THE NATION'S WATER RESOURCES 1975-2000

Volume 4: Hawaii Region

Second National Water Assessment by the U.S. Water Resources Council

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Foreword

The Water Resources Planning Act of 1965 (Public Law 89-80) directs the U.S. Water Resources Council to maintain a continuing study of the Nation's water and related land resources and to prepare periodic assessments to determine the adequacy of these resources to meet present and future water requirements. In 1968, the Water Resources Council reported the results of its initial assessment. The Second National Water Assessment, a decade later, provides a comprehensive nationally consistent data base for the water resources of the United States. The results of the Second National Water Assessment were obtained by extensive coordination and collaboration in three phases.

Phase I: Nationwide Analysis

The Council member agencies researched, analyzed, and prepared estimates of current and projected water requirements and problems and the implications of the estimates for the future.

Phase II: Specific Problem Analysis

Regional sponsors, one for each of the 21 water resources regions, surveyed and analyzed State and regional viewpoints about (1) current and future water problems, (2) conflicts that may arise in meeting State and regional objectives, and (3) problems and conflicts needing resolution.

Phase III: National Problem Analysis

The Council conducted this final phase in three steps: (1) An evaluation of phases I and II, (2) an analysis that identified and evaluated the Nation's most serious water resources problems, and (3) the preparation of a final report entitled "The Nation's Water Resources--1975-2000."

The final report of the Second National Water Assessment consists of four separate volumes as described below. These volumes can assist Federal, State, local, and other program managers, the Administration, and the Congress in establishing and implementing water resources policies and programs.

Volume 1, Summary, gives an overview of the Nation's water supply, water use, and critical water problems for "1975," 1985, and 2000 and summarizes significant concerns.

Volume 2, Water Quantity, Quality, and Related Land Considerations, consists of one publication with five parts:

Part I, "Introduction," outlines the origin of the Second National Water Assessment, states its purpose and scope, explains the numerous documents that are part of the assessment, and ident-

ifies the individuals and agencies that contributed to the assessment.

II, "Water-Management Problem Profiles," identifies ten general water problem issues and their implications and potential consequences.

Part III, "Water Uses," focuses on the national perspectives regarding existing ("1975") and projected (1985 and 2000) requirements for water to meet offstream, instream, and flow-management needs. State-regional and Federal perspectives are compared.

Part IV, "Water Supply and Water Quality Considerations," analyzes the adequacy of fresh-water supplies (ground and surface) to meet existing and future requirements. It contains a national water budget; quantifies surface- and ground-water supplies, reservoir storage, and transfers of water within and between subregions; describes regional requirements and compares them to supplies; evaluates water quality conditions; and discusses the legal and institutional aspects of water allocation.

Part V, "Synopses of the Water Resources Regions," covers existing conditions and future requirements for each of the 21 water resources regions. Within each regional synopsis is a discussion of functional and location-specific water-related problems; regional recommendations regarding planning, research, data, and institutional aspects of solving regional water-related problems; a problem-issue matrix; and a comparative-analysis table.

Volume 3, Analytical Data, describes the methods and procedures used to collect, analyze, and describe the data used in the assessment. National summary data are included with explanatory notes. Volume 3 is supplemented by five separately published appendixes that contain data for the regions and subregions:

Appendix I, Social, Economic, and Environmental Data, contains the socioeconomic baseline ("1975") and growth projections (1985 and 2000) on which the water-supply and water-use projections are based. This appendix presents two sets of data. One set, the National Future, represents the Federal viewpoint; the other set, the State-Regional Future, represents the regional sponsor and/or State viewpoint.

Appendix II, Annual Water Supply and Use Analysis, contains baseline water-supply data and baseline and projected water withdrawal and water-consumption data used for the assessment. Also included are a water adequacy analysis, a natural flow analysis, and a critical-month analysis.

Appendix III, Monthly Water Supply and Use Analysis, contains monthly details of the water-supply, water-withdawal, and water-

consumption data contained in Appendix II and includes an analysis of monthly water adequacy.

Appendix IV, Dry-Year Conditions Water Supply and Use Analysis, contains both annual and monthly baseline and projected water-withdrawal and water-consumption data for dry conditions. Also, a dry conditions water-adequacy analysis is included.

Appendix V, Streamflow Conditions, contains detailed background information on the derivation of the baseline streamflow information. A description of streamflow gages used, correction factors applied, periods of record, and extreme flows of record, are given for each subregion. Also included is the State-Regional Future estimate of average streamflow conditions.

Volume 4, Water Resources Regional Reports, consists of separately published reports for each of the 21 regions. Synopses of these reports are given in Volume 2, Part V.

For compiling and analyzing water resources data, the Nation has been divided into 21 major water resources regions and further subdivided into 106 subregions. Eighteen of the regions are within the conterminous United States; the other three are Alaska, Hawaii, and the Caribbean area.

The 21 water resources regions are hydrologic areas that have either the drainage area of a major river, such as the Missouri Region, or the combined drainage areas of a series of rivers, such as the South Atlantic-Gulf Region, which includes a number of southeastern States that have rivers draining directly into the Atlantic Ocean and the Gulf of Mexico.

The 106 subregions, which are smaller drainage areas, were used exclusively in the Second National Water Assessment as basic data-collection units. Subregion data point up problems that are primarily basinwide in nature. Data aggregated from the subregions portray both regional and national conditions, and also show the wide contrasts in both regional and national water sources and uses.

The Second National Water Assessment and its data base constitute a major step in the identification and definition of water resources problems by the many State, regional, and Federal institutions involved. However, much of the information in this assessment is general and broad in scope; thus, its application should be viewed in that context, particularly in the area of water quality. Further, the information reflects areas of deficiencies in availability and reliability of data. For these reasons, State, regional, and Federal planners should view the information as indicative, and not the only source to be considered. When policy decisions are to be made, the effects at State, regional, and local levels should be carefully considered.

In a national study it is difficult to reflect completely the regional variations within the national aggregation. For example, several regional

reviewers did not agree with the national projections made for their regions. These disagreements can be largely attributed either to different assumptions by the regional reviewers or to lack of representation of the national data at the regional level. Therefore, any regional or State resources-management planning effort should consider the State-regional reports developed during phase II and summarized in Volume 4 as well as the nationally consistent data base and the other information presented in this assessment.

Additional years of information and experience show that considerable change has occurred since the first assessment was prepared in 1968. The population has not grown at the rate anticipated, and the projections of future water requirements for this second assessment are considerably lower than those made for the first assessment. Also, greater awareness of environmental values, water quality, ground-water overdraft, limitations of available water supplies, and energy concerns are having a dramatic effect on water-resources management. Conservation, reuse, recycling, and weather modification are considerations toward making better use of, or expanding, available supplies.

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Physiography

Description

The Hawaiian archipelago is located north of the equatorial currents, in the belt of northeast tradewinds, with no land upwind for 2,000 miles. It trends northwest to southeast more than 1,600 miles across the Pacific from approximately 155° to 179° west longitude and 19° to 28° north latitude. Honolulu is about 2,400 miles southwest of San Francisco. The 132 islands, shoals, and reefs of the archipelago within the State of Hawaii contain a total of 6,447 square miles (4,126,000 acres).

The eight major islands at the southeastern end of the chain comprise 99.9 percent of the land area. In order of decreasing size, they are (in square miles): Hawaii (4,038), Maui (729), Oahu (608), Kauai (553), Moloki (261), Lanai (139), Niihau (73), and Kahoolawe (45) (See Figure 20-1). Hawaii ranks 47th among the States in land area; however with 1,052 miles, Hawaii ranks 17th among the States and territories in length of tidal shoreline.

Hawaii is unique among the States in that it has only two levels of government--State and county. The State capital of Honolulu is located on the island of Oahu. The four counties are Hawaii, subregion 2001 (island of Hawaii), Maui, Subregion 2002 (islands of Maui, Kahoolawe, Lanai, and Molokai), and Kauai, subregion 2004 (islands of Kauai and Niihau). The city of Honolulu, the only community of Hawaii with city limits, is governed jointly with the county as the city and county of Honolulu. Figure 20-2 depicts present land use in the various islands.

Geology

The Hawaiian archipelago, which makes up the region, is a chain of volcanic islands situated over a 1,600-mile-long fissure in the floor of the Pacific Ocean. The eight major islands are tops of enormous shield volcanoes, which project high above the level of the sea in the southeastern end of the chain. Each of the major islands consists of one to five volcanic domes, the bulk of which are composed of thousands of generally thin-bedded highly vesicular basaltic lava flows. The structural features generally associated with these flows, such as an abundance of clinker sections, voids between flow surfaces, and shrinkage joints and fractures, make these rocks highly porous and pervious. The lavas issued forth in repeated outpourings from narrow zones of fissure associated with each volcano. When volcanic activity ceased, lava remaining in the fissures was quickly chilled by the surrounding rock and filled the fissures with narrow vertical sheets of rock with low permeability called dikes. This rock assemblage of highly permeable basaltic lava flows, intruded in part by dikes in the rift zones and free of dikes outside the rift zones, makes up the principal aquifer in the Hawaiian Islands.

