United States
Department of
Agriculture

Soil
Conservation
Service

In cooperation with
United States Department
of the Interior, Office of
the High Commissioner,
Trust Territory of the
Pacific Islands

Soil Survey of the Islands of Airik, Arno, Majuro, Mili, and Taroa, Republic of the Marshall Islands

How To Use This Soil Survey

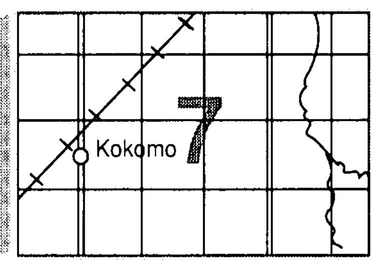
General Soil Map

The general soil map, which is the color map preceding the detailed soil maps, shows the survey area divided into groups of associated soils called general soil map units. This map is useful in planning the use and management of large areas.

To find information about your area of interest, locate that area on the map, identify the name of the map unit in the area on the color-coded map legend, then refer to the section **General Soil Map Units** for a general description of the soils in your area.

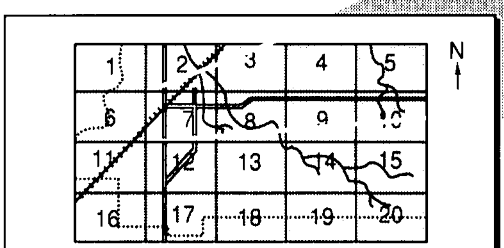
Detailed Soil Maps

The detailed soil maps follow the general soil map. These maps can be useful in planning the use and management of small areas.



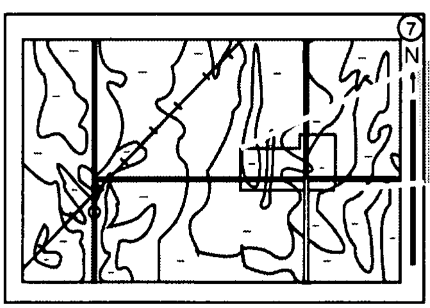
MAP SHEET

To find information about your area of interest, locate that area on the **Index to Map Sheets**, which precedes the soil maps. Note the number of the map sheet, and turn to that sheet.

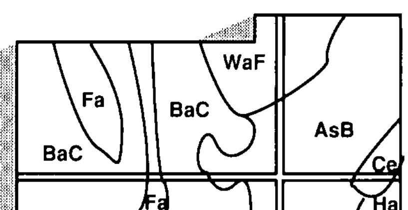


INDEX TO MAP SHEETS

Locate your area of interest on the map sheet. Note the map unit symbols that are in that area. Turn to the **Index to Map Units** (see Contents), which lists the map units by symbol and name and shows the page where each map unit is described.



MAP SHEET



AREA OF INTEREST

NOTE: Map unit symbols in a soil survey may consist only of numbers or letters, or they may be a combination of numbers and letters.

The **Summary of Tables** shows which table has data on a specific land use for each detailed soil map unit. See **Contents** for sections of this publication that may address your specific needs.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in 1979. Soil names and descriptions were approved in 1986. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1986. This survey was made cooperatively by the Soil Conservation Service and the United States Department of the Interior, Office of the High Commissioner, Trust Territory of the Pacific Islands.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

All programs and services of the Soil Conservation Service are offered on a nondiscriminatory basis, without regard to race, color, national origin, religion, sex, age, marital status, or handicap.

Cover: Majuro, the capital of the Republic of the Marshall Islands.

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Issued July 1989

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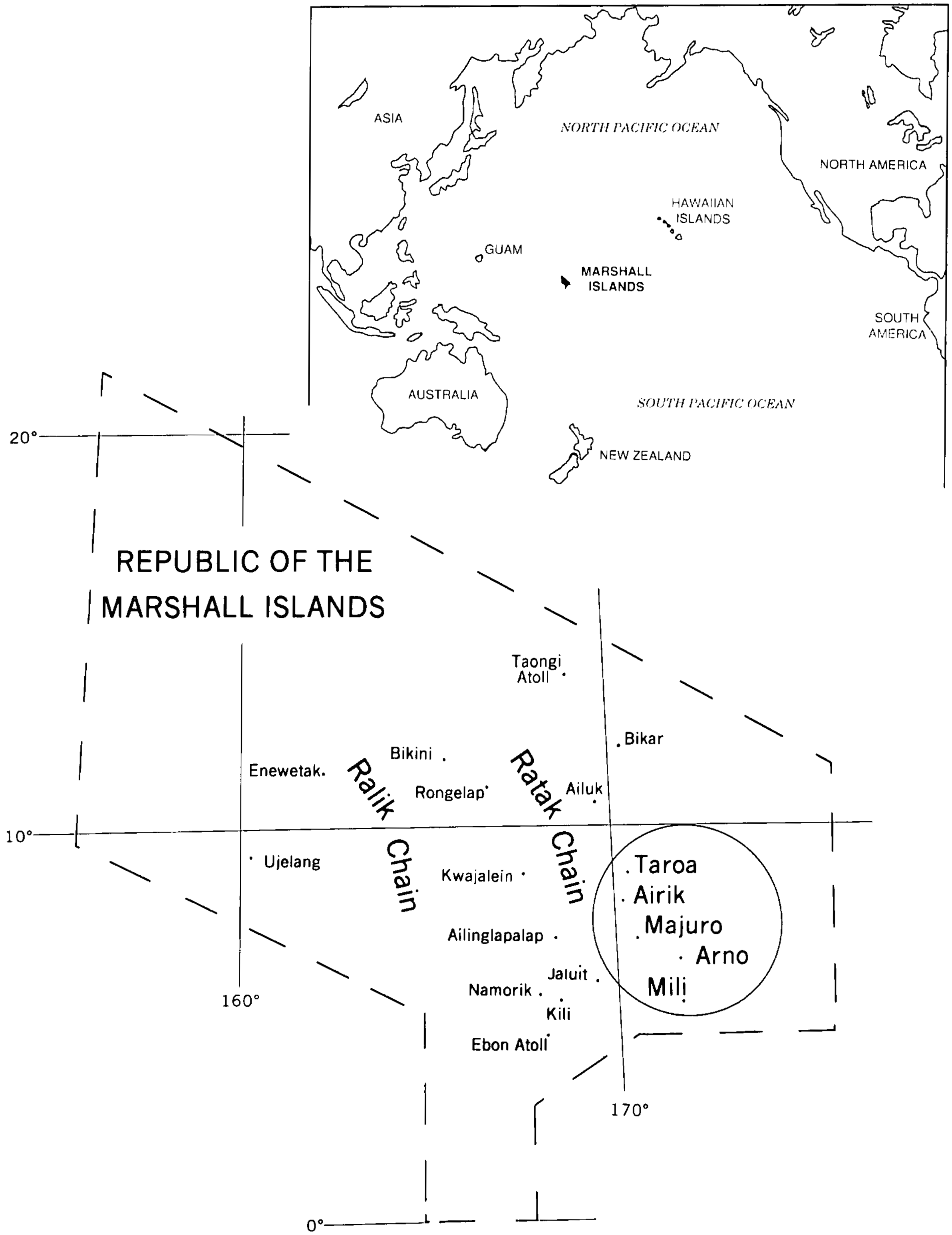
Preface

This soil survey contains information that can be used in land-planning programs in the Republic of the Marshall Islands. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to ensure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to bedrock. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available from the Pacific Basin office of the Soil Conservation Service or from the Department of Resources and Development, Government of the Marshall Islands.



