LEGAL, BUSINESS AND ECONOMIC ASPECTS OF COBALT-RICH MANGANESE CRUST MINING AND PROCESSING IN REPUBLIC OF THE MARSHALL ISLANDS

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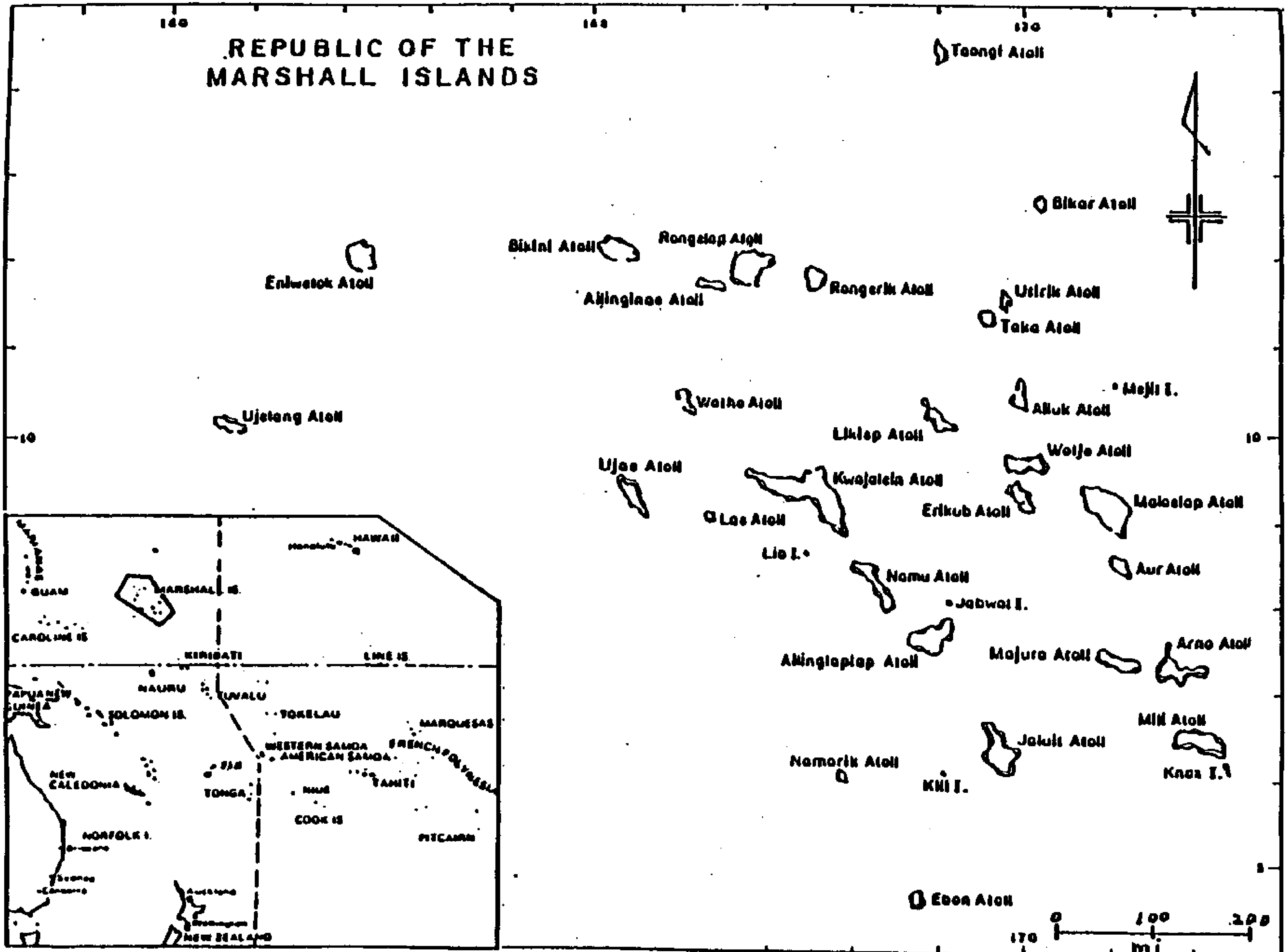

MAP OF THE REPUBLIC OF THE MARSHALL ISLANDS

PART I

LEGAL AND INSTITUTIONAL ISSUES

IN

ESTABLISHING A MANGANESE CRUST PROCESSING PLANT

IN THE

REPUBLIC OF THE MARSHALL ISLANDS

BY

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PART I

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I. INTRODUCTION AND BACKGROUND

A. Geography

The Republic of the Marshall Islands (RMI) is one of three major archipelagoes in the Trust Territory of the Pacific Islands, Pacific Islands Yearbook, (Ed.) John Carter 15th ed. p. 454 (1984, reprinted 1986), and consists of 31 atolls and islands lying between 4 and 14 deg. N. latitude and 160 and 173 deg. E. longitude. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands p. 3 (1984). The atolls form two parallel chains. The Eastern (Ratak) chain consists of 15 atolls and islands, and the Western (Ralik) chain consists of 16 atolls and islands. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands p. 3 (1984). Although the Republic is spread over some 500,000 square miles of sea, the total land area of the Marshall Islands is but 70 square miles. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands p. 3 (1984). The islands are rarely more than 400 yards in width, and none rise more than a few feet above sea level. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 2 (1986).

B. Climate

The climate in the Marshalls is predominantly tropical: warm and humid year-round, with a mean temperature of 80 degrees Farenheit. Invest in Micronesia Guide to Laws and Procedures for Investors in the Trust Territory of the Pacific Islands, High Commissioner, Trust Territory of the Pacific Islands, p. 1

(1978). Tradewinds provide some cooling breezes, especially from December to March. Since the Marshall Islands are so close to the equator, the islanders enjoy about 12-1/4 hours of daylight each day. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 6 (1986).

The Marshall Islands usually have 15 to 20 days of rain per month, with up to 6 inches per day not being uncommon. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 3 (1986). The monthly rainfall average is 12-15 inches, and the wettest months are October and November. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands p. 3 (1984). Although it sometimes rains heavily during the typhoon season, the Marshalls are not really within a typhoon belt. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 3 (1986). The atolls are, however, low-lying and therefore easily flooded during storms and tidal surges, First Five Year Development Plan 1985-1989, Republic of the Marshall Islands p. 4 (1984), and hurricanes are also a possibility. Pacific Business Guide, Pacific (Saffron Walden, Essex) p. 119 (1984).

C. Population

The population of RMI is 36,667. Office of Planning and Statistics, Marshall Islands Statistical Abstract, 1986, at 3. The total Marshall Island population, Majuro, the district center, accounts for 14,004 people. Marshall Islands Statistical Abstract 1986, at 3. A government estimate shows an even further increase in population by 1990 with a projected population of 45,569. Marshall Islands Statistical Abstract, Office of Planning and Statistics p. 9 (1985). Therefore, it should be no surprise that the population growth in the Marshall Islands ranks among the highest in the world, Marshall Islands Guidebook, Marshall Islands, p. 12 (1986), and is expected to increase at a rate of 3.4% per year. Marshall Islands National Development Program 1981-1995, Marshall Islands political Status Commission Special Planning Committee, p. 1 (1981). Currently 50% of the population is under 15 years of age, which further indicates both present and future rapid population growth. Marshall Islands Guidebook, Marshall Islands, p. 12 (1986).

The population explosion is not the only potential problem facing the Republic today. Twenty-two percent of the males and 27% of the females who were in the labor force in 1980 were unemployed. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands p. 23 (1984). Additionally, the RMI has a low per capita income, with a 1981 estimate of $1,619. This figure is somewhat misleading because the lowest 25% of money income earners receive less than 3% of the total income, while the highest 6% receive greater than 25%

of the total. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands, p. 23 (1984).

D. Language

English is the official language of the Marshall Islands, Pacific Business Guide, Pacific (Saffron Walden, Essex), p. 118 (1984). Although it is almost universally spoken, Pacific Islands Yearbook, (Ed.) John Carter, 15th ed. p. 437 (1984, reprinted 1986), many Marshallese are nevertheless not fluent in English. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 21 (1986). This is reflected in comparative literacy rates: English, 25%; Marshallese, 90%. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands p. 24 (1984). Since cultural preservation is important to the Marshallese, part of which is reflected in retaining their language, which they use it in everyday conversation, this is understandable. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 21 (1986).

E. Government

In 1947, the United States entered into a trusteeship agreement with the United Nations, placing the Marshall Islands (along with the Cardenas and the Northern Marianas - except for Guam) under United States Administration. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political

Affairs, p. 8 (1980). The Territory had formerly been held by the Japanese under mandate in accordance with Article 22 of the Covenant of the League of Nations. Issue of the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 51 (Art. 1) (1980). Before that, the Marshalls were dominated by various trading groups and companies beginning in the middle of the 19th Century with the trading partnership of Capelle and DeBrun, when Copra was king. Hezel, The First Taint of Civilization 1983, at Ch. 8. Under the Trusteeship Agreement (Article 6), the United States agreed to: foster development of political institutions as are suitable; promote development of the inhabitants toward self-government for independence; and to promote economic, social, and educational advancement. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 52 (Art. 6) (1980). This agreement was different from other United Nations trusteeship agreements in that the Trust Territory of the Pacific Islands was designated as a strategic area. This designation permitted the United States to use the islands militarily. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 55 (1986). The details of the Trusteeship government are set out in some detail below because the structure of the Republic remains so little changed under the present compact of Free Association with the United States.

1. Politics and Government Under the Trusteeship Agreement

Under the terms of the Trusteeship Agreement with the United Nations, the United States was granted full administrative, legislative, and judicial power over the Territory in 1947. The U.S. President delegated the administrative responsibilities to the U.S. Secretary of the Navy (Executive Order 9875 - July 18, 1947) and appointed a High Commissioner who was vested with all powers of the government and jurisdiction over the Trust Territory, yet subject to the direction of the Secretary. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 11 (1980).