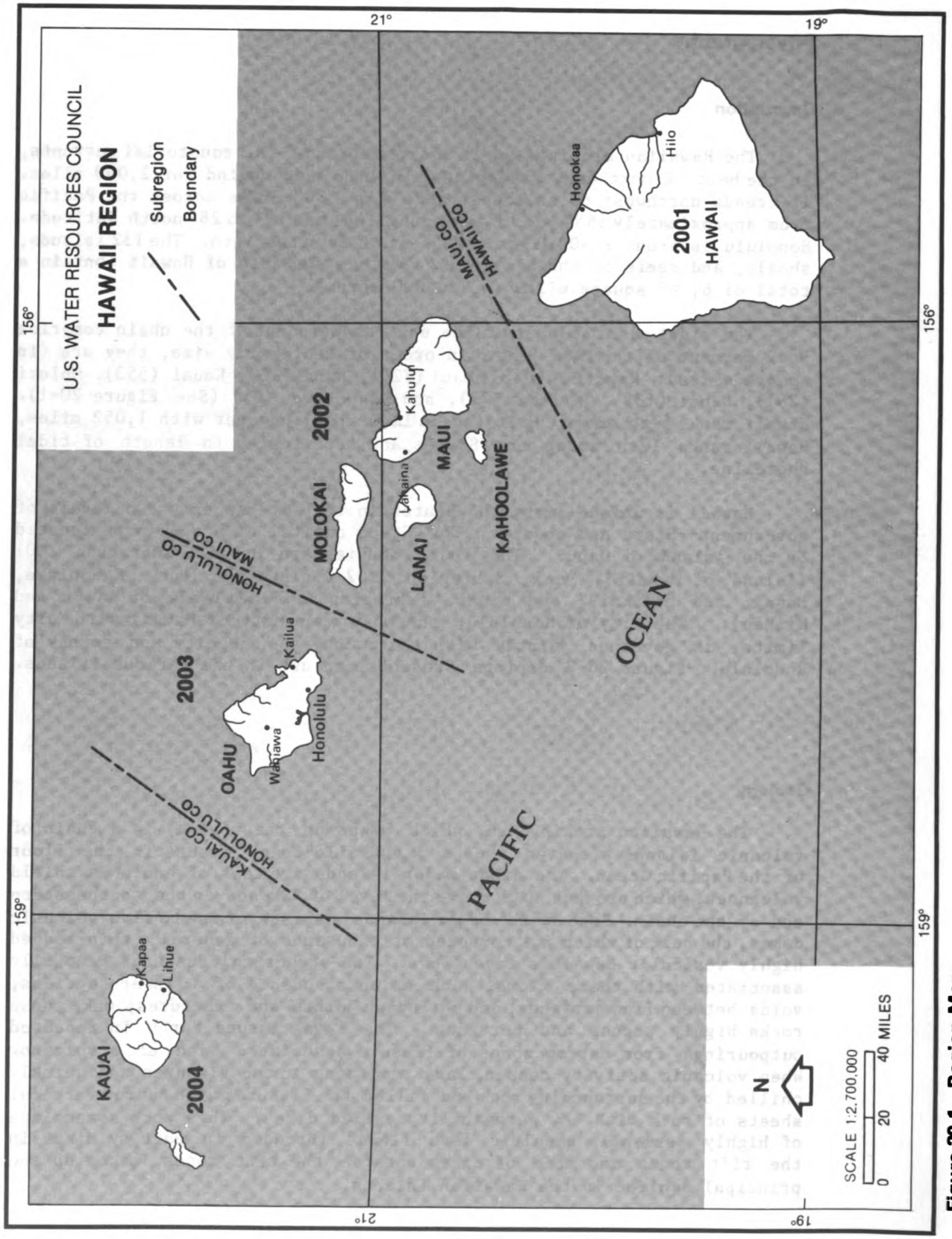

Figure 20-1. Region Map

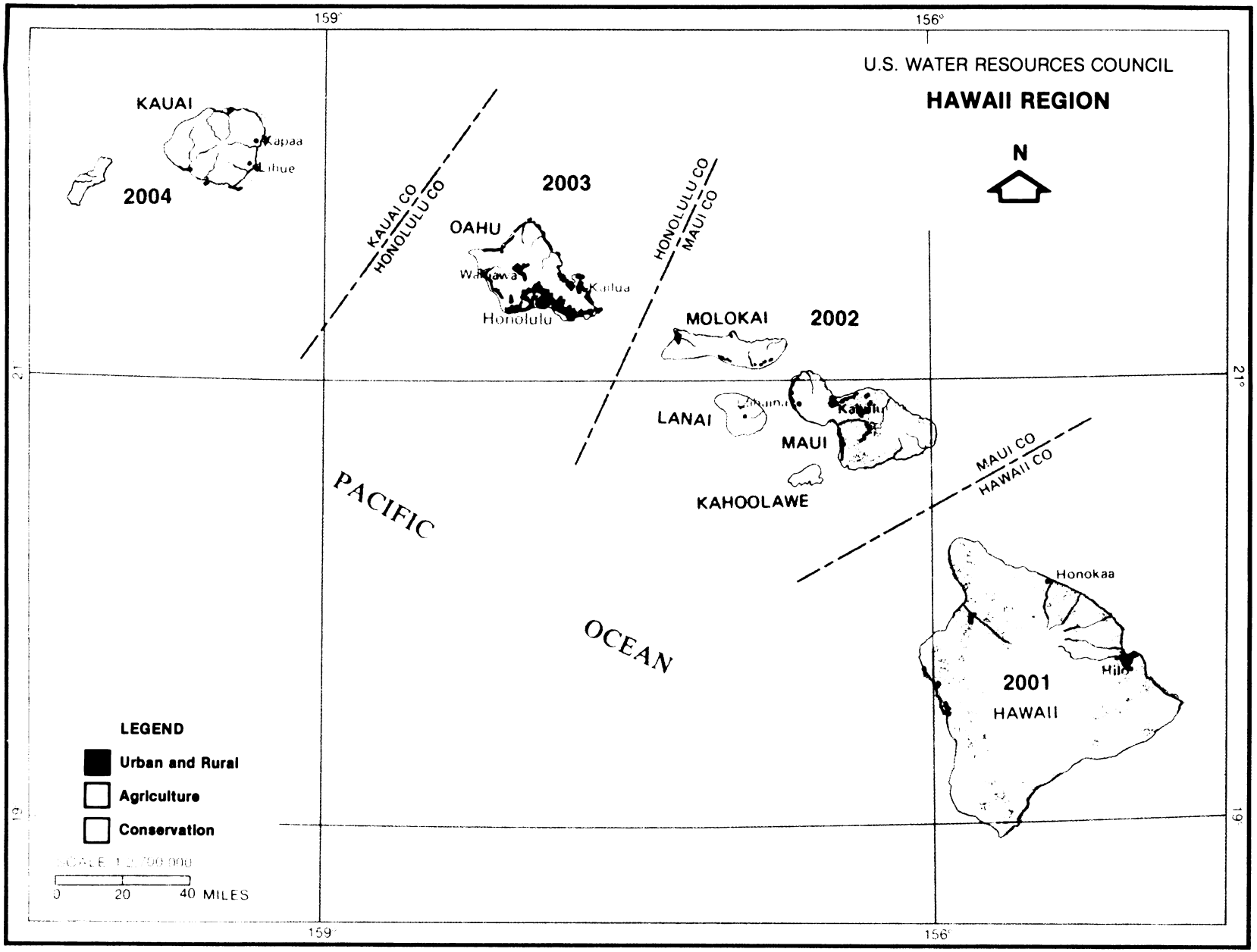

Figure 20-2. Present Land Use

Climate

Hawaii owes its distinctive climate to tropical locale, insularity, topography, persistence of trade winds, and relative infrequency of severe weather. While characteristically mild and relatively uniform the year around, the climate varies markedly from place to place owing to terrain and from time to time under the influence of dirurnal and seasonal changes and occasional storms.

Hawaii's climate ranges from tropical near sea level to subarctic on the uppermost slopes of its highest mountains and encompasses some of the wettest areas on earth along with desert conditions within the span of a few miles. Rainfall gradients are steep, often 25 inches per mile. Drought and flooding are both major problems. On the one hand dry areas may receive nearly a year's average rainfall in a single day; on the other, even normally wet areas may experience long periods of deficient rainfall.

Despite the region's small size, it contains at least seven distinct climatic subdivisions influenced chiefly by topography and the prevailing trade winds: windward lowlands, leeward lowlands, interior lowlands, Kona Coast, windward mountain slopes, leeward mountain slopes, and high mountains.

The extreme temperature range reported in downtown Honolulu is from 57° F to 88° F. Average precipitation ranges from 5.7 inches near Kawaihae on the island of Hawaii to 486.1 inches atop Waialeale on Kauai. The summit of Waialeale is the wettest spot in the United States. The longest volcanic eruption in Hawaii's history lasted 867 days and the highest tsunami (tidal wave) reached 56 feet.

People and the Resources

This section presents a summary of present demographic, economic, and environmental parameters and estimates of future change in the region. Estimates and projections of the population, economy, land and water resources, as well as other parameters, were made for the Water Resources Council by various Federal agencies, as explained elsewhere in the national assessment reports. These data were provided for three reference years, 1975, 1985, and 2000, according to national, regional, and subregional boundries (see Figure 20-1 for subregional boundaries). These federally-developed data constitute the Council's National Future (NF), one perspective on the most probable developments in population and economic growth and the resultant resource use over the next 25 years. State and regional representatives were encouraged to prepare alternative estimates for future growth and resource use in a corresponding perspective known as the State-Regional Future (SRF).

Population

According to State sources, Hawaii's growing population and the needs created by this growth affect every aspect of island living in the region. The interrelationships that apply are fundamental but are worth describing at this stage of regional growth. If the number of employable people increases faster than the ability of Hawaii's economy to generate jobs, this will increase unemployment and result in more competition for those jobs which are available. Due to Hawaii's limited supply of usable land, an increasing population can cause a decline in use of lands for agriculture, open space, and scenic purposes. It can lead to crowding and congestion on streets and highways, parks and beaches. Population growth can outpace Hawaii's ability to finance, develop, and maintain adequate facilities and services such as schools, highways, police protection, sewer and water systems, housing, and health care.

Hawaii's history and development have been determined, to a large extent, by in-migration from many parts of the world. This in-migration stimulated the progress and prosperity that nearly everyone shares. The State's multicultrual heritage and the diverse backgrounds of its people have contributed to the special flavor of life in Hawaii.

The notion that "excessive" population growth sould be stopped is difficult, if not impossible, to apply--even assuming that a consensus could be reached on when and where growth is excessive. There are basic constitutional and philosphical issues involved, as well as pressing economic influences. If population growth slows down too much, undesirable effects can result: economic recessions, excessive out-migration, an unattractive investment climate, and lack of revenues to pay for needed public services. The State believes that the best population strategy is to attempt to influence population growth and, at the same time, undertake appropriate measures to minimize undesirable impacts.

Population Trends. Hawaii's population grew at a rate twice as fast as that of the entire United States from 1960 to 1975. About half of this increase came from in-migration. The rate of in-migration from the mainland is generally sensitive to economic conditions in Hawaii. During periods of high employment the number of people moving to Hawaii from the mainland slows down. The opposite also appears to be true. During periods of sustained economic growth, for example, between 1968 and 1972, in-migration from the mainland increased. Migrants from the mainland tend to be young adults, many with families, highly educated and skilled, and in high-status occupations.

Alien In-Migration. In-migration of foreigners to the region appears to be less sensitive to prevailing economic conditions. Regardless of the economic and employment situation, in Hawaii, aliens have continued to come to Hawaii at a fairly constant rate of between 4,000 and 6,000 each year. New arrivals from foreign contries have special adjustment problems. The presence of relatives and friends in Hawaii can help during this transition period, but there exists a great need for services and programs to assist foreign in-migrants.

Demographic Trends. While Hawaii continues to accommodate a large number of in-migrants, the demographic characteristics of the resident population are also changing. There is an increasing trend toward a more cosmopolitan population in Hawaii. The percentage of interracial marriages per year has increased from 33 percent in the 1967-68 period to over 40 percent in 1974. The fast growing segments of the resident population are those in the 25 to 34 age group and the 65-years-and-over group. The school-age group, those 5 to 17, had the lowest rate of increases. These demographic trends indicate possible changes in the type of services and programs which will be required in the future.

Growth on Oahu and the Neighbor Islands. Oahu continues to be the major population center in Hawaii, with approximately 81.5 percent of the total resident population. Since 1970, however, population growth on the neighboring islands has increased. Between 1970 and 1975, the resident population increased by 11.7 percent on Oahu and 15.1 percent on the neighbor islands. These trends may be desirable in order to alleviate crowding and congestion on Oahu and to stimulate new economic and employment opportunities on the neighboring islands, where population densities are lower.

It is expected that due to shifts within the economy, population dispersal throughout the State will continue. Faster economic growth and employment opportunities on the neighboring islands will probably result from higher growth in tourism and diversified agriculture there. Slower growth in defense and Federal spending, both of which are concentrated on Oahu, may result in slower economic growth and employment opportunities on Oahu than have been experienced in the past. Although Oahu will remain the State's major population center in the foreseeable future, the neighboring islands are expected to gradually absorb a larger proportion of future population growth.

Population projections have been prepared for the State by the Hawaii Department of Planning and Economic Development. These projections assume that fertility will level off close to the near-replacement level approached in 1973 and remain there for the foreseeable future; mortality will decline slightly; and net in-migration will rise from the 1970-1973 average of 7,000 annually to 13,000 by the end of the century. The Department's projections indicate a resident popluation in the region of 865,000 in 1975, 1,058,000 in 1985 and 1,355,000 in 2000. National Future projections of population indicate total population as follows: 787,000 in 1975, 911,000 in 1985, and 1,085,000 in 2000.[1]

As a result of a thorough and careful examination of trends and conditions relating to the population, the following objective and policies have been formulated in the Hawaii State Water Plan (enacted into law in 1978):

- Objective

  Guide population growth to be consistent with the achievement of physical, economic, and social objectives of the State plan.

- Policies

  Manage population growth statewide in a manner that provides increased opportunities for Hawaii's people to pursue their phyical, social, and economic aspirations while recognizing the unique needs of each county.

  Encourage an increase in economic activities and employment opportunities on the neighboring islands consistent with community needs and desires.

  Ensure that adequate support services and facilities are provided to accommodate the desired distribution of future growth throughout the State.

  Seek legislative and other means to manage the rate of migration of new residents to the State of Hawaii, in order that it may be consistent with the achievement of physical, economic, and social objectives of the State plan.

  Foster an understanding of Hawaii's capacities to accommodate population needs.

  Encourage Federal actions that will promote a more balanced distribution of immigrants among the States provided that such actions do not prevent the reunion of immediate family members.

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[1] Differences in population estimates and other parameters may exist for reasons explained in the Foreword of this report.

Pursue an increase in Federal assistance for States with a greater proportion of foreign immigrants relative to their State's population.

Economy

Hawaii's economy is becoming less diversified according to State sources, and more reliant on a few major industries. These industries are tourism, defense, and other Federal spending. Together they provide 81 percent of the State's total earnings. These industries are highly sensitive to national and international economic fluctuations. Hawaii is quite vulnerable to recessions because these industries are largely beyond the State's control and influence. As a result, periodic boom/bust cycles can be very disruptive in terms of personal income, employment, investments, government revenues, and expenditures.

Continued steady growth in tourism, defense, and Federal spending is necessary to provide employment for the growing population. At the same time a concerted effort is being made to assist and attract new industries with future growth potential. A more diversified economic base can help stabilize the economy during periods of national and international recessions. A related concern is the need for future employment opportunities that will contribute to a sustained high standard of living in Hawaii.

Tourism. Tourism is the largest generator of civilian jobs in Hawaii. The visitor industry has good potential for continued growth and will probably provide a sizable share of future jobs. But tourism is subject to economic instability. A drop in the number of visitors vacationing in Hawaii could be caused by a national recession, incidents of crime, airline strikes, or international oil crises. Due to its size and influence uneven growth in tourism can also contribute to boom/bust cycles in construction and related activities. Another concern is that wage rates in the tourism industry are lower than average rates throughout the State. Continued tourism growth is necessary, but efforts will need to be directed at attracting other industries to diversify Hawaii's economic base.

Defense Spending. In terms of employment and overseas income, defense is Hawaii's second most important industry. Defense activities are expected to stabilize or grow slowly in the future. The defense industry has been subject to frequent fluctuations in the past, and has affected Hawaii's economy and employment. Since 1960, for example, the number of military personnel stationed in Hawaii has fluctuated a total of five times by over 5,000 people. These fluctuations in the defense industry are largely beyond State control and influence.

Federal Spending. Federal spending, excluding defense, is the third largest source of overseas income to the State. Federal spending includes funds used for highways, airports, harbors, water and sewer facilities, welfare payments, revenue sharing, and educational programs. Such nonmilitary Federal spending is nearly as great as defense spending and almost double the combined sales from sugar and pineapple. Growth in

Federal expenditures will probably be lower than the average 8 to 9 percent annual growth that occurred between 1968 and 1975. This will affect all sectors of Hawaii's economy which are dependent on Federal spending for a sizable portion of their revenues.

Sugar Industry. Increasing competition from overseas producers and high labor and land costs have affected Hawaii's sugar industry. The lapse of the 40-year-old Sugar Act in 1974 introduced a new element of instability into Hawaii's economy. Unless controls are instituted,[1] it is likely that sugar will experience losses over the next few years and significant fluctuations every few years. Sugar price fluctuations cause related changes in corporate revenues and government tax collections, which in turn affect other economic activites.

It is expected that the sugar industry will remain relatively healthy in the short term. This health is largely due to research efforts which have resulted in high sugar yields per acre. In the long run, however, there are major problems which could threaten the sugar industry in Hawaii. Sugar substitutes, especially high-fructose corn syrup, may pose serious competition to Hawaii's sugar industry. High-fructose corn syrup is a one-to-one substitute for regular sugar; it sells for less, is more profitable, and is constrained only by available processing capacity. The market penetration by sugar substitutes can be expected to increase substantially and the sugar industry on Oahu could suffer major declines due to severe competition for water and land.

Pineapple Industry. Hawaii's total pineapple industry has been clearly on the declne as indicated by its decreasing share of the world pineapple market and the accompanying declines in acreage, production, and employment. However, fresh pineapple sales are increasing rapidly and total sales have held up well because of price increases. The market for fresh pineapple on the mainland has a high potential for future growth. Hawaii has an important locational advantage as well because of its proximity to the mainland market relative to foreign competitors, and the perishability of fresh pineapple. The pineapple companies are now expanding their planting as the demand for fresh fruit grows and the economics of the industry improve.

Diversified Agriculture. The growth of Hawaii's diversified agriculture industry is restricted by a number of problems, most of which are very difficult to eliminate. A major problem among others described below, is the small local market which cannot support large-scale mechanized operations. A large proporation of future growth in diversified agriculture will probably be for export; however, there is concern that Hawaii should increase its agricultural self-sufficiency as well.

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[1] Proposed legislation for an international agreement is now before Congress along with a program of control by import regulations and duties.

