreed-to tasks. We expect that about 75 percent of new roads will have conservation measures in place, while the remaining new roads will be started outside the planned implementation scheme. A priority list of old roads to either close or retrofit with erosion controls will be formed by consensus.

#### *Savanna Grassland Ecosystem*

This scenario provides for a steady decline in area for Savanna Grasslands. It is recognized as the least desirable of the ecosystems and one that is artificially maintained by wildfires. When fire control and eradication measures are implemented, we expect to see a 25 percent reduction in fire frequency, or about 120 hectares per year. The Ravine Forest will naturally expand at a slow pace. We do not plan to wait for natural regeneration in certain critical areas where tree planting and other conservation practices can curtail badland or roadbed erosion. These practices will accelerate regeneration as well as improving water quality in the short term. The broader goal of forest regeneration can be complemented by each smaller objective and installation. This is the ecosystem-based perspective that sets the Improvement Scenario apart from the other two. Improvement project will usually be multi-staged as opposed to single-stage, politically steered projects.

#### *Ravine Forest Ecosystem*

Under this scenario, the ravine forests will expand as a result of many of the practices and policies applied.

The Ravine Forest has a multi-story vegetation structure which ties up water for longer time periods than Savanna Grasslands do. This confers two beneficial properties in the long term:

- storm runoff peaks are flattened, with a more reliable and steady stream flow;
- the ecosystem provides greater water storage, so that the reduction in water yield associated with the dry season is delayed. These effects will increase in value as the forest expands.

*In areas where trees such as Acacia are planted for immediate soil erosion benefits, the groves will provide an environment conducive to native species and habitat regeneration.*

#### *Riparian Areas Ecosystem*

This is the only scenario which specifically protects Riparian Areas as a special ecosystem: we recognize here that it is the most sensitive of the land-based ecosystems in the watershed, and has the primary function of filtering excess sediment, detritus and pollutants from surface runoff and groundwater before they enter the rivers and wetlands. In-kind, local mitigation will be required for

activities that would result in loss of this ecosystem's functions, and economic forces will prevent many activities deemed unavoidable or acceptable in the other scenarios.

The Riparian Areas Ecosystem health will improve with the flattening of storm runoff peaks inherent in plans to reduce Savanna Grassland Ecosystem area. They will expand in area where they are adjacent to Savanna Grasslands because fires will be occurring less often. Understory growth will improve in these edge areas because scouring and inundation by heavy sediment loads will decrease, as will pedestalling (erosion of soil from around the root crown).

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Ugum Management Plan  
Forests Ecosystems Technical Report

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1.0 Introduction

The purpose of this technical report is to describe the role of vegetation and the ecological processes associated with vegetative component of the ecosystem within the Ugum Management Plan area, and to identify management opportunities and environmental concerns relating to human activities within the planning area.

For planning and management purposes the ecological systems within the Ugum watershed were grouped into four broad ecosystems: ravine forest; savanna grassland/badlands; wetlands; and riparian. The concept of the ecosystem in this planning effort is intentionally broad. By delineating ecosystem boundaries by dominant floristics as well as hydrology, changes to energy flow and ecological processes as a result of human intervention can be used as indicators of ecological health.

2.0 The Ecological Basis for Vegetative Management

2.1 The Ravine Forest Ecosystem

2.1.1 Definition of Ravine Forest

The ravine forests of southern Guam are terrestrial plant formations chiefly on volcanic soils or on argillaceous or limestone outcrops consisting of low stature trees and shrubs. The term "ravine forest" refers to its frequent occurrence in ravines and on steep slopes. Much, and perhaps all, of the primary ravine forest areas have been disturbed by human activities.

2.1.2 Floristics

Relative to other ecosystems on Guam, the ravine forests are floristically rich with both native and introduced flora. Although relatively low in stature by tropic forests standards, the vertical structure of the ravine forest provide a range of micro-climates that encourage species diversity. The flora of the ravine forest include many of the species found on the raised limestone. Individual stands of vegetation may be either dominated by a few large woody species, or contain a mixture of species.

Past human activities has introduced many non-native plant species into the ravine forest ecosystem, including the *Areca catechu*, the betel palm. As a result of repeated human-induced and natural disturbances the ravine forest of southern Guam is a secondary forest type as indicated by the widespread presence of *Hibiscus tiliaceus*, *Areca catechu*, and *Cocus nucifera*. The floristics of the original forest of southern Guam cannot be discerned.

Where the ravine forest borders savanna grasslands periodic wildland fires affect species composition of the ravine forest. Early sere vegetation dominant and *Miscanthus floridulus* is often a dominant species in the understory.

#### 2.1.3 Ravine Forest Ecology

The ecology of the ravine forest is a reflection on energy flow, natural disturbances, and past and present human activities in southern Guam. As described above, plant associations have been greatly influenced by the naturalization of introduced species. The introduced species now occupy niches which were previously occupied by native species. The persistence of the introduced species indicate that they are well adapted to the climate and soils within the planning area.

While species diversification within the ravine forest has been altered by human activities, energy flow through the ravine forest has been less affected. Solar energy is the primary energy source entering the ravine forest ecosystem. Guam's proximity to the equatorial zone insures that large amounts of solar energy enters the ecological system year-round. Variations in day length have less effect on the amount of solar radiation reaching the ecosystem than the effect of cloud cover during the rainy season.

The solar energy entering the ravine forest ecosystem can follow several energy paths. Some solar energy is reflected away, some is stored as heat, and some is converted to photochemical energy by photosynthesis. Energy gained by the ecosystem can be lost to the environment by radiation from the plant, by heat conduction or convection, or by evapotranspiration. The vertical structure of the ravine forest vegetation allows for significant interception of the solar radiation by living plants.

The large leaf area in the ravine forest allows for conversion to photochemical energy by photosynthesis. The structure of long-lived woody perennials serves as a storage medium for this photochemical energy as carbon.

The larger leaf area also serves as a pathway for energy exchange through evapotranspiration which also results in a cooler environment surrounding ravine forest as a result of the release of water during evapotranspiration.

With the exception of carbon, hydrogen, and oxygen, plants must obtain all 13 essential mineral nutrients from the growing medium solution. Not only do mineral nutrients need to be present within the ecosystem, but the nutrients must be present in a chemical form and in a location that is available for uptake by plants. Mineral elements are not homogeneously distributed nor are they present in the same chemical form throughout the ecosystem. Mineral nutrients move between the environment and living organisms and back to the environment. The movement of those elements and inorganic compounds that are essential to life is termed nutrient cycling. Mineral nutrients can enter, accumulate (pool), or exit ecosystems through

various complex energy pathways. Much of the health of an ecosystem is determined by the appropriate cycling of mineral nutrients between the abiotic and biotic parts of the ecosystem.

Minerals that are taken up into woody plants are eventually returned to the soil except for the amount carried out of the ecosystem as "products". Minerals are returned to the surface of the soil by litterfall and through the washing and leaching effects of rain on tree foliage and stems. Minerals are also added to the soil by rainfall and dryfall and by the below ground dying and sloughing of roots. Mammals, insects, and other arthropods, earthworms, fungi, and bacteria breakdown the accumulating organic material, decompose it, and render it reavailable for plant nutrition. Soluble nutrients such as nitrogen must be absorbed by plants before being leached out of the rooting zone of the plants.

Plant litter on the soil surface absorbs the energy of raindrops and intercepts surface flow. Organic matter and biological activity in the upper soil horizons increases the water holding capacity of the soil and plays an important role in the storage and release of soil water into the Riparian ecosystem.

## 2.2 The Savanna Grassland Ecosystem

### 2.2.1 Definition of Savanna Grasslands

The savannas of southern Guam are extensive grassland communities on volcanic soils dominated by perennial grasses, bushy shrubs, herbs, and ferns. Frequent wildland fires maintain the savannas as an early seral plant community.

### 2.2.2 Floristics

The savanna plant communities are floristically poor. The diversity of plant species which are adapted to the highly weathered, nutrient poor, very acid volcanic soils of the savannas is very limited. The grassland communities are often dominated by a few species including *Miscanthus floridulus* (swordgrass), *Dimeria chloridiformis*, and *Pennisetum polystachyon*. Periodic wildland fires favor grass species that can rapidly resprout and dominant the site before wind disseminated seed becomes established.

If wildland fire is excluded for a few years, woody shrubs and trees, including *Casuarina equisetifolia* may slowly become established in the savanna plant communities. The woody component is often destroyed once a wildland fire occurs.

### 2.2.3 Savanna Grasslands Ecology

It is generally accepted that the savanna ecosystem is a result of repeated disturbance through land clearing and periodic burning that has occurred since the Spanish colonized Guam 300 ago. Ecological succession resulting in an orderly process of community development involving changes in species structure and community processes with time is disrupted by the periodic burning which resets the ecosystem development back to the earliest pioneer stage.



Existing ecological processes within the savanna ecosystem are largely influenced by modifications to the physical environment resulting from a history of soil erosion and changes to soil chemistry and structure. As with all terrestrial communities solar energy is the primary energy source entering the savanna ecosystem. Unlike the ravine ecosystem the savanna plant communities lack a well developed vertical structure. Solar radiation is intercepted by the tall (1 - 2 m) perennial grasses. Solar energy penetrating the plant canopy reaches the soil surface and is either reflected or the energy is transformed to heating of the soil profile. The heat energy in the soil is largely released back to the surrounding air.

As in the ravine ecosystem a percentage of the solar energy entering the savanna ecosystem is converted to photochemical energy through photosynthesis. This energy is stored in root and leaf structures. The periodic wildland fires convert the stored photochemical energy to heat as it burns, the heat energy exits the ecosystem. Following burning the lack of photosynthesizing leaves results in the rapid die-off of roots. Regrowth of the grassland plant community is usually rapid (within months). The cycle of vegetative growth and burning does not permit a stabilizing of the ecosystem processes.

The net result of these energy exchanges is that large quantities of photochemical energy is stored briefly (2 to 5 years) as plant tissue, but is released as heat into the atmosphere during burning. Also, the environment within the savanna ecosystem tends to be warmer than other ecosystems as a release of heat radiated from the soil.

Nutrient cycling within the savanna ecosystem is affected by the imbalance of essential nutrients as well as rapid combustion of organic matter during burning. Some of the essential nutrients are present at the extreme ranges for plant growth. Calcium is virtually nonexistent in savanna soils while magnesium is present in near toxic levels. The imbalance of nutrients and the very low pH (4.5) limits the availability of several essential nutrient. Mineral nutrients taken up into the grasses are returned to the surface of the soil by leaf fall and the die-back of the fibrous roots. High temperatures cause organic matter to be decomposed faster than it is accumulated.

Combustion of organic matter during the periodic burning results in the release of carbon dioxide, nitrogenous gases, and ash to the atmosphere and the deposit of the minerals in the form of ash. The litter ash is more soluble than the organic matter from which it was formed. Generally, burning may have the following effects on nutrient availability: 1) a temporary increase in the amount of available minerals, a lessening of soil acidity and increase in base saturation, a decrease in the supply of total nitrogen, and a change in the moisture and temperature conditions of the site. Site quality in the savanna has declined as a result of repeated burning. The soil surface has been compacted by rains following the removal of vegetative cover and litter, resulting in a decrease in the rate of water penetration. The ash is

susceptible to being wind blown out of the ecosystem, and susceptible to leaching and erosion by rainwater. The loss of total nitrogen through volatilization is widely recognized and is related to the intensity of the fire. Nitrogen loss is also proportional to the amount of dry matter of fuel consumed, and considerable nitrogen may be lost during intense fires. For examples, fire occurring at the beginning of the dry season result in less loss of total nitrogen than fires occurring in the middle of the dry season with the amount of dry matter is greater and all of the vegetation is consumed. Replacement of the nitrogen by precipitation alone requires many decades. Only the ability of the succeeding vegetation and soil bacteria to replace the available nitrogen lost in burning is an important factor determining the effect of fire on site quality. The lack of nitrogen-fixing plant species in the savanna inhibit the replacement of nitrogen resulting in a nitrogen deficiency.

The badland scarps associated with the savanna are the result of the extreme effects associated with frequent burning of the savanna and high rainfall. Soils within the scarps are extremely low in pH (4.3), calcium, and phosphorous, organic matter. Even plant species adapted to harsh savanna sites, such as *Miscanthus floridulus*, *Dimeria chloridiformis*, and *Gleichenia linearis*, cannot survive in the extreme conditions found within the badland scarps.

## 2.3 The Wetlands Ecosystem

### 2.3.1 Definition of Wetlands

Wetlands are present within the ravine forest, savanna grasslands, and riparian ecosystems. Wetlands are plant communities dependent upon a constant source of water in their substrate. Within the Ugum watershed, wetlands include marshes, bogs, and similar areas.

For the purpose of this technical report, running water (lotic) communities associated with streams are included in the wetland ecosystem.

### 2.3.2 Floristics

The floristics of wetland plant communities is strongly influenced by soils which are waterlogged either frequently or seasonally. Plants existing within this ecosystem are adapted to cope with waterlogged conditions. The wetland communities associated with savannas are often dominated by a few grass and sedge species, including *Panicum maximum*, *Phragmites karka*, and *Rhynchospora* spp. In the ravine forest, wetland flora may include woody trees including *Hibiscus tiliaceous* and *Barringtonia racemosa*.

Wetland plant communities in the lotic component of this ecosystem is limited to algae and benthic plants. Plant communities within the streams fall into two different community types: rapids communities and pool communities.

### 2.3.3 Wetland Ecology

Wetland ecosystems serve as a highly productive interface between terrestrial and open aquatic systems, providing beneficial functions to both, and facilitating a flow of energy

between them. Wetlands ecosystem processes are influenced by the movement of surface and subsurface water which affects gas exchange, temperature, and flow of nutrients. Solar energy is primary energy source entering the wetland ecosystem. Solar radiation is intercepted by the tall (1 to 2 m) perennial grasses. Solar energy penetrating the plant canopy reaches the soil surface and is either reflected or the energy is transformed to heating of the soil profile. Unlike the savanna ecosystem, the high moisture content of the soil buffers the soil profile from large fluctuations in temperature. This is a result of water being a polar molecule with a very high heat exchange capacity. Heat energy is released back to the surrounding atmosphere as the soil water evaporates.

A percentage of the solar energy entering the wetland ecosystem is converted to photochemical energy through photosynthesis. The leaf area serves as a pathway for energy exchange through evapotranspiration which results in a cooler environment surrounding wetlands.

Nutrient cycling in a wetland ecosystem differs from both the ravine forest and savanna. Nutrients can enter the wetland ecosystem as either eroded sediment or as dissolved minerals in subsurface flow from ecosystems above the wetland. Nutrient inputs from surrounding ecosystems are available to the plant communities. Because of the hydric nature of the soils, anaerobic soil conditions exist during periods of saturation which may result in slow decomposition of organic matter, and higher levels of organic matter in the soil than either the ravine forest or savanna ecosystems. The organic matter can serve as a storage of nutrients.

Nutrients can also be transported out of the wetland ecosystem as dissolved minerals in subsurface flow. Nutrients leaving the wetland ecosystem can either be deposited in other terrestrial ecosystems, or the nutrients can enter the Open water ecosystem and be transported to the sea.