Location of the Republic of the Marshall Islands.

Soil Survey of the Islands of Airik, Arno, Majuro, Mili, and Taroa, Republic of the Marshall Islands

By William E. Laird, Soil Conservation Service

Fieldwork by William E. Laird, Harry H. Sato, and Paul A. Bartlett, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service,
in cooperation with
United States Department of the Interior, Office of the High Commissioner,
Trust Territory of the Pacific Islands

General Nature of the Survey Area

The Republic of the Marshall Islands is a nation of low-lying coral atolls and islands scattered over 1.3 million square kilometers of the central Pacific Ocean. The islands are located between 4 and 19 degrees North latitude and 160 and 175 degrees East longitude. Majuro, the capital, is about 3,685 kilometers southwest of Hawaii.

The Marshall Islands lie in two nearly parallel chains running north and south. The Ratak (sunrise) chain is to the east, and the Ralik (sunset) chain is to the west. The Republic's 31 atolls include more than 1,150 islands and islets. The total land area is only 180 square kilometers.

Approximately 30,000 people live in the Marshall Islands, mainly on two atolls, Majuro and Kwajalein. Majuro has a population of about 12,000.

The islands in this survey area—Airik, Arno, Majuro, Mili, and Taroa—are in the Ratak chain of the southern Marshall Islands. Airik and Taroa are part of the Maloelap Atoll. Arno is the largest island of Arno Atoll; Majuro is the principal island of Majuro Atoll; and Mili is the largest island of Mili Atoll. The total land area of these five islands is about 1,571 hectares *(3)*.

The islands are long and narrow and are nearly level. The ocean is on one side of the islands, and a large lagoon is on the other side. The soils formed in coral rubble and sand. They are sandy and have varying amounts of coral gravel and cobbles.

Subsistence farming and copra production are the main agricultural enterprises in the survey area. The major source of local revenue is copra production. The estimated export value of coconut oil is five million dollars. The main subsistence crops are bananas, breadfruit, coconuts, taro, and papaya. The local economy also is supported by fishing, handicrafts, tourism, and government jobs *(4)*.

History

The Marshall Islands have been successively dominated by the Spaniards, Germans, Japanese, and Americans for the purpose of trade, religion, strategic location, and maintenance of sea routes. Germany was the first foreign power to control the Marshall Islands during the late 19th century. It was followed by the Japanese, who administered the islands from 1914 until the end of World War II. Since 1947, the United States has administered the affairs of the islands under the United Nations Trusteeship.

Beginning in 1969, the United States and the government of the Marshall Islands negotiated a compact of free association and a commitment to self-government. The compact was approved and signed by both parties in 1986.

Climate

The climate of the southern Marshall Islands is characterized by heavy rainfall, high temperatures, high humidity, and trade winds throughout the year. Table 1 gives data on rainfall and temperature as recorded at Majuro. Rainfall on Arno Atoll is estimated to be about the same as that on Majuro, slightly higher on Mili Atoll to the south, and slightly lower on Maloelap Atoll to the north.

Rainfall is heavy, averaging more than 25 centimeters in most months and nearly 350 centimeters per year. It averages about 39 centimeters in October, the wettest month. The rain generally falls as showers, but continuous rain is not uncommon.

The average annual temperature is about 27 degrees C. The average monthly temperatures do not vary from the annual average by more than 0.5 degrees, and the difference between the average maximum and the average minimum temperature is less than 6 degrees throughout the year *(11)*.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed.

The soils in the survey area occur in an orderly pattern that is related to the geology, the landforms, relief, climate, and the natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, acidity, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

Soil scientists interpreted field-observed characteristics and soil properties in terms of expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions. Data were assembled from other sources, such as research information and field experience of specialists.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can state with a fairly high degree of probability that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads,and rivers, all of which help in locating boundaries accurately.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by several kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. These latter soils are called inclusions or included soils.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use or require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that it was impractical to make enough observations to identify all of the kinds of soil on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but onsite investigation is needed to plan for intensive uses in small areas.

Detailed Soil Map Units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under "Use and Management of the Soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the substratum, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the substratum. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Ngedebus loamy sand is a phase of the Ngedebus series.

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils, or one or more soils and a miscellaneous area, in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. The Majuro-Rubble land complex is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. The included soils are identified in each map unit description. Some small areas of strongly contrasting soils are identified by a special symbol on the soil maps.

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rubble land is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown are identified by a special symbol on the soil maps.

Table 2 gives the hectarage and proportionate extent of each map unit. Other tables (see "Summary of Tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils.

Soil Descriptions

1—Majuro very cobbly loamy sand. This very deep, somewhat excessively drained soil is generally along the oceanside of coral atolls. It formed in water-deposited sand, gravel, and cobbles derived dominantly from coral. Slope is 0 to 2 percent. Areas are long and narrow and are 1 to 10 hectares in size. The vegetation in uncultivated areas is mainly that of an atoll forest. Elevation is sea level to 3 meters above sea level. The average annual rainfall is about 300 to 350 centimeters, and the average annual temperature is about 27 degrees C.

Typically, the surface layer is grayish brown very cobbly loamy sand about 15 centimeters thick. The next layer is pale brown very cobbly loamy sand about 17 centimeters thick. The substratum to a depth of 150 centimeters is very pale brown very gravelly and very cobbly sand. In some areas a thin layer of organic debris is at the surface.

Included in this unit are small areas of Ngedebus loamy sand and Ngedebus very gravelly loamy sand.

Also included are small areas of Rubble land. Included areas make up about 25 percent of the total hectarage.

Permeability is rapid in the Majuro soil. Available water capacity is very low. The effective rooting depth is 100 to 150 centimeters. Runoff is very slow. The hazard of water erosion is slight, although the erosion caused by waves can be severe during high-intensity storms.

This soil is used for the production of coconuts. It is moderately suited to this use. The main limitation is the very low available water capacity, which causes a high rate of seedling mortality. The seedling survival rate can be increased by heavily composting and mulching around the seedlings. Light, frequent applications of irrigation water also are helpful.

This soil is poorly suited to vegetables and other crops that require cultivation. The main limitations are the very low available water capacity, low fertility, and the very cobbly surface layer. Because the soil is droughty, light, frequent applications of irrigation water are necessary. Maintaining a high content of organic matter conserves moisture and plant nutrients.

Because of the very cobbly surface layer, this soil is only moderately suited to the development of homesites. Septic tank absorption fields cannot properly filter effluent. If the density of housing is moderate or high, community sewage systems are needed to prevent the contamination of water supplies caused by seepage from onsite sewage disposal systems.

The land capability subclass is VIIs.

2—Majuro-Rubble land complex. This unit is on the oceanside of coral atolls (fig. 1). Slope is 0 to 2 percent. Areas are long and narrow and are 1 to 10 hectares in size. The vegetation is mainly that of an atoll forest. Elevation is sea level to 3 meters above sea level. The average annual rainfall is about 300 to 350 centimeters, and the average annual temperature is about 27 degrees C.

This unit is about 50 percent Majuro very cobbly loamy sand and 30 percent Rubble land. The components of this unit occur as areas so intricately intermingled that mapping them separately was not practical at the scale used.