Potential Growth Activities. A major potential for Hawaii's economy is the development of new industries that show signs for growth. These locally-based industries include: apparel and textile manufacturing; commercial fishing and aquaculture; precious coral; motion picture and television production for which Hawaii is the Pacific regional center; and astronomy projects. Those fields with long-term growth potential include energy development and manganese nodule mining and processing. Problems restricting growth of potential industries, including agricultural activities, include: a small Hawaii market; competition from producers outside Hawaii; high costs in supplying overseas markets; lack of raw materials in Hawaii; high land, labor, and material costs in Hawaii; and high overseas shipping costs. Government and private industry must work closely together to overcome these obstacles. Growth in new industries is necessary to further diversify Hawaii's ecnomic base, thereby increasing economic stability. New industries can provide a wider range of employment opportunities and contribute to a higher standard of living for Hawaii's people.

Economic projections indicate that Hawaii's overall growth rate will probably be slow, largely due to an anticipated slowdown in growth in tourism, defense, and Federal spending. Even though Hawaii's economic growth rate is expected to slow, the average amount of growth per year is not expected to differ much from past years.

As a result of a thorough and careful examination of trends and conditions relating to the economy, the following objectives and policies have been formulated by the State Water Plan:

- o General Objectives:

  Increased and diversified employment opportunities to achieve full employment, increased income, and job choice, and improved living standards for Hawaii's people.

  A growing and diversified economic base that is not overly dependent on a few industries.

- o General Policies:

  Expand Hawaii's national and international marketing, communication, and organizational ties, to increase the State's capacity to adjust to and capitalize upon economic changes and opportunities occurring outside the State.

  Promote Hawaii as an attractive market for investment activities that benefit Hawaii's people.

  Seek broader outlets for new or expanded Hawaii business investments.

  Expand existing markets and penetrate new markets for Hawaii's products and services.

Assure that the basic economic needs of Hawaii's people are maintained in the event of disruptions in overseas transportation.

Strive to achieve a sustained level of construction activity responsive to, and consistent with, State growth objectives.

Encourage the formulation of marketing cooperatives to assist small-scale producers, manufacturers, and distributors.

Pursue more favorable marketing arrangements at the regional and local levels for Hawaii's export products.

Encourage labor-intensive activities that are economically satisfying.

Foster greater cooperation and coordination between the public and private sectors in solving Hawaii's employment problems.

Promote economical activities, especially those which benefit areas with substantial unemployment problems.

Maintain acceptable working conditions and standards for Hawaii's workers.

Provide equal employment opportunities for all segments of Hawaii's population through affirmative action and antidiscrimination measures.

Encourage businesses that have favorable financial multiplier effects within Hawaii's economy.

Promote and protect intangible resources in Hawaii, such as scenic beauty and the aloha spirit, which are vital to a healthy economy.

- Agricultural Objectives:

  Increased viability in sugar and pineapple industries.

  Continued growth and development of diversified agriculture throughout the State.

- Agricultural Policies:

  Foster attitudes and activities conducive to maintaining agriculture as a major sector of Hawaii's economy.

  Seek Federal legislation that benefits Hawaii's agricultural industries.

  Promote Hawaii's agricultural products locally, in the continental United States, and internationally.

Support research and development activities that provide greater efficiency and economic productivity in agriculture.

Enhance agricultural growth by providing public incentives and encouraging private initiatives.

Assure the availability of agriculturally suitable lands with adequate water to accommodate present and future needs.

Increase the attractiveness and opportunities for an agricultural education and livelihood.

Expand Hawaii's agricultural base by promoting growth and development of flowers, tropical fruits and plants, livestock, feed grains, forestry, food crops, aquaculture, and other potential enterprises.

Strengthen diversified agriculture by developing an effective marketing and distribution system between producer and consumer.

Promote economically competitive activities that increase Hawaii's agricultural self-sufficiency.

Promote and assist in the establishment of sound financial programs for diversified agriculture.

- Visitor Industry Objective:

  A visitor industry that constitutes a major component of steady growth for Hawaii's economy.

- Visitor Industry Policies:

  Assist in the overseas promotion of Hawaii's vacation attractions.

  Ensure that visitor industry activities are in keeping with the social, economic, and physical needs and aspirations of Hawaii's people.

  Improve the quality of existing visitor destination areas.

  Encourage greater cooperation between the public and private sectors in developing and maintaining well-designed and adequately serviced visitor industry and related developments.

  Ensure that visitor facilities and destination areas are carefully planned and sensitive to existing neighboring communities and activities.

  Develop the industry in a manner that will provide the greatest number of primary jobs and steady employment for Hawaii's people.

Provide opportunities for Hawaii's people to obtain job training and education that will allow for upward mobility within the visitor industry.

Foster a recognition of the contribution of the visitor industry to Hawaii's economy and the need to perpetuate the aloha spirit.

Foster an understanding by visitors of the aloha spirit and of the unique and sensitive character of Hawaii's cultures and values.

- Federal Expenditure Objectives:

  A stable Federal investment base as an integral component of Hawaii's economy.

- Federal Expenditures Policies:

  Encourage the sustained flow of Federal expenditures in Hawaii that generates long-term government civilian employment.

  Maintain Hawaii's supportive role in national defense.

  Promote the future development of federally supported activities in Hawaii that respect statewide economic concerns, are sensitive to community needs, and minimize impacts on Hawaii's environment.

  Increase opportunities for entry and advancement of Hawaii's people into Federal Government.

  Encourage Federal use of local commodities, services, and facilities available in Hawaii.

  Strengthen Federal-State-county communication and coordination in all Federal activities that affect Hawaii.

  Promote the return of federally controlled lands in Hawaii that are not required for the defense of the Nation and the mutually beneficial exchanges of land between Federal agencies, the State, and counties.

- Potential Growth Activities Objective:

  Development and expansion of potential growth activities that serve to increase and diversify Hawaii's economic base.

- Potential Growth Activities Policies:

  Encourage investment and employment in economic activities that have the potential for growth such as diversified agriculture, aquaculture, apparel and textile manufacturing, and energy and marine-related industries.

Expand Hawaii's capacity to attract and service international programs and activities that generate employment for Hawaii's people.

Enhance Hawaii's role as a center for international trade, finance, services, technology, education, culture, and the arts.

Accelerate research and development of new energy-related industries based on wind, solar, ocean, and underground resources and solid waste.

Encourage the formulation of marketing cooperatives to assist small-scale producers, manufacturers, and distributors.

Pursue more favorable marketing arrangements at the regional and local levels for Hawaii's export products.

Promote Hawaii's geographic, environmental, and technological advantages to attract new economic activities into the State.

Provide public incentives and encourage private initiative to attract new industries that will support Hawaii's social, economic, physical, and environmental objectives.

Generate new ocean-related economic activities in mining, food production, and scientfic research.

Natural Resources

The effects of man's land-use patterns on the natural environment in Hawaii have been influenced by several contributing factors, including climate; soils and land forms, especially including slope; the historical development of land ownership; the limited total land area and limited prime agricultural land; and the biological characteristics of species evolving on isolated oceanic islands.

Soil characteristics directly affect agriculture, housing, recreation, wildlife habitat, and water quality. Hawaii's soils are basically of volcanic origin with some marine sediments and coral. Generally, they are easily tilled, exceptionally porous, and permeable to air and water. Due to the wide range of climate in Hawaii, the soils are suitable for many types of vegetation and crops.

Topography determines, to a large degree, potential agricultural use of a given area. If the slope is too steep or rocky, mechanical farming is difficult. Many of the characteristics of prime agricultural land (stable soil, gentle slope, access to water) are also desirable in potential urban sites, thus posing some conflict in land use in some areas of the region.

Land use in Hawaii has been strongly influenced by the land ownership pattern. Historically, government and major private owners have controlled most of the land. Sugarcane, which received first priority in utilization of agricultural land, claimed most of the irrigable lowlands in dry areas and prime uplands where rainfall is adequate. Pineapple, which requires less water, utilizes most of the remaining land suitable for cultivation. About 8 percent of the region is cropland. The balance of the usable land has been devoted primarily to beef cattle grazing. Table 20-1 and Figure 20-2 show present land use.

There are no large watersheds in Hawaii with complex stream systems. Drainage basins are relatively small, usually consisting of one principal stream and some minor tributaries.

Table 20-1.--Hawaii Region surface area and 1975 land use

Surface area or land use type	1,000 acres	Percentage of total surface area
Surface area		
Total	4,126	100.0
Water	31	0.8
Land	4,095	99.2
Land use		
Cropland	321	7.8
Pasture & range	728	17.6
Forest & woodland	1,774	43.0
Other agriculture	67	1.6
Urban	21	0.5
Other	1,184	28.7

About 43 percent of the region (some 1.8 million acres) is forest, ranging from mountain scrub to subtropical rain forest. These areas constitute the principal watersheds. Forests help decrease erosion and sedimentation and are very effective in maintaining high rates of rainwater percolation to ground-water sources. They provide habitat for many unique types of flora and fauna, as well as recreational opportunities.

There are no large lakes or ponds in Hawaii. A few small ponds and stream pools store very limited amounts of water. Swamps in coastal areas are generally brackish, and the water has only limited use. Upland swamps are found where the surface rock has weathered to form impervious beds, such as clay blankets, or where the ground surface is composed of tight pahoehoe lava flows. While these swamps do not have free-flowing water in the usual sense, the soil is saturated and stores some water to feed surface streams. The largest upland swamp is the Alakai Swamp on Kauai, which covers about 4,000 acres. Inland water areas cover about 31,000 acres, less than 1 percent of the region.

Recreational uses of coastal waters include swimming, surfing, fishing, and boating. About 40 unimproved harbor sites and anchorages along the coast of the major islands are used by local boats and occasional transient craft. These sites include stream estuaries, lower canalized reaches of streams, small bays or coves, inlets or natural openings in reefs, and sheltered beach zones where boats are landed or moored in shallow water. Much of Hawaii's shoreline is physically inacessible, or nearly so. About 64 percent consists of cliffs which rise from the water's edge. Many marginally accessible areas are used for water-related recreation, primarily by residents.

Hawaii was the first State to pass a land-use law, in 1961. This law is intended to prevent scattered urban development and urban sprawl into prime agricultural land. The Land Use Act provides for four land use districts: conservation, agricultural, rural, and urban.

Agriculture

The growing and processing of sugarcane and pineapple have been cornerstones of Hawaii's economy. Sugarcane was already growing in Hawaii when Captain James Cook first landed in the islands in 1778; the first of today's modern pineapple companies was established in 1901. Hawaii today is the largest cane-sugar producing State in the Nation. High production costs and competition from foreign countries have caused some pineapple companies to discontinue cannery operations and phase out plantations. However, good growth prospects are seen in increasing shipments of fresh pineapples by air to mainland markets.

Hawaii's sugar industry is noted for its superior technology and mechanization. There are 15 sugar companies and more than 500 independent growers in the State. In 1975 they used 211,400 acres to produce almost 9.5 million tons of unprocessed cane, valued at more than $237 million. Average sugar employment totaled 9,640 in 1975 with an annual payroll of about $115 million. The general excise tax base of sugar processing in Hawaii was $275 million in 1976.

Pineapple is the State's second largest agricultural industry. The fruit is grown on 50,000 acres of plateau areas on four of Hawaii's six major islands--Oahu, Maui, Molokai and Lanai. Average full-time equivalent employment (both field and mill) dropped from 8,400 in 1970 to 5,100 in 1975. The general excise and use tax base for pineapple canning in Hawaii was $95 million in 1976. Production exceeded 18 million cases of fruit and juice and 471,000 cases of concentrated juice in 1975-1976.

While production of sugar and pineapple have long been keystones of Hawaii's economy, increase of diversified agriculture is a major State goal. That some success has been achieved is indicated by the fact that diversified agriculture, defined as all crops other than sugar and pineapple, rose from $15 million in 1965 to $39 million in 1975, approximately 165 percent.

More than 500 farms sold $9.8 million of flowers and nursery products, chiefly anthuriums and orchids, in 1973. Important products of livestock farms as of 1975 included cattle ($17 million in sales), milk ($21 million), and eggs ($11 million). Coffee sales declined sharply during the past decade, but production of macadamia nuts and horticultural products increased rapidly.

In 1975, Hawaii produced 44 percent of the fresh market vegetables consumed locally, 32 percent of the fresh market fruits, 92 percent of the eggs, all of the fresh milk, 18 percent of the poultry meat and 35 percent of the red meat. The State produced 8 million (dressed weight) pounds of pork.

The number of farms in Hawaii as of 1975 was 4,270, encompassing 2,300,000 acres. While both of these figures declined during the past decade, the value of crop sales rose to $373 million, more than double the total for 1965. These figures, however, include sugar and pineapple. Total cropland will remain nearly the same during the rest of the century, encompassing 321,000 acres in 1975 and 320,000 acres in 2000. (See Table 20-2.)

Table 20-2.-- Projected changes in cropland and irrigated farmland in the region--1975, 1985, 2000

(1,000 acres)

Land category	1975	1985	2000
Total cropland ----------	321	320	320
Cropland harvested ---------	321	320	320
Irrigated farmland ---------	142	147	150

Energy

Except for the burning of bagasse by the sugar plantations to provide energy for plantation uses, including mill operations and pumping of water, Hawaii depends almost entirely on petroleum products for all its energy requirements. Hawaii has no coal, natural gas, nor nuclear energy; no significant hydroelectric power; and no developed geothermal resources. A geothermal well, however, has been drilled successfully on the island of Hawaii and may eventually provide energy for a power generation plant.

While this almost total dependence on petroleum remains risky, Hawaii has potential alternate energy sources which provide challenging prospects. A recent State report lists the following alternate energy sources recommended for State research and development: solid waste, hydroelectric power, wind, geothermal energy, ocean thermal energy conversion, coal liquefaction and gasification (mainland import), bioconversion (of bagasse, kelp, algae, etc.), waves, tides and ocean currents, granual coal, and nuclear power. Table 20-3 depicts Hawaii's dependence on fossil fuels.

Table 20-3.--Hawaii Region electric power generation--1975, 1985, 2000 (gigawatt-hours)

Fuel source	1975	1985	2000
Fossil	5,167	10,301	25,873
Nuclear	0	0	0
Conventional hydropower	0	0	0
Total generation	5,167	10,301	25,873

Environment

The eight major islands of Hawaii are the summits of a largely submerged range of volcanic mountains. Volcanic eruptions are still occurring at the southernmost end of the chain, on the island of Hawaii. In the northwestern Hawaiian Islands beyond Kauai, the earliest island masses have been leveled to shoals and coral reefs or basaltic remnants.