Wetland ecosystems that are surrounded by savanna plant communities can be affected by wildland fires during drought periods. The higher moisture content with the wetland plant communities usually result in lower combustion of above ground biomass and rarely does a wildland fire completely consume the wetland plants.

The net result of these energy exchanges is that large quantities of photochemical energy is stored as soil organic matter and in plant biomass (above and below ground).

Ecological processes in the lotic community differs significantly from that of the terrestrial wetland community. Differences between streams and other ecosystems revolve around the input of solar radiation, current, and land-water interchange. Solar radiation entering the lotic community is controlled by canopy closure of the riparian community. Portions of the streams are completely shaded by woody vegetation present in the adjacent riparian ecosystem. In lower-gradient and higher-order streams, the stream channel by definition is wider and there

commonly is a gap or opening between the parallel strands of the riparian vegetation. These gaps in canopy affect species diversity and abundance in the lotic community by permitting more solar radiation to reach the open water. In general the amount of vegetative biomass in the lotic community on an area basis is much less than that of the other ecosystems. Much of the solar radiation reaching the lotic community is reflected or transformed in heating the water. Depending on the amount of suspended sediment in the stream, much of the solar radiation is diffused. A small amount of the solar radiation is converted to photochemical energy by photosynthesis.

The accumulation of biomass of the algae and benthic plant communities is an important energy source for the stream fauna. Much of the energy gained by the lotic component is transported downstream in the current and enters the sea.

## 2.4 The Riparian Ecosystem

### 2.4.1 Definition of Riparian

Riparian vegetation is defined as "vegetation growing on or near banks of a stream or other body of water on soils that exhibit some wetness characteristics during some portion of the growing season". Riparian ecosystems differ from wetland ecosystems in that wetland plant communities are adapted to saturated soil conditions, and riparian communities are associated with open water environments, such as streams.

### 2.4.2 Floristics

Because riparian ecosystems are located along stream channels, prominent zonation is longitudinal. Changes are more pronounced in the upper part of streams because the gradient, volume of flow, and chemical composition change rapidly. The change in composition of communities is likely to be more pronounced in the first mile than in the upper watershed. The riparian plant communities in the Ugum are longitudinal zoned with plant communities similar to wetland and ravine forest ecosystems found in the higher stream orders near the coast. *Hibiscus tiliaceus*, *Cocus nucifera*, and *Barringtonia racemosa* and other species which are adapted to periodic inundated and waterlogged soil conditions are commonly associated with riparian zones nearer the coast. The width of the riparian ecosystem is widest near the coast where the influence of the stream extends well beyond the stream channel.

In the upper watershed where volume of flow is much less, the savanna grassland vegetation often dominates, and the width of the riparian ecosystem is much narrower.

### 2.4.3 Riparian Ecology

The riparian ecology is closely linked to the watershed morphology in that the associated riparian plant communities follow an organized stream system from the upper watershed to the sea. Riparian ecosystem processes are influenced by the movement of open water in streams as well as subsurface flow from adjacent ecosystems. The riparian ecosystem

extends to either side of stream channels. As with the other ecosystems, solar energy is the primary energy source to the ecosystem and the ecological processes within the riparian zone is similar to those described for the other ecosystems. Because the riparian ecosystem is located along the lower slopes, soils which have eroded from upper slopes are intercepted by the physical presence of vegetation in the riparian zone. This results in an accumulation of soil in the riparian zone.

Stream channels are often associated with geomorphic faults resulting in subsurface water flow being closer to the soil surface. The combination of accumulated soil and higher soil moisture results in the site quality being higher in the riparian zone. Higher site quality in the riparian (at least where woody plant species dominate), results in a greater accumulation of biomass.

Soluble nutrients that are not absorbed by the biotic component of the ecosystem can exit the riparian ecosystem through subsurface flow that enters the open water. Soil which are eroded along the stream channel during high water flow exits the ecosystem as suspended sediment.

### 3.0 Resource - values/products/activities

The public and private lands within the Ugum watershed are valued for many uses including: gathering of native and wild plant products, harvest of wild and feral animals, a source of clean water, production of agriculture crops, and recreational activities. The biological communities and associated habitats together comprise ecosystems within a watershed.

Human are more than a biological component of ecosystems. Society, through economics, establishes value of commodities derived from ecosystems. People can have a profound effect on the biological and environmental components and affect the flow of energy within and between ecosystems. All of the resource values and products derived from the Ugum watershed as well as the activities occurring within the watershed are dependent on the sustainability of the ecological systems which comprise the watershed.

Past human activity in the watershed has gradually altered the species diversity and development of plant communities. Access into the watershed was determined routes suitable for ox carts, and trails and roads generally followed ridgetops. Ravine forests along the trails were cleared and burned to allow farming and grazing. Much of the existing savanna grasslands are probably a result of repeated clearing and burning of vegetation along the trails. As the soil eroded native forest vegetation could not re-establish and the adapted *Miscanthus* spp. dominate these areas. Humans also introduced and propagated a variety of plant species to the ravine forest. The introduced plants which were adapted to the multistory environment were able to become reproduce and are now a component of the ravine forest ecosystem.

Previous human activities which altered the energy flow or species composition and distribution in the watershed were not regarded as serious impacts because the land and resource economic value were relatively low. Today, and in the foreseeable future, the land and resource economic values of the watershed are increasing. The increasing economic resource value is, and will continue to put increasing pressure to develop the land for further economic return. Potential development activities in the watershed include agriculture cropping, golf course development, construction of homes and the related needed infrastructure, and recreational activities.

The watershed is an important source of clean water for the residents of southern Guam. The capability of the watershed to continue providing the quantity and quality of water is largely dependent on maintaining functional ecosystems which intercept precipitation reaching the soil surface and control the flow of water to the intake pipes and the water treatment plant on the lower Ugum River. The ecosystems can absorb a limited amount of development, but either excessive or poorly planned and/or located development has the potential to have a profound affect on the future ability of the ecosystems to function properly.

Activities in one ecosystem may result in adverse impacts to adjacent ecosystems, or in the case of water quality, activities in ecosystems far removed from the stream channel may reduce water quality as the impact is shifted from one community to another.

#### 4.0 Alternative mitigation measures

There are two approaches to mitigation of human activities: preventive mitigation and corrective mitigation. By definition preventative mitigation requires taking action to prevent an activity from resulting in an adverse impact. Corrective mitigation occurs after an impact has occurred and is designed to lessen the impact of the adverse action. While energy flow and ecological processes are best described at the ecosystem level, mitigation measures are generally activity specific and best discussed at the activity level and related back to the ecological processes affected.

#### 4.1 Agriculture

Agriculture activities have occurred in the ravine forest, savanna grassland, riparian, and wetland (terrestrial component) ecosystems. Preventive mitigation is necessary to ensure the changes to the ecological processes are within the ability of the various ecosystems to recover. Mitigation should include careful selection of sites to be used for agriculture. In general, clearing of ravine forest should be avoided. Once the forest vegetation is cleared, nutrient storage and cycling is disrupted, and recovery of the ecosystem is slow. If an area of ravine forest is cleared and farmed, essential nutrients are quickly lost through leaching and the physical loss of soil by erosion. Once the nutrients are loss and soil erosion occurs, agriculture activities are no longer economical and the site converts to a less productive savanna grassland.

Wetlands should also be avoided as agriculture sites. The wetland ecology depends on the flow of surface and subsurface water which is largely determined by drainage patterns and the soil profile. Agriculture activities which involve tillage disrupt the drainage pattern and can destroys the natural soil profile. Once the hydrology is disrupted only expensive corrective mitigation measures can restore the ecological processes.

Agriculture activities within the riparian ecosystem should be discouraged. The riparian areas are critical in reducing the amount of sediment, pesticides, and fertilizers from entering the streams.

Areas within the savanna grasslands are suited for agriculture activities as long as careful consideration is given to site selection, and agronomic practices. Preventive mitigation can be accomplished through conservation planning prior to tillage and planting and the installation of appropriate conservation practices. While conservation planning needs to be site specific some standard conservation practices that should be used in most, if not all, plans include:

- Conservation cropping sequence (328)
- Conservation tillage (329)
- Contour farming (330)
- Cover and green manure crop (340)
- Crop residue use (344)
- Field windbreak (392)
- Filter strip (393)
- Contour hedgerow (422)

#### 4.2 Golf course development

There are presently no existing golf course developments within the watershed. A golf course development requires the clearing and shaping of a large area (a hundred hectares or more), and the creation of a controlled ecosystem dependent on constant human intervention.

Because golf course developments involve extensive areas and major land disturbance actions, both preventive and corrective mitigation measures are required.

Because golf course development are intended to create a non-natural ecosystem, impacts to off-site ecosystems and resource values need to be addressed and mitigated for in the planning and construction phases. Off-site impacts may involve sedimentation as a result of on-site erosion, clearing of vegetation and removal of top soil from distant ecosystems, changes to sub-watershed hydrology, and pesticide and/or fertilizer contamination.

The extensive area required for golf course development usually results in several ecosystems being converted. Proper site selection is an important mitigation measure. In general, development should be limited to savanna grasslands. Clearing of ravine forest, riparian vegetation, and wetlands should be avoided. Prior to vegetation removal and ground disturbance, effective sediment control and erosion control structures must be in place.

Because soils covering development sites are often unsuitable for turf grass management, large quantities of top soil are stripped from distance ecosystems and transported to the development site. This results in the total destruction of natural ecosystems to create an artificial ecosystem completely dependent on external inputs of soil, water, and nutrients. Preventive and corrective mitigation of stripped sites is required to prevent off-site degradation. Revegetation of stripped sites will be a critical corrective mitigation measure. Conservation practices to revegetate stripped sites should include:

Critical area planting (342)  
Grass waterway (412)  
Mulching (484)  
Tree planting (612)  
Filter strip (393)

#### 4.3 Road construction

Access is essential for most human activities whether agriculture, recreational, or homes. With the exception of the paved road into Talofoto Falls, the existing road system in the watershed is generally in an unimproved condition and follow historic ox trails. Existing roads are present in all ecosystems: ravine forest, savanna grasslands, riparian, and wetlands. Generally, road location and standards are determined during the construction phase. Little or no concern of off-site impacts are addressed. The objective of current road maintenance activities is to keep the roads functional, and are not intended to mitigate off-site impacts.

Both preventive and corrective mitigation is required on existing and future roads. The importance of proper road location and design cannot be over emphasized. Generally, roads should be located along ridges in the savanna grasslands where minimum ground disturbance is required. Roads transecting ravine forest must be carefully located and designed since the



forests are generally found on side slopes. Roads should be located away from riparian and wetland sites. Clearing of vegetation should be of minimum width and the width should not be increased simply to allow more sunlight to dry the soil during construction.

Corrective mitigation measures involve revegetating the disturbed cut and fill areas of constructed roads. Grasses, legumes, or trees should be prescribed for revegetation on a site specific basis.

Roads constructed above wetlands and streams should be designed as not to interrupt the natural drainage to the point that wetland vegetation can no longer survive.

#### 4.4 Recreation activities

There are presently three categories of recreational activities occurring within the watershed: hunting, developed river-oriented, and undeveloped wildland-oriented. Natural vegetation is regarded as an important component of each category of recreation.

The natural vegetation provides important habitat for species desired by hunters, and hunting occurs in each of the ecosystems. Feral pigs are hunted in the ravine forest and riparian area. Philippine deer are hunted in the savanna grasslands, and black francolin are sought in the wetland ecosystems. In regards to hunting, the intentional setting of wildland fires to provide access and to draw deer into the open has the most adverse affect to the ecological processes. Hunters using off-road vehicles to access areas also results in resource damage. A single hunter with little regard for resource values can have a long term negative effect through the intentional setting of wildland fires or creating tire depressions which erode during the wet season.

At least one commercial enterprise with transports tourists into the wildlands is operating in the watershed. This undeveloped wildland-oriented recreationalist is often advertised as ecotourism, but there is strong evidence that the off-road traffic of the tour operators is resulting in considerable resource damage in terms of soil erosion and contributing to an expansion of badlands within the savanna grasslands. The number of unimproved roads within the upper watershed has doubled in the past 20 years, much of these unimproved roads are the result of off-road traffic by tour operators. Both preventive and corrective mitigation measures are required.

#### 5.0 Recommended mitigation measures

For each of the management plan scenarios, except the No Action scenario, the recommended mitigation measures include both preventive mitigation and corrective mitigation measures. The intensity of the mitigation measures increase as the level of ecosystem protection increases.

5.1 Scenario I: No Action

Recommended mitigation under the No Action scenario is limited to voluntary cooperation with individual land owners in assessing potential preventive conservation practices on agriculture lands. Minimum adoption and implementation of conservation practices are expected under this scenario.

5.2 Scenario II: Maintenance, Current Zoning

Recommended mitigation under the Maintenance, Current Zoning scenario include conservation measures which would permit development without measurable degradation of the existing ecological processes.

5.2.1 Agriculture

The objective of agriculture under this scenario is to promote sustainable agriculture through proper site location and adoption of conservation practices. The Government of Guam, through the Soil and Water Conservation Districts, would actively support conservation planning on all agriculture lands within the watershed. Voluntary adoption and implementation of conservation practices specifically to protect water quality and quantity would be emphasized. The goal of conservation practices in this scenario is to protect water quality and quantity by: 1) preventing non-point source sediments from reaching stream courses, and 2) maintaining forest vegetation. Generally agriculture fields would be located within the savanna grassland ecosystems on flat or only gentle slopes. Included in agronomic conservation practices would be:

Conservation tillage (329)  
Cross-slope farming (330)  
Crop residue use (344)

5.2.2 Golf course development

The objective of golf course development under this scenario is to promote economic development. Appropriate agencies within the Government of would require that potential environmental impacts are identified through an assessment and that impacts are effectively mitigated through preventive and corrective measures. Preventive mitigation should include minimizing the clearing of ravine forest, and impacts to wetlands and riparian zones. Erosion control through effective filter strips would be required. Corrective mitigation should include replacement plantings of cleared ravine and riparian vegetation. If wetlands are adversely impacted by the golf course development, constructed wetlands should be developed to mitigate the loss of wetlands.

5.2.3 Road construction

The objective of road construction is to provide access to other uses in the watershed. Appropriate agencies within the Government of Guam would require roads be designed and

constructed to appropriate standards for the intended use. Preventive mitigation would include avoiding sensitive areas, such as wetlands and unstable slopes. Corrective mitigation would include re-establishment of vegetation on cut and fill slopes.

#### 5.2.4 Recreational activities

The objective of recreational activities is to promote economic development and public enjoyment of the natural environment. Appropriate agencies within the Government of Guam would permit commercial recreational activities that would not contribute to non-point source sedimentation. Cooperative agreements with land owners would be negotiated that would allow government monitoring of the impacts of tour groups. Wildland fires would be suppressed when resource values were threatened.

#### 5.2.5 Residential construction

The objective of residential construction is to promote economic development as well as an opportunity for private individuals to improve their quality of life through home ownership. Variances to existing zoning would be rare. Single family homes would be encouraged. Building permits would not be issued for construction within riparian ecosystem. Filling or damaging wetland ecosystem would not be permitted. Retention and planting of trees and shrubs around homes would be encouraged.