Included in this unit are small areas of Ngedebus loamy sand and Ngedebus very gravelly loamy sand. Included areas make up about 20 percent of the total hectarage.

The Majuro soil is very deep and somewhat excessively drained. It formed in water-deposited sand, gravel, and cobbles derived dominantly from coral. Typically, the surface layer is grayish brown very gravelly or very cobbly loamy sand about 15 centimeters thick. The next layer is pale brown very cobbly loamy sand about 18 centimeters thick. The substratum to a depth of 150 centimeters is very pale brown very cobbly and very gravelly sand.

Permeability is rapid in the Majuro soil. Available water capacity is very low. The effective rooting depth is 100 to 150 centimeters. Runoff is very slow, and the hazard of water erosion is slight.

The Rubble land is deep or very deep and is excessively drained. It consists mainly of coral gravel, cobbles, stones, and boulders. The spaces between these are filled with sand. In many areas a thin layer of organic debris is at the surface.

Permeability is very rapid in the Rubble land. Available water capacity is very low. The effective rooting depth is 100 to 150 centimeters. Runoff is very slow. Brief periods of flooding caused by ocean waves can occur during high-intensity storms. Erosion commonly is very severe during these storms. Also, sand and coral fragments may be deposited in some areas.

This unit is used for the production of coconuts. The Majuro soil is moderately suited to this use, and the Rubble land is poorly suited. The unit is poorly suited to other crops because of the stoniness and because of the damage caused by salt spray. The main limitations are the very low available water capacity and low fertility. The limited available water capacity causes a high rate of seedling mortality. The seedling survival rate can be increased by light, frequent applications of irrigation water. It also can be increased by heavily mulching and composting around the seedlings. Composting and mulching improve fertility.

This unit is poorly suited to the development of homesites because of the cobbles and the brief periods of flooding.

The Majuro soil is in land capability subclass VIIs, and the Rubble land is in land capability subclass VIIIs.

3—Ngedebus loamy sand. This very deep, somewhat excessively drained soil is in the interior and along the lagoon side of coral atolls. It formed in water- and wind-deposited sand derived dominantly from coral. Slope is 0 to 2 percent. In places the surface is hummocky. Areas are long and narrow and are 2 to 20 hectares in size. The vegetation in uncultivated areas is mainly that of an atoll forest. Elevation is sea level to 3 meters above sea level. The average annual rainfall is about 300 to 350 centimeters, and the average annual temperature is about 27 degrees C.

Typically, the surface layer is grayish brown loamy sand about 23 centimeters thick. The next layer is light

Figure 1.—Rubble land exposed by ocean waves in an area of the Majuro-Rubble land complex. (Photo courtesy of U.S. Department of Agriculture, Forest Service)

gray sand about 22 centimeters thick. The substratum to a depth of 150 centimeters is pinkish white and pink gravelly sand.

Included in this unit are small areas of Ngedebus very gravelly loamy sand and Majuro very cobbly loamy sand. Also included are small areas of Ngedebus loamy sand, dark surface. Included areas make up about 20 percent of the total hectarage.

Permeability is rapid in this Ngedebus soil. Available water capacity is low. The effective rooting depth is 100 to 150 centimeters. Runoff is very slow. The hazard of water erosion is slight, but the erosion caused by waves and wind can be severe during high-intensity storms.

This soil is used mainly for the production of coconuts. It is well suited to this use. Maintaining a high content of organic matter conserves moisture and plant nutrients. The content can be increased or maintained by mulching, managing crop residue, applying compost, and growing cover crops. Burning the vegetation destroys the organic matter and results in a decrease in fertility.

This soil is moderately well suited to such crops as bananas, breadfruit, and papaya. The main management needs are measures that maintain the content of organic matter and compensate for the low available water capacity. The content of organic matter can be maintained by mulching, managing crop residue, applying compost, and growing cover crops. Light, frequent applications of irrigation water are necessary. The crops should be planted away from areas strongly affected by ocean salt spray.

Some areas are used as sites for homes. This soil is well suited to the development of homesites. Septic tank absorption fields cannot properly filter effluent. If the density of housing is moderate or high, community sewage systems are needed to prevent the contamination of water supplies caused by seepage from onsite sewage disposal systems.

The land capability subclass is IVs.

4—Ngedebus loamy sand, dark surface. This very deep, somewhat excessively drained soil is generally in the interior of coral atolls. It formed in water-deposited sand derived dominantly from coral. Slope is 0 to 2 percent. Areas are long and narrow or are oval. They are 1 to 10 hectares in size. The vegetation in uncultivated areas is mainly that of an atoll forest. Elevation is 1 to 3 meters above sea level. The average annual rainfall is about 300 to 350 centimeters, and the average annual temperature is about 27 degrees C.

Typically, the surface layer is very dark grayish brown loamy sand about 33 centimeters thick. The substratum to a depth of 150 centimeters or more is pink sand.

Included in this unit are small areas of Ngedebus loamy sand and small areas of Ngedebus very gravelly loamy sand, dark surface. Also included are small depressional areas of a mucky, wet soil that generally is used for taro. Included areas make up about 15 percent of the total hectarage.

Permeability is rapid in this Ngedebus soil. Available water capacity is moderate to a depth of about 30 centimeters and low below that depth. The effective rooting depth is 100 to 150 centimeters. Runoff is very slow, and the hazard of water erosion is slight.

Most areas are used for the production of coconuts or breadfruit. This soil is well suited to those crops. Measures that maintain the content of organic matter are needed. Examples are mulching, managing crop residue, applying compost, and growing leguminous cover crops. Burning the vegetation destroys the organic matter and results in a decrease in fertility.

This soil is well suited to such crops as bananas, cucumbers, melons, papaya, squash, and sweet potatoes. Adding large amounts of organic matter or commercial fertilizer helps to maintain the natural fertility of the soil. Light, frequent applications of irrigation water are necessary.

This soil is well suited to the development of homesites. Septic tank absorption fields cannot properly filter effluent. If the density of housing is moderate or high, community sewage systems are needed to prevent the contamination of water supplies caused by seepage from onsite sewage disposal systems.

The land capability subclass is IIIs.

5—Ngedebus very gravelly loamy sand. This very deep, somewhat excessively drained soil is on coral atolls. It formed in water-deposited sand and gravel derived dominantly from coral. Slope is 0 to 2 percent. In places the surface is hummocky. Areas are long and narrow or are somewhat circular. They are 1 to 10 hectares in size. The vegetation in uncultivated areas is mainly that of an atoll forest. Elevation is sea level to 3 meters above sea level. The average annual rainfall is about 300 to 350 centimeters, and the average annual temperature is about 27 degrees C.

Typically, the surface layer is grayish brown very gravelly loamy sand about 45 centimeters thick. The upper 20 centimeters of the substratum is light brownish gray gravelly loamy sand. The lower part to a depth of 150 centimeters is light gray and very pale brown gravelly sand.

Included in this unit are small areas of Ngedebus loamy sand and Majuro very cobbly loamy sand. Also included are small areas of Ngedebus loamy sand, dark surface. Included areas make up about 20 percent of the total hectarage.

Permeability is rapid in this Ngedebus soil. Available water capacity is very low. The effective rooting depth is 100 to 150 centimeters. Runoff is very slow. The hazard of water erosion is slight, but the erosion caused by waves and wind can be severe during high-intensity storms.