In 1951, the administrative responsibilities were transferred to the Department of the Interior and headed by the Secretary of the Interior. By then, 116 municipalities had been established, which took the form of either elective or traditional type of government, depending on the circumstances of the particular municipality. Eventually, six district legislatures were created: Palau (1955), Truk (1957), Ponape (1958), Marshalls (1958), Yap (1959), and Marianas (1962). Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 11 n. 43 (1980). A judicial system was established in 1952, consisting of a High Court, which was presided over by a Chief Justice (appointed by the Secretary of the Interior); and a District Court for each Administrative

District. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 11 (1980).

A territorial-wide legislative body emerged in 1964, with the evolution of the elected Congress of Micronesia. The Congress was a bicameral legislature, consisting of a House of Delegates (12 members: 2 from each of the 6 Districts: term - 4 years), and a General Assembly (21 members: 2 or more Assemblymen from each District, according to population; term - 2 years). The legislature operated in a manner similar to the U.S. House and Senate, with a bill originating in either the House or the Assembly, and then becoming amended, altered, or rejected. Passage of a bill required a majority of both the House and the Assembly. The High Commissioner (who retained Executive Power) could submit proposed legislation, and could also veto bills passed by the legislature. The High Commissioner (with the approval of the Secretary of the Interior) could also declare a bill "passed" if he designated it as urgent, even though the legislature had failed to pass it. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 12-13 (1980).

This bicameral legislature was authorized to legislate only on subjects of local application, and was prohibited from passing any bills which were inconsistent with Executive Orders of the U.S. President and the Secretary of the Interior; U.S. Treaties and International Agreements; U.S. laws applicable in the Trust Territory; or the Bill of Rights of the Trust Territory Code. The legislature was also forbidden to tax property held by the United States, and to apply a higher tax to property held by nonresidents of the Trust Territory. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, pp. 12-13 (1980).

A major issue considered by the 1965 legislature was the Trust Territory's right to self-determination as stated in Article 6 of the Trusteeship Agreement. In 1969, the Congress of Micronesia established a status commission, which recommended that the Trust Territory should become either self-governing in Free Association with the United States, or completely independent. Issue on the Trust Territory of the Pacific Islands, U.N. Department Political Affairs, p. 14 (1980).

Talks with the United States ensued at a slow pace, and seven years later, in 1976, the United States entered into a separate Commonwealth agreement with the Northern Marianas, while negotiations continued with the rest of the Trust Territory. In 1978 (by then, the Trust Territory had been divided into 4 units: Northern Marianas, Federated States of Micronesia (FSM), Republic of the Marshall Islands (RMI), and Palau), Palau, the FSM, and the RMI agreed to the "Statement of Agreed Principles for Free Association," which provided that the "Micronesians" (whom the people of the Trust Territory had become known as) shall enjoy full internal self-government, but with the United States to maintain full authority and responsibility for security and defense for at least 15 years (subject to renegotiation thereafter). Although either side could unilaterally terminate the Compact Agreement, if it is terminated by any party other than the United States, or if terminated by mutual consent, the United States would no longer be obligated to provide the same amount of economic assistance previously agreed upon. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 14 (1980).

That same year, 1978, the Congress of Micronesia was abolished by the Secretary of the Interior. This was done subsequent to the division of the Trust Territory into 4 Divisions (Palau, FSM, Northern Marianas, and the RMI). Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 13 (1980).

To prepare for the assumption of self-government, each of the remaining districts - Palau, FSM, and the RMI established their own constitutional governments. Draft Environmental Impact Statement for the Compact of Free Association, Office for Micronesian Status Negotiations, p. 21 (1984). The RMI adopted its own Constitution in 1978, which was to take effect on May 1, 1979. The Constitution provided for a modified Parliamentary system of government. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 22 (1980).

Under the RMI Constitution, the legislative authority became vested in the Nitijela, which replaced the now abolished Congress of Micronesia, at the District level. The Nitijela was given full legislative authority within its jurisdiction, but subject to certain limitations which preserved the responsibilities of the United States under the Trusteeship

Agreement. Draft Environmental Impact Statement for the Compact of Free Association, Office for Micronesian Status Negotiations, p. 21 (1984). The Nitijela consists of 33 members, who are elected from electoral districts which are apportioned by population. The members themselves elect a speaker, who presides over the Nitijela. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 22 (1980).

Most of the executive authority previously exercised by the High Commissioner at the territory-wide level has now become vested in the Cabinet. Draft Environmental Impact Statement for the Compact of Free Association, Office for Micronesian Status Negotiations, p. 22 (1984). The Cabinet consists of a President (Head of State), who is elected by a majority vote of the Nitijela, and ten Ministers (Finance, Foreign Affairs, Resource and Development, Transport and Communication, Social Services, Public Works, Education, Health Services, Justice, and Interior and Outer Island Affairs) who are appointed by the President. The Ministers must be members of the Nitijela. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 22 (1980); First Five Year Development Plan, 1985-1989, Rephased for 1986-1987 - 1990/91, at p. 6.

The Constitution also provides for a Council of Iroij, which primarily has consultative duties. Pacific Islands Yearbook, (Ed.) John Carter, 15th ed. p. 439 (1984, reprinted 1986). The Council consists of 12 members (5 are iroij laplaps from the Ralik chain, and 7 are iroij laplaps from the Ratak chain). The Republic of the Marshall Islands: An Emerging Nation, Development Through Self-Reliance, Inc. p. 49 (1986). The Council's function is to consider matters concerning the RMI, and then may express their opinions to the Cabinet. The members may also request the reconsideration of any bill affecting: customary law/traditional practice, land tenure, or any related matter which has been adopted on third reading by the Nitijela. Constitution of the Republic of the Marshall Islands, sec. 2, p. 11 (1979).

There are also 24 local governments consisting of: council, mayor, appointed officials, and a police force. The right to local government is guaranteed in the Constitution. These often share responsibilities with the central government. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands pp. 6-7 (1987).

The RMI Constitution also provides for a High Court, with unlimited original jurisdiction to hear civil and criminal cases, and which as appellate jurisdiction over cases originally filed in subordinate courts. A Supreme Court serves as the final Court of Appeals. The Chief Justice in both the High Court and the Supreme Court are appointed by the Cabinet (with the approval of the Nitijela). Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 22 (1980).

2. <u>The Compact of Free Association</u>

October 21, 1986 marked the beginning of the Compact of Free Association between the United States and the RMI. What the Compact Agreement entails is essentially: sizable United States economic aid to the RMI in exchange for long-term use of the United States missile testing range at Kwajalein Atoll. <u>Marshall Islands Guidebook</u>, Marshall Islands, pp. 36A (1986).

Under the Compact, the RMI would have full capacity to conduct it's own internal and foreign affairs including: matters relating to the law of the sea and the marine resources; foreign commercial, diplomatic, economic, and trade relations; and international treaties and agreements. <u>Issue on the Trust Territory of the Pacific Islands</u>, U.N. Department of Political Affairs, p. 26 (1980). However, the United States would retain full authority over security and defense in the RMI. <u>Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers</u>, Steven C. Smith, p. 50 (1986).

The RMI will receive an estimated $750 million during the duration of the Compact period, including a $10 million development fund to encourage and attract foreign investors for joint venture business activity; technicial assistance from numerous federal agencies at the request of the RMI; nuclear clean-up of the Bikini atoll; a $150 million fund to settle claims of the Marshallese arising from U.S. nuclear testing and to provide them with continuing medical treatment.

Marshall Islands Guidebook, Marshall Islands, p. 36A (1986). According to the Compact, the purpose of the United States economic assistance is to aid Micronesian governments in advancing the economic self-sufficiency of their people. Past Achievements and Future Possibilities: A Conference on Economic Development in Micronesia, The Micronesian Seminar, p. 63 (1984). During the 15 year Compact period, the funding will be graduated, and will decrease after the fifth and tenth years. It is expected that 40% of the designated funds will go towards economic development, including: infrastructure programs, maintenance, and other revenue gathering projects. The United States will also continue to provide other unrestricted grants and Federal program assistance, including: postal service, FAA service, CAB service, weather prediction service, and Federal Emergency Management Agency for assistance (for disasters). Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 51 (1986). But whether or not the United States funding will actually promote self-reliance in Micronesia will depend on how the government leaders decide to utilize the economic assistance. Past Achievements and Future Possibilities: A Conference on Economic Development in Micronesia, The Micronesian Seminar, p. 63 (1984). Previously, grants have been devoted primarily towards social services and welfare programs instead of development of the infrastructure and income-producing activities that were arguably intended. Some of the expenditures which were allotted for capital improvements were used to encourage consumption of imported goods. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 31 (1980). There also have been allegations of fraud and mismanagement, together with calls for legislation to ensure resource accountability. Issue on the Trust Territory of the Pacific Islands, U.N. Department of Political Affairs, p. 31 (1980). Therefore, the United States government now requires a development plan, periodic audits and annual reports on plan implementation, under the Compact Agreement. Past Achievements and Future Possibilities: A Conference on Economic Development in Micronesia, The Micronesian Seminar, pp. 65-66 (1984).

As noted above, the United States agrees to defend the RMI against outside forces to the same degree as U.S. citizens are defended. In return, the United States has the option to foreclose access or use of the RMI by any military forces of a third country. The RMI also agrees to refrain from actions which the United States determines to be imcompatible with its obligation to defend the RMI. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 51 (1986).

The Compact also allows the Marshallese to freely enter the United States to take employment without special authorization. Likewise, Americans are also allowed to enter the Marshall Islands for employment, but subject to local laws. Marshall Islands Guidebook, Marshall Islands, p. 36A (1986).