### 5.3 Scenario III: Improvement, Adjusted Zoning and Land Use Policy

#### 5.3.1 Agriculture

The objective of agriculture under this scenario is to promote sustainable agriculture through proper site location and adoption of conservation practices. The Government of Guam, through the Soil and Water Conservation Districts, would actively support conservation planning on all agriculture lands within the watershed. Zoning and land use policy would limit agriculture activities to specific soils and slopes. A conservation plan would be required and practices designed to protect water quality and quantity would be mandatory. Generally agriculture fields would be located within the savanna grassland ecosystems on flat or only gentle slopes. Included in agronomic conservation practices would be:

- Conservation tillage (329)
- Contour farming (330)
- Cover and green manure crop (340)
- Crop residue use (344)
- Field windbreak (392)
- Filter strip (392)
- Contour hedgerow (422)

#### 5.3.2 Golf course development

The objective of golf course development under this scenario is to promote economic development. The Government of Guam, appropriate agencies, would require that potential environmental impacts are identified through an assessment and that impacts are effectiveness mitigated through preventive and corrective measures. Preventive mitigation would include minimizing the clearing of ravine forest, and impacts to wetlands and riparian zones. Erosion control through effective filter strips would be required. Corrective mitigation would include replacement plantings of cleared ravine and riparian vegetation. If wetlands are adversely impacted by the golf course development, constructed wetlands would be developed to mitigate the loss of wetlands.

Stripping of top soil would be closely monitored and corrective mitigation would be required, including timely revegetation.

#### 5.3.3 Road construction

The objective of road construction is access to other uses in the watershed. The Government of Guam, though appropriate agencies, would require roads be designed and constructed to appropriate standards for the intended use. Preventive mitigation would include avoiding sensitive areas, such as wetlands and unstable slopes. Corrective mitigation would include re-establishment of vegetation on cut and fill slopes.

Existing roads would be brought up to standards. Roadways that are not serving a specific purpose would be closed and revegetated.

#### 5.3.4 Recreational activities

The objective of recreational activities is to promote economic development and public enjoyment of the natural environment. The Government of Guam, through the appropriate agencies, would permit commercial recreational activities that would not contribute to non-point source sedimentation. Cooperative agreements with land owners would be negotiated that would allow government monitoring of the impacts of tour groups. An active education program on the impacts of wildland fires would be initiated. Wildland fires would be suppressed. Reforestation of savanna grasslands would be emphasized and as well as establishment of vegetative fuel breaks to compartmentalized wildland fires.

#### 5.3.5 Residential construction

The objective of residential construction is to promote economic development as well as an opportunity for private individuals to improve their quality of life through home ownership. Zoning for residential construction would incorporate protection and enhancement of forest ecosystems. Variances to zoning would be rare. Single family homes would be encouraged. Building permits would not be issued for construction within the riparian ecosystem. Filling or damaging wetland ecosystem would not be permitted. Retention and planting of trees and shrubs around homes would be encouraged.

## 6.0 Results of mitigation

### 6.1 Ravine forest

#### 6.1.1 Scenario 1: No Action

Portions of the ravine forest would be cleared for other uses over the next twenty years. Where ravine forests are cleared for agricultural activities, site productivity would decline as the nutrients are used by crop plants and leached, and soil erosion occurs. Land users would increase use of fertilizers and pesticides to maintain crop production at an economic level. When the cost of fertilizer and pesticide treatment decreases the profit significantly, the and the cleared areas would be abandoned. Some of the abandoned lands would begin to recover as early seral vegetation becomes established and the natural nutrient cycling processes rebuild. Areas that were cleared on marginal or steep lands are abandoned would likely convert to savanna grasslands. A portion of the sediment eroding from the agricultural lands would eventually enter the streams and water quality would be adversely affected.

Construction of roads through the ravine forest would permit access that would lead to additional clearing for other uses, such as homesteads and agriculture. Roads would be of poor quality and wide strips of ravine forest would be cleared to facilitate drying of the road surface.

Golf course development would result in some clearing of ravine forest areas. During the construction phase, a portion of the sediment eroding from the site would enter the streams and water quality would be adversely affected. Cleared areas would be converted to fairways, greens, and infrastructure development. The hydrology of the sub-watershed would be affected resulting in increases in peak flow in the sub-watershed.

Recreational activities involving off-road vehicle use would increase. The number of pioneered roads through the ravine forest would also increase and the destruction of vegetation and rutting would result in gully erosion forming and an increase in the amount sediment entering the streams.

Residential construction would occur in all ecosystems. There would be a loss of important riparian and wetland vegetation.

#### 6.1.2 Scenario 2: Maintenance

Less area than the No Action scenario would be cleared over the next twenty years. Agricultural activities would be limited to appropriate soils and slopes. Installed conservation practices would limit soil loss to acceptable levels and very little of the eroded sediment would enter streams. Water quality would not be materially degraded as a result of agricultural activities. Site productivity would not be degraded and abandoned agricultural lands would convert back to ravine forest vegetation over time.

New road construction through the ravine forest would be designed and constructed to standards. Revegetation of cut and fill slopes would control erosion and water quality would not be adversely affected.

Some ravine forest vegetation would be cleared for golf course development but reforesting an equal area of savanna grasslands with appropriate species would mean no net loss of forest vegetation. Over time ravine forest species would become established in replanted areas.

Recreational activities would increase but use of off-road vehicles would be monitored. Most recreation in the ravine forest environment would be foot traffic and continued hunting for feral pig.

Residential construction within the ravine forest would be limited. Impacts to ravine forest ecosystems would result from infrastructure development (power, sewage, and water lines).

#### 6.1.3 Scenario 3: Improvement

Only limited areas of the ravine forest would be cleared for development and roads. Forestland cleared for agriculture would remain productive through conservation practices. Virtually no erosion would occur on agricultural lands, and there would be no discernible degradation of water quality.



## 6.2 Savanna grassland

### 6.2.1 Scenario 1: No Action

Savanna grasslands would expand as forested ecosystems are cleared for agriculture and abandoned over the next twenty years. Portions of the savanna grasslands would temporarily be converted to agriculture use but would convert back to grasslands. Wildland fires would continue to maintain the existing grasslands in an early succession stage. Erosion from burned grasslands would continue to contribute the most sediment to the Ugum Rivers and its tributaries. Site quality would continue to decline and badland areas would increase in size.

Construction of roads through the savanna grasslands would permit access that would lead to additional wildland fires, off-road vehicle, and related erosion. Lack of proper road design and construction would result in erosion of cut and fill slopes which would contribute to the sediment load in the streams.

Golf course development would result in conversion of savanna grasslands. During the construction phase, a portion of the sediment eroding from the site would enter the streams and water quality would be adversely affected. Erosion would decrease following construction and establishment of vegetation. The hydrology of the sub-watershed would be affected resulting in a slight decrease in peak flow in the sub-watershed.

Recreational activities involving off-road vehicle use would increase. The number of pioneered roads through the savanna grasslands would increase and the destruction of vegetation and rutting would result in gully erosion forming and an increase in the amount of sediment entering the streams.

Most residential construction would occur in the savanna grasslands. Construction of homes and roadways would permanently remove savanna vegetation. Grasslands adjacent to homes would be affected by human activities including increased foot and vehicle traffic, garbage dumping, and wildland fires.

### 6.2.2 Scenario 2: Maintenance

Less area would be converted to savanna grassland than the No Action scenario would be cleared over the next twenty years. Agriculture activities would be limited to appropriate soils and slopes. Installed conservation practices would be limit soil loss to acceptable levels and very little of the eroded sediment would enter streams. Water quality would not be further degraded as a result of agricultural activities. Site productivity would not be degraded and abandoned agricultural lands would convert back to savanna grasslands.

New road construction through savanna grasslands would be designed and constructed to standards. Revegetation of cut and fill slopes would control erosion and water quality would not be adversely affected.

Savanna vegetation cleared for golf course development would be in a less eroding state once vegetation is established. Savanna grasslands would be planted to trees as a mitigation measure of golf course development in ravine forest areas.

Recreational activities would increase but use of off-road vehicles would be monitored. Wildland fires would continue at the current rate.

Most residential construction would occur in the savanna grasslands. Additional planning and construction standards would reduce adverse impacts from the No Action scenario. Construction of homes and roadways would permanently remove savanna vegetation. Grasslands adjacent to homes would be affected by human activities including increased foot and vehicle traffic, garbage dumping, and wildland fires.

#### 6.2.3 Scenario 3: Improvement

The area of savanna grasslands would decline over the next twenty years as sites are used for sustainable agriculture and reforested. Erosion in the watershed would decrease as areas are reforested. Site quality would improve where savanna areas are converted to forest and agriculture use. Water quality would improve.

### 6.3 Wetland

#### 6.3.1 Scenario 1: No Action

Some wetlands would be converted to other uses over the next twenty years. Where wetlands are converted to agricultural use, site productivity would decline as the nutrients are used by crop plants and leached, and soil erosion occurs. Land users would increase use of fertilizers and pesticides to maintain crop production at an economic level. Some of the fertilizers and pesticides would enter streams and result an adverse impact to water quality. Hydrology of the converted wetlands would be disrupted for several years as a result of cultivation. Converted wetlands would slowly recover once the site is abandoned.

Construction of roads through the wetlands would destroy the hydrology of wetland site. Traffic through the wetlands would continue to degrade the surrounding wetland as erosion increases.

Golf course development and home construction would result in some destruction of wetlands.

#### 6.3.2 Scenario 2: Maintenance

There would be no net loss of wetlands under this scenario. Specific wetlands would be filled or degraded by development but constructed wetlands would mitigate these impacts. Agriculture would not impact wetlands. Wildland fires would continue periodically to burn through the wetlands. Road construction would be designed and located to avoid degrading wetland quality. Vegetation in streams and rivers would not be materially affected.

#### 6.3.3 Scenario 3: Improvement

Conservation on agriculture lands would reduce soil erosion and farm-related sedimentation of wetlands. Constructed wetlands resulting from golf course development would have some native wetland plant species. Designed roads would have reduce road-related sedimentation of wetlands. Residential construction would avoid degrading wetland values, and water quality would improve.

6.4 Riparian

6.4.1 Scenario 1: No Action

Riparian vegetation would be cleared for development activities. Agricultural fields would encroach into the riparian zone degrading the quality of vegetation and adversely affecting the ecological processes associated with the riparian zone. Golf course construction would result in further loss of riparian vegetation. Roads constructed through riparian would destroy vegetation and be a source of sedimentation. Residences constructed within the riparian ecosystem would permanently replace riparian vegetation.

6.4.2 Scenario 2: Maintenance

Limited activity would be allowed in the riparian ecosystem minimizing adverse impacts. Generally there would be no net loss of riparian vegetation.

6.4.3 Scenario 3: Improvement

Same as scenario 2.

END OF REPORT

## WETLANDS by R.L. Sablan

### I. Introduction

The Ugum Watershed covers an area of approximately 11.8 square kilometers (7.33 square miles) or 4,691 acres in five distinct subwatersheds, and twenty three (23) miles of rivers. The vast majority of wetlands and open water features identified as part of this management planning effort and by the U.S. Fish and Wildlife Service (USFWS) Wetlands Inventory 1983 (1975 aerial photographs), approximately 102 hectares (255 acres), are located primarily within the riparian and flood plain areas of the various river systems. Wetlands, including open water habitat make up approximately 5.4 % of the watershed.

The official wetland definition for Guam is as follows:

"Those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, mangroves, natural ponds, surface springs, estuaries and similar such areas."

For the purposes of this management plan wetlands were only delineated (identified) using current inventory sources (USFWS) and did not include wetland specific field surveys with the exception of 12 hectares identified during vegetation inventories. An important note is the fact that the primary basis for determining wetland ecosystem resources within the watershed was through the remote interpretation of 1975 aerial photographs. Stereoscopic interpretation based on vegetation types, visible hydrology, and geography was conducted, therefore an inherent margin of error exists with inventory results that are only accurate subject to ground verification and more detailed scientific analysis (U.S. Fish and Wildlife Service, 1983). The general consensus among wetland experts suggests that the inventory is significantly short of the actual total wetland resources for any given land unit (Lee L.C., personal communication, 1994). When conducting land-use analysis for wetland resources land owners, managers, resource personnel among others should require site specific wetland determinations in all cases due to strict regulatory control with regard to modification and impact of wetlands by both federal and local authorities. In most cases resource agencies are mandated to assist in the verification process to the most practical extent.

Wetlands identified in the Ugum Watershed are classified in two (2) broad categories as either Pulustrine or Riverine. Pulustrine systems primarily include but limited to inland (nontidal) freshwater wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens (ref.). Some of the more typical systems found in the Ugum Watershed are dominated by *Phragmites karka* (Karriso), *Hibiscus tileacious* (Pago), or a combination of both.

Headwater wetlands which occur on steep slopes as well as on broad drainage flats within savanna grasslands may be dominated by low growing (emergent) sedges and mixed with *Phragmites*. Headwater wetlands are highly seasonal except for those in shallow ravines (depressions), slumped areas on steep slopes (indicating springs), and other narrow riparian areas associated with seasonal streams.

Riverine wetlands include all wetlands associated with deepwater habitats of rivers their channels or banks and are characterized by the periodically or continuously flowing water, or which form links between two bodies of water standing water.

The major difference between Pulustrine and Riverine wetlands adjacent to rivers or streams is that Riverine wetlands are confined to that area between river banks (top of bank to top of bank) under the influence of flowing or moving water while Pulustrine wetlands make up the remaining area from the river bank to uplands. Pulustrine wetlands are common in flood plains, however both Pulustrine and Riverine wetlands may be located in and constitute a majority of a given riparian zone.

## II. Assessment of Resource Functions/Products/Activities

The various functions and beneficial products of wetlands are well documented (University of New Orleans) The functions of wetlands within the Ugum Watershed include;

- Water quality protection
  - Sediment trapping (control)
  - Chemical detoxification
  - Nutrient recycling and removal of organics
- Groundwater recharge and discharge
- Streamflow maintenance and water supply
- Flood protection (storage and conveyance)
- Productivity (food and fiber)
- Wildlife, fisheries, and coral reef protection
- Aesthetics, recreation, and cultural resources
- Education and research

### A. Water Quality Protection (Mechanical)

Mechanical water quality protection is achieved through sediment deposition of a significant percentage of total suspended solids including organic material or detritus. Because many wetlands are depressional and located at various receiving points within a given river system, from headwater wetlands to coastal estuaries, they act as multiple sediment basins each in turn accounting for a percentage of the settling-out function as water moves through a watershed. Important factors for the effective removal of sediment are based on the velocity and volume of water through the system and wetland vegetation type.

This function may be expressed as average residence time, however hydrologic factors determining a given volume/time unit of water runoff entering wetlands, residence time, and discharges are best quantified as a hydroperiod. Unless normal rates of erosion, quantities of sediment, and water carrying that sediment are not exceeded, wetlands will function to remove sediment without detrimental effect to the wetland itself. Excessive rates of sediment deposition will tend to *overload* a given wetland and accelerate the rate of surface or soil profile change where water tables and flow patterns eventually alter wetland size, vegetation patterns or create wetlands at new locations as water seeks new areas to accumulate. Where standing water provides for fish habitat excessive loading will affect the fish that live feed and reproduce in the wetland.