This soil is used mainly for the production of coconuts. It is well suited to this use. Because of the very low available water capacity, seedling mortality may be a problem. Mixing the surface layer with compost and mulching around the seedlings increase the seedling survival rate. A high content of organic matter can be maintained by growing leguminous cover crops between the coconut trees, by applying compost and mulching around the trees, and by returning crop residue to the soil.

Because of the very low available water capacity, this soil is poorly suited to such crops as bananas and papaya. These crops can be grown if the surface layer is heavily mulched. Light, frequent applications of irrigation water are necessary. Burning the vegetation destroys the organic matter and results in a decrease in fertility.

Some areas are used as sites for homes. This soil is well suited to the development of homesites. The main management concern is the hazard of wave damage during periods of high waves and typhoons. Septic tank absorption fields cannot properly filter effluent. If the density of housing is moderate or high, community sewage systems are needed to prevent the contamination of water supplies caused by seepage from onsite sewage disposal systems.

The land capability subclass is VIs.

6—Ngedebus very gravelly loamy sand, dark surface. This very deep, somewhat excessively drained soil is on coral atolls. It formed in water-deposited sand and gravel derived dominantly from coral. Slope is 0 to 2 percent. In places the surface is hummocky. Areas are long and narrow or are somewhat circular. They are 1 to 10 hectares in size. The vegetation in uncultivated areas is mainly that of an atoll forest. Elevation is about 1 to 3 meters above sea level. The average annual rainfall is about 300 to 350 centimeters, and the average annual temperature is about 27 degrees C.

Typically, the surface layer is very dark gray very gravelly loamy sand about 20 centimeters thick. The upper 18 centimeters of the substratum is pale brown loamy sand. The lower part to a depth of 150 centimeters is pink sand and gravelly sand.

Included in this unit are small areas of Ngedebus loamy sand, dark surface, and Ngedebus very gravelly loamy sand. Also included are small depressional areas of a mucky, wet soil that generally is used for taro. Included areas make up about 15 percent of the total hectarage.

Permeability is rapid in this Ngedebus soil. Available water capacity is low. The effective rooting depth is 100 to 150 centimeters. Runoff is very slow, and the hazard of water erosion is slight.

Most areas are used for the production of coconuts or breadfruit. This soil is well suited to those crops. Measures that maintain the content of organic matter are needed. Examples are mulching, managing crop residue, applying compost, and growing leguminous cover crops. Burning the vegetation destroys the organic matter and results in a decrease in fertility.

This soil is moderately suited to such crops as bananas, cucumbers, melons, papaya, squash, and sweet potatoes. The main limitation is the low available water capacity. Light, frequent applications of irrigation water are needed. Applying compost and mulching conserve moisture. Fertility can be maintained by adding large amounts of organic matter or commercial fertilizer.

This soil is well suited to the development of homesites. Septic tank absorption fields cannot properly filter effluent. If the density of housing is moderate or high, community sewage systems are needed to prevent the contamination of water supplies caused by seepage from onsite sewage disposal systems.

The land capability subclass is IVs.

7—Urban land-Ngedebus complex. This unit is mainly at the Majuro Airport, in the village of Rita on Majuro Island, and on the old airbases on Mili and Taroa Islands. Slope is 0 to 2 percent. The vegetation is mainly atoll forest plants and low-growing vines. Elevation is 1 to 3 meters above sea level. The average annual rainfall is about 300 to 350 centimeters, and the average annual temperature is about 27 degrees C.

This unit is about 60 percent Urban land and 30 percent Ngedebus loamy sand and Ngedebus very gravelly loamy sand. The components of this unit occur as areas so intricately intermingled that mapping them separately was not practical at the scale used.

Included in this unit are small areas of Ngedebus loamy sand, dark surface, and Ngedebus very gravelly loamy sand, dark surface. Also included are many small bomb craters. Included areas make up about 10 percent of the total hectarage.

The Urban land occurs mainly as areas of houses, other small buildings, streets, airports, and fractured concrete on former airstrips used during World War II.

This Ngedebus soil is very deep and somewhat excessively drained. It formed in water-deposited sand and gravel derived mainly from coral. Typically, the surface layer is grayish brown loamy sand or very gravelly loamy sand about 45 centimeters thick. The substratum to a depth of 150 centimeters or more is pinkish white and pink sand and gravelly sand.

Permeability is rapid in this Ngedebus soil. Available water capacity is low. The effective rooting depth is 100 to 150 centimeters. Runoff is very slow, and the hazard of water erosion is slight.

Most areas of the Ngedebus soil are left idle. Some are used for the production of coconuts or pandanus. Fear of unexploded bombs and land mines has hampered development in some areas. Areas of fractured concrete are moderately suited to the production of coconuts if a large enough hole is provided for each seedling. Additions of organic material, such as compost and mulch, reduce the seedling mortality rate and improve fertility. Light, frequent applications of irrigation water are needed.

This unit is well suited to the development of homesites. Septic tank absorption fields cannot properly filter effluent. If the density of housing is moderate or high, community sewage systems are needed to prevent the contamination of water supplies caused by seepage from onsite sewage disposal systems.

The Ngedebus loamy sand is in land capability subclass IVs, and the Ngedebus very gravelly loamy sand is in land capability subclass VIs. The Urban land is not assigned to a land capability classification.

Use and Management of the Soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

Crops

General management needed for crops is suggested in this section. Also, the system of land capability classification used by the Soil Conservation Service is explained.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Detailed Soil Map Units." Specific information can be obtained from the Soil Conservation Service or the Department of Resources and Development, Government of the Marshall Islands.

The potential of the soils in the survey area for increased food production is fair. Many areas that currently are not used for crops could be cropped. Crop production also could be increased by extending the latest technology to all of the cropland in the survey area. This soil survey can facilitate the application of such technology.

The management needed to obtain high yields of various crops depends on the kind of soil and the crop. It can include a drainage system, proper planting and seeding rates, the selection of suitable high-yielding crop varieties for planting, appropriate methods of tillage, control of weeds and plant disease, applications of fertilizer, measures that are effective in maintaining the content of organic matter, and proper irrigation systems.

On many of the soils in the survey area, applications of fertilizer are needed if crops are to be grown. The kinds and amounts of fertilizer to be applied should be based on the results of soil tests and on the needs of the crop. The latest information about growing crops can be obtained from the Marshall Islands Department of Agriculture, located in Majuro.

Subsistence farming is the main type of agriculture in the Marshall Islands *(6)*. On a typical farm, coconut and breadfruit trees are intermixed with bananas, taro, or other crops. This type of farming is suitable in most areas because the farms are small, machine cultivation is not necessary, and commercial fertilizer generally is not applied.

The key to successful subsistence farming is maintaining the content of organic matter in the soil.

Fertility is generally low in most soils on coral atolls. Most of the nutrients needed for plant growth are held by organic matter in the surface layer. A high content of organic matter in this layer is needed if yields are to be sustained. The content can be increased by adding plant residue, mulch, compost, animal manure, and fallen leaves and branches to the surface of the soil.

Compost is a mixture of decaying plant material used as a fertilizer or mulch. A good way to make compost is to dig a pit, fill it with chopped plant material, add animal manure if any is available, and then cover with soil. Every month or two, the material should be turned over. In about 6 months, the compost should be thoroughly rotted and ready to use.

The practice of burning the vegetation to clear land or control weeds should be discouraged. Burning results in a loss of organic matter and a decrease in fertility. Also, it can damage the roots of coconut and other desirable trees.