Construction of Hawaii's coastal zone, by volcanic action, living organisms such as coral, and sedimentation, has been countered by wave action and erosion. Coastal topography generally consists of cliffs formed by wave action, broad bays between volcanic headlands, smaller bays which once were river mouths, shallow lagoons, and beaches of rock and sand. Much of the coastline is rugged and inaccessible.

Rains and prevailing northeasterly tradewinds have been the dominant factors in the weathering and erosion of Hawaii's mountain masses, affecting chiefly the wet windward sides of the islands. The drier leeward sides of the islands have longer and more gentle slopes.

Kauai, Maui, and Oahu have the highest percentages of steep land due to more advanced erosion. Hawaii, the geologically youngest island, has the greatest percentage of land with less than 10 percent slope.

On the windward side of most of the islands, heavy rains send water cascading over high cliffs and down steep streams directly into the sea. Perennial streams are found in areas of adequate rainfall where weathering of the ground surface is favorable for sustained runoff. Drainage on the more circular domes follows the radial pattern of the lava flows. There is insufficient dendritic (branching) drainage to form a tributary system of streams, lakes, and rivers.

The first organisms established on the islands from other lands were probably plants. Spores and seeds drifted in the wind or floated on the ocean surface. Others were attached to the feathers of birds or were passed in their droppings. Probably only a small percentage of these new arrivals successfully established themselves on the bare lava flows, but each new colonist changed the natural environment in some way, and a succession of species began.

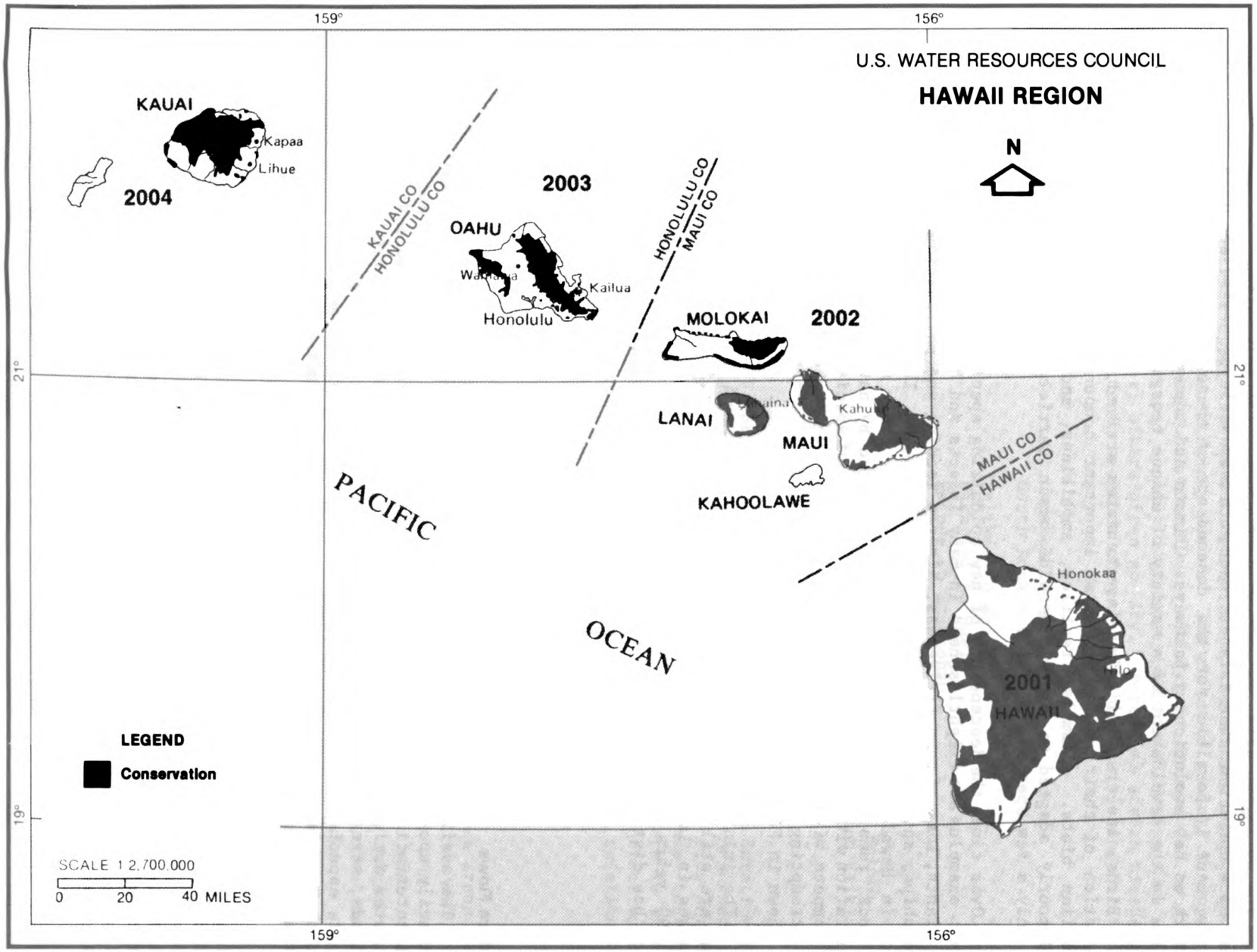


Figure 20-3. Environmental Resources

The extensive adaptive radiation of new species in Hawaii was dependent upon isolation. Many islands, each with many valleys, peaks, and lava flows, made it possible for the descendants of these early arrivals to embark on new evolutionary pathways. Climate and topography played major roles in the development of a variety of unique ecosystems.

Birds, insects, and other invertebrates arrived, began an adaptive radiation of their own, and become important components of the native Hawaiian biota. Mammals, reptiles, amphibians, and fresh-water fish, all poorly adapted to cross the wide ocean barrier, were represented by only a few species.

Over time, the descendants of new colonizing species changed in many ways; examples are flightlessness in many insects and birds, arborescence in plants, loss of competitiveness, altered feeding and pollination relationships, and behavioral and morphological changes. The natural environment in Hawaii before the arrival of man was truly unique. Due to the islands' remoteness, an ecosystem has developed by natural selection and adaptation with a surprisingly small diversity of species, poorly equipped to compete with foreign introduction of both plants and people. Hawaii is attempting to preserve this unique ecosystem in conservation areas as shown in Figure 20-3.

The islands are mantled today by communities of plants and animals that are still adjusting to the stresses of recent immigrations and to changes in land and water use. The remnants of the Hawaiian ecosystem of 200 years ago exist only in enclaves where man's resource utilization has disturbed them least.

Surface Flows

The availability of surface water in any area within the Region depends primarily upon the amount of rain that falls upon the area and upon soil characteristics and land farms. Where rainfall is plentiful and well distributed during the year, as in the mountainous areas of each of the major islands, streams are usually perennial and abundant. Where rainfall is light, especially in the southwestern end of each of the major islands and on Kahoolawe, Lanai, and Niihau, streams are ephemeral, flowing only during infrequent periods of extremely heavy storm rains.

The availability of surface water in any area is also influenced by the geology of the area. There is little streamflow in some areas of abundant rainfall because the rain falls upon highly permeable rocks. Most of the rain sinks rapidly into the ground to either reappear eventually at lower elevations as springs draining dike-held bodies or perched water bodies, or become part of the basal water body that underlies each island. Springs, either from perched water bodies or from the basal water body, maintain streamflow in some areas of lesser rainfall. Some

streams are perennial throughout their length while others are perennial in their upper reaches but ephemeral in their lower reaches because their streambeds are extremely porous. The effect of geology is apparent when the characteristics of streamflow are analyzed. Streams fed by ground water (springs or seeps) usually have sustained flows during the drier seasons of each year; others often go dry. Perennial stream discharges into the ocean occur in sections of each of the major islands as indicated below:

Hawaii:	Hamakua Coast North Kohala Coast
Maui:	Palikea to Wailua Makapipi to Huelo Waihee to Honokohau
Molokai:	Waialua to Waikolu
Oahu:	Waikele to Halawa, Kalihi to Palolo Waimanalo to Punaluu, Anahulu and Kiikii
Kauai:	All parts except the sector west of Waimea Conyon

The duration of surface flow depends primarily upon the duration and amount of rainfall during any particular period of time. This is so because the streams are short and steep. Except for the portion of flow derived from ground water, and in a few places, from outflow from swampy terrain, streamflow responds directly to rainfall. In most cases, there is little lag time between rainfall and runoff. Temporal variations of surface water, therefore, correspond closely to variations in rainfall. This relationship is somewhat moderated by several watershed factors.

Ground Water

Most of the rain falls on volcanic terrain in mountainous areas. The highest rainfall occurs along the lower windward slopes of the very high mountains on the islands of Hawaii and Maui and at or near the summits of the lower mountains of Kauai, Oahu, and West Maui. A part of the rainfall infiltrates and provides recharge to underlying ground-water bodies. The quantity of recharge to ground water is dependent on the availability of rainfall and the ability of the surface rocks to absorb the rainfall. Except for areas where sugarcane is heavily irrigated, the areas of greatest recharge to ground water generally coincide with the areas of greatest rainfall.

The ability of surface rocks to absorb the rainfall for deep infiltration is generally correlative with their water-bearing property. The pervious nature of surface volcanic rocks is commonly reduced considerably by deep weathering. Hence, the surface rocks of younger islands, such as Hawaii, are generally more pervious than those of older islands, such as Kauai, even though the rock types and their modes of eruption may be similar.

Ground water occurs as basal water, as dike-impounded water, and as perched water. Ground water in dike-free rocks outside the eruptive zones occurs as basal water, the fresher part of which forms a lens-shaped body floating on saline ground water, whose salinity approaches that of seawater. Where permeable rocks are overlain by caprock material in coastal plain areas, basal water bodies occur under artesian conditions and are commonly several hundred feet thick. Where caprock material is absent, basal water bodies are thin, are generally brackish near the coast, and occur under free water table conditions. Basal water bodies provide most of the ground water developed in the Hawaiian Islands.

Dike-impounded ground-water bodies occur mostly in dike-intruded lava flows and occasionally in other rock types within the eruptive zones. Occurrence of these bodies in calcareous sediments is not known in the Hawaiian Islands. Because they occur and are easily developed at the higher altitudes, they provide important sources for gravity-flow domestic and irrigation water systems. The natural discharge from dike-impounded water bodies provides the base flow of many of the larger perennial streams.

Ground water bodies perched above dike impounded and basal water bodies are common in the region. Most, however, are small and quickly drained after rains. The perching members are weathered ash, weathered lava surfaces, soil, or any poorly permeable horizon interbedded in lava flows, cinders, calcareous sediments, or other permeable rocks. Many perched water bodies have been developed by tunneling and provide important sources of water, especially at high altitudes in isolated places. Principal ground-water resource areas are shown on Figure 20-4.

Water Withdrawals - Consumption

The NF estimate for 1975 fresh-water withdrawals for the Hawaii Region was 1,879 mgd (Figure 20-5). Over three-fourths of the withdrawals were used for irrigated agriculture; the remainder was used for domestic, manufacturing and commercial purposes. The projected decline of about 28 percent in total withdrawals between 1975 and the year 2000 directly correlates with the estimated decrease in agricultural withdrawals (Figure 20-5).

Total consumption estimates derived by the NF (Figure 20-5) are relatively constant over the next 25 years. However, consumptive use of water withdrawals will increase from about 32 percent in 1975 to about 49 percent in 2000. Significant increases in consumption are projected in the manufacturing and domestic categories, increasing about 51 and 43 percent, respectively, by the year 2000.

Instream Uses

Instream uses in the region include recreation, fish and wildlife, esthetic enjoyment, and some hydroelectric power production. The Wailua River on Kauai is the only navigable stream in the State; therefore, navigation does not consitute a major instream use. The total amount of surface water used in hydroelectric power production was 74,480 million gallons in 1975 (Hawaii, 25,580; Maui, 17,100; Kauai 31,800).