### B. Water Quality Protection (Chemical)

Wetlands function to protect down stream waters from chemical pollution by acting as accumulation points of pesticides, solvents, fuels, heavy metals and other chemicals of largely human origin. While a wetland may function as a buffering system for water the affects of chemical accumulations, if chronic, may adversely affect the wetland itself by inhibiting the normal growth and reproduction of plants and animals in the wetland. Some decomposition of chemicals to less toxic compounds may occur over long periods of time, however the rate of effective decomposition and natural recycling (biodegradation) and fate of toxic materials in wetlands is not well known and likely differs depending on the type of material (Mitsch and Gosselink, 1986). Wetland soils are hydric meaning they lack oxygen for substantial periods of time, however a thin layer of soil and standing water above hydric soils does contain oxygen. Basic chemical reactions and the process of degradation will result in various rates of Chemical Oxygen Demand (COD) in addition to Biological Oxygen Demand (BOD) [T. Dunne, 1978]. It follows that excessive rates of either and in this case COD will eventually deprive living organisms of minimum available dissolved oxygen levels. Therefore, the functional benefits of wetlands to buffer down stream waters from chemical pollution may also result in the degradation of wetlands chemically and physically while at the same time still allowing the undesirable introduction of chemicals into the food chain (T. Dunne).

### C. Water Quality Protection (Biological)

Biologically, wetlands provide the beneficial function of nutrient uptake and consumption by plant material and the slow but beneficial decomposition of organics. Wetlands could be considered for and are known to provide effective land treatment of wastewater if designed and operated properly. High concentrations of nutrients and organics in stream water will cause higher levels of BOD and further resulting in higher rates of algae growth and distribution. In turn, algae requires dissolved oxygen that would otherwise be available to fish and other stream biota.

Wetlands serve to accumulate nutrients such as phosphorous and nitrogen where they are utilized by wetland plants (J.F. Berry, 1993). As in all cases where the protection of water quality is critical any wetland or system of wetlands within a watershed could be rendered ineffective where the quantity of water and/or the concentration of physical or chemical inputs exceeds wetland capacity to retain and process that material.

All ecosystems have limiting factors and abilities to absorb adverse impacts, yet in the case of wetlands normal conditions provide for high levels of protection of otherwise adverse impacts are reduce with regard to impacts on other water resources. All indications point to the fact that long term exposure to adverse levels of physical or chemical impacts eventually reduce the functional attribute of a given wetland system or loss of the wetland entirely (T. DUNNE).

### D. Groundwater Recharge and Discharge

Hydrologic conditions within the Ugum Watershed provide limited opportunities for groundwater recharge because soils have low percolation and storage qualities. Generally, southern watersheds are believed to have limited potential for groundwater production although groundwater is available at quantities below economic production yield levels.

Ground water discharges generally occur as springs with associated wetlands on steep slopes and at the base of hills and mountains where ground water encounters bedrock material and is forced to the surface. It is not known how or to what extent wetlands in the watershed function to recharge groundwater aquifers, however some wetlands tend to be located where discharges occur and water enters surface streams or rivers. (K.N. Brooks, 1991)

### E. Stream Flow Maintenance and Water Supply

Wetlands are recharged during the wet months (rainy season) of the year and release water over longer periods of time roughly proportionate water quantity inputs. The hydrologic function or what may be referred to as the "hydroperiod" of wetlands is important in maintaining stream flows through the transitional periods from wet to dry seasons attenuating large quantities during high rain fall periods and releasing water over a longer period of time into the dry season (K. Brooks and J. Berry). The reservoir (storage) function of wetlands is only beneficial if the system of wetlands within a given watershed remains undisturbed relative to location and size.

### F. Flood Protection

Many of the larger wetlands identified in the Resource Assessment are located along major river and tributary flood plains. Flood events will cause water to overtop banks and continue downstream within the various flood plains slowing water down by spreading flows out over a broader vegetated areas. Wetlands which are also flood plains exist at these locations because the water table adjacent to rivers is relatively high year round unless extreme drought conditions occur. Wetlands function for flood protection much the way they function for water storage and stream flow maintenance in that they are stable vegetated systems where water may accumulate over time and release water slowly. A given river systems capacity to transport water down stream at low velocities and quantities for a given flood event.

### G. Productivity

A wetland includes vegetation which may be valuable for wood products, and food. Betelnut trees are typically located along the fringe of wetlands and often within wetlands in sheltered valley floors. Pago bark is excellent rope or lashing material and was extensively used by early Chamorros for construction purposes. Likewise, taro production typically was located in or close to wetlands. Pandanas trees produce a fruit bundle which when husked yields a starchy and sweet nut likely of high nutrient value. Pandanas make up a significant component of wetlands and wetland fringe areas in ravine forests in the Ugum Watershed.

#### H. Wildlife, Fisheries, and Coral Reef Protection

The trophic relationships in wetlands, basically summarized, include the various biological processes of a typical detritus-based system. With the exception of possible foraging and cover habitat for water buffalo and wild pigs much of the energy and matter movement in wetlands are carried out by insect, invertebrates, fungi, bacteria and other small to microscopic animal life which consume litter and other decaying material (ENSR Consulting and Engineering, 1994).

From the human consumption standpoint wetlands provide important shelter and foraging areas for wild pigs and deer which have been a traditional food animal for Chamorros. In addition, areas of open water such as rivers, streams, and ponded areas within wetlands include freshwater prawns, eels, and introduced talapia (fish) which are utilized as food. Wetlands also support numerous small indigenous fish and insects such as gobbies, flagtails, water spiders, worms, leaches among others. Wetlands provide critical habitat for the Marianas Moorhen and the threatened Bittern (Kaka).

Coral reefs are protected through the wetland function of trapping sediment and the consumption or biological up-take of nutrients and minerals. A significant quantity of sediment is trapped in wetlands that would otherwise settle out in marine waters and on coastal reefs. Likewise, unless the watershed includes vegetated water systems, of which wetlands are the most significant, few opportunities might exist for the filtering and up-take of nutrients and minerals. The opposite condition of a functional watershed that includes a balance of wetlands areas, rivers, ponds, etc. is the channelization of run-off into streams and rivers with very little residence time for the overall treatment of surface water run-off.

#### I. Aesthetic, Recreational, and Cultural Resources

Wetlands make up a significant portion of most southern watersheds and river systems. Aesthetically, wetlands are distinguishable in the river valleys where the mosaic of vegetation may range from forested lands to broad depressional emergent grasses and shrubs.

Because wetland areas retain water over long periods of time, even during the dry season, they will stand out on the landscape as dark green vegetated areas surrounded by dryer and some times light brown savanna grasslands. Appreciation of wetlands at a smaller more intimate scale will reveal picturesque ponds, streams with shaded riparian wetlands, occasional bird sightings, and a number of plants or trees which have spectacular flowers such as the Pandanas, Phragmites (in bloom), and many other small flowering (seeding) sedges, vines, and ferns.

Most of the recreational opportunities associated with wetlands stem from the fact that the areas are quite beautiful, are habitat to several bird species, are areas where betelnut may be gathered, and where freshwater shrimp and fishing is possible. One of the unfortunate but common recreational use of wetlands in South/Central Guam is off-roading. Wetlands provide a certain challenge to off-roaders in that specially modified trucks with large "mud" or "swamp" tires may use a wetland area as an obstacle feature.

Typically, an exciting off-road experience includes fording rivers, swampy areas and other wetland sites in order to test a driver's skill and the effectiveness of specialized equipment.

Culturally or historically, wetlands have served as places where taro and rice crops could be cultivated. Another possible use of wetlands is for the gathering of medicinal plants by Surahanu's or traditional medicine people. Furthermore, wetlands have always played an important role as water sources, especially those areas associated with springs and ponds.

#### J. Education and Research

Wetlands, depending on the type, may be rich in wildlife and plant species as diverse as any ecosystem in tropical island regions. The abundance of juvenile aquatic life in mangrove wetlands is well documented as are the unique plants which are specifically adapted to a range of water levels. Pulustrine wetlands, and especially the more monotypic *Phragmites* wetlands, are somewhat less diverse from both the wildlife and plant species standpoint. However, Pulustrine wetlands also include forested wetlands which are much more diverse in plant and animal species. Moreover, *Phragmites* wetlands are not well studied at this time and therefore provide good opportunities for scientific research. Often what is perceived as simple and monotypic may be substantially diverse if scientists are encouraged to evaluate, classify, and study the system. While wetlands as distinct ecosystems are well known for many of the above mentioned functions and even values, the opportunities to closely research regional variations and specific conditions of wetlands for a given watershed or island remain a viable area for additional research.

For example, the specific wetlands identification and delineation procedures used by the federal government have, under certain circumstances, been inaccurate and inappropriate due to the broad regional parameters and assumptions applied in their development. Island specific conditions are not always well suited to or match conditions developed largely based on Hawaiian Island or southeastern state conditions.

### III. Resource Problems

#### A. Wildland Fires

Wildland fires represent the major adverse impact to wetlands in the Ugum Watershed at the present time. The affects of fire on wetlands in the watershed are the immediate impact of vegetation loss along the fringe of wetlands and in the case where fires completely burn through a wetland the loss or displacement of nearly 100% of vegetation and wildlife. The longer term impacts of fire in the watershed results in accelerated erosion rates after fires, development and expansion of badlands, and the deposition of eroded soil in wetland areas. Excessive soil loading during the first wet season after wildland fires may have serious implications in the long term wetland alterations of both the soil profile and resultant invasion of less desirable wetland species (*Phragmites*) (G. Wiles and M. Ritter) and upland weed or savanna species. Infilling of wetlands, the resulting change in species type and composition may eventually cause shrinkage, loss, or conversely flooding and establishment of new wetlands downstream (G. Wiles and M. Ritter). When savanna grasslands burn there is likely an increase in the demand for habitat and forage resources by wildlife on adjacent resources. When savanna grasslands burn and wetlands do not, wetlands become islands of refuge for displaced wildlife thereby stressing available cover, food stocks, therefore increased populations may exceed wetland ecosystem carrying capacities.

An additional concern with regard to wetland functional abilities and fire is the release of nutrients from burned areas that eventually leach from the savanna lands into wetlands and ultimately streams and rivers. It is not clear what levels of nutrient loading in wetlands and other surface waters occur after fires and how effective wetlands are in absorbing leached nutrients before they enter downstream surface waters.

#### B. Off-road Activities



Off-road activities in the Ugum Watershed may be identified by three (3) specific user or activity groups; (1) farming activities; (2) hunting and/or gathering activities; (3) tourism related recreational activities. Since a majority of the land in the watershed is privately owned, controlled by gates or inaccessible by vehicles during the wet season there are few if any other off-road activities in the watershed.

### 1. Farming Activities

Routine maintenance of active access roads and the opening of new roads for the propose of agricultural activities constitutes a major activity in the watershed. Farming roads, for the purpose of this report are considered as off-road activities because a significant portion of the activity is not systematically developed or planned in accordance with best management practices. Farming roads that are located along wetland fringes or actually cross streams and wetlands resulting in repeated impacts to hydric soil (compaction, erosion..etc.), vegetation, and ultimately habitat degradation.

### 2. Hunting/Gathering Activities

Hunting and gathering activities are widespread throughout the watershed and much of the associated off-road activity is not sanctioned by landowners. Because of this the off-road activities for hunting tend to increase the number of jeep trails across the landscape and the main issue with hunters is to access wildlife and plant resources in the most efficient and direct manner possible without regard for resource protection. As with farming activities and more so, off-road activities for hunting are unregulated and/or planned in that wetlands may be crossed in order to access remote sections of the watershed to gather wildlife and plant resources regardless of resource damage.

### 3. Tourism Activities

Portions of the watershed are utilized by Safari Tours, Inc. for off-road and off-road sightseeing activities on a near daily basis. It has been noted that part of the off-road experience for tourists is to traverse steep and rough terrain, badland areas, and muddy (wet) areas in order to provide a variety of exhilarating experiences and to access remote and spectacular areas such as rivers, caves, historical sites, and areas where wildlife, mainly water buffalo, tend to congregate.

The touring activity is sanctioned and arranged through the landowner as a permitted activity, however there do not appear to be guiding rules or standards of conduct with regard to where or how the activity is conducted as long as it does not interfere with other landowner activities such as farming. The potential to impact wetland areas and wildlife is great for this activity from the standpoint of direct impacts on wetland resources for the "muddy" experience and indirectly as a result of erosion from the multiple short-term creation of new and challenging jeep trails.

### C. Sediment Loading

Sediment loading problems result from the problems of Wildland fires and off-road activities outlined above. The natural rate of sediment loading from undisturbed lands is not a problem that should require attention at this point with the exception of those areas that have been previously disturbed and continue to erode unabated.

Other possible sources of sediment loading or erosion are related to potential future human disturbances such as residential home development, golf course development or any number of possible activities permitted in an "A" (Agricultural) Zone. Two (2) sediment (erosion) loading issues are of concern when development projects involve disturbing pristine areas within the watershed; those related to construction impacts and short term erosion and those related to long term erosion when disturbed areas are not properly revegetated or restored.

Wetlands will be impacted by excessive erosion when projects are not planned and developed with wetland resource protection standards. Development projects may also require or necessitate fill and/or the modification of wetlands as part of the project.

Some of the more typical wetland impacts or significant potential uses associated with land-uses in agricultural areas are; utilizing wetlands as wastewater treatment areas, stormwater control and disposal areas, modifications to control flooding as water features such as lakes, ponds, and reservoirs, seasonal cultivation, permanent conversion from wetland to farm fields (draining), water harvesting (pumping) for irrigation, filling for roads, bridges, infrastructure, homes, and other development structures.

### **III. Alternative Mitigation Measures, Best Management Practices, and Management Issues**

The following measures, practices, and issues are arranged in three broad categories; policy development, planning applications, and construction/Operational practices.

#### **A. Planning Applications**

##### **1. Avoidance - Environmental Land-Use Planning**

The primary management practice for the protection of natural wetland systems which will provide for or maintain the most beneficial functions is avoidance.

Environmental land use planning, if conducted appropriately will identify development constraints for a range of natural resources one of which may be wetlands. Identification of wetlands and wetland functions within a given land parcel or unit should be considered during the initial scoping process for project feasibility.

In the past, wetlands were only identified as a constraint issue when government resource personnel brought the issue to the permitting table. Resource personnel, often become involved in the planning process after the developer had finalized plans and was requesting final construction permit approval.

The main concern with this management issue is to have wetlands as well as other landscape and wildlife constraints identified early in the planning process in order to design development around major constraints as opposed to manipulating the natural constraints to fit the development plan. Wetland fill, excavation, or modification permits are time consuming, expensive, require mitigation and involve at least four federal and local agencies requiring two (2) separate but related permit approvals.

##### **2. Environmental Impact Assessments**

The Environmental Impact Assessment (EIA) is a basic planning tool for environmental land-use planning. EIA's are required by Guam Executive Order 90-10 and by the National Environmental Policy Act, 1969 (NEPA) for federal projects and expenditures. EIA's provide the basis for decisions, document the significant constraints to development and mitigation necessary to minimize environmental impacts.