The fertility of a soil depends on several factors, such as the content of organic matter, the pH, and the amount of available nutrients. The most important plant nutrients are nitrogen, phosphorus, and potassium. In coral atoll soils, iron, manganese, copper, and zinc are in short supply *(7)*. Growing leguminous cover crops between the trees can increase the content of nitrogen in the soil. Recommended species are *Canavalia obtusifolia* and *Vigna marina (5)*. The cover crops also help to control weeds. Applying wood ash adds potassium to the soil.

The main crops grown in the survey area are coconuts, bananas, breadfruit, and taro. Many other climatically adapted crops can be grown if fertilizer is applied and organic material is added. These crops include Chinese cabbage, cucumbers, limes, papaya, peppers, sugarcane, squash, sweet potatoes, tomatoes, and watermelons. Vegetable gardens should not be planted in areas that are strongly affected by ocean salt spray. A trench dug around garden plots keeps the roots of coconut trees from penetrating the garden and depleting the supply of plant nutrients.

Irrigation can overcome the low available water capacity of the soils. A drip system is the most efficient method of irrigation. It allows for light and frequent applications, and it works at low water pressures. Unlike a sprinkler system, it is not affected by strong trade winds.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Recreation

The soils of the survey area are rated in table 3 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 3, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 3 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 5 and interpretations for dwellings without basements and for local roads and streets in table 4.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils are nearly level or gently sloping and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Steep slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry.

Paths and trails for hiking should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building site development, Sanitary facilities, Construction materials, and Water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil Properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 150 centimeters. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 150 centimeters of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

Building Site Development

Table 4 shows the degree and kind of soil limitations that affect shallow excavations, dwellings without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 150 centimeters for graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock or a very firm dense layer, stone content, soil texture, and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and *small commercial buildings* are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings and dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, depth to bedrock, large stones, slope, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 150 centimeters are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills are generally limited to less than 180 centimeters. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, and depth to a high water table affect the traffic-supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock, the available water capacity in the upper 100 centimeters, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

Sanitary Facilities

Table 5 shows the degree and kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 5 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 60 and 180 centimeters is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock, and flooding affect absorption of the effluent. Large stones and bedrock interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured, porous bedrock is less than 120 centimeters below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 60 to 150 centimeters. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 5 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 30 or 60 centimeters of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope and bedrock can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 5 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 180 centimeters. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

Table 6 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a *probable* or *improbable* source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 150 centimeters.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 180 centimeters high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 150 centimeters. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 150 centimeters of suitable material, a low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 90 centimeters. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have a moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 30 to 90 centimeters. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 30 centimeters. These soils may have layers of suitable material, but the material is less than 90 centimeters thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 6, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 90 centimeters thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 100 centimeters of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 100 centimeters. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 50 to 100 centimeters of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 50 centimeters of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

Water Management

Table 7 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and for embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 150 centimeters. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 6 meters high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 150 centimeters. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 150 centimeters of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulfur. Availability of drainage outlets is not considered in the ratings.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of soil blowing or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock affect the construction of grassed waterways. A hazard of soil blowing, low available water capacity, restricted rooting depth, toxic substances such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps.

Estimates of soil properties are based on field examinations and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution, the engineering classification, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

Engineering Index Properties

Table 8 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 150 centimeters.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil Series and Their Morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as about 15 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system *(2)* and the system adopted by the American Association of State Highway and Transportation Officials *(1)*.

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 8 centimeters in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 8 centimeters in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

Rock fragments larger than 8 centimeters in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 8 centimeters in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Physical and Chemical Properties

Table 9 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at ⅓ bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Salinity is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils. The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the table. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In table 9, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter in a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

Soil and Water Features

Table 10 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the infiltration of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding, the temporary inundation of an area, is caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall is not considered flooding, nor is water in swamps and marshes.

Table 10 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *occasional* that it occurs, on the average, once or less in 2 years; and *frequent* that it occurs, on the average, more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; January-December, for example, means that flooding can occur during the period January through December.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons that form in soils that are not subject to flooding.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 10 are the depth to the seasonal high water table, the kind of water table, and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 10. Only saturated zones within a depth of about 2 meters are indicated. An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Depth to bedrock is given if bedrock is within a depth of 150 centimeters. The depth is based on many soil borings and on observations during soil mapping. The rock is either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low*, *moderate*, or *high*, is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories *(10)*. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 11 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Entisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Psamment (*Psamm*, meaning sand, plus *ent*, from Entisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Tropopsamments (*Tropo*, meaning tropical, plus *psamment*, the suborder of the Entisols that is sandy).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Tropopsamments.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is carbonatic, isohyperthermic Typic Tropopsamments.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

Soil Series and Their Morphology

In this section, each soil series recognized in the survey area is described. Characteristics of the soil and the material in which it formed are identified for each series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the *Soil Survey Manual (9)*. Many of the technical terms used in the descriptions are defined in *Soil Taxonomy (10)*. Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed Soil Map Units."

Majuro Series

The Majuro series consists of very deep, somewhat excessively drained soils that formed in water-deposited coral rubble and sand. These soils are along the oceanside of coral atolls. Slope is 0 to 2 percent. The average annual rainfall is about 350 centimeters, and the average annual temperature is about 27 degrees C.

These soils are sandy-skeletal, carbonatic, isohyperthermic Typic Troporthents.

Typical pedon of Majuro very cobbly loamy sand, in an area where the slope is 2 percent; Mili Island, Mili Atoll; about 1,300 meters south of the northern tip of Mili Island and 25 meters east of the oceanside; latitude 6 degrees 5 minutes 30 seconds N. and longitude 170 degrees 43 minutes 45 seconds E.

A—0 to 15 centimeters; grayish brown (10YR 5/2) very cobbly loamy sand; weak medium angular blocky structure; very friable, nonsticky and nonplastic; common fine and medium roots; many fine interstitial pores; about 30 percent coral cobbles and 10 percent gravel; strongly effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

AC—15 to 32 centimeters; pale brown (10YR 6/3) very cobbly loamy sand; single grain; loose, nonsticky and nonplastic; common fine and medium roots; many fine interstitial pores; about 30 percent coral cobbles and 10 percent gravel; strongly effervescent; moderately alkaline (pH 8.0); gradual wavy boundary.

C1—32 to 62 centimeters; very pale brown (10YR 7/3) very cobbly sand; single grain; loose, nonsticky and nonplastic; few fine and medium roots; many fine interstitial pores; about 40 percent coral cobbles and 15 percent gravel; strongly effervescent; moderately alkaline (pH 8.2); gradual smooth boundary.

C2—62 to 150 centimeters; very pale brown (10YR 8/3) very gravelly sand; single grain; loose, nonsticky and nonplastic; many fine interstitial pores; about 30 percent coral gravel and 10 percent cobbles; strongly effervescent; moderately alkaline (pH 8.2).

The depth to bedrock is more than 150 centimeters. The content of coarse fragments ranges from 35 to 70 percent in the control section. Reaction is neutral to moderately alkaline throughout the profile.

The A horizon is dark grayish brown (10YR 4/2), grayish brown (10YR 5/2), or light brownish gray (10YR 6/2). The fine-earth fraction of this horizon is fine sand, loamy sand, or sand, and the content of cobbles ranges from 30 to 50 percent by volume.