Finally, under the Compact, the United States will recognize Micronesia's marine sovereignty: Micronesia's right to harvest, regulate, and exploit living and nonliving resources from the sea, as recognized by international law. Therefore, the Micronesians could arguably negotiate and implement fishery and ocean mining agreements. Past Achievements and Future Possibilities: A Conference on Economic Development in Micronesia, The Micronesian Seminar, p. 88 (1984).

As also noted above, the Compact Agreement can be unilaterally terminated by either party. If terminated by the RMI, or by mutual consent, the U.S. will not be obligated to provide the same amount of economic assistance. However, the security and defense agreements would still remain in force. Issue on the Trust Territory of the Pacific Islands, U.N. Department of the Political Affairs, p. 28 (1980).

F. Ports

Majuro has an ocean port lying at 7 deg. 08' N. Long. and 171 deg. 22' E. Lat. The entrance channel is 333.5m. wide, 22.32km. long, and 34m. deep. The commercial dock is 63m. long, and there are 4 warehouses available for use. There is also one 30t crawler and one 25t mobile crane available. Lloyd's Ports of the World, Colchester, Essex, UK: Lloyd's London Press, p. 419 (1987). The port, however, lacks the capability of efficient and secure handling and storage of international cargo. The port also requires a new fender system. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands, p. 347.

The current five year development plan includes a project to correct the faulty fender system and to repair damages to the dock, as well as the construction of a container freight service yard to accommodate several hundred containers. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands p. 354 (1984). Construction appears presently to be underway.

G. Transportation

Land transportation systems are currently found principally on Majuro and Ebeye. Majuro has the longest paved road - 30 miles - in all of Micronesia. The other islands and atolls use cleared paths as roads for automobiles (which are few in number). Republic of the Marshall Islands: An Emerging Nation: Overview for Peace Corps Volunteers, Steven C. Smith, p. 42 (1986).

The RMI plans to upgrade the road program in the 1985-1989 plan period by: constructing eight box culverts to alleviate the problem of sea water flooding; resealing the road in Majuro; constructing curbs and gutters on that road; and improving drainage. The plan also calls for improving traffic congestion and safety by: installing road safety devices; conducting driver education courses; requiring safety checks for automobiles; and checking street lights. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands pp. 338-342 (1984).

Since all of the islands/atolls are surrounded by water, it would be only natural that water passage is the most important mode of transportation. Republic of the Marshall Islands: An Emerging Nation: Overview for Peace Corps Volunteers, Steven C. Smith, p. 42 (1986). Currently, an inter-island field trip service provides transportation for both cargo and passengers between the outer islands. Draft Environmental Impact Statement for the Compact of Free Association, Office for Micronesian Status Negotiations, pp. 34-35 (1984). But this service is not operated on a regular basis due to diversion for medical emergencies, frequent breakdowns, and lack of outer island load centers. The current plan hopes to remedy this problem by purchasing two landing crafts, which are much more economical than the micro-ships currently being used. Also in the plan are an island load center project, and an intra-atoll lagoon boat project. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands pp. 351-352 (1984).

Additionally, shipping services are provided by eight shipping companies: United Micronesia Development Association (Tiger Line), Saipan Shipping Company, Palau Shippping Company, and Oceania Line, Inc. (all of which are Micronesian-owned and operated companies); and Matson Navigation, Daiwa Navigation, Nauru Pacific Line, and Philippines, Micronesia and Orient Navigation Company (all owned and operated by foreign companies). Draft Environmental Impact Statement for the Compact of Free

Association, Office for Micronesian Status Negotiations, pp. 34-35 (1984).

Air transportation is also available, and provided by: Air Nauru, Air Tungaru, Continental Air Micronesia, and South Pacific Island Airways. They all service the Majuro International Airport. Pacific Business Guide, Pacific (Saffron Walden, Essex), p. 119 (1984). Additionally, Air Marshall Islands (a government corporation) provides passenger, mail, and some cargo service to the outer islands which have airstrips. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands p. 362 (1984).

H. Energy

There are electricity generating plants on Majuro, Ebeye, and Jaluit of the RMI. Just about all of the electricity generated at the plants are generated by imported petroleum fuels. Currently the biggest problem is the dependency on imported fuel. The plant on Majuro is a 14 megawatt plant, built to run on "black oil." It is operated by a joint government - private company. Costs for power was $0.088 per kilowatt in 1984. The 1985-1989 Plan has, budgeted $26 million for energy and electric projects, most of which will go toward building a power/desalination plant in Ebeye. The Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, pp. 47-49 (1986).

I. Water

Fresh water in the RMI appears to be sufficient, and will probably be adequate for the ever growing population. It is supplied by water catchments, and wells which tap the fresh water lenses. Marshall Islands National Development Program 1981-1995, Marshall Islands Political Status Commission Special Planning Committee, p. 69 (1981). There is currently a public water system operating in Majuro which consists of: a water treatment plant; 11 miles of water mains; a 17 million gallon municipal storage facility; and a further 1.5 million catchment at the airport. Another 12 million gallon reservoir is planned during the 1985-1989 period. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 48 (1986).

J. Sewage and Garbage

Garbage will create a serious problem in the future because of the scarcity of land in Micronesia generally. Currently, it does not present a problem because the land fill areas for garbage dumps are removed from the population centers. Marshall Islands National Development Program 1981-1995, Marshall Islands Political Status Commission Special Planning Committee, p. 70 (1981).

Sewage disposal presents a far more serious problem. This is reflected by the prevalence of gastro-intestinal diseases, which ranks as RMI's third leading cause of illness and death. Marshall Islands National Development Program 1981-1995, Marshall Islands Political Status Commission Special Planning Committee, p. 70 (1981). However, a Majuro sewer project that began in late 1986 is now nearly completed. Marshall Islands Guidebook, Marshall Islands, p. 3 (1986).

K. - Communications

Telecommunication is accomplished in the RMI by: telephone, satellite, and high frequency radio links. The RMI is also linked to the rest of the world by telex and cable services. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 44 (1986).

Although intra-island communication is done by telephone, only 2% of the households, have a telephone. Service is often unreliable, and there are often complaints of poor transmission. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 44 (1986).

Inter-island communication between Majuro and outer islands is done via single side band high frequency radio. Since these calls can be heard by everyone on the system, there is no privacy in such a conversation. There is currently a public service high frequency system, which is primarily used for relaying government, health care, or emergency messages. Also, the local AM radio stations often broadcast messages to the public, or to individuals. Republic of the Marshall Islands: An

Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 44 (1986).

International telecommunication is provided on the RMI by 10 satellite circuits (6 to Hawaiian Telephone and beyond; 1 to Japan; 1 for the ITT telex and telegram; 1 to Saipan). Although the calls are easy to make, they are expensive. Telephone and telex signals are transmitted by 10-meter "standard B" earth stations which are owned and operated by COMSAT. Terminals are located only in Majuro and Ebeye. The satellites that receive and transmit the signals orbit 22,300 miles above the equator and are a part of the International Telecommunications Satellite Organization's global network. Satellite traffic is then routed to the switching facilities in Hawaii and then continues via a satellite hop or undersea cable. Currently, $11.3 million has been budgeted for the 1985-89 development period to improve the telecommunication system. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, pp. 43-44 (1986).

II. PROPERTY LAWS

A. Land Tenure in the Marshall Islands

Land is a scarce resource in the RMI, and therefore plays an important role in society. Land ownership in the RMI is limited to RMI citizens, and the customary land tenure system (which is similar to the feudal system) currently remains in effect under the Trust Territory Code, as there are virtually no statutes dealing with real property. Therefore, in the absence of such laws, customary law is enforced. Marshallese Property Law: A Clash Between Native Customs and Western Law (California State Bar Journal v. 52, No. 6), Thomas Paine Dunlap, p. 500 (Nov./Dec. 1977).

The Marshallese do not "own" land on an individual basis, in fee simple, as is customary in Europe and North America. Land is held by the entire clan, with the family members each holding a generally nontransferable interest in the entire family parcel. This lineage "holding" consists of four separate interests: dri-jerbal, alab, iroij erik, and iroij lablab. Individual parcels of the lineage land are assigned to clan members who maintain dri-jerbal rights, as workers of the land. They are responsible for cultivating the land and for paying a tribute to the alab from the proceeds. The alab (clan head) is responsible for assigning parcles of land to the dri-jerbal to harvest. The iroij erik (sub-chief) hears any dispute which arise between the worker and the clan head. Also, no permanent disposition of land can be made without his consent. He also receives proceeds from the cultivated land. Above the iroij erik is the iroij lablab (chief). He is not required to be a member of the clan. The chief may have obtained his interest through war victories. He has the final word on land interest distribution, and is also the prime dispute resolver between other interest holders. Like the clan head and the sub-chief, the chief receives a portion of the proceeds from the land. Marshallese Property Law: A Clash Between Native Customs and

Western Law (California State Bar Journal v. 52, No. 6), Thomas Paine Dunlap, p. 501 (Nov./Dec. 1977).

Generally, inheritance of lineal lands is matrilineal. For example, if A (a female) is the founder of a lineage, all of her children may become a clan head. After the death of all of A's children, the eldest child of A's eldest daughter becomes the clan head and so forth. The children of A's male children, however, become excluded. Marshallese Property Law: A Clash Between Native Customs and Western Law (California State Bar Journal v. 52, No. 6), Thomas Paine Dunlap, p. 502 (Nov./Dec. 1977).

Although an interest in lineal land is inherited, a clan member can become divested of this right if he fails to fulfill his obligation. Divestment of this interest, however, could only occur with the consent of the chief, and must be made for good cause. Marshallese Property Law: A Clash Between Native Customs and Western Law (California State Bar Journal v. 52, No. 6), Thomas Paine Dunlap, pp. 502-503 (Nov./Dec. 1977).