##### **3. Low Impact/Compatible Uses**

Low impact and compatible land uses in or adjacent to wetlands may provide viable development options if planned for and implemented considering wetland ecosystem sensitivities. Ecotourism has been promoted in Guam and internationally as a major marketing idea with the concept that tourism must be integrated with natural ecosystems as opposed to the systematic consumption of natural resources without real concern for long term sustainable yield. Nature tours and wilderness appreciation are significant ingredients in the existing off-road

touring enterprise, however the tours cannot be considered as compatible with resource protection due to unplanned and uncontrolled off-road impacts which are believed to cause significant erosion.

Golf course development if planned appropriately and managed with environmental protection in mind could be considered a low impact use. Exceptions to this view are related to undesirable impacts of pesticide and fertilizer use, temporary construction impacts, and the loss of native forest and other resources.

A golf course, in order to be considered compatible or as having low impact on resources would have to incorporate most the following design and operational features:

- be located almost entirely on existing badlands or savanna grasslands
- involve no loss of native wetlands or only minor modifications
- involve little if any irrigation where irrigation is sourced from deep ground water and appropriate surface sources
- should be managed pesticide and fertilizer free
- constructed in small incremental phases to reduce construction impacts

Ecotourism and what might be considered Ecogolf are just two examples of land uses that may feasibly be designed as compatible with wetlands and other resource systems. Some level of development will eventually be realized in the watershed, therefore those uses that derive financial benefits to landowners yet only passively consume resources while applying sustainable use management concepts, or convert less desirable and stable (with lower erosion rates) ecosystems to stable ones should be emphasized.

#### 4. Wetland Mitigation Banking

Wetland Mitigation Banking involves the setting aside of wetland and upland areas for Enhancement Mitigation and resource protection in exchange for permitted impacts at other sites. The banking concept requires several key components; availability of land for conservation (and mitigation) in perpetuity, an established exchange rate and mechanism (rules), and government oversight or assistance in the banking system. Mitigation banking may be more attractive to large project developers or landowners that have large properties. Resource managers find that banking offers certain benefits whereby substantial commitments are made in a protected environment to restore, enhance and provide for wildlife habitat.

Large landowners in the Ugum Watershed might be interested in banking wetlands for profit and tax incentives, but the concept of banking commits land resources to one exclusive use which might be viewed as too prohibitive. Other potential pitfalls of Banking are the tendency for developers to choose (propose) enhancement of less diverse and simple wetlands, little technical guidance has been established as standards, and the enhancement is always off-site in that impacts may not be mitigated for in the same ecological system or watershed. Wetland Mitigation Banking does not necessarily require the creation of new wetlands for wetlands lost. This may be the major drawback to banking even considering that the method is accepted by the U.S. EPA and Corps of Engineers (J.F. Berry)

#### B. Policy Development

##### 1. Education

One of the primary and proactive policy issues for watershed management and wetlands protection overall is public education about wetland conservation. Wetlands conservation education should be a critical component of a larger public education and landowner education effort for the Ugum Watershed.

Education curriculum for wetlands conservation should be centered on wetlands functions for water quality protection, habitat protection, flood control, economic benefits..etc. as well as the legal and economic consequences and costs of destroying (filling, dredging, clearing, polluting) wetlands. When landowners and the

general public are aware of wetland functions that provide for a certain "quality of life" they will then begin to form personal and community values about the treatment, conservation and use of wetlands in the Ugum watershed.

Watershed management/protection concepts formalized with this plan will provide the broad based multiple use and functional benefit framework for understanding.

## 2. Local Legislation

Guam law lacks wetland specific legislation for the study, conservation and management of wetland ecosystems. The current legal mandate for wetlands is based on Government of Guam Executive Order 90-13, Territorial Land Use Commission Wetlands Rules and Regulations, and the Guam Water Quality Standards. These legal mechanisms are regulatory in nature and exist primarily as components of rules promulgated for laws that are not specific to wetland ecosystem protection, however they are specific to wetland resources mainly water quality and wildlife protection. Development of these regulations have for the most part followed typical federal protection schemes in that conservation and management historically focused on specific resources or components of ecosystems as opposed to taking a conservation stance for systems and subsystems within larger land/marine units. There are indications that the U.S. Fish and Wildlife Service is rethinking the approach of the Endangered Species Act where protecting specific animals may not be as beneficial as treating the overall health and multiple use issues of entire environs (ecosystems) to protect species habitat.

Wetland protection policy might be best expressed in laws that require wetlands as ecosystems to be integrated in general land use planning at the watershed level or statewide (territory) level. This as opposed to wetland legislation that addresses wetlands protection without contextual consideration with larger land use planning and development issues. Existing enforcement mechanisms may be adequate at both local and federal levels, yet substantive and long term protection via local legislation might be realized with wetlands protection as a component of all land use planning and zoning.

## 3. Cooperative Agreements

Cooperative agreements could be made with land owners, lease tenants, and responsible individuals with special interests in the Ugum Watershed. This management measure should be implemented either as an overlay to existing or new management measures or if nothing else is accomplished mutual assistance in protecting wetland ecosystems and private property interests. Issues that could be addressed by a cooperative agreement include, notification of resource damage (protocol), a process to involve resource agencies in development planning, technical assistance for development design, wetland determinations, technical advice, and many others as needed (University of New Orleans). This management should be the basis for managing development and conservation activities in the watershed and all parties involved need to agree to the general guidance provided.

## 4. Conservation Easements/Areas

The establishment of Conservation Easements is provided for in Public Law 12-25, the Guam Land Conservation Act. In most cases conservation easements are proposed as a form of mitigation for environmental and natural resource impacts that occur as a result of development.

Often times, monetary compensation or a financial commitments are not feasible within the scope of a project or as matter of financial ability for land owners. The dedication of a Conservation Easement in many ways provides a legal and binding commitment to conserve land resources in exchange for otherwise undesirable environmental impacts.

## 5. Property Tax Incentives

Property tax incentives may prove to be a viable method for relief from strict legal requirements which limit land uses in wetlands. Many landowners, especially in the Ugum Watershed own large land parcels (in excess of 20 acres). If a significant portion of these lands are wetlands it may be beneficial from a conservation standpoint to allow for wetland tax reductions. Special conditions must be incorporated in order to receive tax credits (reductions) that are only available if wetlands remain undisturbed and loss of credit if wetlands are proposed to be damaged, permitted, or otherwise. In addition, the federal tax code allows for tax deductions when gifts of conservation lands are made to either private conservation groups or government agencies in the form of conservation easements or wildlife preserves (U.S. EPA 1992).

### C. Construction/Operational Practices

#### 1. Construction Best Management Practices for Wetlands

There are two types of construction in wetlands those activities that are designed to minimize or avoid impact such as would be required for walkways and bridges and activities that permit filling, dredging, or some type of modification to wetlands that are considered a permanent loss of wetland area.

##### a. Buffers

When land alteration activities are planned for areas immediately adjacent to wetlands buffers provide a measure of assurance that inadvertent or accidental encroachment does not occur. Wetland buffering is for all practical considerations no different from buffering for any number of water bodies. Each situation is unique depending on such factors as slope and vegetation cover in the proposed buffer zone. The primary and immediate concern with buffering wetlands is water quality and the effects of erosion that may cause detrimental impacts.

##### b. Full Spanning Structures

When access is required through a wetland bridges should be designed if practical and cost effective to be full spanning. This should be the first choice to avoid and minimize wetland impacts.

##### c. Pile Support Structures

In cases where full spanning structures are determined to be impractical from both a cost and engineering standpoint the next design consideration should be pile supported structures. Piles will cause some minimal level of impact, however this design method is often the next most desirable method for access through wetlands or for buildings that partially encroach into wetlands. Depending on the purpose and use of a building pile support foundations may be viable for an entire structure.

##### d. Erosion Control and Construction/Development Site Controls

Construction activities that are located partially in wetlands should be well planned and coordinated. Stringent construction site monitoring may be needed to avoid off-site impacts. Environmentally sensitive construction phasing while often constraining, will provides the best insurance that sensitive wetland areas are well delineated and that stormwater (erosion) is intercepted and treated prior to discharge and overflow into wetlands or streams. The main concern when requiring stringent erosion control, phasing, and monitoring plans is to ensure that each subsequent and individual construction area is manageable from an environmental protection standpoint.

The relative size of a given land area under active construction (disturbance) should be equivalent to the contractor's ability to maintain and control work activities and protection measures.

Environmental Protection Plans (EPP's), Erosion Control Plan (ECP's), and Water Quality Monitoring Plans (WQMP's) are existing mitigation type requirements that are useful in controlling the occurrence of off-site and on-site environmental damages that are not part of the construction activities.

## 2. Fire Control

An active plan to minimize and control activities which involve fire or flammable substance use within the watershed together with access for fire fighting crews and equipment may substantially reduce the number of accidental fires. Public education and enforcement hunting regulations could also contribute significantly in controlling wildland fires resulting from illegal hunting activities.

## 3. Pesticide, Fertilizer, and Hazardous Material Control/Management

The use of chemical pesticides, herbicides, fertilizers, and other petroleum based products by land owners and farmers should be strictly controlled. In conjunction with buffers and other conservation practices limited use of chemical agents may be permitted, however formal use and application plans must be formulated and implemented to reduce leaching to wetlands and streams. Although wetlands provide a natural buffer in as much as they are believed to act as chemical sinks any wetland system may be easily overcome by over applications, improper applications and accidental spills. Integrated pest management plans offer some basis for prudent chemical use in farming and landscape applications. Future land uses which increase the density and intensity of urban development will bring with it new issues and concerns for water quality and habitat protection from adverse exposure to chemicals carried by surface waters.

## 4. Stormwater Management

Stormwater drainage system designs must balance the needs to control flooding and disposal for developed area (impervious surfaces) and the important recharge functions of the watershed. Non-point pollution issues should be resolved through design concepts which minimize lined channel features and maximize vegetated drainage swales, open and shallow ponding basins, and other on-site disposal/control methods. Wetlands may play an important role in stormwater disposal and treatment, however untreated point discharges of stormwater should not be permitted. Guam's water quality standards specify that wetland water quality standards are the same for the surrounding bodies of water in a given zone. Direct discharges of stormwater to wetlands are regulated basically as entering surface waters. Another important issue is the recharge of stormwater to ground and surface supplies within the same subwatershed. Proposals to redirect stormwater from one subwatershed to adjacent watersheds should be carefully assessed and in most cases not permitted without substantial evidence that significant impact would not occur individually or cumulatively. Because soils in the watershed are highly erodible it follows that drainage systems will require regular maintenance to remove accumulated sediment.

## 5. Wetland Monitoring

As part of any plan for watershed management where potable water resources are a primary concern, and given the evidence that wetlands play an important if not critical role in water quality maintenance, ecosystem health should be monitored for long term effects. Sediment loading, pesticide accumulations, vegetation health, wildlife populations and diversity and hydrological changes could be assessed systematically over the long term. If possible a holistic approach to watershed monitoring should be developed in order to measure the effectiveness of management practices and applications. Without some type of monitoring beyond the water quality analysis conducted at the Ugum Water Treatment Plant there will be no possible way to quantify impacts and management effectiveness. Furthermore, in the event significant problems arise, it will be critical to identify and isolate pollution problems at their source.

## IV. Management Scenario Assessments

Two Management Scenarios (alternatives), Maintenance and Improvement, were developed in addition to a No Action scenario. Each scenario takes into consideration the likely land use trends that would develop over a 20 year period from the date of this plan.

#### **No Action Scenario**

This scenario assumes that existing trends for resource protection, management and uses will continue to develop. It is important to note that the No Action Scenario does not mean that efforts to protect ecosystems such as wetlands will cease or that resources such as wildlife and water quality will receive less attention. It only assumes that a management plan will not generally guide land uses and land use practices. In the absence of a formal Watershed Management Plan government agencies will likely create working relationships to address the minimal protection standards for drinking water quality, however government will play a largely regulatory role in the watershed.

A. Permit Reactive - Wetland protection efforts will be hindered in that protection measures will typically be considered at or near the end of the planning cycle unless the development proposed involves prior review and permitting actions through the Territorial Land Use Commission or similar public land management entities (Chamorro Land Trust Commission). Since access is largely restricted even passive monitoring of wetland resource is not likely. The Guam Environmental Protection Agency may conduct aerial surveillance annually if funding is available. Government resource agencies are currently only permitted to enter private lands within the watershed at the invitation of land owners or when illegal activities are reported.

Access to government of Guam lands in the upper watershed is also limited with most entrances originating on Navy or private property. It is very unlikely that private land owners will seek clearing and grading permits for many of the smaller development or construction activities in the watershed simply because the area is remote and inaccessible. When construction (clearing or grading) permits are sought and wetlands are a major issue any effort by regulating or resource agencies will be hard pressed to interject wetland avoidance considerations for development design.

B. Fire Control - Uncontrolled wildland fires will prevail as an annual impact slowly reducing or damaging wetlands either through direct loss of vegetation or by increased sediment loading of in wetlands. As wildland fires increase in acreage and/or number there may be stepped-up efforts by fire officials to focus on wildland fire prevention and fire fighting capabilities, however there has not been a recent trend to address the issue as urgent or as a top priority. Current suppression efforts are applied to the protection life and real property.

C. Program Drive Management - Resource protection will be program driven at the agency level. Wetlands protection efforts are largely informally coordinated at the present time. Limited funding is available for public education, wetland resource study, detailed inventories, and resource planning. The major emphasis is on enforcement which is perceived publicly as negative and a general infringement on private property rights. The opportunity to apply a broad range of protection and planning initiatives to private land owners does not currently exist. The Department of Agriculture, Guam EPA and U.S. Army Corps of Engineers with specialized assistance from the Natural Resources Conservation Service (NRCS) and the Bureau of Planning will continue to drive the permit process. The problem with individual programs as the main emphasis for management is that each agency will tend to assert management control according to what often amounts to narrow objectives as opposed to a programmed approach to integrated resource management with consensus driven objectives for ecosystem function goals.

D. Buffers - This scenario allow for the continuation of limited soil conservation measures as specified for farming activities. At the request of resource personnel farmers may include some form of buffering concept when developing new agricultural fields or when activating and managing existing (fallow) fields. Buffers between wetland systems and any development are only required as conditions to clearing, grading and/or building permits. Agricultural operations do not typically require these permits. Buffers for other types of development are likely to be required after plan reviews, however this may be too late in the development process.

E. Ecosystem Functions - Concern for ecosystem functions will be minimal overall for the entire watershed. Wetland ecosystem functions are managed and protected more than any other ecosystem in the watershed largely due to existing regulations and laws which protect wildlife, wetland habitat, and water quality. Concern for wetland functions will exist as long as wetlands are protected systems or are regulated under the Clean Water Act. If a watershed master plan is not implemented and development increases over the next 20 years it most likely that the functional connections between different ecosystems will degrade and eventually cause adverse impacts to wetlands. Management of wetlands and protection of wetland functions can only be effective in the long term if upstream and downstream systems are also managed.

Wetlands will not endure prolonged or designed utilization as sediment sinks, non-point source pollution filters, and other uses above and beyond natural conditions. Attitudes that suggest that wetlands can be relied upon for increased functional uses to support or mitigate human activities (development) miss the point. Wetlands function optimally under natural conditions and provide marginal benefits based on stress limitations as passive buffers for water quality.