The C horizon is very pale brown (10YR 7/3 or 8/3), pinkish white (7.5YR 8/2), or pink (7.5YR 8/4). The fine-earth fraction of this horizon is fine sand, sand, or coarse sand, and the content of coral gravel, cobbles, and stones ranges from 35 to 70 percent by volume.

Ngedebus Series

The Ngedebus series consists of very deep, somewhat excessively drained soils that formed in water- and wind-deposited coral sand. These soils are adjacent to coastal beaches and in the interiors of atolls. Slope is 0 to 2 percent. The average annual rainfall is about 350 centimeters, and the average annual temperature is about 27 degrees C.

These soils are carbonatic, isohyperthermic Typic Tropopsamments.

Typical pedon of Ngedebus loamy sand, in an area where the slope is 2 percent and the vegetation is a forest of coconut palms; Malel Island, Arno Atoll; latitude 7 degrees 04 minutes 40 seconds N. and longitude 171 degrees 51 minutes 50 seconds E.

A—0 to 23 centimeters; grayish brown (10YR 5/2) loamy sand; single grain; very friable, nonsticky and nonplastic; common fine and few coarse and medium roots; many fine interstitial pores; about 5 percent coral gravel; strongly effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

AC—23 to 45 centimeters; light gray (10YR 7/2) sand; single grain; loose, nonsticky and nonplastic; common fine and coarse roots; many fine interstitial pores; strongly effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

C1—45 to 75 centimeters; pinkish white (7.5YR 8/2) gravelly coarse sand; single grain; loose, nonsticky and nonplastic; few coarse roots; many fine interstitial pores; about 20 percent coral gravel; strongly effervescent; moderately alkaline (pH 8.2); gradual smooth boundary.

C2—75 to 150 centimeters; pink (7.5YR 8/4) gravelly coarse sand; single grain; loose, nonsticky and nonplastic; about 20 percent coral gravel and 5 percent coral cobbles; moderately alkaline (pH 8.2).

The depth to bedrock is more than 150 centimeters. Depth to the water table is 100 to 150 centimeters.

The A horizon is light brownish gray (10YR 6/2), grayish brown (10YR 5/2), or dark grayish brown (10YR 4/2). The fine-earth fraction of this horizon is coarse sand to fine loamy sand. The content of gravel is 0 to

15 percent, and the content of cobbles is 0 to 5 percent.

The C horizon is pinkish white (7.5YR 8/2), pink (7.5YR 8/4), white (10YR 8/2), or very pale brown (10YR 8/3). The fine-earth fraction of this horizon is fine sand, sand, or coarse sand, and the content of gravel and cobbles is 0 to 35 percent.

Formation of the Soils

The major factors that affect soil formation are climate, plants and animals, relief, parent material, and time. The interactions among these factors determine the characteristics of a soil at any given point. Each of these factors affects the formation of every soil, and each modifies the effects of the other four. The relative effect of an individual factor varies from one soil to another. The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made about the effect of any one unless conditions are specified for the other four.

The Marshall Islands are coral atolls. Millions of years ago, volcanoes from the ocean floor formed high volcanic islands. In time marine and stream erosion flattened and submerged the volcanic islands. As coral grew around the submerged islands, shallow reefs formed. The soils formed in calcareous sand and gravel—the broken pieces of coral. They are very young because the parent material is recent sediment.

The islands are nearly level. Elevation ranges from sea level to about 3 meters above sea level. Rainfall is heavy, and temperatures are warm. The vegetation is mainly coconut palms and the plants characteristic of a coral atoll strand forest.

The climate, parent material, topography, vegetation, and age of the soils are all fairly uniform throughout the survey area. As a result, the number of different soils is limited. Only seven map units are delineated. The variables used to separate them in mapping were the content of coarse fragments on and below the surface, the content of organic matter in the surface layer, and depth to the water table.

Subtle differences among the soil-forming factors account for the differences among the soils on the islands. For example, the Ngedebus soils that have a dark surface layer have more organic matter in the surface layer than other Ngedebus soils. The higher content of organic matter results from a protected position in the interior of the islands. The soils in these protected areas receive less newly deposited sand than other soils on the islands and thus are older. Also, they are less affected by salt spray and thus support denser and more varied vegetation, which is the origin of the organic matter.

The content and size of coarse fragments in the soils are related to the position on the landscape. Nearly all of the areas of cobbly and rubble land are along the oceanside of the islands, and sands and loamy sands are generally along the lagoon side *(8)*.

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Glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as centimeters of water per centimeter of soil. The capacity, in centimeters, in a 150-centimeter profile or to a limiting layer is expressed as—

Very low	0 to 8
Low	8 to 15
Moderate	15 to 23
High	23 to 30
Very high	more than 30

Base saturation. The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation-exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bottom land. The normal flood plain of a stream, subject to flooding.

Boulders. Rock fragments larger than 60 centimeters in diameter.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 7.5 to 25 centimeters in diameter.

Cobbly soil material. Material that is 15 to 35 percent, by volume, rounded or partially rounded rock fragments 7.5 to 25 centimeters in diameter. Very cobbly soil material is 35 to 60 percent of these rock fragments, and extremely cobbly soil material is more than 60 percent.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers.

Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 25 and 100 centimeters.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—These soils have very high and high hydraulic conductivity and low water holding capacity. They are not suited to crop production unless irrigated.

Somewhat excessively drained.—These soils have high hydraulic conductivity and low water holding capacity. Without irrigation, only a narrow range of crops can be grown and yields are low.

Well drained.—These soils have intermediate water holding capacity. They retain optimum amounts of moisture, but they are not wet close enough to the surface or long enough during the growing season to adversely affect yields.

Moderately well drained.—These soils are wet close enough to the surface or long enough that planting or harvesting operations or yields of some field crops are adversely affected unless artificial drainage is provided. Moderately well drained soils commonly have a layer with low hydraulic conductivity, a wet layer relatively high in the profile, additions of water by seepage, or some combination of these.

Somewhat poorly drained.—These soils are wet close enough to the surface or long enough that planting or harvesting operations or crop growth is markedly restricted unless artificial drainage is provided. Somewhat poorly drained soils commonly have a layer with low hydraulic conductivity, a wet layer high in the profile, additions of water through seepage, or a combination of these.

Poorly drained.—These soils commonly are so wet at or near the surface during a considerable part of the year that field crops cannot be grown under natural conditions. Poorly drained conditions are caused by a saturated zone, a layer with low hydraulic conductivity, seepage, or a combination of these.

Very poorly drained.—These soils are wet to the surface most of the time. They are wet enough to prevent the growth of important crops (except rice) unless artificially drained.

Drainage, surface. Runoff, or surface flow of water, from an area.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Fallow. Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grains are grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fine textured soil. Sandy clay, silty clay, and clay.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 7.6 centimeters in diameter.

Green manure crop (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard rock. Rock that cannot be excavated except by blasting or by special equipment that is not commonly used in construction.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, prismatic, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Hard, consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in centimeters per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle).—Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow.—Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Water, released at high points, is allowed to flow onto an area without controlled distribution.

Large stones (in tables). Rock fragments 7.6 centimeters or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters; *medium*, from 5 to 15 millimeters; and *coarse*, more than 15 millimeters.

Muck. Dark colored, finely divided, well decomposed organic soil material.