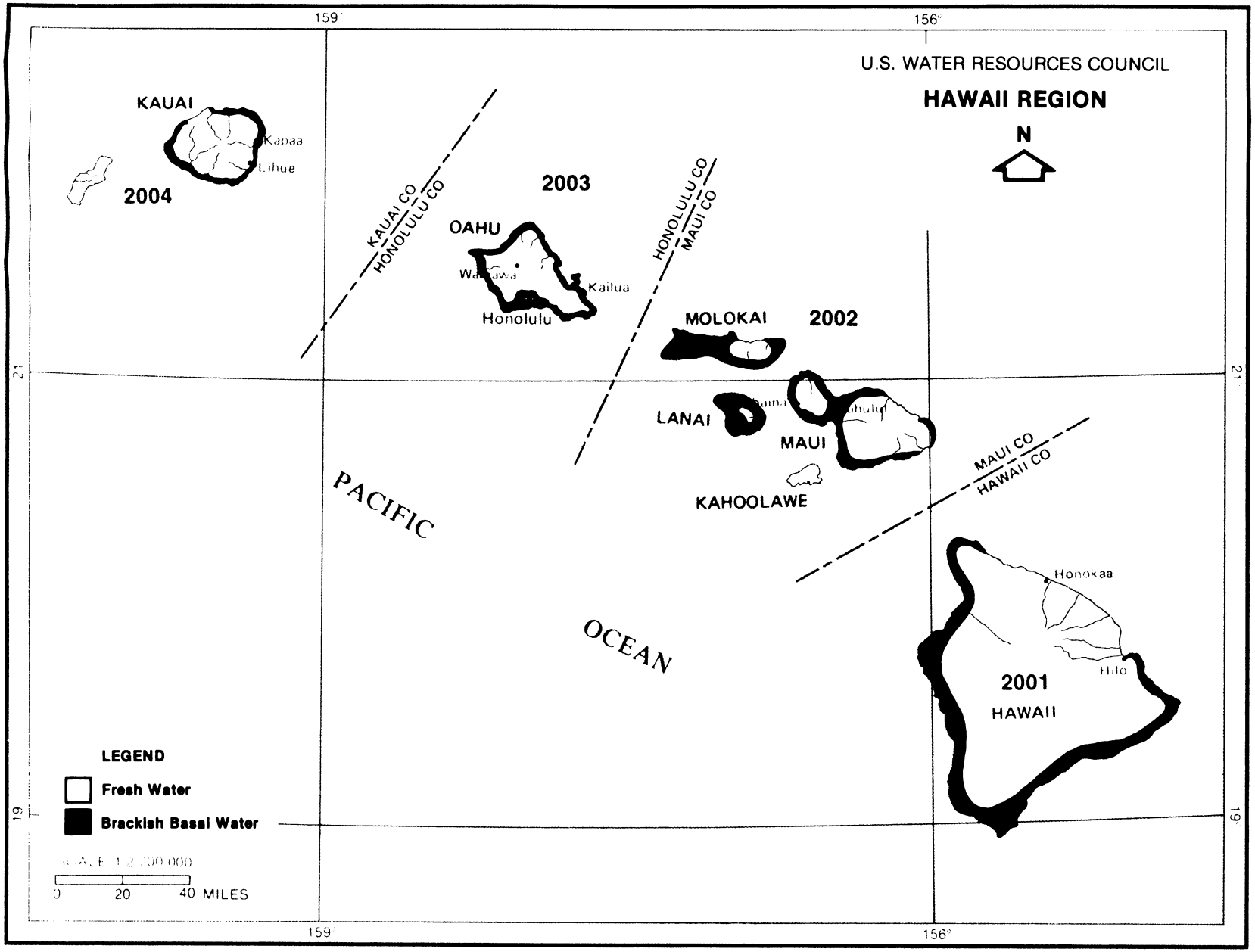
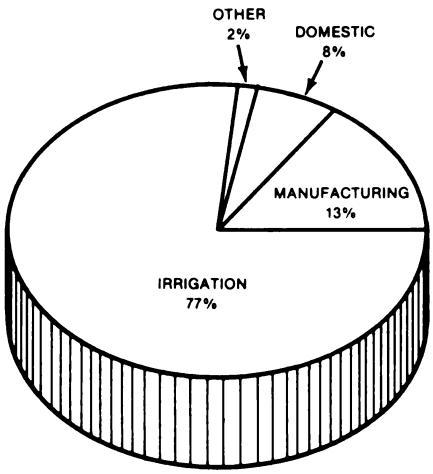
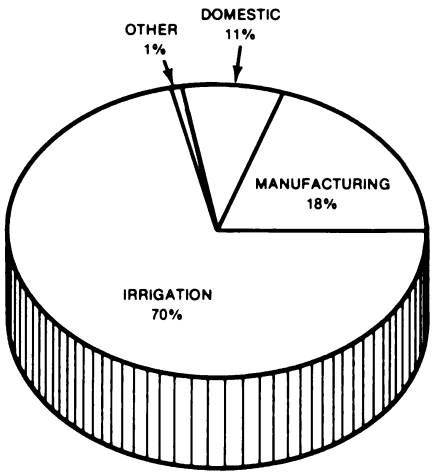


Figure 20-4. Major Aquifers

ANNUAL FRESHWATER WITHDRAWALS

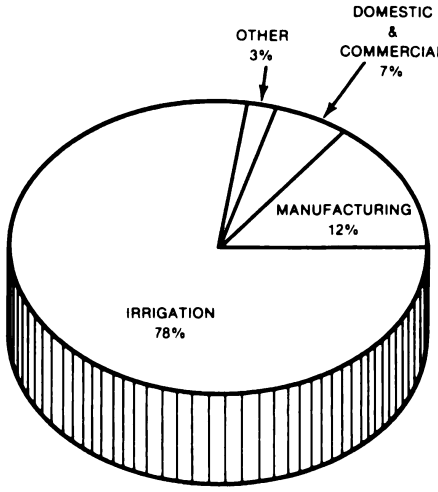


1975
Total Withdrawals — 1,879 MGD

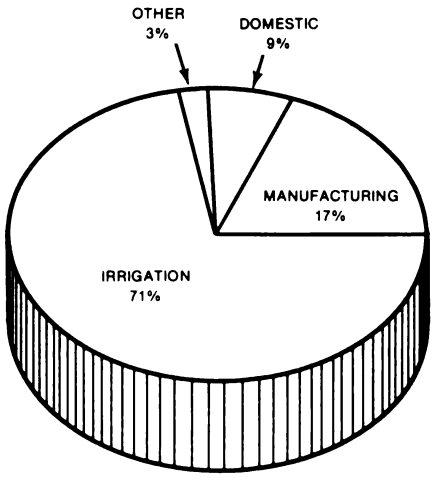


2000
Total Withdrawals — 1,349 MGD

ANNUAL FRESHWATER CONSUMPTION



1975
Total Consumption — 605 MGD



2000
Total Consumption — 666 MGD

Figure 20-5. Withdrawals and Consumption

There are about 400 perennial and intermittent streams in the State. The major threat to the integrity of stream and reservoir ecosystems involves conflicting offstream demands for water. Approximately half of the fresh water used in Hawaii is diverted from streamflow. Agricultural irrigation which consumes about three-fourths of total fresh-water withdrawals is the major water use. More and more streams are tapped each year and the water diverted many miles for use in drier areas. Periodic serious drought compounds the problem, resulting in reservoir drawdown and cessation of streamflow. The migration of larvae in streams may be stopped completely and spawning habitat eliminated. Water level changes in reservoirs may also affect spawning, or, in more serious cases, result in massive fish kills due to oxygen depletion. The National Future total of instream flow approximation for fish and wildlife is 4,590 mgd, about 68 percent of average annual outflow.

No streams or reservoirs are assured protection from the affects of conflicting water resources use. Increasing demands for diverse water functions and use will engender increasing conflicts. A system of priorities will be needed to resolve these conflicts.

Water Supply and Demand

Critical in water resources planning is the balancing of the utilization, conservation, development, and control of available water and related land resources to meet identifiable and projected needs on a timely basis. Comprehensive, multiobjective water resources planning through multidisiciplinary coordination can produce alternatives that would serve as the basis for decisions, possible legislation, programs, and priorities designed to cope with any anticipated shortages before they become critical.

It is evident that Hawaii's total water resources are greater than identifiable needs and demands for the next quarter century. But broad views and determination of statistical averages can mask possible deficiencies and needs which might develop in smaller areas. This has been shown to be the case for the Hawaii Region and its separate island subregions. Therefore, the analysis of the demand-supply relationship was carried out for smaller areas--the established hydrologic areas comprising the island subregions.

Estimates of future water requirements are limited to what might be called primary requirements. These are for: (1) municipal supplies, those serving identifiable communities and providing water for domestic, commercial, and some industrial use; (2) industrial water supplies, those owned and operated by industry; and (3) agricultural water supplies, those serving private and public agricultural lands.

The water supply analysis is based on a series of assumptions. The broadest of these is that there will be a continued upward trend in employment and production within the region and that government policies and programs will be consistent with this assumption to the extent that

development of water supplies will continue to be implemented and encouraged. The NF estimate of future self-supplied industrial water needs is based upon the forecasts developed by the Office of Business Research and Analysis of the U.S. Bureau of Domestic Commerce. An important assumption underlying the forecasts is that the objectives of the 1972 Water Pollution Control Act Amendments will be met, indicating that by the year 2000 there will be no discharge of polluted effluents in the waters of the region. This will require steadily increasing recirculation rates by the large water users and the discharge of all waste water into the public sewer system by the small water users. Another important assumption in underlying NF is that cooling water would be recycled through the use of cooling lagoons or cooling towers, and that plants using brackish water for once-through cooling would switch to closed systems using fresh water. These key assumptions would have the effect of reducing total industrial water use in the region despite regional projections increasing industrial production in the future.

The future use of water to irrigate crops in Hawaii is of paramount importance in making projections for diverse purposes and uses because water needed for crop irrigation far exceeds that for any other use. But to determine the future water needs for irrigation is difficult because, at this time, there does not appear to be a reasonable method for projecting the rate of growth of agriculture or when any expansion or decline might occur. Problems relating to the economics of irrigation, the current flux in water rights, and the scarcity of developable sources of supply, all contribute to the uncertainty in predicting future water needs for irrigation. Also, in evaluating the needs for irrigation, it is not known whether replacements or mitigation measures will be sought for productive agricultural lands being taken for nonagricultural purposes, such as urban growth, industrial parks, or highway construction.

The uncertainty relating to requirements for irrigation water directly affects the future economic position of the sugar industry. Sugar continues to maintain its stature as the biggest export commodity. Current industry programs, such as consolidation of plantations, new irrigation methods, new harvesting techniques, and an improved cane-cleaning process at the mills indicate a stable outlook in the years ahead. The loss of marginal plantations and the consequent reduction in sugarcane acreage from 239,000 acres in 1970 to 221,400 acres in 1975 will be offset by planned expansion of cultivated areas amounting to more than 14,000 new acres by 1980. The increasing application of new irrigation methods will not only bring about a savings in water consumption, but also, an increase in yield. This savings in water consumption is expected to bring about the cultivation of additional lands, where feasible. The current level of irrigation water use may not be the optimum for several reasons. Irrigation in the islands is generally considered as supplemental and designed to provide moisture for plants during periods of rainfall deficiency. The estimation of what might be considered an adequate supply of irrigation water is imprecise because of the fluctuating nature of rainfall in the islands. In certain hydrologic areas the lack of sufficiently large storage reservoirs

to handle the large, long-period flow volumes, coupled with the chance occurrence of a series of dry periods, makes irrigation water shortages almost unavoidable.

Even with population and economic growth and increasing urbanization, agriculture is projected to remain the dominant water user for the foreseeable future. However, competition for use of readily developable supplies is increasing. The regional multiobjective planning perspective is vital to resolving competitive issues. To determine future water supply problem areas, projections of demand were compared with developed and developable water resources. Supply-demand relationships for each island and hydrologic area were developed and future (2000) water requirements compared with the capability of the present source facilities. Prior reports prepared as part of the national assessment provide details of analyses that were made.

As previously stated, on a statewide scale no foreseeable shortages of water are projected. The recoverable supply is nearly three times the aggregate of statewide needs through the year 2000, although it is possible that the existing supply capability may become inadequate before that time. The island-by-island view, however, does show many serious problems. For example, the demand for water on the island of Oahu is projected to exceed currently available annual supplies by 30 percent by the year 2000.

Comparative Analysis

Table 20-4 compares the National Future (NF) and State-Regional Future (SRF) estimates of streamflows and water needs in the Hawaii Region.

The State-Regional Future was extracted from the Hawaii Water Resources Regional Plan, but because the plan did not include 1985 as a time period, totals were not available for that year. The plan projected figures for water withdrawals for the year 2000; these can be compared with the National Future. No projections are available for consumptive water use.

One of the main differences between the NF and the SRF is the determination of population growth. NF projections show lower growth for the region than the SRF, while the study team for the economic analysis of the regional plan, which consisted of State and county planners, predicts a population increase by 57 percent between 1975 and 2000.

What is not shown in the table is the effect of the tourist industry. In 1975 visitors averaged 60,000 per day in the region. In the year 2000 it is estimated that this total will substantially increase. The effect of the tourist industry is demonstrated in the volumetric requirements for domestic water, which accounts for the great differences in the total withdrawals.

A major goal of the region is to encourage more agricultural development. This is reflected in the difference between NF and SRF irrigation withdrawals projected for the year 2000.

Table 20-4.-- Socioeconomic and volumetric data summary: the Hawaii Region

Category	1975		1985		2000	
	NF	SRF	NF	SRF	NF	SRF
SOCIOECONOMIC DATA (1000)						
Total population	787	865	911	1,058	1,085	1,355
Total employment	365	347	431	451	519	599
VOLUMETRIC DATA (mgd)						
-Base conditions-						
Total streamflow	7,352	NE	7,352	NE	7,352	NE
Streamflow at outflow point(s)	6,747	NE	6,716	NE	6,686	NE
Fresh-water withdrawals	1,879	1,516	1,619	NE	1,349	2,129
Agriculture	1,449	948	1,229	NE	954	1,354
Steam electric	0	0	0	NE	0	0
Manufacturing	252	321	181	NE	139	241
Domestic	148	226	172	NE	209	436
Commercial	29	[a]	36	NE	46	[a]
Minerals	1	1	1	NE	1	NE
Public lands	0	0	0	NE	0	0
Fish hatcheries	0	0	0	NE	0	0
Other	0	20	0	NE	0	98
Fresh-water consumption	605	NE	636	NE	666	NE
Agriculture	476	NE	484	NE	476	NE
Steam electric	0	NE	0	NE	0	NE
Manufacturing	74	NE	88	NE	112	NE
Domestic	44	NE	52	NE	63	NE
Commercial	11	NE	12	NE	15	NE
Minerals	0	NE	0	NE	0	NE
Public lands	0	NE	0	NE	0	NE
Fish hatcheries	0	NE	0	NE	0	NE
Other	0	NE	0	NE	0	NE
Ground-water withdrawals	790	882	NE	NE	NE	NE
Evaporation	1	NE	1	NE	1	NE
Instream approximation						
Fish and wildlife	4,590	NE	4,590	NE	4,590	NE

NE - Not estimated.

[a] SRF domestic water use includes commercial and institutional requirements.

Problems

Water Supply

Water is more than an economic resource. It sustains life. It is a natural resource without which there would be no economy. Consequently, it is imperative that all water resources be conserved, developed, and managed sytematically and wisely if the Hawaii Region is to maintain a thriving economy.

Normal rainfall over the Hawaii Region ranges from less than 7 inches in some areas to more than 450 inches annually in others, and there are marked variations, not only in amounts over very short distances, but also in duration and intensity. The volcanic terrain, impervious in some areas and highly porous in others, disposes of the rainfall in a number of specialized ways so that it is impossible to use the yardstick of normal water-soil relationships in measuring ground-water supplies and surface runoff.

In general, Hawaii's water supply problems are due to inequalities in the distribution of the rainfall. There are wide fluctuations in daily, monthly, seasonal, and annual amounts; inequality in the distribution of these amounts over windward and leeward areas, and considerable loss of water through immediate runoff where the terrain gradient is steep and the surface of the ground impervious. The major overall problem is to supply water of adequate quality when needed and where needed, for municipal, industrial, agricultural, and other uses. Effective planning and management are needed to resolve the problem.