Since lineage land belongs to the entire clan, it may not be permanently alienated without the consent of all interest holders. An interest holder may not assign his own rights without the consent of the other holders. Marshallese Property Law: A Clash Between Native Customs and Western Law (California State Bar Journal v. 52, No. 6), Thomas Paine Dunlap, p. 503 (Nov./Dec. 1977). Therefore, the lease or sale of the land requires the consent of all involved. This can represent a virtually insurmountable obstacle for foreign business organizations attempting large-scale, long-term ventures dependent upon a secure real property interest for purposes of financing and business planning.

Besides sale and leasing of land, there are a few other traditional methods of alienation which results in new lineages. Ninnin land is that which a male worker gives to his children contrary to the usual matrilineal custom. This gift can only occur, however, with the unanimous consent of the clan, the head, and the chief. This new land right can then be passed matrilineally, or again as ninnin in the future. Kotra (Mo Land) is land in which only the chief owns all interests, with no one else having any vested rights. The workers are strictly paid a wage for working the land. Kithe is land which a male gives to his wife when they become married. This gift, like ninnin, requires unanimous consent of the rest of the clan, and the chief. The right of succession usually then becomes vested in the wife's lineage. Marshallese Property Law: A Clash Between Native Customs and Western Law (California State Bar Journal v. 52, No. 6), Thomas Paine Dunlap, p. 504 (Nov./Dec. 1977).

Some of the Marshallese citizens transfer their interests in land by will. However, this too is subject to the consent of the chief, just as an inter vivos gift of land would be. The chief is required to follow the normal customary standard and may only depart from the standard for good cause. Marshallese Property Law: A Clash Between Native Customs and Western Law (California State Bar Journal v. 52, No. 6), Thomas Paine Dunlap, p. 505 (Nov./Dec. 1977).

B. Leasing Land in the Marshall Islands

Although RMI laws restrict land ownership to RMI citizens, noncitizens and noncitizen corporations may lease public or private lands for commercial purposes and for residential purposes connected with the business. Before the land can be leased, a business permit must be obtained, and the High Commissioner must approve of the lease. Invest in Micronesia: Guide to Laws and Procedures for Investors in the Trust Territory of the Pacific Islands, High Commissioner, Trust Territory of the Pacific Islands, p. 13 (1978).

A lease for private land is often both difficult to obtain, and time consuming because of the customary laws discussed above. Negotiation of the terms and conditions of private leases are the responsibility of the parties involved, but subject to District regulations. Moreover, as noted in the previous section, security of leasehold tenure is difficult if not impossible to ascertain under the current systems as there appears to be no central registry setting out with certainty who holds what interests in land. Therefore it is extremely difficult to ascertain - as one must under customary law - who one's lessors are.

Rental rates for public and private land are calculated in the same manner. It is usually based on a percentage per year (usually 7%) return to the owner on the appraised or negotiated value of the land. However, in the case of a major business which has significant intrinsic or extrinsic value, this calculated fixed minimum rental amount is often credited against a negotiated percentage of the gross receipts. Invest in Micronesia: Guide to Laws and Procedures for Investors in the Trust Territory of the Pacific Islands, High Commissioner, Trust Territory of the Pacific Islands, p. 13 (1978).

C. Water Zones

In 1984, the Nitijela of the RMI enacted a statutory scheme for internal water, archipelagic water, territorial sea, exclusive economic zone, and contiguous zone in the Republic. The provisions, however, are to be read subject to the provisions of any treaty or other international obligation which is finally accepted by RMI and approved by the Nitijela. P.L. 1984-25, Nitijela of the Marshall Islands (1984).

Under the Act, internal water is all the water on the landward side of the baseline from which the breadth of the territorial sea is measured; and where closing lines are drawn, the water inland off the closing lines to the extent that they are outside the baseline. Archipelagic water (if any) comprises all areas of sea which is contained within the baselines (baselines are determined by the Cabinet in accordance with the rules of international law). Territorial seas are those areas of the sea which are within 12 nautical miles from the baseline of the RMI. The sovereignty of the RMI extends beyond its land area, over internal waters, archipelagic waters, and the territorial seas, and includes the airspace over them, the seabed and subsoil under them, and the resources contained therein. P.L. 1984-25, Nitijela of the Marshall Islands (1984).

The contiguous zones are the areas of the sea within 24 nautical miles seaward from the baseline from which the breadth of the territorial sea is measured. Within the contiguous zone, the RMI has all rights which are necessary to: prevent infringement of customs, fiscal immigration, sanitary laws, and regulations within the territory; and to punish such infringement. P.L. 1984-25, Nitijela of the Marshall Islands (1984).

The exclusive economic zones (EEZ) are the areas of the sea which have as their inner limits, the outer limits of the territorial sea (12 nautical miles from the baseline). The zone has as its outer limits an area of 200 nautical miles seaward from the baselines from which the breadth of the territorial sea is measured. Within this zone, the RMI has sovereign rights for the purpose of exploring, exploiting, conserving, and managing the natural resources of the seabed, subsoil, and waters; and with regard to other activities for economic exploitation/exploration of the zone (i.e., energy from water currents). In addition, the RMI has whatever other rights which are conferred or recognized by international law. P.L. 1984-25, Nitijela of the Marshall Islands (1984). Currently, there is no effective enforcement of the EEZ. However, the 1985-1989 Plan indicates the RMI's intention to purchase two patrol boats to police the EEZ. First Five Year Development Plan 1985-1989, Nitijela of the Republic of the Marshall Islands, p. 355 (1984).

The Act also gives the Cabinet the power to make regulations (in accordance with the rules of international law) to: regulate scientific research within the EEZ; to regulate the exploration/exploitation of the EEZ for the production of energy and other economic purposes; regulate the construction, operation and use of artificial islands, and structures within the EEZ; prescribe measures for the protection of the marine environment of the EEZ; and to provide for such other matters as are necessary to give effect to the rights and obligations of the RMI in relation to the EEZ. P.L. 1984-25, Nitijela of the Marshall Islands (1984).

The Nitijela has also established a Marshall Islands Maritime Authority (MIMA) to regulate economic use of the RMI's waters. Besides acting as agent for fishing fleets, MIMA issues fishing and mineral exploration permits, certificates of seaworthiness and proficiency, regulates the use of port facilities, and is responsible for the maintenance of navigational bids. First Five Year Development Plan, Nitijela of the Republic of the Marshall Islands, p. 346 (1984).

So far, preliminary surveys have revealed the presence of large deposits of manganese nodules within the 200 mile EEZ. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 47 (1986). Therefore, under this Act, the RMI would be entitled to regulate exploitation of such minerals. More surveys are planned for the 1985-1989 plan period. Republic of the Marshall Islands: An Emerging Nation: An Overview for Peace Corps Volunteers, Steven C. Smith, p. 47 (1986). See Part II of ths report for a detailed explanation of the effect of these laws and policies on the extraction of crusts from waters under RMI's control.

III. LAND USE LAWS IN THE MARSHALL ISLANDS

There are several land use and planning laws which would presently affect the way in which manganese cursts could be processed in a large industrial facility in the RMI. None of these, individually or collectively, are as prohibitive as the previously discussed difficulties with security of land tenure under RMI's traditional ways of holding interests in real property.

A. Land Planning Act

The Land Planning Act (51 TTC chap. 1) establishes district land planning commissions, provides for the development of comprehensive planning programs, and establishes regulations for the protection and promotion of public health, safety, and general welfare within the particular district. Its goal is to encourage the most appropriate use of land, to provide open space, prevent undue population concentration, to conserve natural environment, and to assure adequate provisions for facilities and utilities. 51 TTC sec. 2 (1980). It is the responsibility of the commission to prepare and recommend for adoption by the legislature a proposed master plan; subsidiary plans; development programs; and land use control laws that are proper for implementing the plan. 51 TTC sec. 5 (1980).

In implementing the master plan, the Nitijela may enact zoning and land use laws for the master plan area in order to loosen congestion; secure safety; promote health and welfare; to provide adequate light and air; to avoid overcrowding; to facilitate adequate transportation, water, sewage, schools and parks; to protect real property value; and to safeguard and enhance the master plan area. The zoning law shall conform to and shall implement the master plan. Use zones (which appear to be continuances from the Trust Territory Code) are: Residential-1 (low density single family); Residential-2 (medium density single family); Residential-3 (multi-family); Residential-Commercial (mixed); Commercial; Resort; Transportation, Industrial-1 (warehousing and limited commercial); Industrial-2 (offensive industrial uses); Public; Village; Agriculture; Conservation; Watershed; Historic Preservation; Planned Development; and Floating Zone. Land is not allowed to be used in any way unless it is in conformity with the master plan. 51 TTC 7 (1980).

The Nitijela passed an additional planning act in 1987 (P.L. 1987-8, Planning and Zoning Act 1987) adding to the powers of the planning commissions, the Chief Planner, and local planning offices. First, both the planning commissions and planning offices are made mandatory at local levels (ss. 4.1 and 6.1). While the commissions are to be advisory to the council and execute all its land use and planning policies (5.2), it is composed primarily of the elected mayor and members of council (4.2). The mandatory planning office must have a planning officer, whose duties also appear to be to carry out and execute all matters relating to planning and zoning prescribed by the ordinances of the council as well as to grant building and construction permits. (7.4.)