Munsell notation. A designation of color by degrees of three simple variables—hue, value, and chroma.For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 1 square meter to 10 square meters, depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of centimeters per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.02 centimeter
Slow	0.02 to 0.5 centimeter
Moderately slow	0.5 to 1.5 centimeters
Moderate	1.5 to 5.0 centimeters
Moderately rapid	5 to 15 centimeters
Rapid	15 to 50 centimeters
Very rapid	more than 50 centimeters

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poor filter (in tables). Because of rapid permeability, the soil may not adequately filter effluent from a waste disposal system.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are—

Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Residuum (residual soil material). Unconsolidated, weathered or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Root zone. The part of the soil that can be penetrated by plant roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Saprolite (soil science). Unconsolidated residual material underlying the soil and grading to hard bedrock below.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the substratum. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 meters in 100 meters of horizontal distance.

Small stones (in tables). Rock fragments less than 7.6 centimeters in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stones. Rock fragments 25 to 60 centimeters in diameter.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from about 10 to 25 centimeters. Frequently designated as the "plow layer," or the "Ap horizon."

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Tables

Table 1.—Rainfall and Temperature

(Recorded at Majuro in the period 1955-79)

Month	Average rainfall	Temperature		
		Average	Maximum	Minimum
	cm	*°C*	*°C*	*°C*
January	20.3	27.0	29.2	24.8
February	15.8	27.3	29.5	25.0
March	23.2	27.3	29.3	24.9
April	30.7	27.1	29.5	24.7
May	30.8	27.2	29.7	24.8
June	31.3	27.2	29.7	24.7
July	32.2	27.2	29.7	24.7
August	28.9	27.3	29.9	24.8
September	33.3	27.4	30.0	24.7
October	39.0	27.3	30.0	24.7
November	34.7	27.3	29.8	24.8
December	28.5	27.2	29.4	24.9
Annual	348.7	27.2	---	---

Table 2.—Hectarage and Proportionate Extent of the Soils

Map symbol	Soil name	Airik	Arno	Majuro	Mili	Taroa	Total	
							Area	Extent
		Hectares	*Hectares*	*Hectares*	*Hectares*	*Hectares*	*Hectares*	*Percent*
1	Majuro very cobbly loamy sand	8	0	324	35	8	375	23.9
2	Majuro-Rubble land complex	10	22	0	17	18	67	4.3
3	Ngedebus loamy sand	12	21	40	168	48	289	18.4
4	Ngedebus loamy sand, dark surface	10	98	208	21	10	347	22.1
5	Ngedebus very gravelly loamy sand	15	11	0	28	24	78	5.0
6	Ngedebus very gravelly loamy sand, dark surface	4	18	26	10	7	65	4.1
7	Urban land-Ngedebus complex	2	0	228	71	49	350	22.3
	Total	61	170	826	350	164	1,571	100.0

Table 3.—Recreational Development

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated)

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
1. Majuro	Severe: flooding, small stones.	Severe: small stones.	Severe: small stones.	Moderate: too sandy.
2*:				
Majuro	Severe: flooding, small stones.	Severe: small stones.	Severe: small stones.	Moderate: too sandy.
Rubble land.				
3. Ngedebus	Severe: flooding.	Slight.	Moderate: small stones, flooding.	Slight.
4. Ngedebus	Severe: flooding.	Moderate: too sandy.	Moderate: too sandy.	Moderate: too sandy.
5. Ngedebus	Severe: flooding.	Moderate: small stones.	Severe: small stones.	Slight.
6. Ngedebus	Severe: flooding, small stones.	Severe: small stones.	Severe: small stones.	Moderate: too sandy.
7*:				
Urban land.				
Ngedebus	Severe: flooding.	Slight.	Moderate: small stones, flooding.	Slight.

* See description of the map unit for composition and behavior characteristics of the map unit.

Table 4.—Building Site Development

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "moderate" and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition. It does not eliminate the need for onsite investigation)

Soil name and map symbol	Shallow excavations	Dwellings without basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
1 Majuro	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: small stones, large stones, droughty.
2*:					
Majuro	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: small stones, large stones, droughty.
Rubble land.					
3 Ngedebus	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: droughty, flooding.
4 Ngedebus	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Moderate: droughty.
5 Ngedebus	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: droughty.
6 Ngedebus	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Moderate: flooding.	Moderate: droughty.
7*:					
Urban land.					
Ngedebus	Severe: cutbanks cave.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Moderate: droughty, flooding.

* See description of the map unit for composition and behavior characteristics of the map unit.

Table 5.—Sanitary Facilities

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "severe," "poor," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition. It does not eliminate the need for onsite investigation)

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
1 Majuro	Severe: flooding, poor fliter.	Severe: seepage, flooding, large stones.	Severe: flooding, seepage, too sandy.	Severe: flooding, seepage.	Poor: seepage, too sandy, small stones.
2*: Majuro	Severe: flooding, poor filter.	Severe: seepage, flooding, large stones.	Severe: flooding, seepage, too sandy.	Severe: flooding, seepage.	Poor: seepage, too sandy, small stones.
Rubble land.					
3 Ngedebus	Severe: flooding, wetness, poor filter.	Severe: seepage, flooding.	Severe: flooding, seepage, wetness.	Severe: flooding, seepage.	Poor: seepage, too sandy, small stones.
4 Ngedebus	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
5 Ngedebus	Severe: flooding, wetness, poor filter.	Severe: seepage, flooding.	Severe: flooding, seepage, wetness.	Severe: flooding, seepage.	Poor: seepage, too sandy, small stones.
6 Ngedebus	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
7*: Urban land.					
Ngedebus	Severe: flooding, wetness, poor filter.	Severe: seepage, flooding.	Severe: flooding, seepage, wetness.	Severe: flooding, seepage.	Poor: seepage, too sandy, small stones.

* See description of the map unit for composition and behavior characteristics of the map unit.

Table 6.—Construction Materials

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition. It does not eliminate the need for onsite investigation)

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
1 Majuro	Fair: large stones.	Probable	Probable	Poor: too sandy, small stones, area reclaim.
2*: Majuro	Fair: large stones.	Probable	Probable	Poor: too sandy, small stones, area reclaim.
Rubble land.				
3 Ngedebus	Good	Probable	Probable	Poor: small stones, area reclaim.
4 Ngedebus	Good	Probable	Improbable: too sandy.	Poor: too sandy.
5 Ngedebus	Good	Probable	Probable	Poor: small stones, area reclaim.
6 Ngedebus	Good	Probable	Improbable: too sandy.	Poor: too sandy, small stones.
7*: Urban land.				
Ngedebus	Good	Probable	Probable	Poor: small stones, area reclaim.

* See description of the map unit for composition and behavior characteristics of the map unit.