The SRF estimated total fresh-water withdrawals in 1975 at about 1.5 billion gallons per day, and the NF estimated withdrawals at 1.9 bgd.

Surface water diverted from streams represents the major source of water in Hawaii. The extensive ditch systems constructed in the region collect stream water to serve various needs, especially those of sugarcane production. They are designed to cover more than the normal or dry weather flows. Existing reservoir capacities are utilized, but large quantities of potential usable stream water are lost to the sea. Hawaii's topography and geology are generally unfavorable to the construction of large impounding reservoirs for storage of surplus streamflow.

Highly permeable soils and rocks permit much of the rainfall to infiltrate to ground-water supply. Basal sources of ground water are lenses of fresh water floating on intruded sea water; the quality of the water in these lenses is very high and must be protected from contamination. Tidal fluctuation in shoreline areas causes deterioration of the lens and the water in these areas is brackish. The fresh water-salt water balance in the lens is sensitive and the withdrawal of fresh water must be carefully managed to prevent deterioration in quality by salt water intrusion.

Water sources have been extensively developed in Hawaii. The changing economy, especially that of resort complex developments and diversified agriculture, is increasing the demand for water in "dry areas." There is greater competition at the present time for undeveloped or partially-developed water sources, and this is gradually imposing additional problems relating to further exploitation of water resources.

Pumping from ground-water supplies is currently within safe yield limits. A critical problem of overdraft could occur in some aquifers. This could occur in the Pearl Harbor aquifer on the island of Oahu if additional water development facilities are constructed without compensating conservation measures. It is expected that the water users on Oahu will provide adequate voluntary controls to prevent overdraft in the Pearl Harbor aquifer. However, the State Department of Land and Natural Resources is ready to impose regulatory measures through the ground-water use act, should voluntary controls fail.

One or more water-deficient problem areas with the potential for more productive development exists on all the major islands. Construction of water development facilites is underway for most of these areas contingent on available funds from various levels of government.

To effect the sound long-range planning necessary to protect the region's water resources and to provide for their maximum beneficial development and use, the State is participating in a cooperative program for the collection of basic hydrologic data with the U.S. Geological Survey. In addition to the data program, detailed hydrologic studies of water resources are being undertaken to determine the availability of additional supplies of water on Oahu. Similar detailed studies will be undertaken in other areas as the need arises.

Increasing water resources through control of waste and other conservation measures is an essential part of water resources and related land planning. Such measures include: prevention of waste of ground water, sealing of leaking artesian wells, sealing springs, construction of ground-water recharge installations, increasing irrigation efficiency and waste-water management, improvement of land treatment measures in watersheds, and the implementation of nonstructural as well as structural measures for flood control.

According to the SRF, all islands have sufficient water supply to meet the demand for the 1975-2000 period, except the island of Oahu, whose demand will begin to tax the total supply of fresh water by the year 2000. This projection is based upon the assumption that the estimate of availble ground water is correct. However, there are two important reasons for caution. First, estimates of natural infiltration, from irrigation and reservoir storage, and the percentage of infiltrated water that can be intercepted before flowing underground to the ocean, cannot be measured directly. By necessity, they are based on a limited number of historical observations. As a result, these estimates may be too high or too low. Second, it is not known how much of the assumed historical ground-water supply has been obtained by excessive reduction of the volume of the basal lens, a process

which cannot continue indefinitely without affecting the quality of water because of salt-water intrusion.

It can be costly, both economically and environmentally, to develop less accessible water sources or to introduce a technology, such as desalination of brackish and/or sea water. Environmental costs may accrue when streamflows are diverted so as to disrupt the natural habitat for certain fresh-water species or when pumping of ground water is excessive thereby increasing the probability of salt-water intrusion.

In examining the economic implications of the need to increase Oahu's fresh-water supply, a number of basic parameters are considered, such as population growth, rate of consumption, estimated yield of ground-water resources, and the introduction of new technologies. Some of the many recommended actions being addressed to offset the water supply problems on the island of Oahu in the year 2000 are as follows: (1) implementation of water conservation policies and use of devices to prevent the escalation in per capita demand; (2) implementation of an exchange of potable quality water, presently used for irrigation purposes, for treated waste water to increase the available supply; (3) efficient development of ground-water which includes improving well spacing in order to increase the yield without increasing salinity; (4) blending fresh water with brackish water; and (5) extending the supply of potable quality water through the introduction of new technologies, which includes converting brackish or sea water to potable water.

The water supply problem on Oahu is well known and is being addressed by the following responsible agencies: the Hawaii Department of Land and Natural Resources (Division of Water and Land Development), the Honolulu Board of Water Supply, the Federal military units, and private entities who are developing water for specific purposes. The Hawaii Department of Land and Natural Resources has the overall reponsibility for water resources in the State and has the legal responsibility to impose controls to handle the situation.

Water Quality

The foregoing discussion regarding the exchange of high quality water for low quality water to bring about the efficient distribution of water from various uses exemplifies the need for a water policy affecting both quantity and quality requirements on an integrated basis. As long as there is an abundant supply of high quality water for all uses there is little need to worry about the quality of requirements. However, when the supply of high quality water becomes deficient, the emphasis then turns to the quality aspects. The recent Federal legislation regarding water pollution and drinking water quality mandates that drinking water be of the highest quality and that the systems selling water to the public must deliver water that is free from pathogenic organisms, toxic material, and other substances that could be harmful to the consumer. The water pollution law concerns itself mainly with waters in the rivers, lakes and shoreline and provides a time schedule by which these waters should be suitable for wildlife habitat and for the recreational activities of fishing and swimming.

The Safe Drinking Water Act brings water systems under State surveillance and requires water suppliers to conduct extensive water sampling and monitoring programs to assure the consumers that the water being supplied meets standards established by EPA. There are approximately 143 water systems in Hawaii supplying 25 people or more that are subject to the Safe Drinking Water Act of 1975. Of these systems, 56 are government operated and 87 are privately owned. Many of the systems rely on surface water supplies which often have undesirable taste, odor, and turbidity, especially following heavy rains. In order to construct the treatment facilities needed to improve the water quality to meet drinking water standards, the water suppliers are faced with high capital improvement costs which, according to the present Federal law, must be passed on to the consumers. Rather than burden the resident population with these costs, assistance has been requested from both the State and Federal governments. The Federal Government should seriously consider grants to all entities, government and private, for the purpose of constructing facilities and for the monitoring programs required by Federal legislation.

The remainder of the drinking water systems obtain their water from ground-water aquifers. Some of these aquifers are considered to be in potential danger of contamination by cesspools, the injection of waste in deep wells, and by salt-water intrusion. In order alleviate the potential pollution hazards, especially in highly urbanized areas, the countries in the region are embarking on an extensive program for the collection and treatment of municipal waste. Presently, the facilities to treat domestic sewage are designed to include secondary treatment, and the effluents from the treatment plants are discharged through ocean outfalls into currents which will carry them away from the shoreline.

Because of the high cost of sewage treatment facilities, requests have been made to amend the requirements for secondary treatment when the effluent is being disposed in deep ocean outfalls which preclude the return of contaminants to shoreline areas. Primary treatment which removes the undesirable floatable material from sewage should be the only treatment required for these plants. Secondary treatment and tertiary treatment should be reserved for those facilities whose effluent is discharged in streams, lakes, shoreline waters, or injected into coastal aquifers.

It has been proposed that effluents from sewage treatment plants be reused for the irrigation of sugarcane. The use of these effluents for irrigation would make available, on an exchange basis, a large supply of potable quality water for use in drinking water systems. Many problems need to be resolved before all the sugar plantations will agree to the exchange. The problems include undesirable leaf growth caused by nutrients, long-term effects of trace substances present in the effluent, the added cost of transmitting waste water to the cane fields and the cost of disposal facilities needed during wet weather when all of the effluent cannot be used for irrigation.

At a recent hearing on Oahu, one of the sugar companies agreed to use the sewage effluent for irrigation. This is a major step toward effecting an exchange of potable quality water for nonpotable irrigation water.

Floods

Flood damage in Hawaii has been large and extensive, amounting to about $102,690,000 from 1900 to 1970. Substantial sums have been spent to provide flood protection in many areas, but damages continue to rise and other areas are still vulnerable. The toll in human lives and damages is by far the greatest from tsunami inundation. Since 1819, 352 lives have been lost due to tsunamis; a total of 234 lives were lost during the April 1946 and May 1960 tsunamis alone. Damages from these two tsunamis were in excess of $55 million. High surf has caused much damage to the exposed northerly sections of each island. Damages have been heaviest on Oahu because of extensive development in the area along the shore. As the neighboring islands develop and population increases, they may face the same risk in damages unless strict land use controls are imposed in areas subjected to high surf and tsunami inundation.

The Flood Disaster Protection Act of 1973 (Public Law 92-234) requires the purchase of flood insurance as a condition of receiving any form of Federal or federally related financial assistance. For communities that do not participate in the flood-plain management program no Federal financial assistance will be provided for acquisition or construction of structures located on flood plains, and federally subsidized flood insurance will be denied to those communities. All of the counties in Hawaii elected to participate in this program. Land-use and control measures, designed to guide the rational use of the flood plains, have been applied in conformance with the requirements of the flood insurance agency.

Weather

Despite its relative infrequency, severe weather is a part of Hawaii's climate. Hawaii's most common form of severe weather is rain, intense enough to cause urban and flash flooding, erosion and sedimentation, crop and property damage, and even to endanger life. Other severe weather effects include high waves and strong winds that cause extensive damage.

While the fact is often overlooked, the Hawaiian islands lie across the path of tropical storms and hurricanes moving through the central Pacific. These are more numerous than had been suspected before the era of weather satellites. While most of them have either bypassed Hawaii (or merely struck glancing blows), it is possible that the islands may be hit broadside by the powerful winds, torrential rains, and high waves of one of these storms. The protection of life and property may not be receiving sufficient consideraion in the utilization of areas vulnerable to severe weather. Deficiencies exist in both long-range planning and in the issuance and use of weather warnings.

There are several reasons why only limited reliance can be placed upon severe weather warnings for the safeguarding of life and property in

vulnerable areas. First, the information on the approach and occurrence of severe weather is frequently inadequate. Sophisticated weather radars in use elsewhere for detecting, tracking, and estimating the intensity of severe weather systems like those which cause flash floods have not been made available in Hawaii. Conventional weather reports (rainfall occurrence and intensity) like those available over land areas are lacking from the ocean surrounding Hawaii. Real time weather reports even from the islands themselves are limited in number and frequency.

Second, severe weather is often highly localized. For example, damaging flash floods may affect only one or two small areas while places only a short distance away are unaffected.

Third, the time lag between heavy rain and subsequent flooding may be 30 minutes or less. This period is much too short for weather warnings to be issued and acted upon. Efforts to predict flash floods without risking too many false alarms have not been very successful.

Efforts to meet these problems include satellite observations to determine the location and movement of potentially hazardous weather systems in the vicinity of the islands; telemetered rain gages and volunteer observers to report the threat or occurrence of heavy rain and other severe weather; and cooperative programs with Civil Defense for posting beaches and access roads during periods of high waves.

The most important need regarding severe weather in Hawaii is to acknowledge that it occurs; to learn as much as possible about its frequency, geographical distribution, and effects; and to take these effects into account in water and land resources planning. The severe weather forecasting system should be supported and its effectiveness increased. The safe and appropriate utilization of coastal zones, flood plains, and other areas vulnerable to severe weather depends upon the existence and effectiveness of an adequate severe weather warning system.

Tsunamis

Tsunamis, or tidal waves, pose a threat of flooding and other damage to many of Hawaii's coasts. To meet that threat, several effective measures have been taken. Maps delineating tsunami inundation areas are conspicuously featured in the telephone directory. However, there have been disagreements among the experts about the inundation areas in the concerted effort that is being made on this matter. A Pacific-wide network of seismic and tide stations provides real-time data for determining whether a tsunami hazardous to the islands has been generated. State and county civil defense agencies utilize sirens and an emergency broadcasting system (EBS) to warn threatened areas.

The greatest remaining threat to the State is from tsunamis generated locally, in the Hawaiian area itself. The high speed at which these waves travel, coupled with the short distances involved, permit warning times of only a minute or two for coasts nearest the generating area to about

30 minutes for the more distant parts of the State. To cope with this, Civil Defense is installing a number of ground-motion warning devices throughout the State and instructing the populace to head for higher ground without delay whenever a strong earthquake is felt.

Environment

As a multiple-island State, the shorelines of each of the islands, the offshore waters, and the inshore waters are of major importance and concern from the standpoint of habitat protection, food supply, and recreation. The following discussion will highlight some of the State environmental concerns.

The waters from 3 to 200 miles offshore fall outside the boundaries of any one subregion and are primarily a regional concern. In fact, offshore resource management problems in Hawaii are a national and international concern, and the State will only play a part in future programs. The National Marine Fisheries Sevice of the U.S. Department of Commerce is currently preparing a National Fisheries Plan that will have major impact on the future of Hawaii's offshore fisheries resources. The State Division of Fish and Game has played a role in the development of the plan and will be involved in its ultimate implementation on a cooperative State-Federal basis. Management of offshore waters for nonfisheries resources is complicated by unresolved jurisdictional questions. Undoubtedly these resources, such as the manganese and gem coral deposits on the ocean floor, will be developed and the development, transportation, and processing may have adverse effects on marine habitat.

The future of Hawaii's marine resources is tied to maintenance of habitat quality. Pollution represents one of the most significant concerns. The effects of offshore dumping of oil on fish and wildlife resources are poorly documented. Hawaii has never had a major oil spill, but the potential is real, and contingency plans are presently inadequate to protect fisheries and marine bird resources.

The interface between shoreline and sea in Hawaii is not easily categorized. The inshore habitat reflects the islands' volcanic origins. Rocky materials characterize nearly two-thirds of the State's more than 1,000 miles of tidal shoreline. The wide variation in geologic age of the islands of the chain is also illustrated by differences in inshore topography. Extensive coral reef development around the older islands provides important habitat for inshore species. The location and extent of reef structure, in turn, plays an influential role in sandy beach development. Estuarine development, as well, may vary from the sharp fresh-salt interface of sea cliffs and shorelines to the expansive and shallow brackish water drainage basins, such as Pearl Harbor on Oahu.