In the absence of such mandatory commissions and if a local council neglects to "make ordinances for proper planning and zoning as contemplated under this Act...the Minister may appoint the Government Chief Planner to perform all or any of the functions and duties conferred on the Planning Commission or the local government under this Act." (7.1.) Among the duties specifically delegable by the Minister are the powers to make plans and zoning regulations. However, the regulations so made are effective only after the national legislature - the Nitijela - approves them. (7.2 and 7.3.) Among the land use regulations which each local government is specifically required to pass are those requiring a building permit from the district commission for any building, the placement of all new buildings, and providing for the adequacy of catchment areas for a supply of water for every building and industry. (9.1(a)-(c).) Suggested zone classifications for each district ordinance are residential, commercial, industrial, resort, public and watershed. (12.1.) The industrial zone is to provide not only for infrastructure but is specifically directed to be located away from residential and commercial areas. (12.1(c).) Without a Certificate of Conformity from either the appropriate local government agency or the Government Chief Planner, certifying compliance with the applicable zoning ordinances, occupancy of any building is an offense punishable by fine. (16.1 and 16.2.) However, by the terms of the Act, only Majuro and Kwajalein are subject to its provisions unless and until the Minister for Planning declares it applicable to other local government councils. (s. 23 and s. 10.) So far, there is no zoning ordinance for either local government authorized to undertake local zoning, though Majuro is seeking advice on how to proceed. Interview with Mayor Kabua, June, 1988, in Majuro.

It is perhaps worth noting that the Constitution of the RMI specifically guarantees to the people of the Marshalls the right to local government (Articles IX and XIII) but the "municipal code" enacted by the legislature (Local Government Act of 1980, P.L. 1981-2) first requires that each local government adopt its own "constitution" which is subject to approval and amendment by the Minister for Local Government matters. (s. 9 et seq.) The boundaries of local governments are particularly reviewable by the said Minister, but, other things being equal, the boundaries extend seaward for a distance of 5 miles. (Constitution, Art. IX.) There are 24 local government councils in the RMI, which are aided in their administration by a collection of model ordinances, procedures and memoranda together with summaries of applicable laws all provided by the Department of Interior and Outer Island Affairs. (Interview with Will Allan, Internal Affairs, June 28, 1988, in Majuro.)

B. The Master Plan for Majuro

While the First Five Year Development Plan, 1985-1989 (rev'd, 1986-87 - 1990-91) contains a few elements of land master planning in its 400+ pages, it is essentially an economic plan. There are, to be sure, a few pages on environmental protection, physical planning (Ch. 19) and manganese crust mining (Ch. 18). The comprehensive land use development plan noted in the Development Plan (at p. 330) appears to be mainly a collection of models and was not completed in a form which would serve as a comprehensive guide for land use decisions at the time of our last site visit in 1988. As noted in the previous section on land use controls, the 1987 Planning and Zoning Act (Bill,#98) has not yet been implemented, and local governments in the RMI - including Majuro - are in the early stages of implementation through zoning. (Interview/Mayor Kabua, June, 1988, in Majuro.) So far, we could find no existing zoning ordinance. Hence, a brief description of the old plan follows.

The final submission of the Master Plan for Majuro (islands of Darrit, Uliga, and Dalap) took place in November, 1968. Although the entire RMI is 70 square miles, Majuro makes up a mere 3.5 square miles. Therefore, to the thousands who make their home there, land is a precious commodity. This is a significant factor that was taken into consideration when the master plan was made. Another important factor is that Majuro is strategically located - it is the eastern gateway to Micronesia. Therefore, it is the entry point for passengers and cargo destined for other parts of the Trust Territory. Summary Plan for Majuro, Hawaii Architects and Engineers, Inc., pp. 4-6 (1968).

The Plan proposed: that an intercontinental airfield be developed in Majuro; that docking and harbor facilities be considerably expanded to accommodate large ships, a small craft harbor, and all warehousing and open storage needs; that some of the streets be realigned, all streets paved, and sidewalks constructed; that Darrit remain as a low-density residential community; that high-density residential areas be developed in Uliga and Dalap; that a compact town center be developed adjacent to the harbor; that a resort complex be located in Dalap; that industrial areas be established near the dock and airfield; that ten nursery, four elementary, two middle, and one high school be constructed; that recreation facilities be developed; and that adequate water, power, and sewer facilities be provided. Summary Plan for Majuro, Hawaii Architects and Engineers, Inc. (1968).

The Master Plan also includes land use provisions, which: establish locations and densities for residential development; designates areas for orderly growth of commercial, industrial and resort activities; and allocates land for agricultural use. The plan allows for a town center in Uliga, which should include the business district, dock, harbor, warehouses, private industry, civic center, central park, recreation facilities, school, churches, and housing. However, with the total land area of Uliga being only 505 acres, the plan allows only 60 acres for industrial use. Summary Plan for Majuro, Hawaii Architects and Engineers, Inc., p. 16 (1968). The area needed for a manganese nodule processing plant alone exceeds this zoning allotment.

IV. ENVIRONMENTAL LAWS

Section 161(b) of the Compact of Free Association obligates the RMI to develop standards for environmental protection which are substantively similar to that of the United States. Draft Environmental Impact Statement for the Compact of Free Association, Office for Micronesian Status negotiations, p. 68 (1984). Prior to 1984, the Trust Territory Environmental Protection Board (TTEPB) covered environmental matters in the RMI. However, an Act was drafted to provide for an Environmental Protection Authority. Five Year Plan, at 332. South Pacific Regional Environmental Program: Coastal and Inland Water Quality In the South Pacific, South Pacific Commission, p. 46 (1984). The National Environmental Protection Act of 1984 (P.L. 1984-31) provides for the establishment of a National Environmental Protection Authority for the protection and management of the environment. The authority is a corporate body, whose primary object is the preservation and improvement of the quality of the environment. It consists of a chairman, and four other members (2 with adequate qualifications and experience in the subject of environment; 1 with adequate skill and experience in environmental management; 1 representative of the general public). The chairman and the four members will be appointed by the RMI President, in consultation with the Minister in charge of health services. P.L. 1984-31, Nitijela of the Marshall Islands (1984).

The authority functions to: administer the provisions of the act; recommend to the Minister, national environmental policy and criteria for the protection of the environment; undertake investigations as to causes, extent, nature, and prevention of pollution; conduct research related to any aspect of envirommental degradation; specify standards, norms and criteria for the protection and maintenance of the environment; publish reports with respect to environmental protection; specify methods to be adopted in carrying out tests; provide information to the public regarding improvement of the environment; establish liaison with other countries with respect to environmental protection; advise the Minister as to the need for any new legislation; promote long-range planning in environmental protection; to promote methods of converting residues; and to classify land, water and air according to present and future uses. P.L. 1984-31, Nitijela of the Marshall Islands (1984).

To accomplish their objectives, the authority is empowered to: make regulations with respect to primary and secondary drinking water, pollutants, use of pesticides and other harmful chemicals, hazardous waste, and historical preservation; acquire land for the purpose of its own use, conservation or rehabilitation; acquire land-vehicle, seacraft, aircraft or other machinery to carry out its duties, or if an emergency, to requisition the machinery; obtain advice/services of any person in the RMI with or without payment of a fee; make contracts for goods and services which are necessary to perform its functions; expend money to carry out its duties; borrow money (with the Minister's approval) as it requires for its purposes; accept grants or other monetary assistance; detect and prosecute offenses in contravention of the regulations of this act; whenever necessary and when duly authorized by the Authority or the Court may enter an establishment to detect offenses in contravention of this act. P.L. 1984-31, Nitijela of the Marshall Islands (1984).

Section 23 of the act provides for regulations to be made to require a permit for the discharge of a pollutant into or on the air, land or water, or the conduction of an activity which results in the discharge of a pollutant into or on the air, land or water. Regulations will be made for the issuing, modification, suspension, revocation and termination of the required permit, along with regulations providing for the posting of appropriate bonds/securities for compliance. P.L. 1984-31, Nitijela of the Marshall Islands (1984). So far, the Authority is in preliminary stages of development and only the EIS portion of its legislative charge has been implemented. Interview with Will Swain, EPA, June, 1988, Majuro.

Under Article 13 (Mining and Coastal Erosion) of the Convention for the Protection of the Natural Resources and Environment of the South Pacific Region of 1986, the RMI is responsible to take all appropriate measures to prevent, reduce, and control environmental damage within the 200 nautical mile zone established in accordance with international law. This provision includes mining activities. Currently, there are not presently any mining regulations in the Trust Territory Code, or the Marshall Islands Code. Interviews with Will Swain, EPA, June, 1988, Majuro. However, since the end of World War II, U.S. mining regulations have been applied in Micronesia. Under these regulations, mineral rights to all natural resources beneath the land surface belong to the land owner. Trust Territory of the Pacific Islands Five Year Indicative Development Plan 1976-1981, Congress of Micronesia, p. 152 (1976). Under the RMI land tenure system, mining rights would therefore belong to all the interest holders in the land. Thus, before a mining company could obtain a lease, it must first get the consent of all interest holders. (See previous section on traditional property rights and difficulties with security of tenure, discussed therein.)

However, a manganese nodule processor is more concerned with offshore mining regulations. According to the 1976-1981 Trust Territory of the Pacific Island Five Year Indicative Development Plan, permission will be given to those who are interested to undertake exploration of offshore minerals on a bid basis. Trust Territory of the Pacific Islands Five Year Indicative Development Plan 1976-1981, Congress of Micronesia, p. 152 (1976). Exploitation of RMI mineral resources (specifically including cobalt-rich manganese crusts) is a specific objective and strategy of the RMI under its Five Year Plan (see pp. 313-14).

It should also be noted that under sections 224 and 226 of the Compact, the RMI is granted access to federal funds and technical assistance to formulate and implement environmental programs. This is to ensure that the intent of both parties to the Compact, to prevent damage to the Micronesian environment and to enrich the general understanding of the natural resources, is implemented. Draft Environmental Impact Statement for the Compact of Free Association, Office for Micronesian Status Negotiations, p. 68 (1984).

V. SEA PORT CHARGES

The Sea Port Charges Act of 1983 empowers the Cabinet (rather than the Marshall Islands Development Authority) to make regulations rising reasonable charges for the use and enjoyment of sea ports. The fees must be paid into the Sea Ports Trust Fund, which will be utilized for the improvement and/or maintenance of port facilities. P.L. 1983-11, Nitijela of the Marshall Islands (1983).