Table 7.—Water Management

(Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "severe." Absence of an entry indicates that the soil was not evaluated. The information in this table indicates the dominant soil condition. It does not eliminate the need for onsite investigation)

Soil name and map symbol	Limitations for—		Features affecting—			
	Pond reservoir areas	Embankments, dikes,and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
1. Majuro	Severe: seepage.	Severe: seepage, large stones.	Deep to water	Large stones, droughty.	Large stones, too sandy.	Large stones, droughty.
2*:						
Majuro	Severe: seepage.	Severe: seepage, large stones.	Deep to water	Large stones, droughty.	Large stones, too sandy.	Large stones, droughty.
Rubble land.						
3. Ngedebus	Severe: seepage.	Severe: seepage, piping.	Deep to water	Droughty, fast intake, soil blowing.	Large stones, too sandy, soil blowing.	Large stones. droughty.
4. Ngedebus	Severe: seepage.	Severe: seepage, piping.	Cutbanks cave	Droughty, fast intake.	Too sandy	Droughty.
5. Ngedebus	Severe: seepage.	Severe: seepage, piping.	Deep to water	Droughty, fast intake.	Large stones, too sandy.	Large stones, droughty.
6. Ngedebus	Severe: seepage.	Severe: seepage, piping.	Cutbanks cave	Droughty, fast intake.	Too sandy	Droughty.
7*:						
Urban land.						
Ngedebus	Severe: seepage.	Severe: seepage, piping.	Deep to water	Droughty, fast intake, soil blowing.	Large stones, too sandy, soil blowing.	Large stones, droughty.

* See description of the map unit for composition and behavior characteristics of the map unit.

Table 8.—Engineering Index Properties

(The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated)

Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments >8 cm	Percentage passing sieve number—			
			Unified	AASHTO		4	10	40	200
	cm				*Pct*				
1 Majuro	0-32	Very cobbly loamy sand	SM, GM, GP-GM, SP-SM	A-1	35-50	50-70	45-65	25-40	10-20
	32-150	Stratified very gravelly loamy sand to extremely cobbly sand.	GP-GM, GM, SP-SM, SM	A-1	35-50	25-70	20-65	15-50	5-15
2*: Majuro	0-32	Very cobbly loamy sand	SM, GM, GP-GM, SP-SM	A-1	35-50	50-70	45-65	25-40	10-20
	32-150	Stratified very gravelly loamy sand to extremely cobbly sand.	GP-GM, GM, SP-SM, SM	A-1	35-50	25-70	20-65	15-50	5-15
Rubble land	0-150	Fragmental material	GP	A-1	75-90	0-10	0-5	0-5	0
3 Ngedebus	0-45	Loamy sand	SM	A-1, A-2	0-5	85-100	80-100	45-80	15-30
	45-150	Stratified sand to gravelly sand.	SP-SM, SM	A-1, A-2, A-3	0-25	70-100	65-100	30-80	5-35
4 Ngedebus	0-33	Loamy sand	SM	A-1, A-2	0-5	85-100	80-100	45-80	15-30
	33-150	Sand	SP-SM, SM	A-1, A-2, A-3	0-5	85-100	80-100	45-60	5-15
5 Ngedebus	0-45	Very gravelly loamy sand.	SP, SM	A-1	5-15	70-80	65-75	35-50	5-10
	45-150	Stratified loamy sand to gravelly sand.	SP-SM, SM	A-1, A-2, A-3	0-25	70-100	65-100	30-80	5-35
6 Ngedebus	0-33	Very gravelly loamy sand.	GM, GP-GM	A-1	5-25	35-50	30-45	20-30	10-15
	33-150	Sand, loamy sand	SP-SM, SM	A-1, A-2, A-3	0-5	85-100	80-100	45-60	5-15
7*: Urban land.									
Ngedebus	0-45	Loamy sand	SM	A-1, A-2	0-5	85-100	80-100	45-80	15-30
	45-150	Stratified sand to gravelly sand.	SP-SM, SM	A-1, A-2, A-3	0-25	70-100	65-100	30-80	5-35

* See description of the map unit for composition and behavior characteristics of the map unit.

Table 9.—Physical and Chemical Properties of the Soils

(The symbol < means less than; > means more than. Entries under "Erosion factors—T" apply to the entire profile. Entries under "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated)

Soil name and map symbol	Depth	Moist bulk density	Permea-bility	Available water capacity	Soil reaction	Salinity	Shrink-swell potential	Erosion factors		Organic matter
								K	T	
	cm	*g/cc*	*cm/hr*	*cm/cm*	*pH*	*mmhos/cm*				*Pct*
1	0-32	1.20-1.40	15-50	0.04-0.06	6.6-8.4	<2	Low	0.05	5	1-3
Majuro	32-150	1.50-1.70	15-50	0.01-0.07	6.6-8.4	<2	Low	0.02		
2*:										
Majuro	0-32	1.20-1.40	15-50	0.04-0.06	6.6-8.4	<2	Low	0.05	5	1-3
	32-150	1.50-1.70	15-50	0.01-0.07	6.6-8.4	<2	Low	0.02		
Rubble land	0-150	---	>50	0.0-0.1	---	<2	Low	---	---	<.1
3	0-45	1.20-1.40	15-50	0.08-0.10	6.6-8.4	<2	Low	0.10	5	1-3
Ngedebus	45-150	1.50-1.70	15-50	0.04-0.07	7.4-9.0	<2	Low	0.10		
4	0-33	1.20-1.40	15-50	0.08-0.10	6.6-8.4	<2	Low	0.10	5	10-15
Ngedebus	33-150	1.20-1.40	15-50	0.05-0.07	6.6-8.4	<2	Low	0.10		
5	0-45	1.20-1.40	15-50	0.04-0.07	6.6-8.4	<2	Low	0.05	5	1-3
Ngedebus	45-150	1.50-1.70	15-50	0.04-0.07	7.4-9.0	<2	Low	0.05		
6	0-33	1.20-1.40	15-50	0.04-0.06	6.6-8.4	<2	Low	0.05	5	10-15
Ngedebus	33-150	1.20-1.40	15-50	0.05-0.07	6.6-8.4	<2	Low	0.10		
7*:										
Urban land.										
Ngedebus	0-45	1.20-1.40	15-50	0.08-0.10	6.6-8.4	<2	Low	0.10	5	1-3
	45-150	1.50-1.70	15-50	0.04-0.07	7.4-9.0	<2	Low	0.10		

* See description of the map unit for composition and behavior characteristics of the map unit.

Table 10.—Soil and Water Features

("Flooding," "water table," and terms such as "rare," "very brief," and "apparent" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern or that data were not estimated)

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hard-ness	Uncoated steel	Concrete
					m			*cm*			
1 .... Majuro	A	Occasional ...	Very brief...	Jan-Dec	>1.8	---	---	>150	---	High	Low.
2*:											
Majuro	A	Occasional ...	Very brief...	Jan-Dec	>1.8	---	---	>150	---	High	Low.
Rubble land	A	Occasional ...	---	---	>1.8	---	---	>100	Hard ...	---	---
3 .... Ngedebus	A	Occasional ...	Very brief...	Jan-Dec	>1.0	Apparent	Jan-Dec	>150	---	High	Low.
4 .... Ngedebus	A	Rare	---	---	>1.8	---	---	>150	---	High	Low.
5 .... Ngedebus	A	Occasional ...	Very brief...	Jan-Dec	>1.0	Apparent	Jan-Dec	>150	---	High	Low.
6 .... Ngedebus	A	Rare	---	---	>1.8	---	---	>150	---	High	Low.
7*: Urban land.											
Ngedebus	A	Occasional ...	Very brief...	Jan-Dec	>1.0	Apparent	Jan-Dec	>150	---	High	Low.

* See description of the map unit for composition and behavior characteristics of the map unit.

Table 11.—Classification of the Soils

Soil name	Family
Majuro	Sandy-skeletal, carbonatic, isohyperthermic Typic Troporthents
Ngedebus	Carbonatic, isohyperthermic Typic Tropopsamments

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