The formation of a wide variety of inshore habitat types has serious implications for fish and wildlife management. Opportunities for commercial exploitation, as well as recreational and educational use, of inshore fish and wildlife resources are equally diverse. But the resources are clearly

finite, and in many cases, diminishing under growing demand. Inshore areas have been seriously abused in the spread of urbanization, despite the fact that herein lies one of Hawaii's greatest natural resources. The extent of dependency upon the inshore environment is difficult to determine, but it surely becomes economically and socially significant in consideration of the future of tourism, recreational opportunity, and commercial fishing. Even harder to define is the integral role that unaltered natural inshore environment plays in the maintenance of the quality of life in Hawaii. It seems reasonable to expect that fish and wildlife management problems within the inshore areas will increase at a greater rate than the rapidly growing regional population.

The effect of man on the inshore environment has been severe and, in places, irreversible. Only the more remote or inaccessible areas are relatively unaltered. Fish and wildlife managment programs should be designed to identify those habitats that are important to the environment, to restore those habitats that are in poor condition, and to insure that further destructive change will not occur. Habitats worthy of protection are those whose benefits are balanced between the environmental and economic needs of the region. Following is a discussion of some of the causes of habitat degradation.

Siltation

While siltation of inshore waters has become an enormous resource problem, the sources of the problem are terrestrial and, to a great extent, man-related. Several major sources have been identified: soil erosion in cultivated fields, subdivison development, highway construction, cane waste-water discharge, and overgrazing by cattle and feral mammals. The most severely affected sites are drainage areas for natural water courses, such as Kaneohe Bay and Pearl Harbor. In other cases siltation is not so localized (the south shore of Molokai, Lanai, and Kahoolawe).

In combination with changing nutrient levels, silt runoff entering the inshore environment is responsible for the destruction of coral reef habitat as well as unsightly and unsafe water pollution. Large areas are rendered "biological deserts," unusable by man and the fisheries resources upon which he depends. It is particularly significant that the areas most affected are often the most critical areas in fisheries and waterbird resources production (estuaries, coral reefs, fish ponds). On a regional level, management goals must be directed at land-use activities. Inadequate controls, insufficient baseline data, competitive demand for land, and lack of foresight have all contributed to this massive problem. Siltation sources must be identified and the effects of sedimentation assessed with the objective of insuring that adequate soil conservation methods are employed. This may involve modification of permitted uses of conservation-zoned land. It should also involve more stringent regulations relating to potentially significant land-use projects, with increased attention directed to the protection of inshore fish and wildlife resources. More rigorous and biologically meaningful State-enforced standards of inshore environmental quality need to be developed. Research on the effects of siltation on

the inshore environment and on possible means of reclaiming affected areas needs to be expanded. Also, information and education programs are needed to publicize the problem and to provide the land user with available soil conservation information.

Sewage Pollution of Inshore Waters

Current methods of sewage disposal are inadequate to meet the demands of increasing population. Release of untreated sewage within the inshore environment continues despite the availability of improved methods. Typically, this has resulted in a shift in aquatic species composition. High nutrient levels stimulate algal infestations, which, in turn, may smother the coral reef habitat. Sedimentation of untreated sewage materials is also serious. Other problems include bacterial contamination of shellfish and increased toxicity levels in other species.

The State has been investigating and implementing alternative methods of disposal often in the absence of adequate environmental baseline information. Two directions in particular seem to hold the most current attention. Deep water outfall, as planned for the windward community of Oahu, is a feasible possibility because of its insular environment. The relative deficiency of nutrients in offshore waters, existing ocean current systems, and steep topographical dropoffs all significantly lessen the detrimental effects of sewage effluents on the habitat.

Deep injection of sewage effluents appears to involve more unanswered, but potentially serious, resource quality questions. Sufficient baseline data and past experience are not available to predict the effects of this technique with any certainty. Inshore salt water, estuarine areas, and shoreline brackish or fresh-water ponds are all potentially susceptible to the short- and long-term effects of injection-well, sewage-effluent disposal systems. Baseline studies for alternative disposal plans should be conducted as early as possible in the planning process. Research needs to be conducted on the effects of sewage effluents on fish and wildlife resources and on the possible uses of sewage effluents to increase productivity in aquaculture projects.

Chemical Pollution

Chemical pollution of inshore water, particularly estuarine areas, is often the result of inefficient transport and disposal methods. While there have been no major oil spills in Hawaii, confined areas with extensive industrial use or continually plagued with the effects of chemical pollution as a result of negligence. Oil from storm drains, shoreline tanks, and refinery pipeline leaks affect aquatic species' composition. Small oil slicks, presumably from bilge pumping activities offshore, continue to pollute the beaches periodically.

Information regarding heavy metal concentrations within inshore waters is limited in Hawaii, but seems to indicate little cause for immediate alarm.

Concentrations appear to be at normal average "background" levels. Within Pearl Harbor, heavy metal levels in fish and crabs near known effluent sources are higher than elsewhere. Mercury concentrations in billfish do not appear related to heavy metal sources in Hawaii.

Extensive pesticide use in Hawaii has raised serious concerns from fish and wildlife biologists in the past. Many of the persistent chlorinated hydrocarbon insecticides have been phased out of use in recent years, although large amounts have been applied prior to the institution of stringent regulations. It was estimated in 1968 that the amount of pesticides used per square mile in Hawaii was over ten times the concentration used on the mainland. Information on the effects of this activity on Hawaiian fish and wildlife is poorly documented, although pesticide use has been implicated in inshore mollusks (oysters), waterfowl, and fish kills. Much of the pesticide used in past years was applied by domestic pest control operators. Chemical misuse continues to this day, with the application of noncleared pesticides, improper calibration of equipment, and disregard of label directions. More stringent regulations and improved enforcement of existing laws are needed to prevent further degradation of inshore habitat by chemical pollutants. This would include expansion of the monitoring program to obtain better baseline and trend data on chemical pollutant levels. Efforts should be made to utilize improved biological survey and indicator species techniques to monitor changes.

Thermal Pollution

Electricity needs in Hawaii are met through powerplants on each populated island. Oahu alone produces about 90 percent of the power utilized in the islands, so problem sites associated with thermal pollution are largely concentrated on that island. Concern has developed over the effects of cooling water effluents on the inshore environment. Limited research investigations at powerplants on Oahu have revealed little significant biological impact, although some shift in species composition has been noted. Localized depression of phytoplankton biomass and productivity and zooplankton biomass have been recorded. Cooling water discharge may increase the standing crop of fishes. The aquatic habitat within Oahu's harbors is stressed by a variety of other effects, some already noted. Thus, it is difficult to relate conditions specifically to thermal effluents.

As an alternative to oil-burning steam generation plants, nuclear powerplants have been suggested for future use in Hawaii. Serious environmental concerns have been raised and need to be answered adequately before such plants are constructed. Research effort should be expanded to monitor the effects of thermal effluents on aquatic life. Aquaculture research programs in Hawaii should investigate the possible use of powerplant thermal effluents to increase fisheries productivity.

Conflicting Land Use

Shoreline development has altered inshore fish and wildlife habitat significantly. Aquaculture projects may compete with water birds for use

of limited shoreline or estuarine areas. Sand mining activities which alter inshore habitat have not been adequately monitored in the past with respect to their effects on fish and wildlife resources. The offshore seabird sanctuaries are threatened by unauthorized trespassing and vandalism. Current regulations, if implemented, could prevent shoreline development projects that would have detrimental impacts on inshore resources. These problems will continue to expand in magnitude unless the condition of fish and wildlife resources receives more attention in consideration of development alternatives and multiple use. Multiple use of inshore habitat (seabird nesting islets, estuaries, coral reef areas) should be encouraged only within the constraints of the overall fish and wildlife management objectives--that is, the maintenance and/or improvement of the conditions of existing fish and wildlife resources. Means should be sought to insure the improvement or replacement of inshore fish and wildldife habitat which is detrimentally affected by development projects.

Endangered Species Protection

The utilization of limited esturaine habitat by endangered waterbirds has attracted considerable attention to the management of these areas in recent years. Both State and Federal legislation protect the individual species.

Available wetland habitat in the State is a fraction of its former abundance. Industrial development, housing, and resort construction have depleted much of the original estuarine habitat. The 1973 Federal Endangered Species Act includes several provisons for habitat protection, but the implications of this legislation are not fully clear.

On the Federal endangered species list, Hawaii has the dubious distinction of leading all the other states by a wide margin--58 percent of the birds listed for whole United States are from Hawaii. A recent tentative list of endangered terrestrial arthropods in Hawaii numbers over 350. And of the 1,400 species,subspecies, and varieties of native higher plants listed as endangered, 639 (45.6 percent) are from Hawaii.

Nearly all efforts in the preservation of endangered species in Hawaii have been directed towards the birdlife, although the protection of habitat is critical to the perpetuation of all native plants and animals. The problem has been attacked on four levels: (a) determination of the status and distribution of endangered species; (b) investigation of the factors which have resulted in the endangered status of these species; (c) captive propagation and replenishment of wild populations; and (d) habitat protection. The program has been hampered by inadequate funding, conflicting management objectives, and limited regulatory authority.

There is a need to selectively review habitats for endangered species. The importance of the species may not always warrant the strict protection now being proposed when weighed against the benefits of the needs.

Summary

In this section is a map and matrix (Figures 20-6a and 20-6b) and a summary table of the problems and the agencies addressing the problems (Table 20-5). The region has concluded that there are no problems in the Hawaii Region that are not being addressed or do not have an agency designated as responsible for addressing the problem.

No geographic problem areas were identified by the Hawaii Department of Land and Natural Resources. The problem matrix shows water quantity, water quality, related land, and other issues as tabulated by Federal representatives for the entire subregions.

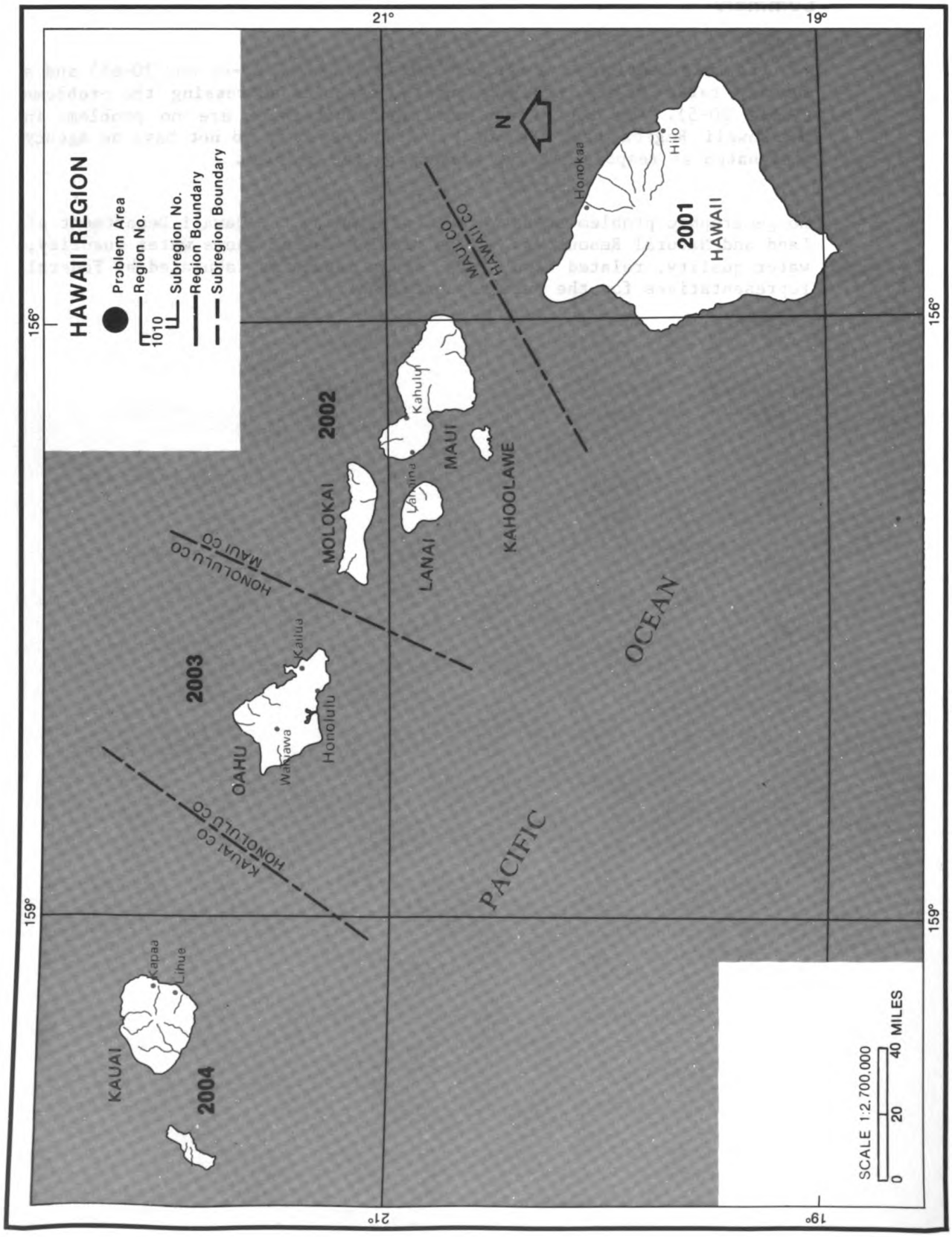


Figure 20-6a. Problem Map (No problem areas identified)

HAWAII REGION (20)

PROBLEM MATRIX

Problem area		Problem issues O= Identified by Federal Agency Representatives X= Identified by State-Regional Representative													
		Water quantity				Water quality				Related lands					
No. on map	Name	Fresh surface	Ground	Marine and estuarine	Surface/depth	Fresh surface	Ground	Marine and estuarine	Surface/depth	Flooding	Drainage	Erosion and sedimentation	Dredge and fill	Water related use conflicts	Other
Subregion 2001	Hawaii County	O				O		O		O		O		O	O
Subregion 2002	Maui County	O				O	O	O		O		O		O	O
Subregion 2003	Honolulu County	O				O	O	O		O		O		O	O
Subregion 2004	Kauai County	O				O		O		O		O		O	O