VI. SUMMARY OF SELECTED COMMERCIAL REGULATIONS AND LAWS

RMI welcomes foreign investment capital as long as it will make a positive contribution toward economic development. In fact, private investment (domestic and foreign) is encouraged in Micronesia generally, with an emphasis on reducing the trade gap, stimulating production, and increasing per capita income. Invest in Micronesia: Guide to Laws and Procedures for Investors in the Trust Territory of the Pacific Islands, High Commissioner, Trust Territory of the Pacific Islands, p. 4 (1978). Investment is made simpler in the RMI since the standard currency is the U.S.

dollar. Micronesian Business News, U.S. Department of the Interior, p. 1 (Fall 1986). The summaries which follow are based on laws and reports of laws passed both during Trust Territory and Republic periods for the Marshalls and it appears to the authors that those laws which are cited are still applicable and unrepealed by the RMI Nitijela, except as noted in the following text.

Entry into the Trust Territory to establish a business appears to be relatively straightforward. As long as entrance is made via a licensed carrier, for a period of less than 30 days, and not for the purpose of seeking employment, no entry permit or U.S. visa is required. U.S. citizens merely need to show proof of citizenship. Visitors, however, are required to have received proper immunizations, a roundtrip (or onward ticket), and evidence of financial responsibility. Invest in Micronesia: Guide to Laws and Procedures for Investors in the Trust Territory of the Pacific Islands, High Commissioner, Trust Territory of the Pacific Islands, p. 4 (1978).

In keeping with the requirement that foreign investment is encouraged as long as it will make a positive contribution toward economic development, all non-citizen (a "non-citizen") is: a person who is not a RMI citizen; a person who is married to a person who is not a RMI citizen; a person who is under the age of 18 who is adopted by parents, at least one of whom is not a RMI citizen; or any company, corporation, or association in which a person who is not a RMI citizen owns any interest) investors are required to obtain a business permit prior to engaging in any business enterprise in the RMI. 33 TTC secs. 1 and 2 (1980). Under the Foreign Investors Business Permit Act (33 TTC sec. 1), the prospective investor must complete an "Application for Business Permit" (Form 997 revised). This completed form must be submitted to the Department of Resources and Development along with a nonrefundable filing fee of $100. Invest in Micronesia: Guide to Laws and Procedures for Investors in the Trust Territory of the Pacific Islands, High Commissioner, Trust Territory of the Pacific Islands, p. 4 (1978).

The application must include: name of the business; form of business organization; names of officers, directors, and proposed/existing stockholders and their citizenship; proposed site of principal office in the RMI; District in which applicant wishes to do business; purpose, scope and objective of the business; total capital anticipated to be initially invested; detailed investment analysis for the first 3 years; and any other information that the Director of Resources and Development or the board may deem necessary. The application must also contain the following proposals: the initial issuance of stock; the consideration per share of stock issued; subsequent contemplated issuance of stock; agreeing not to revalue stock shares not issued, without the permission from the Board; agreeing not to restrict the issuance/sale of stock which would be available to RMI citizens; agreeing to offer shares of stock at principal place of business in the RMI; detailing stock purchase programs for employees; proposal to establish a RMI Corporation; proposal for management participation to be allowed to RMI citizens; that employment preferences be accorded to RMI citizens; proposal for training programs for RMI citizens; proposal for wage/benefit program; proposed economic and social program that the applicant intends to implement, 33 TTC sec. 6 (1980).

The Director of Resource and Development will then review each application and request any other information which he believes will be useful to the Board. After the Board has reviewed the file, they shall undertake an investigation of the desirability of allowing the applicant to do business in the particular District. The Board will then determine whether allowing the applicant to do business would promote the economic advancement of the citizens of the particular District and the RMI. Criteria for the Board's decision include: economic need for the proposed service/activity; the degree to which such an operation will effect a net increase in exports and/or decrease imports; extent to which the operation will deplete a nonrenewable natural resource; extent of participation by the RMI citizens at the outset; degree of willingness to form a RMI Corporation in the future; willingness of the applicant to give employment preference to RMI citizens; extent to which skills required for such an enterprise is available among the RMI citizens; extent to which such an operation will contribute to economic well being of the District. In granting the permit to the applicant, the Board may also determine the conditions under which the permit may be granted. Then, if the Board determines that the permit should be granted, and if the High Commissioner approves, the permit shall be issued. 33 TTC sec. 7 (1980).

Additionally, any person, partnership, corporation, or association engaging in: importing; exporting; banking (or savings and loan); dealing securities; insurance; operation of a hotel; the practice of law, medicine, dentistry, or accounting; the operation of a commercial airline; the operation of commercial shipping; trading, travel, or commercial agency; or a small business is required to obtain a business license. P.L. 1983-20, Nitijela of the Marshall Islands (1983). This requirement will be applicable to the manganese nodule processor if he engages in export of the minerals.

Another regulation under the former Trust Territory Code which is applicable to the manganese nodule processor is Title 49 (Protection of Resident Workers Act), which deals with nonresident workers. The Congress of Micronesia determined that it was essential to a balanced and stable economy that the Trust Territory citizens be given preference in employment in occupations and industries in the then Trust Territory. 49 TTC sec. 2 (1980). Therefore, work permits are required for all skilled nonresident workers (nonskilled foreign workers are not allowed to be imported for work), and, they shall be employed only to supplement the labor force of available and qualified resident workers, and only in accordance with the regulations of the Act. 49 TTC sec. 4 (1980). To allow otherwise would defeat one of the purposes of promoting foreign investment - increasing the per capita income.

The Act established a Trust Territory employment service (within the department of resources and development). The purpose of the service is to create a system of free public employment offices in the Trust Territory for workers seeking employment, and for employers seeking workers. 49 TTC sec. 5 (1980).

Under the Act, an employer desiring to import nonresident employees faces a long series of process. First, the employer must file an application with the RMI employment service. The application must state: the place and nature of the business; number of workers desired, along with the required qualifications; wages to be paid; and date on which the workers are desired, and the district(s) in which they are desired. The employment service will then attempt to fill the available positions from a list of Trust Territory residents who had registered with the service and who are qualified for the particular positions. If the employment service is unable to fill the positions with qualified residents, they must then publicize the available job openings for a period of thirty days. The importation of nonresident workers will only be considered if the service fails to locate qualified resident workers at the end of the 30-day period. When this occurs, the Chief of the Division of Labor is notified, and he then determines whether the employment of nonresident workers will be in the best interest of the RMI. He is also empowered to determine what length of time and under what conditions the employer will be authorized to hire nonresident workers for the available positions. If the Chief decides to allow nonresident workers, a nonresident employment agreement must be entered into between the employer, and the government. The agreement will contain: a statement that the employer requires nonresident workers for immediate employment; statement of intended wages; an agreement to comply with the minimum employment conditions; period of time the nonresidents are permitted to work; a statement of the employer's responsibility for return (to home) transportation of the nonresident workers. 49 TTC sec. 8 (1980).

Additionally, before any nonresident worker is allowed entry into the Trust Territory, he must present a sworn affidavit indicating that he has a minimum of 2 years experience in the particular line of work; marital status; whether he has children; and that he had not been convicted of a felony or crime involving moral turpitude. 49 TTC sec. 8 (1980).

The employer who imports a nonresident worker shall lodge with the chief employment officer a security in cash or bond in an amount not to exceed $1000, as the chief immigration officer requires. This security shall be available to the government to defray the costs of the removal of the worker to his place of origin at the conclusion of his employment. This security will be returned if the employee eventually becomes a RMI citizen. P.L. 1983-27, Nitijela of the Marshall Islands (1983).

Setting aside the strict business license and nonresident workers' regulations that a prospective manganese nodule processor faces, there is the advantage of tax incentives that will be applicable to the foreign investor. To encourage foreign investment in the RMI, the Compact will apply the same tax exemptions that are currently being applied to American businessmen operating in other U.S. Territories and possessions. Also, contributions to nonprofit Micronesian institutions may also be deductible. Past Achievements and Future Possibilities: A Conference on Economic Development in Micronesia, The Micronesian Seminar, p. 87 (1984).

Another attractive incentive for doing business in the RMI is the low wages paid to private sector employees. The average yearly wage of Micronesians working in the private sector was $3,241. Marshall Islands Statistical Abstract, Office of Planning Statistics, p. 39 (1985).

VII. CONCLUSIONS

The legal impediments to the construction and operation of a manganese crusts processing plant are neither numerous nor onerous. This is perhaps to be expected in an emerging nation with far more interest in development of a sound economic base than in land planning and regulation and environmental protection. Moreover, the development of such a large industrial project is of such comparatively enormous size and impact that it is difficult to conceive of its proceeding without special legislative consideration by the Nitijeła and, correspondingly, a special legal, planning and environmental regime tailored expressly to govern it, provided the Nitijela is minded to permit such a development in the RMI. Such legislation would obviously supercede all local ordinances and regulations of the local governments unless it could be argued that the Constitutional provisions guaranteeing the Marshallese local government are by such laws somehow abrogated. Likewise, the Nitijela could override, supplant and otherwise supercede any previous national legislation such as the environmental laws and regulations and the national planning framework.

However, assuming these laws remain in place, it is likely that a processing plant would need to go through the environmental impact assessment process as set out in RMI's environmental laws, together with whatever air and water pollution standards the Agency eventually promulgates. Morever, while such a processing plant seems to fit well within the parameters of the Five Year Development Plan, it may not fit so well within whatever zoning Majuro eventually adopts, if any, under national zoning and planning enabling legislation (the legislation is arguably directive depending upon how one reads the provisions relating to planning commissions). Technically, Majuro must act or the national planner will act for it. However, it is worth noting that the current mayor of Majuro is the daughter of the current President of the RMI who is also a chief, and so it is presumably unlikely that such draconian measures would be undertaken by the national government against the local government of Majuro.