F. Land-Use and Zoning Manipulations - Currently there are three (3) methods for obtaining rezoning and other land-use intensity changes beyond the uses permitted for a given zoning designation. The first and most comprehensive process is to apply for changes through the Territorial Land Use Commission, however this is often the least preferred method for developers because of higher costs, intense scrutiny, and a lengthy approval time period in addition to requires such as Environmental Impact Assessments. The second method is through the Summary Zone Change process for parcels equal to or less than two acres from "A" to "R-1" or "R-2" and "R-1" to "R-2". This process is administered through the Department of Land Management and the legislature with minimal line or utility agency input. The third process involves requesting rezoning through the legislature as a matter of public law. In the last three (3) years the legislative process is believed to have approved as much as 10 times the number of applications for the first two methods combined.

The legislative process has the potential to cause nearly immeasurable impact on a given community and the island as whole because changes are rapid, typically involve only the applicants, does not consider infrastructure or natural constraints, has not been well documented for planning purposes, and basically has no connection to organized and recognized planning principals. Implications for watershed management are potentially grave if rural, pristine, remote, and sensitive areas are re-zoned without consideration to ecological function for water quality, habitat protection, and any number of the previously mentioned issues for watershed management. Appropriate planning methods (master planning) for controlling development to protect the watershed under a status quo situation are few and time consuming especially considering the fact that a comprehensive land use plan for Guam has been proposed for nearly four years without final approval. Zoning manipulations in the watershed without this plan will severely stress available regulatory and conservation capabilities and regulate agencies to damage mitigation as opposed to planned and guided development.

#### **Maintenance Scenario**

The Maintenance Scenario is based on the assumption that existing trends will remain and that conservation and environmental protection measures will primarily be aimed at maintaining watershed conditions and water quality at current levels of use and for any new development. A not net change in resource qualities is expected, yet only limited retrofitting for existing problems will occur through individual agency initiatives.

A. Coordinated Management - Coordinated management will only exist when agencies form such associations which will likely be project or issue oriented. Coordination on a watershed and ecosystem management level will not exist. Urgent needs to address adverse environmental impacts will tend to be temporary and short term resolving symptomatic problems as opposed to fixing causes.

Both informal and formal associates between agencies such as the Army Corps of Engineers, Department of Agriculture, and Guam EPA exist for wetland protection, enforcement, delineation, and permit work. The maintenance of these working relationships should remain intact, however expanded management efforts, which



recognize the added significance of protecting water quality for drinking purposes, may not receive added emphasis or financing.

B. Mitigation of New Damage - Requirements for mitigation of wetland alterations are more or less established through federal and local permit and enforcement procedures. Realization of appropriate and successful mitigation still has not been met as many mitigation projects are not well monitored and often have open-ended completion time lines. A comprehensive wetland management program does not exist in Guam where certain staff are exclusively dedicated to wetland protection and mitigation projects. Wetland protection efforts, although significant, are collateral work functions for technical experts at the above mentioned agencies.

C. Maintenance of Existing Fire Suppression and Control Policies - Existing fire prevention and control strategies do not address ecosystems specifically, therefore wetlands are part of the overall fire control and prevention strategy along with savanna grasslands and all other vegetated systems.

D. Prioritized Resource Protection - Resource components of ecosystems will continue to be monitored, and managed on a priority basis. Because surface fresh water quality is the primary emphasis for watershed protection only the more apparent resources, mainly water, will be protected from the standpoint of treatment. Eventually pollution sources will be addressed upstream from the catchment and treatment facility only after additional treatment remedies are attempted. Integrated management of water resources should include treatment of all watershed components. Priorities for resource protection will remain narrowly focused on the end product rather than the processes which contribute to quality assurance up-stream. The natural priority emphasis is reversed from what it should be and will remain highly reactive to changes in quantity and quality. The problem with this type of management is it is almost always reactive and does not address issues related prevention, a more cost effective approach. Wetlands may take years to exhibit the symptoms of degradation at which time restoration may have to address ecosystem recovery and all of the interrelated issues such as long established human practices which cause system degradation.

E. Access Restrictions to Government Lands - Most of the wetlands located on government lands are headwaters. Headwater wetlands, are often more seasonal in nature yet they provide a high degree water quality protection and eventually influence the physical, chemical and biological process downstream. Headwater wetlands actually exist in each subwatershed and are therefore important areas for protection.

All of the government land in the upper Ugum Watershed are under the administrative jurisdiction of the Chamorro Land Trust Commission (CLTC). Access is limited to jeep trails and extremely limited during the wet season from property outside of the Ugum Watershed. A large valley, associated Ravine and wetland areas, and very steep slopes in excess of 30% restrict access from private property in the Ugum Watershed.

The ideal situation for government lands is to have administrative and management control transferred to a government of Guam line agency as a conservation area. Agencies such as the Department of Parks and Recreation or the Department of Agriculture's Division of Aquatic and Wildlife Resources may be able to secure funding for monitoring and protection of the area. The opportunity for private non-profit conservation organizations to manage the area exists, however the CLTC may seek monetary rent or lease payments to keep the area in conservation. Development of the government lands is not feasible without great expense and would offer few if any benefits higher than those associated with watershed functions for water quality.

F. Mitigate Expansion of Badlands - The expansion of badlands equates to increases in erosion which eventually impacts wetlands. Very few wetlands are likely to be found within badland areas, however the concern for rehabilitating badlands is to protect those wetlands immediately adjacent to badlands. Small gullies and season drainage channels which exit badlands are subject to increasing water velocities during even the shortest duration

and intensity rain storms. This scenario will prescribe that soil erosion be abated through the application of conservation and erosion control measures at critical drainage points downstream of badland areas. Erosion will likely continue in badlands to some extent but the overall emphasis will be to slow and eventually stop outward expansion of the badlands.

G. One Stage Improvement Projects - Improvement projects will not involve long term monitoring, evaluation, or follow-up measures for apparent project failures. If resources are dedicated to resolving ecosystem degradation the project will likely only include measures as a single effort. Funding and manpower to guarantee successful resolutions will be expended based on the best project plan available. This mode of problem resolution to wetland degradation has been proven to be ineffective for all but the simplest of mitigation projects. Many studies have shown that wetland mitigation or enhancement projects require multi-stage or phased actions in order to achieve success. The typical wetland restoration project might involve activities over a three to five year period to evaluate success and much more time to correct project failures and replant or redesign hydrologic components of the project.

H. No Net Loss of Ravine Forest, Riparian Areas, and Wetlands - A national "Not Net Loss" policy exists for wetland ecosystems as declared by President Reagan in 1990. However, the U.S. Army Corps of Engineers may permit wetland impacts without compensatory mitigation if all practicable and appropriate steps are taken to minimize impacts (USEPA and USACOE 1990). The Nationwide Permit system typically involves such minimal impact situations. Most state and territorial governments have adopted the policy as a standard when considering wetland permit applications and proposed mitigation plans. The same holds true for Guam. The main constraint to achieving a total "No Net Loss" policy is related to de minimus impact situations where all practical alternative and design modifications have been exhausted and where only marginal (insignificant) functions exist in relation to systemwide functions. Resource agencies also have limited capabilities to monitor every minor impact. Rural and remote areas of Guam may add to the problem because routine access is not available without special enforcement and inspection circumstances prior to requests for entry. On the other hand remote areas are also less likely to experience wetland filling by virtue of few development pressures with the possible exception of remote farming activities.

I. Best Management Practices (BMPs) Encouraged - Resource agencies involved with land owners and development would encourage construction and operational practices to include BMPs to protect wetlands. Buffers, pretreatment stormwater drainage systems, erosion control measures, fire prevention measures, site development planning, and other BMPs could be implemented to minimize wetland impacts from human activities. Mandatory environmental protection practices would still exist as conditions to clearing, grading, and building permits for certain types of development, however BMPs for such activities as farming and off-road recreation would remain voluntary. The key to acceptance of voluntary BMPs implementation is close coordination, working agreements, infield presence of resource personnel, readily available advice, consultation, and in some cases actual assistance by resource agencies for developers or clients.

J. Limit Unplanned Land Use Changes - Some local government agency or a consortium of agencies will have to take the lead and responsibility in monitoring land use proposals early in the policy decision making process. The importance of a higher protection status for land, water, and wildlife resources in the watershed cannot be overshadowed by individual desires to maximize land development potential if it would impose undue risk to the ecological health and function of the watershed for the primary benefit of potable water supply. The Ugum Watershed Management Plan must be implemented on a broader scale than simply guiding site specific actions and assisting individuals to minimize human induced impacts. The plan must be the foundation and justification for responsible regional land use planning in the watershed. As an added benefit the plan may be used as a planning template for similar southern watersheds.

### **Improvement Scenario**

The Improvement Scenario would allow for the implementation of a number of Mandatory Conservation Practices and BMPs as well as impose restrictions for land uses. This scenario also would strongly encourage a number of

conservation programs to be developed and implemented over the long term. Resource and Land Management entities would play a critical and often determining role in land use development and future policy making decisions. The watershed and all of its eco-components would be systematically monitored and evaluated for preventative and remedial resource actions where resource agencies have clearly identified duties (roles) and real time response modes to address any significant issues. This management option would likely be administered through a technical advisory board with public participation in all aspects of management and operate in accordance with the Administrative Adjudication Act in the development of Operational Rules and Regulations necessary to enforce a process of decision making. Selection of this management scenario would will require that clients either direct the ultimate implementation of scenario prescriptions or seek a lead agency to accept the primary stewardship role for watershed protection and conservation.

A. Protection of Riparian Areas (Riparian Area Performance Standards) - The protection of riparian areas will result in the added protection or recognition of riparian wetlands as important habitat areas for the maintenance of stream flows, water quality, stream water temperature regulation, the important leaf, woody debris, and other organic material for downstream productivity and habitat. Riparian habitat protection has developed substantially in other parts of the world as a field of study and unique ecosystem component providing benefits to both terrestrial and aquatic wildlife systems as well as for water quality maintenance. The protection riparian areas and riparian wetlands in the Ugun Watershed will ensure that a natural buffer exists between upland activities and aquatic systems, including the ultimate fate of fresh water (quality) in the estuarine and marine environments. In the event a given riparian area is also classified as wetlands then the specified (required) buffer will extend from the edge of the riparian area upland. In this case buffers are effectively doubled in so far as protection of river and stream functions are concerned because the stream buffers would essentially overlap wetland riparian areas. The regulatory mechanism for protecting riparian wetlands is already in place through the Federal Clean Water Act, however in those cases where riparian areas are not wetlands, the rules on buffers must be adopted though the mandates and authority of the Watershed Management Plan.

B. Master Plan for Roads (Ugun Watershed Road Master Plan/Limited Road (Rural) Improvement Standards) - As part of a Master Plan for road development and maintenance wetlands and streams or rivers must be protected though the implementation of regulations and performance standards that specify full spanning bridges or pile support bridges. In as much as possible, a Master Plan for Roads will guide road development away from rivers and wetlands; and where such crossing are necessary the selection of low impact and if possible low cost crossing locations will be identified through a sensitivity assessment process with clear and practical environmental and engineering criteria provided to guide the selection process.

C. Active Fire Prevention (Ugun Watershed Fire Prevention Plan) - Active fire protection should also consider wetlands as areas to be protected. Often times wetlands are viewed and treated as natural fire breaks in a wildland fire scenario. While this may be acceptable in extreme terrain conditions where options to control fire from entering wetlands are limited, the protection of wetlands from fire should be the rule rather than the exception where access and conditions permit.

D. Multi-stage Improvements (Wetland Mitigation Performance Standards) - Wetland mitigation projects must be comprehensive and account for multi-phase construction, monitoring, and valutive/corrective components. Standards and mitigation guidelines must be developed to raise success rates for mitigation projects. All mitigation efforts should be based on the best available scientific information on replacement and compensation of functions. Interdisciplinary efforts will result in better projects with better goals and objectives based on wetland functions. Minimum standards or guidelines have not been formalized in Guam, however they are urgently needed to ensure that projects are well designed and implemented.

E. Conservation and Net Gain of Desirable Ecosystems/types - It will be important to establish a hierarchy of desirable functional attributes for wetland ecosystems and to a lesser extent social values for mitigation and enhancement projects that may be proposed in the watershed. The tendency has been to mitigate and enhance for easily attainable functions such as flood protection while equally important but difficult to construct functions for water quality filtering and habitat creation are secondary goals. The best method for determining mitigation goals is to closely examine and document wetlands that are to be impacted or lost to determine the functions and system

structure then design mitigation to meet those functions as a minimum goal. The emphasis for mitigation must be placed on attaining the highest and most appropriate functions while recognizing that wetland creation efforts are subject to many long term factors negatively affecting final successes. If mitigation plans set low function goals from the start, then the likelihood of attaining compensatory functions may never be met.

F. BMPs Necessary (Mandatory) - See Minimum Modification of Wetlands.

G. Buffers Mandatory - See Minimum Modification of Wetlands.

H. Minimum Modification of Wetlands - The modification, fill, or otherwise loss of wetlands and wetland functions is best addressed through the development and site planning processes. The application of Environmental Impact Assessments is the best method to identifying wetland constraints is the EIA is conducted without bias to a predetermined development concept that requires maximization of land area. Recognition of the fact that a given land area may have limitations due to a number of constraints, wetlands being a major one, will in the long term save money. The average cost of construction mitigation not including mitigation planning and long term monitoring is estimated to be \$20.00 per square meter or approximately \$80,000.00 per acre (C. Weddle, 1992). This cost is roughly equivalent to the price per square meter of agricultural zoned property. It is estimated that the total cost would be double if planning and monitoring were added.

As stated several times in this report, existing regulatory controls provide adequate incentive to avoid wetlands and therefore minimize modifications. The only exception to the effectiveness of wetland regulation are limited monitoring and enforcement abilities. All other legal mechanisms are in place. Overall, a heavy handed enforcement and regulatory approach to management will not in it's self ensure proper planning and consideration for wetland functions, instead public education and awareness and planning assistance must be added to the approach.

BMPs that address project and site specific construction and operational environmental protection during development will directly and indirectly result in wetland protection and reduced impacts. The management situation assumed here is that when modifications are proposed resource agencies are involved in the guidance and planing process, whereby the final outcome justifies minimal modification as the only practical alternative to sound development.

The alternative analysis of the Corps of Engineers Section 404 Permit process is an excellent example of consideration that must be made if for no other reason than the same criteria for assessment will be applied to any project proposal to modify wetlands, some permit exceptions aside.

I. No Unplanned Zoning/Land Use Changes - All land use decision making efforts will include watershed protection and management concerns and constraints early in the planning process. The Ugum Watershed Management Plan should be formally presented to the Territorial Land Use Commission, Territorial Seashore Protection Commission, Chamorro Land Trust Commission, Territorial Planning Commission, the Guam Legislature, and the Governor. In addition, resource agencies such as the Department of Commerce must be made aware of the plan since they promote the research and development of potentially impacting aquaculture industries. It is very likely that several if not all of these land management entities will acknowledge the plan as vital to land use decision making including the wetland management and protection practices specified.

J. Off-road Traffic for Recreation - Off-road recreation activities that involve wetlands will be prohibited unless specifically permitted by federal and local authorities.