Figure 20-6b. Problem Matrix

Table 20-5

Problem Summary

Problem	Occurrence	Agency Addressing Problem	Authority
Water Supply			
If present trends continue the total esimated traditional supply sources can only support an increase in demand through the end of this century (2000).	City & County of Honolulu, Oahu	BWS (City & County of Honolulu) DLNR	County Charter Hawaii Revised Statute (HRS) Chapter 176 - Water Resources
Water Quality			
Whenever water policies are being stated, the policy must address both quantity and quality requirements.	regionwide	DPED	HRS Chapter 201 - Department of Planning & Economic Development
Financing of monitoring, laboratories, and treatment facilites in order to meet the drinking water quality standards.	regionwide	EPA DOH BWS/DWS (all counties)	Public Law (PL) 93-52 Drinking Water Act Act 10, Session Laws Hawaii 1977 County Budgets
Floods			
Damages continue to occur from stream, storm wave, and tsunami flooding due to unwise use of Hawaii's flood plains and coastal zone. Completion of floodplain mapping and county implementation of zoning construction, and building ordinances to regulate uses in the flood plain are recommended.	regionwide	HUD CE DPED DLNR DPW (all counties) SCS SGS	PL 93-234, Flood Disaster Protection Act of 1973 PL 86-645, Flood Control of 1960 HRS, Chapter 205A, Coastal Zone Management HRS, Chapter 179, Flood Control and Flood Water Conservation County Zoning, Building and Grading Ordinances PL 83-566 as amended (Mapping) Organic Act of 1879
Improvement in the forecasting of severe weather and tsunamis is necessary to allow adequate time to evacuate people in flood plains.	regionwide	NOAA	15 U.S. Code 311 and 313 Weather Forecasts and Warnings

Problem	Occurrence	Agency Addressing Problem	Authority
Environmental Quality			
Degradation of marine, **estuarine**, and fresh-water **habitat** of the State. Degradation includes siltation, sewage, chemical, and thermal pollution, and conflicting land and water uses.	regionwide	EPA	PL 92-500, Federal Water Pollution Control Act Amendments
		NOAA	PL 92-583, Coastal Zone Management Act of 1972
		DOH	HRS, Chapter 342 Environmental Quality; Public Health Regulations (PHR); Chapter 37 Water Pollution Control; Chapter 37A, Water Quality Standards; Chapter 37B, Conservation Standard
		SCS	PL 83-566, Watershed Protection and Flood Prevention
			PL 74-46, Soil Conservation Act 1935
			PL 87-703, Food & Ag. Act 1962
		SWCD	HRS, Chapter 180, Soil & Water Conservation District
		DPED	HRS, Chapter 205A, Coastal Zone Management
			HRS, Chapter 205, Land Use Commission; HRS, Chapter 183, Forest Reservations Water Development, Zoning DLNR Regulation 4, Land Use Regulations within Conservation Districts.
		DPW	County Ordinances
		CE	PL 92-500, Federal Water Pollution Control Act Amendments of 1972.

ABBREVIATIONS

BWS	County Board of Water Supply
CE	U.S. Corps of Engineers
DLNR	Department of Land and Natural Resources
DOH	Department of Health
DPED	Department of Planning and Economic Development
DPW	County Department of Public Works
DWS	County Department of Water Supply
EPA	U.S. Environmental Protection Agency
HUD	U.S. Department of Housing and Urban Development
NOAA	National Oceanic and Atmospheric Administration
OBERS	Bureau of Economic Analysis and the Economic Research Service
SCS	U.S. Soil Conservation Service
SWCD	Soil and Water Conservation Districts
USGS	U.S. Geological Survey

Conclusions and Recommendations

It has been concluded that there are no severe water and related land-resource problems in the Hawaii Region that are not now being addressed by an agency designated to have the responsibility and authority to solve the problem.

The region recommends that the Federal Government continue to provide grants for the initial cost of constructing facilities and for monitoring the programs required by Federal legislation.

Implementation of study recommendations should be funded in order to alleviate the problems and concerns which continue to resurface with each study that is completed.

Water Supply

Oahu is the only island that is projected to experience a possible imbalance of supply and demand by the year 2000.

The Oahu problem is being addressed by the Hawaii Department of Land and Natural Resources, the Honolulu Board of Water Supply, the Federal military units, and private entities who are developing water for specific purposes. The Hawaii Department of Land and Natural Resources has the overall responsibility of water resources in the State and has legal responsibility to impose controls to handle the situation.

Water Quality

The State Department of Health has accepted the primacy of administering the Safe Drinking Water Act in Hawaii. Rules and regulations have been passed and the water suppliers are mandated to provide their customers with drinking water of the highest quality, free of pathogenic organisms, toxic material, and other substances that could be harmful to the consumer. The required treatment facilities and monitoring programs are increasing the cost of drinking water throughout the State. All capital improvements as well as maintenance costs are being passed on to the consumers in the form of rate increases.

The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) are concerned itself with the quality of water in rivers, lakes, and coastal waters. The State Department of Health has accepted primacy in the administration of this act. Under Section 208 - Areawide Waste Treatment Management Plans, the Department of Health is in the process of reviewing the State water quality standards. The Department is also mandating the control of point source pollution through the installation of waste-water treatment plants. Part of the capital improvement and all of the operation and maintenance costs for treatment and control of facilities are being passed on to the public in the form of sewer charges.

The Federal requirements for water pollution control and safe drinking water are placing a heavy financial burden on the State, the counties, and the public.

It is recommended that the State adopt a water policy which will integrate quality and quantity in the management of its water resources.

Floods

Flood damage in Hawaii has been extensive and costly even though substantial funds have been spent to provide protection.

The Flood Disaster Protection Act of 1973 (Public Law 92-234) required the purchase of flood insurance as a condition of receiving any form of Federal or federally-related financial assistance. All the counties in Hawaii participated in this program and the land-use and control measures designed to guide the rational use of flood plains were being enacted in conformance with the requirements of the flood insurance agency. In June 1977 the Flood Disaster Protection Act was amended by Congress in an effort to make the law workable, and the result was a weakened law that did not require full-scale flood-plain management.

It is recommended that government agencies in Hawaii continue to implement their flood-plain management regulations.

Environment

Major causes of environmental degradation in Hawaii are siltation, sewage, chemical and thermal pollution, and conflicting land use in the shoreline area. Of major importance and concern are habitat protection, food supply, and recreation. Two Federal programs now underway are addressing these concerns. One is the Areawide Waste Treatment Management Plan under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). The objective of this plan is to establish a regulatory program for the control of all point and nonpoint sources of pollutants.

The second is the Coastal Zone Management Plan which is devoted to identifying permissible land and water uses in coastal areas.

It is recommended that fish and wildlife management programs be designed to identify habitats that are important to the environment and to restore those habitats that are in poor condition and to further insure that future destructive changes will not occur. The restoration of other habitats that are in poor condition must be balanced against environmental and economic considerations. It is also recommended that recreation programs be coordinated with the fish and wildlife management programs to complement the objectives of habitat protection.

Further, it is recommended that:

- The best soil conservation practices be applied to control sources of siltation, transport, and depositon of sediment.
- Research be conducted on the effects of siltation on inshore environment and on developing technology to reclaim affected areas.
- Research be conducted on the effects of sewage effluents on fish and wildlife resources and on the possible uses of sewage effluents to increase productivity in aquaculture projects.
- More stringent regulations be imposed to prevent the degradation of inshore habitat by chemical pollutants.
- A monitoring program be established to obtain better base line and trend data on all pollutant levels.
- Research be undertaken to determine the effects of thermal effluents on aquatic life.
- Inshore fish and wildlife habitats which have been detrimentally affected be improved or replaced.
- Multiple use of inshore habitats be encouraged within the constraints of overall fish and wildlife management objectives.

Endangered Species

Fifty-seven percent of the birds and 46 percent of the species, subspecies, and varieties of native higher plants cataloged on the Federal endangered species list are from Hawaii. The Hawaii Department of Land and Natural Resources is addressing the problem through the conservation-district management plan, which will enable better administration of the habitat areas located in conservation land-use districts.

It is recommended that research be conducted on the ecological requirements critical to the survival of endangered species.

Also refuge areas should be developed to assure the survival of the birds and plants on the Federal endangered species list.

Water Developments vs. Fresh-water Habitat

Fresh-water habitats are threatened by stream diversions, flood-plain development, and filling of wetlands. The proposed new water quality standards for the region address the stream diversion problem, while the Coastal Zone Management Plan addresses the legal and institutional control mechanism in flood-plain management and filling of wetlands.

Planning Studies

Hawaii Water Resources Regional Plan

The Hawaii Region completed a Level B Study in 1978. The Study has identified water and related land-resource needs and problems, proposed alternative solutions, and developed a schedule for implementation of recommended actions. The Hawaii Level B report will be submitted to the Governor, the legislature, the President, and the Congress. It will serve as a general guide to aid decisionmakers in the evaluation, choice, and implementation of water resource project proposals within the State of Hawaii.

Because the Hawaii Region had a Level B Study underway at the time of the Second National Water Assessment, the regional sponsor for the assessment has concluded that severe water and related land-resource problems have already been identified and are being addressed by agencies having the responsibility and authority for the recommended programs and actions needed toward resolution of the problems.

The results of the Hawaii Level B Study and this assessment serve as a guide to the designated agencies in carrying out their reponsibilities.

Coastal Zone Management Plan

The State of Hawaii is in the last year of a three-year planning effort to develop a coastal zone management program under the provisions of the National Coastal Zone Management Act of 1972. The Act declares that it is a national policy to preserve, protect, develop, and restore the resources of the coastal zone. The State management program will include:

-- an identification of boundaries of the coastal zone subject to the management program.

-- a definition of what shall constitute permissible land and water uses within the coastal zone which have a direct and significant impact on the coastal waters.

-- an inventory and designation of areas of particular concern within the coastal zone.

-- an identification of the means by which the State proposes to exert control over the land and water uses, including a listing of relevant constitutional provisions, legislative enactments, regulations, and judicial decisions.

-- broad guidelines on priority of uses in particular areas, including specifically those uses of lowest priority.

-- a description of the organizational structure proposed to implement the management program, including the responsibilities and inter-

relationships of local, areawide, State, and regional agencies in the management process.

Areawide Waste Treatment Management Plan

The State Department of Health is in the process of developing an areawide waste treatment management plan under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). The Federal Water Pollution Control Act has concerned itself with the control of point sources of pollutants. Attention is now directed to the identification and control of nonpoint sources of pollutants. The ultimate objective of the 208 planning process is to establish a regulatory program for the control of all point and nonpoint sources of pollutants.

Environmental Protection Agency guidelines for areawide waste treatment management planning state:

> The land use aspects of 208 planning provide a direct linkage with other areawide planning efforts within the area including those supported under the HUD 701, water and sewer, and flood insurance and disaster programs, DOT transportation plans and NOAA coastal zone management plans. 208 planning should be viewed as providing the water quality component of the comprehensive plans for the area.

Since the State is in the process of developing a State plan (208) and a coastal zone management plan, water quality objectives can be addressed in the context of the overall State and county goals, objectives, and policies that will be developed and articulated as part of this planning process. A major portion of the work program of Hawaii's Coastal Zone Management planning program is devoted to identifying the permissible land and water uses which have a direct and significant impact on coastal waters, and analyzing existing legal and institutional control mechanisms. Therefore, the major remaining items that will require action through the 208 process are the control of nonpoint sources of pollution, control of underground injection wells, stormwater management, and the financing of these and other control mechanisms.

Comprehensive Water Resources Planning

The U.S. Army Corps of Engineers conducts comprehensive water resources planning by specific authority of Congress. The Corps' authorized studies in Hawaii are:

1. The Kaneohe Bay Urban Water Resources Study which has been completed and is undergoing final review at the Washington level.

2. The Hilo Area Comprehensive Study which is scheduled to be completed in 1982.

3. The Kailua-Kona Comprehensive Study for which funds have not been appropriated.

The comprehensive studies examine the water resource problems of a geographic area and seek implementable solutions of two kinds. The first are measures or projects which the Corps has authority to implement. These include: navigation, flood control, and shoreline protection. The second are measures in which the Corps by doing planning studies may assist local government in implementing.

Urban Studies

The Army Corps of Engineers was authorized to conduct the Kaneohe Bay Urban Water Resources Study under its Urban Studies Program. The objective of the program is to work with local and State governments to develop realistic plans which can help solve water and land related problems in a given region. The study will provide a range of urban water resource plans that are compatible with comprehensive urban development goals of the Kanoehe Bay Region.

Data

A good basic data program must incude data collection, storage, retrieval, dissemination, and means for anticipating probable future needs.

Hawaii's data program has two general gaps. First, in some cases there is a lack of raw data. Second, raw data where available are often not as valuable as should be because the storage, retrieval, dissemination, and analysis program is lacking or inadequate.

While either lack of data or lack of a good storage, retrieval, dissemination and analysis program is evident to some degree in all of the problem areas (water supply, water quality, floods, erosion, etc.) the gaps are most critical in environmental programs; for example, water quality and ecosystems management, particularly endangered species protection and habitat management. Water data collection in the past has concentrated on determining water quantity. Future concerns will require more information on water quality on the interrelationships between water and other aspects of the environment. A significant step in this direction is being taken by the State Department of Health in the development of an areawide waste treatment management plan, Section 208 of Public Law 92-500. The Department of Health is now in the process of revising State water quality standards based on an ecosystem approach. The ultimate objective of the 208 planning process is to establish a regulatory program for the control of all point and nonpoint sources of pollution.

A major gap and one that affects all of the water and related land-resource areas is the lack of an agreed upon base resource inventory including present land and water use. Data on zoned use and land cover are available, but neither of these can substitute for present land use. Projections of land and water use in the year 2000 will be inaccurate to the degree that present use is unknown or estimated. Also, as long as agencies are using different data bases, coordinated resource planning and management is difficult and requires much more agency cooperation.

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The purpose of the Council is to encourage the conservation, development, and utilization of water and related land resources on a comprehensive and coordinated basis by the Federal government, States, localities, and private enterprises with the cooperation of all affected Federal agencies, States, local government, individual corporations, business enterprises, and others concerned.

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