Of far greater significance is the traditional tenurial relationships among the Marshallese with respect to their land. There appears to be no mechanism for even the national government to transfer interests in fee simple to foreign corporations, even under traditional real property notions of eminent domain. Thus the only mechanism for an international consortium to obtain sufficient interests in land to develop such a long-term installation as a processing plant would be through leasehold, short of amending the constitution of the RMI, surely too extreme a solution even for the economic benefits of such a plant.

While it is clear the mechanism exists for the granting of such a leasehold, the traditional land tenure system with the multiple interests of multiple parties makes it extremely difficult to account for all of them so that all interested "owners" become party to the lease. Since land holdings traditionally extend a reasonable distance out into the ocean (particularly onto reefs) going offshore or on landfill does not alter the complexity of the problem of ownership. Discussions with both government, business and expatriot officials on Majuro lead the authors to conclude that this indefiniteness of ownership interests produces sufficient uncertainty with respect to the security of a leasehold that it threatens the development not only of a manganese crusts processing plant, but virtually any substantial investment in the RMI. Not only are the risks considerable for the entrepreneur, but for the lender providing developmental funds for commercial development. Indeed, there are already several instances of individuals claiming interests in leased property coming forward well after a lease is executed and claiming additional compensation in the form of rent. While this may well be the exception and represent a modest breakdown in traditional methods of resolving such disputes (such individuals are supposed to go to their chiefs with such complaints, not the lessee, according to one cabinet minister in a position to speak with authority on the subject) this is relatively cold comfort to a foreign investor and his lending institution, both of whom could end up in court over the matter, where the common law of the United States is as likely to be applied as the traditional law of the Marshallese.

It strikes the authors that there are two possible solutions to this problem of multiple interests. First, and most comprehensive, the RMI could establish a special land court to establish conclusively all interests in given (or all) parcels of land in the RMI by holding well-publicized hearings over a period of months or years. These interests would then be reduced to a certificate and that certificate recorded on an appropriate register. What is suggested is a form of the land court or torrens system of title registration which is used with mixed results in parts of the United States and, we understand, in Australia and New Zealand. Second, the national government of the RMI could theoretically take the property by eminent domain, or the leasehold interests only, and transfer the leasehold interest to the investor/developer for purposes of approved development. This is a quick-fix, and probably contrary to traditional notions of land tenure in the RMI. It is conceivably also unconstitutional. In any event, either solution would require statutory authority by means of carefully drafted legislation passed by the Nitijela.

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PART II

ECONOMIC AND PHYSICAL ASPECTS OF COBALT-RICH MANGANESE CRUST MINING AND PROCESSING IN THE MARSHALL ISLANDS

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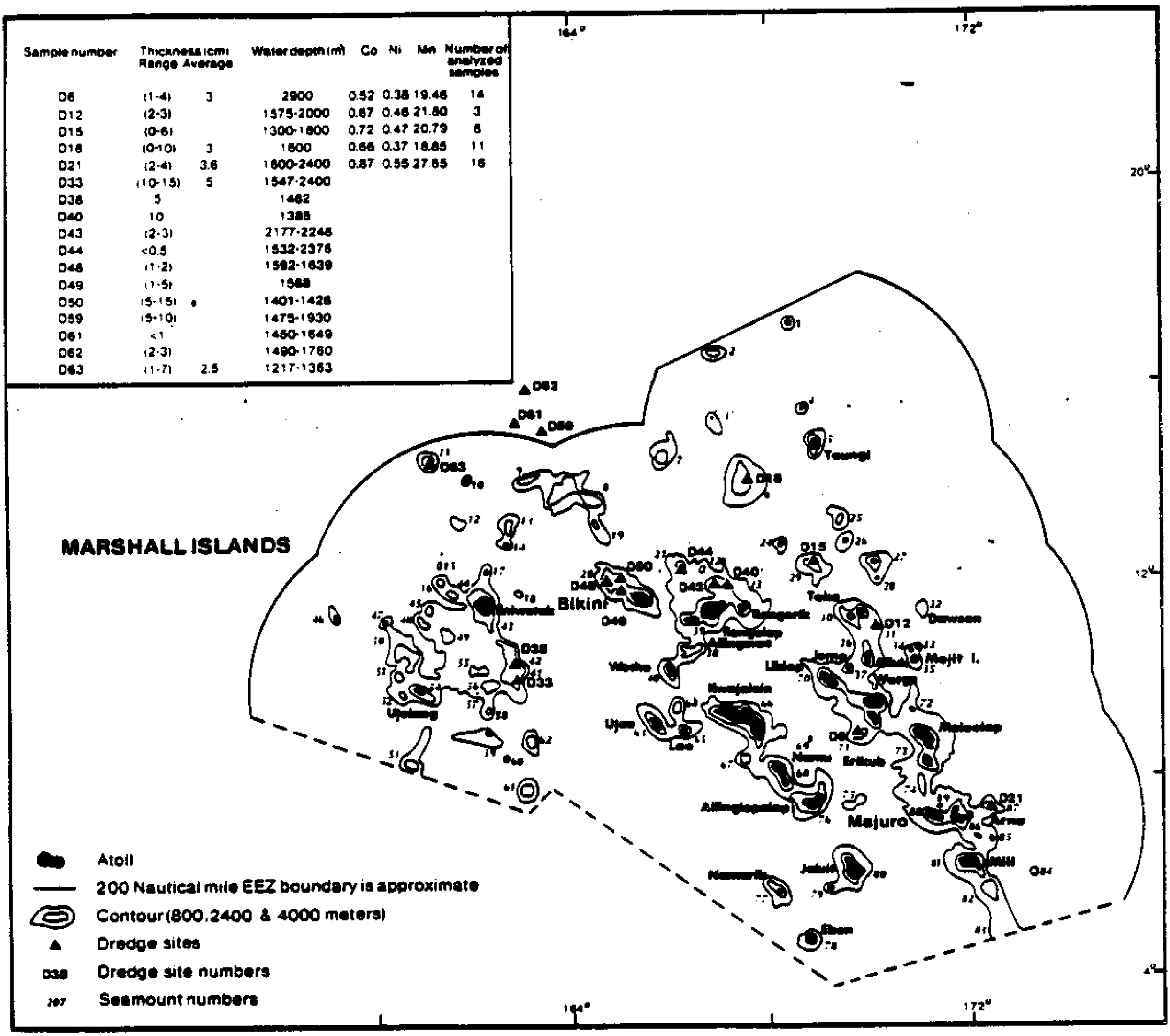
CONTENTS

INTRODUCTION

The 200-nautical-mile Exclusive Economic Zone (hereafter EEZ) of the Marshall Islands includes an ocean area of about two million square kilometers (km^2). There are 89 seamount areas within the EEZ of the Marshall Islands that have been identified as having permissive areas of cobalt-rich manganese crusts (hereafter crusts) with possible commercial exploitation potential. Figure 1 shows the approximate (unofficial) EEZ boundaries for the Marshall Islands, the 89 known seamount areas, and the location and numbers of crust dredge sites. Based on the limited data on the distribution of crusts in the Pacific, it appears that the Marshall Islands ranks among the top three most prospective areas in the Pacific to have crusts (Johnson et al., 1986; Clark et al. 1985; Hein et al. 1987). The Marshall Islands provides a good example of the issues that will be addressed in moving from crust exploration to possible mining and processing in the early part of the 21st century.

Associated with the commercial mining of a crust deposit in the Marshall Islands EEZ would be consideration of alternative sites for processing crusts. Transnational corporations (TNCs) will decide whether to process crusts in the Marshall Islands where transportation costs and taxes are expected to be low, or to process crusts at a distant site, such as Australia or Canada, where energy and water costs are expected to be much lower, suitable ports and plant sites exist, but transportation costs, environmental regulations, and taxes will probably be greater. The decision on where to locate a crust processing



Sample number	Thickness (cm) Range	Average	Water depth (m)	Co	Ni	Mn	Number of analyzed samples
D6	(1-4)	3	2900	0.52	0.38	19.46	14
D12	(2-3)		1575-2000	0.67	0.46	21.80	3
D15	(0-6)		1300-1800	0.72	0.47	20.79	6
D18	(0-10)	3	1600	0.66	0.37	16.85	11
D21	(2-4)	3.6	1600-2400	0.87	0.55	27.65	16
D33	(10-15)	5	1547-2400				
D38	5		1462				
D40	10		1388				
D43	(2-3)		2177-2246				
D44	<0.5		1532-2376				
D48	(1-2)		1582-1639				
D49	(1-5)		1588				
D50	(5-15)	•	1401-1428				
D59	(5-10)		1475-1930				
D61	<1		1450-1649				
D62	(2-3)		1490-1760				
D63	(1-7)	2.5	1217-1363				

Figure 1. The approximate (unofficial) EEZ boundaries for the Marshall Islands, the 89 known seamount areas, and the location of 17 known dredge sites.

plant will be heavily influenced by economics as well as by TNC objectives and strategies.

HISTORICAL REVIEW OF TNC INTEREST IN MARINE NODULES, CRUST AND POLYMETALLIC SULFIDE DEPOSITS

During the 1970s a number of TNC consortiums were actively interested in developing mining and processing technologies to mine deep seabed nodules at depths greater than 4,000 meters. A major assumption behind this R&D activity was that costs of production from land-based mines would increase, metal prices would rise in constant dollars, and competitive seabed mining technologies could be developed.

By the end of the 1970s, TNCs had changed their views on the commercial potential for seabed nodule mining. Land-based mines were not encountering higher mining costs, long-term metal prices were not rising in constant dollar terms, and the technology for deep seabed nodule mining was far more expensive than originally envisioned. In addition, the outlook was becoming less favorable that acceptable mining terms would be included in the Law of the Sea Treaty, which applies to mining outside the limits of the EEZ where the best, known nodule deposits exist. As a consequence, TNCs shelved their ocean mining plans.