K. Economic and Tax Incentives - The development of wetland specific tax and conservation incentives or an incentive package that addresses a variety of ecosystem protection and conservation programs should be explored fully. Whenever strict land use policies and regulations apply to one resource or land area are proposed that do not necessarily apply to similar adjacent areas, some type of incentive or compensatory program will be demanded from affected parties. The legal ramifications embodied in the "Takings Doctrine" necessitate extra

consideration along with considerations for community benefit. Opportunities for wetland protection legislation should also include similar legislative efforts to require a method of funding and compensating other affected parties. In many ways protective legislation (highly regulatory in nature) are only palatable if compensation and the willingness to compromise is also presented, preferably at the same time. For additional treatment of this subject refer to pages 10. and 12. of this report under Mitigation Banking, Conservation Easements, and Property Tax Incentives.

L. Public Education - As a minimum, public education on the benefits of watershed management should include every effort to capitalize of existing forums and venues for education. Annual events such as the Department of Education's Science Fair, Earthweek, Clean Water Week and many other organized events celebrating or serving to heighten awareness of nature resource conservation should be utilized for watershed management education. In addition, responsible resource agencies should formulate a public education campaign for the Ugum Watershed early during plan implementation. Educational material is available on watershed management issues and wetlands protection from the U.S. Environmental Protection Agency, Coastal Zone Management Program (U.S.), the U.S. Fish and Wildlife Service, National Park Service, and numerous non-governmental organizations. Funds permitting, it would be very beneficial to produce printed literature as well as videographic products explaining watershed management and protection uniquely tailored to and specifically for the Ugum Watershed.

## **VI. Recommendations for Wetland Ecosystem and Resource Management**

- Watershed management and resource personnel should strongly emphasize that impacts to and development in wetlands are expensive undertakings. The permit process alone is often seen as prohibitive, lengthy, and technically demanding. Justifications for wetland filling, dredging and impacts are not acceptable without complete alternative analysis efforts of which the primary alternative to avoid wetlands must be exhaustive.

- Erosion control for new development and construction projects should necessarily be strict. The long term conversion of badlands to savanna or forest ecosystems will provide positive impact with regard to efforts to limit soil erosion and sedimentation of wetlands.

- Master planning a road system that provides adequate access to various private lands in the watershed while recognizing that some roads and jeep trails are represent a duplication of utility will help guide development and reduce the current uncontrolled road and trail development in the watershed. Various roads that are poorly planned in that they cross rivers, streams and wetlands at multiple locations could be eliminated. Seldom used roads that only serve or encourage access to poachers should also be eliminated and restored to natural conditions. Any effort to reduce the sheer number of roads in the watershed will should greatly contribute to erosion control.

- All future (new) farming enterprises must be located in upland areas of savanna grasslands. Aquaculture ponds likewise should be located in uplands or prohibited entirely from the watershed since water quality criteria will be especially difficult to meet without substantial pretreatment prior to discharge to wetlands and other waters during harvesting operations. Additionally, the sustainability of water supplies for drinking water will continue to be an important issue for southern residents who depend on an efficient and clean Ugum water source. Competing uses for Ugum water such as farming (irrigation) and aquaculture will reduce water supplies at the Ugum Water Treatment Plant.

- Long term monitoring of stream flows, water quality, sedimentation and potential pollutants should be implemented as early as possible in order to attain quality background data for future watershed assessments. In addition, qualitative and quantitative aspects of ecosystem and wildlife habitat health should be monitored.

- Motorized access to public lands in the upper watershed should be discouraged if not prohibited due to the steep terrain and sensitive headwater wetlands. Eventually the public lands should be designated as conservation areas.

- Public education efforts should focus on ecosystem functions for water quality protection in view of development potential and related pollution potential.

A. Planning Assumptions and Criteria. The basic planning assumptions for the watershed area over the next 20 years are as follows:

1. Fires - No Action Scenario would result in a 25% increase in area burnt from the 400 acres per year to 500 acres per year. recorded

Maintenance Scenario would maintain the current level of fires at 400 per acre.

The Improvement Scenario would result in a reduction of acres burnt from 400 to 300 acres or a 25% decrease in fire events.

The weighted mean erosion rate for the watershed from fires was calculated at 56 tons/acre/ year.

2. Buffers Established at ?????

3. Residential Development growth would equal 500 single family units at the end of the planning period.

4. Off-Road Recreation would continue to exist.

5. Farming activities would increase minimally

6. Golf Course Exists in the watershed and is a potentially viable development.

7. Roads No Action = Double at current standards with annual maintenance on 25% of the roads.

Maintenance = Double with new roads having conservation practices applied over 50%. No maintenance of existing roads.

Improvement = Double roads, 75% of new roads designed with conservation practices. Repair 25% of the worst eroding and designed roads. Restrict access to sensitive areas (steep slopes). Some roads would be out (put to sleep). Retrofit viable roads as phased priorities dictate.

Ugum Management Plan  
Wildlife Technical Report

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U.S.D.A. Natural Resources Conservation Service  
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1.0 Introduction

The purpose of this technical report is to describe the role of wildlife and the ecological processes associated with the wildlife component of the ecosystem within the Ugum watershed, and to identify management opportunities and environmental concerns relating to human activities within the planning area.

For planning and management purposes the wildlife component are described in the content of the four broad ecosystems used in the Forests and Savanna Grasslands Technical Report. These ecosystems are: ravine forest; savanna grassland/badlands; wetlands; and riparian. Wildlife is regarded as an integral population within the defined ecosystems.

2.0 The Ecological Basis for Wildlife Management

Isolation is a major factor affecting biotic diversity on islands. As an oceanic island Guam began with no terrestrial animals, but over time various species gradually colonized and an ecosystem developed. Immigration and colonization by wildlife species were greatly influenced by the isolation. Island biogeography suggests that prior to human inhabitation, the number of species stabilized. New species colonized Guam at a rate equal to the rate at which existing species went extinct. The diversity of wildlife species on Guam was limited by the distance from any continent. Not only was Guam's small physical size and isolation determinants of diversity, but also the relatively few plant species on which the animals can forage for foliage, fruit, pollen, other animals, etc.

The arrival of human settlers greatly altered the biotic diversity on Guam. Early settlers not only introduced new food crops but a wide array of insect, animal, and bird species as well. In some cases the introduced animals became part of the food web of the native animals, in others the introduction of non-native animal species has resulted in the extinction of certain species.

As a result of introductions, both intentional and unintentional, the number of animal species present of Guam has never been greater. Unfortunately, the diversity in native animals has declined as a result of habitat changes as well as competition and predation by introduced animals.



Information on the life history of many, if not most, of the native animals is inadequate. This report relies on the premise that the wildlife component on the ecosystems will be maintained as long as the habitat and ecological processes within an ecosystems remain functional. A notable exception to this is the introduction of non-native animals which can either out compete native animals or predators that can disrupt the ecological balance sufficiently to cause a species to become extinct, e.g. brown tree snake.

## 2.1 Ravine Forest Ecosystem

The floristic richness of ravine forest results in diverse habitats. The Ugum Planning area contain some of the largest contiguous stands of ravine forest remaining on Guam. The diverse flora, multistory structure, and energy pathways in the ravine forest create a great variety of habitat niches allowing for many species to coexist in an ecosystem with a minimum of direct competition.

The importance of animals in the maintaining ecosystem health is often underestimated; animals aid in pollination of many plant species, cycling of energy, and controlling pest populations. The vegetation of the ravine forest provides food, shelter, or substrate for other animals. Food webs are complex with many potential energy pathways available. Photochemical energy stored as plant material is the primary energy source for the herbivores, such as many insect species. The insects in turn are an energy source for larger animal species, such as birds, reptiles, and small mammals.

Prior to the introduction of the brown tree snake (*Boiga irregularis*), the ravine forest supported populations of native bird species. Bird population surveys since the 1960's has shown a significant, if not devastating, reduction in avian populations. The ecological impact of the reduction of the native bird population in the ravine forest can only be described in general terms. Dispersal and/or scarification of seed of plant species which rely on birds has been significantly reduced. Populations of certain native plant species may be adversely affected.

The ravine forest is suitable habitat for the Mariana fruit bat (*Pteropus mariannus mariannus*). Population statistics for the species are not available but a declining population trend is most likely the case as a result of the introduction of the brown tree snake. Ecologically, the bats are important in the dispersal of plant seed.

The presence of feral pig (*Sus scrofa*) in the ravine forest has certain ecological implications. The feral pig is not native to Guam, and the population of feral pigs has is largely keep in check by availability of suitable habitat and hunting pressure. There is strong evidence showing that the feeding habits of feral pigs, where roots of certain tree species are excavated, is causing localized erosion.

The Philippine deer (*Cervus mariannus*) is another introduced animal species which has become naturalized over the past 200 years. The Philippine deer utilizes the ravine forest for

cover and foraging. Population statistics for the species are not available, but a stable or slightly increasing population trend is estimated. Philippine deer freely move between the savanna grassland and the ravine forest to feed.

The ecological function and importance of the numerous animal species that comprise the ravine forest ecosystem can not be adequately described in this short technical report. Raulerson, et al (1978) reports the results a biological study conducted in the vicinity of Ugum dam site.

## 2.2 Savanna Grassland Ecosystem

While the floristic richness of the savanna grassland ecosystem is inferior to the ravine forest, animals are an important component of the ecosystem. Soil animals perform a significant role in organic matter decomposition and mineral cycling in the savanna grassland ecosystem by:

1. Physically disintegrating tissues and increasing the surface area available for bacterial and fungal action.
2. Selectively decomposing material such as sugar, cellulose, and lignin.
3. Transforming plant residues into humic materials.
4. Mixing decomposed organic matter into the upper layer of the soil.
5. Forming complex aggregates between organic matter and the mineral fractions of soil.

While soil-dwelling animals, microfauna, and mesofauna serve important ecological functions in all ecosystems, their role in the savanna grasslands is even more critical since the soils are generally nutrient deficient.

The quantity and quality of niches in the savanna grasslands is limited resulting is fewer species being present. Most of the avian species and all of the larger mammal species observed have been introduced. The savanna grasslands is suitable habitat for Philippine deer (*Cervus mariannus*). The deer utilizes the savanna grasslands for cover and forage. The Philippine deer feed nocturnally and therefore is rarely observed during daylight hours. The Philippine deer is well noted for foraging on new shoots of swordgrass (*Miscanthus floridulus*). Ecologically, the deer utilizes a niche that was not occupied prior to its introduction and therefore does not directly significantly compete with native wildlife species. Legal and illegal hunting of the Philippine deer is a key factor in regulating the deer population. Human activity involving the hunting of the Philippine deer has had significant effects on the ecological function of the savanna grassland ecosystem as described in the Forest and Savanna Grassland Technical Report.

The savanna grassland is also suitable habitat for black francolin (*Francolinus francolinus*). Because the black francolin nests in the savanna grasslands it has been less susceptible to predation by the brown tree snake, and the population of the black francolin is

stable and perhaps increasing slightly. Other native or introduced birds are rarely occurred utilizing the savanna grasslands.

The feral Asiatic water buffalo (*Babalis bubalis*) utilizes the savanna grassland ecosystem. The population of the water buffalo is largely controlled by hunting.

A number of reptiles, snails, geckos, skinks, and small mammals such as rats (*Rattus* spa) are components of the savanna ecosystem. The frequent wildland fires that burn through the savanna grasslands is a factor in regulating the population dynamics of these small animals.

### 2.3 Wetland Ecosystem

The volcanic clay and argillaceous limestone soils within the Ugum watershed retard water percolation and permit surface waters to accumulate. Many interior wetlands are located along the upper drainages of rivers and smaller tributaries. Wetlands vary greatly in habitat and include freshwater marshes and running water (lotic) environments.

Freshwater marshes dominated by dense, nearly pure stands of *Phragmites karka* that are 2-5 m in height are also common. Less prevalent species including *Panicum muticum*, as well as sedges (e.g. *Eleocharis ochrostachys* and *Cyperus* spa.) and the fern *Acrostichum aureum* are often present. The freshwater marshes are suitable habitat for the common moorhen (*Gallinula chloropus*), an endangered species. The moisture regime of the freshwater marshes may be seasonal, and wildland fires during the dry season can temporary alter the habitat in the marshes.

The seasonal wetness of the terrestrial wetland communities attracts a number of animals from other ecosystems. Many animals may only make brief visits to the wetland ecosystems before returning to their original niches. While these visits may be temporary the wetlands function as an important component of the landscape ecology by providing a source of water for many species of animals.

The lotic environment is suitable habitat for a variety of native fish and aquatic invertebrates, including gobies, eels, and shrimp. Tidal intrusion affect the species diversity in the lower section of the Ugum River.

### 2.4 Riparian Ecosystem

Freshwater swamps of woody vegetation are found along river courses, and in wet depressions in forests. *Hibiscus tiliaceus* is usually a dominant species. In the lower reaches of the Ugum watershed, *Barringtonia racemosa* is a prevalent species. *Pandanus tectorius*, *Cynometra ramiflora*, *Cocus nucifera*, *Bambusa vulgaris*, and *Areca catechu* may also contribute significant habitat in the freshwater swamps. The multistory structure of the woody vegetation creates numerous niches suitable for wildlife. Although suitable avian habitat still exists predation by the introduce brown tree snake has eliminated much of Guam's native forest birds.

The island's only large population of island swiftlets (*Aerodramus vanikorensis*) forages exclusively over the Talofofo River valley adjacent to the lower Ugum watershed.

Soil animals, reptiles, snails, geckos, skinks, and small mammals are components of the freshwater swamps. Feral pigs also utilize this habitat and are important in nutrient and mineral cycling.

### 3.0 Resource - values/products/activities

Wildlife on the public and private lands within the Ugum watershed are valued for many uses including: harvest of wild and feral game animals, birds, fish, shrimp, and eels. The sustainable population of all wildlife species is a function of quality habitat as well as harvest pressure.

### 4.0 Alternative mitigation measures

Few measures have been taken to manage wildlife resources in the Ugum watershed. Most of the watershed is privately owned, with the Government of Guam owning portions of the headwaters. Access is limited to a large portion of the water and while this is not intended as a mitigation measure, the practice has served to partly limited hunting as well as adverse modifications to much of the wildlife habitat.

Existing data regarding the inter-relationships, energy pathways, and food webs involving the wildlife component of the various ecosystems, restrict the availability of management options. The fact that suitable wildlife habitat exist to support the ecological functions allows some flexibility in the approach to maintain viable populations of all species.

Mitigation measures center around maintaining habitat and linkages between habitats. Mitigation measures should be activity specific.

#### 4.1 Agriculture

Commercial agriculture activities within the watershed are limited to a few hectares. Cropping is generally rotated each year because of weed and pest problems that increase if cropping is continuous. Because commercial agriculture is frequently a clean-till operation, wildlife value of cropped land is limited. Mitigation should include careful selection of sites to be used for agriculture. In general, clearing of ravine forest, riparian, and wetland vegetation should be avoided. Once the vegetation in these ecosystems is cleared, wildlife values are diminished.

Agricultural activities within the savanna grasslands would have the least adverse impact on wildlife values, as long as careful consideration is given to site selection, and agronomic practices. Preventive mitigation to prevent off-site impacts, such as sedimentation of wetlands, can be accomplished through conservation planning prior to tillage and planting and the installation of appropriate conservation practices.

Wildlife values in and around agriculture site could be improved by establishing trees and shrubs that provide food for wildlife species.

4.2 Golf course development

There are presently no existing golf course developments within the watershed. A golf course development modifies the natural ecosystem and generally results in an environment not suitable for many native wildlife species. Any modification or destruction of wetlands should be mitigated with the construction or enhancement of other wetlands. Conversion of ravine forest or riparian vegetation to lower quality should be mitigated with improvement of wildlife habitat in adjacent areas. Savanna grasslands could be converted to a more suitable habitat by establishing trees and shrubs.

4.3 Road construction

Access into most of the watershed is presently limited by the extent of the road system and gates controlled by the private land owners. Increased access would generally have an adverse impact on the wildlife values of the watershed. Hunting pressure would increase with access which would result in more frequent wildland fires. Access would also encourage development (agricultural and residential use) of the forested ecosystems. Mitigation would include proper road location and construction to specific standards that would reduce off-site impacts. Clearing of vegetation should be of minimum width. Revegetation of disturbed cut and fill areas of constructed roads would also reduce off-site impacts.

4.4 Recreation activities

There are presently three categories of recreational activities occurring within the watershed: hunting, developed river-oriented, and undeveloped wildland-oriented. Natural vegetation and wildlife are regarded as important components of each category of recreation.

Important game species include the Philippine deer, feral pig, feral Asiatic water buffalo, and black francolin. Hunters started wildland fires to provide access and draw the Philippine deer into the open, illegal hunting are two serious problems associated with hunting. Public awareness and enforcement of Guam game laws would help mitigate the hunting concerns.

Developed river-oriented recreation is presently limited to the Talofoto Falls site. Providing interpretive visitor information regarding wildlife values would increase the awareness of the recreationists.

Undeveloped wildland-oriented recreation centers on transporting tourist into the wildlands. Tourist experience a 4x4 jeep ride, observe the wildland vegetation and wildlife. Maintaining wildlife values is important to this industry. Presently, wildlife viewing is probably limited because the Philippine deer is nocturnal, and many of the native bird species have been extirpated as a result of the brown tree snake. Increasing the frequency and diversity of wildlife

sightings would benefit this industry. Mitigation could include active recovery plans for native wildlife.

#### 4.5 Residential construction

Residential construction within the watershed is presently very limited, there are no permanent homes constructed within the watershed boundary. Some landowners are in the process in sub-dividing portions of their property for the purpose of selling to individuals. In general residential construction has an adverse impact on native wildlife habitat and species populations. Mitigation should include proper land use zoning, lot sizes, and construction standards which prevent off-site impacts. Clearing of ravine forest, riparian vegetation, and wetland vegetation should be avoided. Prior to vegetation removal and ground disturbance, effective sediment control and erosion control structures must be in place to avoid adverse impacts to the lotic communities. Encouraging home builders to protect or plant native trees and shrubs would help mitigate the loss of vegetation.

Increased human population to the wildland areas would probably result in an increase incidence of illegal hunting and wildland fires. Public awareness and enforcement of Guam game and fire laws would help mitigate problems associated with increased human population.

The population of feral dogs and cats would also increase with increase residence. These feral animals would hunt and harass native wildlife species. Active monitoring and capture of feral dogs and cats would help mitigate this problem.

#### 5.0 Recommended mitigation measures

For each of the management plan scenarios, except the No Action scenario, the recommended mitigation measures include both preventive mitigation and corrective mitigation measures. The intensity of the mitigation measures increase as the level of ecosystem protection increases.

##### 5.1 Scenario I: No Action

Recommendation mitigation under the No Action Scenario is limited to voluntary cooperation with individuals land owners in assessing potential preventive conservation practices on agriculture lands. Minimum adoption and implementation of conservation practices are expected under this scenario.

##### 5.2 Scenario II: Maintenance, Current Zoning

Recommended mitigation under the Maintenance, Current Zoning scenario include conservation measures which would permit development without measurable degradation of the existing ecological processes.

##### 5.2.1 Agriculture

The objective of agriculture under this scenario is to promote sustainable agriculture through proper site location and adoption of conservation practices. The Government of Guam,

through the Soil and Water Conservation Districts, would actively support conservation planning on all agriculture lands within the watershed. Voluntary adoption and implementation of conservation practices specifically to maintain wildlife values would be emphasized. The goal of conservation practices in this scenario is to protect wildlife habitat and water quality and quantity by: 1) preventing non-point source sediments from reaching stream courses; 2) maintaining forest vegetation; and 3) establishing suitable wildlife tree and shrub species in and around fields. Generally agricultural fields would be located within the savanna grassland ecosystems on flat or only gently slopes. Conservation practices to benefit wildlife habitat would be:

Streambank and shoreline protection (580)

Tree planting (612)

Water- and sediment control basin (638)

#### 5.2.2 Golf course development

The objective of golf course development under this scenario is to promote economic development. Appropriate agencies within the Government of Guam would require that potential environmental impacts are identified through an assessment and that wildlife impacts are effectively mitigated through preventive and corrective measures. Preventive mitigation would include minimizing the clearing of ravine forest, and impacts to wetlands and riparian zones. Biological assessments would be conducted in order to avoid impact habitat currently occupied with native birds and bats.

Streams and rivers adjacent to or downstream of golf course development would be monitored to determine impacts to lotic communities.

Corrective mitigation would include replacement plantings of cleared ravine and riparian vegetation. If wetlands are adversely impacted by the golf course development, constructed wetlands would be developed to mitigate the loss of wetlands.

#### 5.2.3 Road Construction

The objective of road construction is to provide access to other uses in the watershed. Appropriate agencies within the Government of Guam would require roads be designed and constructed to appropriate standards for the intended use. Preventive mitigation would include avoiding sensitive areas, such as wetlands and unstable slopes. Corrective mitigation would include re-establishment of vegetation on cut and fill slopes.

#### 5.2.4 Recreation

The objective of recreational activities is to promote economic development and public enjoyment of the natural environment. Appropriate agencies within the Government of Guam

would permit commercial recreational activities that would no contribute to habitat destruction. Government would actively encourage tour operators to include wildlife awareness material in their tours.

#### 5.2.5 Residential construction

The objective of residential construction is to promote economic development as well as an opportunity for private individuals to improve their quality of life through home ownership. Variances to existing zoning would be rare. Single family homes would be encouraged. Building permits would not be issued for construction within the riparian ecosystem. Filling or damaging wetland ecosystem would not be permitted. Retention and planting of trees and shrubs around homes would be encouraged.

#### 5.3 Scenario III: Improvement, Adjusted Zoning and Land Use Policy

Recommended mitigation under the Improvement scenario include adjustments to zoning to prevent degradation of wildlife habitat and to commit to long-term wildlife recovery plans while still permitting economic development.

##### 5.3.1 Agriculture

The objective of agriculture under this scenario is to promote sustainable agriculture through proper site location and adoption of conservation practices. Government of Guam, through the Soil and Water Conservation Districts, would actively support conservation planning on all agriculture lands within the watershed. Zoning and land use policy would limit agriculture activities to specific soils and slopes. A conservation plan would be required and practices designed to protect and enhance wildlife habitat would be encouraged. Generally agriculture fields would be located within the savanna grassland ecosystems on flat or only gentle slopes. Conservation plans would consider the following practices:

- Streambank and shoreline protection (580)

- Tree planting (612)

- Water- and sediment control basin (638)

- Wildlife upland habitat management (645)

- Wildlife wetland habitat management (644)

##### 5.3.2 Golf course development

The objective of golf course development under this scenario is to promote economic development while maintaining wildlife habitat. Appropriate agencies within the Government of Guam would require that potential environmental impacts are identified through an assessment and that impacts are effectiveness mitigated through preventive and corrective measures. Preventive mitigation would include minimizing the clearing of ravine forest, and



impacts to wetlands and riparian vegetation. Corrective mitigation would include replacement plantings of cleared ravine and riparian vegetation. If wetlands are adversely impacted by the golf course development, constructed wetlands would be developed to mitigate the loss of wetlands. Golf course would be encouraged to retain and establish trees and shrubs that have high wildlife value.

Areas mined for top soil would be closely monitored and corrective mitigation would be required, including timely revegetation and wildlife enhancement plantings.

#### 5.3.3 Road construction

The objective of road construction is access to other uses in the watershed. Appropriate agencies within the Government of Guam would required roads be designed and constructed to appropriate standards for the intended use. Preventive mitigation would include avoiding sensitive areas, such as wetlands and unstable slopes.

#### 5.3.4 Recreation

The objective of recreational activities is to promote economic development and public enjoyment of the natural environment. Appropriate agencies of the Government of Guam would permit commercial recreational activities that would not contribute to habitat degradation. Wildlife interpretative materials would be made available to recreationists. Enforcement of Guam game laws would be strengthened through cooperative agreements with land owners.

#### 5.3.5 Residential construction

The objective of residential construction is to promote economic development as well as an opportunity for private individuals to improve their quality of life through home ownership. Zoning for residential construction would incorporate protection and enhancement of wildlife habitat. Variances to zoning would be rare. Single family homes would be encouraged. Building permits would not be issued for construction within the riparian ecosystem. Filling or damaging wetland ecosystem would not be permitted. Retention and planting of trees and shrubs around homes would be encouraged.

6.0 Results of mitigation measures

6.1 Ravine forest

6.1.1 Scenario 1: No Action

Wildlife habitat would be reduced as development for other uses convert habitat.

Where ravine forests are cleared for agricultural activities, wildlife populations which could not successfully mitigate would be destroyed. Agriculture insect pest would increase. Abandoned agricultural land would be poor habitat for the original ravine forest wildlife species. Wildlife diversity in and around agricultural fields would decline.

Road construction through ravine forest would permit access that would lead to additional clearing of habitat. Erosion from poorly designed and constructed roads would increase sediment loading of streams and creeks, adversely affecting lotic wildlife species.

Golf course development would result in some clearing of ravine forest leading to a decline in suitable habitat. No native bird populations would increase in and around golf course development.

Recreational activities involving off-road vehicle use would increase. The number of pioneered roads through the ravine forest would also increase and hunting of feral pigs would increase.

Increasing number of private residences would clear suitable habitat. Number of feral dogs and cats would increase adding stress to wildlife populations. Water quality would decline and lotic wildlife populations would be adversely affected.

No recovery of native bird populations would be possible. Incidence of wildland fires would increase.

6.1.2 Scenario 2: Maintenance

Less area than the No Action scenario would be cleared over the new twenty years. Native bird populations would remain the same or decrease as a result of continued predation by the brown tree snake. Agricultural activities would be limited to appropriate soils and slopes thereby not having an adverse impact on wildland species.

Hunting pressure would remain the same. Golf course development would not materially impact wildlife species between suitable wildlife habitat would be created to mitigate for habitat converted. Recreational activities would increase but not materially impact wildlife habitat.

#### 6.1.3 Scenario 3: Improvement

Only limited areas of the ravine forest would be cleared for development and roads. Forestland cleared for agriculture would remain productive through conservation practices. Existing forest vegetation would remain suitable as wildlife habitat. Ecosystem processes would remain functional.

An active recovery effort for native bird species would set the stage for increasing bird populations. Recreational activities involving wildlife viewing would increase.

#### 6.2 Savanna grasslands

##### 6.2.1 Scenario 1: No Action

Wildlife habitat of the savanna grasslands would expand as forested ecosystems are cleared for agriculture and abandoned over the next twenty years. Portions of the savanna grasslands would temporarily be converted to agriculture use but would convert back to grasslands. Wildland fires would continue to maintain the existing habitat. Erosion from burned grasslands would continue to degrade the lotic habitat. Construction of roads through the savanna grasslands would encourage legal and illegal hunting of Philippine deer and burning of the grasslands to remove wildlife cover.

Golf course development would result in a reduction of ravine, riparian, and wetland habitat. During the construction phase sediment entering the rivers and streams would degrade the lotic communities.

Recreation activities involving off-road vehicle use would increase but emphasis on wildlife values would not occur.

##### 6.2.2 Scenario 2: Maintenance

Existing value of savanna wildlife value would be maintained. Legal and illegal hunting would continue at current levels.

##### 6.2.3 Scenario 3: Improvement

Wildlife habitat value would improve as savanna grasslands are planted to trees. Wildland fire frequency would decline permitting more woody shrubs and trees to become established within the savanna grasslands resulting in a slight improvement of habitat value. Public awareness of adverse impacts of wildland fires to wildlife value would increase as a result of interpretative programs.

#### 6.3 Wetland

##### 6.3.1 Scenario 1: No Action

Wetland habitat would be degraded where development occurred. Some wetland habitat would be cultivated for agriculture. Golf course development would impact wetland habitat through filling and alterations to sub-watershed hydrology. Chemical pollution from fertilizers and pesticides would enter wetlands. Residential construction would fill or degrade

wetland values. Wildland fires would periodically burn through the wetlands. Road construction through or adjacent to wetlands would disrupt hydrology of wetlands. Habitat suitable for moorhens would be reduced.

Sedimentation from terrestrial ecosystems would degrade lotic communities resulting in a declining population of aquatic wildlife.

#### 6.3.2 Scenario 2: Maintenance

Area in wetlands would remain appropriately the same. Specific wetlands would be filled or degraded by development but constructed wetlands would mitigate these impacts. Agriculture would not impact wetlands. Wildland fires would continue periodically burn through the wetlands. Road construction would be designed and located to avoid degrading wetland quality. Moorhen habitat would not increase or decrease.

Quality of lotic communities would not change.

#### 6.3.3 Scenario 3: Improvement

Conservation on agriculture lands would reduce soil erosion and farm-related sedimentation of wetlands. Constructed wetlands resulting from golf course development would be of high quality and provide suitable moorhen habitat. Designed roads would have reduce road-related sedimentation of wetlands. Residential construction would avoid degrading wetland values.

Water quality would improve resulting in an increase in aquatic life.

### 6.4 Riparian

#### 6.4.1 Scenario 1: No Action

Riparian vegetation would be cleared for development activities degrading the wildlife habitat. Native bird populations would continue to decline. Bat population would decline over next twenty years. Agricultural fields tilled in the riparian zone would be a source of sediment to streams and rivers. Golf course construction would result in clearing of riparian vegetation with an increase in sedimentation entering the streams and rivers. Fertilizer and pesticide pollution would enter streams and rivers at a greater rate. Roads constructed through riparian would degrade habitat and be source of sedimentation. Residences constructed within the riparian ecosystem would degrade habitat and be a source of sedimentation. Hunting of feral pig would increase as a result of increased access to the riparian area.

Aquatic life would be adversely affected as riparian vegetation is cleared and sediments enter the streams and rivers at a higher rate.

#### 6.4.2 Scenario 2: Maintenance

Limited activity would be allowed in the riparian ecosystem. Habitat would remain unchanged. Native bird populations would remain the same or decrease as a result of continued predation by the brown tree snake.

#### 6.4.3 Scenario 3: Improvement

Minimum clearing of riparian vegetation would occur under this scenario. Ecological processes within the riparian ecosystem would function properly. Habitat values would not be degraded. Recovery actions could result in increase native bird populations within the riparian zone. Public awareness on the value of riparian wildlife values would increase as a result of interpretative programs.

END OF REPORT