During the early 1980s, government and academic research interests turned to recently discovered cobalt-rich crusts and deep seabed polymetallic massive sulfide deposits. A major difference in the research activity in the 1980s is that governments are supporting most of the research, and industry has played a minor role to date. The reverse was true in the 1970s when private industry took the lead in nodule R&D (Johnson and Clark 1988).

During the 1980s, TNCs in mining have undergone major changes in their priorities and strategies. The causes of the changes are complex, but they center around a failure to sustain satisfactory profits--many firms operated in the red for most of the first half of the 1980s. TNCs have eliminated most major expenditure activities that either were not expected to generate acceptable profits within a few years or were considered high risk. On both counts, ocean mining failed to pass the test for continued TNC investment interest. The assessment of the mining industry is that there will be no "commercial" mining of nodules, crusts, or sulfides during this century. The time required to develop a commercial crust operation is a minimum of ten years compared to land-based projects that can be developed in about five years.

Second, TNCs consider the risks associated with ocean mining much higher than with land-based mines. TNCs commonly adjust for a higher level of risk by requiring a higher return on investments. However, no reputable analyst believes high profit rates are likely with first-generation seabed mining technologies. The combination of a long project development period, high risks, and a high probability of lower-than-average profits have led major TNCs to shelve their plans for commercial seabed mining.

The above gloomy assessment of seabed mining by TNCs has resulted in a dramatic decrease in marine exploration supported by TNCs. However, substantial scientific exploration activity of crust deposits has been supported by the West German, Japanese, and U.S. governments. Some of this research is in conjunction with the private sector--most notably in Japan and West Germany.

The reasons for increased interest in marine minerals by governments appear to be the result of a number of factors. First, the establishment of the 200-nautical-mile EEZ in the early 1980s transferred vast quantities of marine mineral resources from international to national responsibility. Second, governments have a much longer planning horizon than private TNCs, plus governments are also concerned with strategic issues associated with ocean metals.

A few companies have been interested in obtaining mining rights over prospective areas for major crust deposits, and this activity is expected to increase in the 1990s. The strategy of these TNCs appears to be to acquire important exploration areas, but with modest exploration obligations. Agreements between governments and private consortiums made between now and the end of this century could determine where and by whom commercial developments will be made in the next century.

GOVERNMENT POLICIES AND OBJECTIVES TOWARD MARINE MINING

Although the government of the Marshall Islands does not have a specific policy document with respect to marine mining, it clearly states its intentions to encourage private sector investment in exploration and development of seabed minerals in its five-year development plan. Specifically, the Marshall Islands First Five-Year Development Plan: 1986/87-1990/91 (rephased for 1986/87-1990/91), 1988, lists "large-scale mining of seabed minerals including cobalt and manganese" as one of the projects where private sector investment is encouraged by the government.

At present, the private sector contributes less than 10 percent of government revenues. The government is anxious to promote private sector development that can produce export earnings and is likely to give substantial tax incentives to major investors interested in commercial development of manganese crusts.

The objectives and strategies for private sector development outlined in the First Five-Year Plan: 1986/87-1990/91 (rephased for 1986/87-1990/91), 1988, follow:

Objectives

- o assist the establishment and growth of viable private enterprises in the economy to develop domestic resources including seabed minerals;
- o assist the growth of commercial production in the rural areas in agriculture, fishing industries, and services;
- o assist the development of self-employment opportunites; and
- o develop a substantial tax base in the private sector to generate revenue for the public sector.

Strategies

- o create the necessary physical and institutional infrastructure;
- o offer tax incentives to encourage foreign and domestic investments;
- o facilitate the growth of an adequate flow of banking, finance and credit facility; and
- o assist the establishment of necessary links with foreign investors and markets through an investment promotion campaign.

GOVERNMENT AGENCIES RESPONSIBLE FOR INVESTMENTS IN MARINE MINERALS

The following government agencies would probably have primary responsibility for manganese crust mining and processing.

Ministry of Foreign Affairs

The initial point of contact for any organization wanting to explore for manganese crusts in the Marshall Islands EEZ is the Ministry of Foreign Affairs. To date, all activity has been of a scientific nature, and permission has been readily obtained for research vessels from the United States, West Germany, and the People's Republic of China to sample and evaluate manganese crust resources. Marine minerals exploration data is submitted to the Ministry of Foreign Affairs. However, the only library of exploration data that was located during the author's visit to the Marshall Islands was compiled by James Abernathy, a private geologist, who makes the information available to the government on request. The Ministry of Foreign Affairs sometimes put representatives on foreign research vessels operating within the Marshall Islands EEZ in order to view research activities. These representatives are not scientists.

The Ministry of Resources and Development

This ministry has the responsibility for activities associated with the exploitation of mineral resources. However, to date, the ministry has not been active in the minerals area.

The Marshall Islands Marine Resources Authority

This Authority was established in 1988 "to provide for exploration, exploitation, regulation, corporation and management of marine resources" (Nitijela of the Marshall Islands 1988). The Authority reports to the Nitijela (Parliament) through the Minister of Resources and Development.

Most of the act establishing the Authority deals with fishery issues--the only existing commercial activity involved with resources in the Marshall Islands EEZ. The following powers and duties of the Authority appear to be of particular significance to ocean mining (Nitijela of the Marshall Islands 1988):

> to conserve, manage and control the exploration and exploitation of all living and non-living resources in the Fishery Waters and seabed and subsoil thereunder...,

> to issue licences for the exploration and exploitation of the seabed and subsoil of the Fishery Waters;

> to participate in the planning and execution of programs related to..., or the exploration or exploitation of non-living resources of the ... seabed or subsoil thereof, in which the Government or any agency of instrumentality thereof has a proprietary interest, direct or indirect, by way of stock ownership, partnership, joint venture or otherwise.

With respect to the terms and conditions for the issuance of licenses the following appear important:

> Section 28. Issue of Licenses for Non-Living Resources
>
> > The Authority, or Director on its behalf, may issue licenses for the exploitation and exploration of the non-living resources of the Fishery Waters, and seabed and subsoil thereunder, subject to such terms and conditions it may prescribe from time to time by regulation.
>
> Section 29. License Fees
>
> > There shall be payable in respect to each license issued by the Authority such fees, royalties or other charges as may be prescribed by the Authority.

To date, the Authority has not been involved in any activities pertaining to exploration or mining of manganese crusts.

The Foreign Investment Advisory Board

This Board was established by an act of the Nitijela of the Marshall Islands in 1987. The purpose of the Board is "to promote, encourage and study foreign investment and therefore to promote and facilitate economic development of the Marshall Islands and for matters connected therewith and incidental thereto."

The Board reviews all investments and makes recommendations to the Cabinet, which must approve or disapprove all investments. To date, the Board has had few investment proposals to consider. However, government officials report that it is not efficient to handle all investments in this manner, and recommendations are being made to give the relevant minister the authority to approve or disapprove small investment proposals.

The Board consists of the following seven members:

(a) The minister of resources and development (chairman)

(b) The minister of foreign affairs

(c) The chief secretary

(d) The secretary of finance

(e) The secretary of the interior and outer island affairs

(f) Two other persons appointed by the president

STATUS OF MARINE MINERALS ACTIVITIES IN THE MARSHALL ISLANDS

A number of consultants from private companies have proposed that minerals policy and marine minerals exploration activities in the Marshall Islands be paid for by the Marshall Islands government. None of these proposals fall in the category of private sector investment in crust exploration--as companies proposing these investments are not planning to risk their own financial resources.

For the past two or three years there has been a proposal by a major U.S. diamond dealer to obtain rights to the prospective areas for manganese crusts within the Marshall Islands EEZ. The terms and conditions of the proposal are not known but appear to involve giving the diamond dealer a period of time to form a consortium of mining companies that would begin exploration for manganese crust deposits in the Marshall Islands EEZ. Apparently the agreement under discussion proposes, in lieu of taxes that are very low, a higher sales royalty of between 8 and 15 percent.

A three-man team has been appointed by the president of the Marshall Islands to negotiate the terms of the manganese crust exploration and development agreement. The attorney general and a private geologist are on the negotiating team.

Investment Environment

The Marshall Islands government encourages private sector investment from Western countries--particularly the United States. But, the investment environment for large-scale private investments in the Marshall Islands is untested because no large private investments now exist. In the context of the Marshall Islands, a private investment of a few million dollars is considered large. However, a manganese processing plant will require an investment of over US$500 million, which is many times the next largest private investment in the Marshall Islands.

The present Marshall Islands government is likely to give high priority and substantial tax concessions in order to attract investments for manganese crust exploration and development. However, the lack of negotiating ability within government with respect to mineral projects and the tendency for important projects to bypass established investment guidelines could result in agreements that are not in the long-term interests of the Marshall Islands. The present, strong president probably will not be in power when actual commercial seabed mining and processing developments occur.

Major investments in marine mining and processing in the Marshall Islands would probably be made by a consortium of companies, and a special Minerals Development Agreement would have to be negotiated and probably enacted into legislation by the Nitijela.

CRUST RESOURCES IN THE MARSHALL ISLANDS

There have been a number of scientific cruises to collect manganese crusts from seamounts in the Marshall Islands. Although these cruises have only sampled a very small percentage of the area of the Marshall Islands, they have established the Marshall Islands as one of the most promising areas in the Pacific for the occurrence of large manganese crust deposits that may have commercial potential over the next 25 years (see Campbell 1981; Clark et al. 1984; Clark et al. 1985; Duennebier and Schlanger 1988; Hein et al. 1986; Hein et al. 1987; Hein et al. 1988; Hein, personal comm. 1988; Midpac 3/1 and 3/2, 1987; Halbach, personal comm. 1988).

Table 1 provides two rankings of the crust potential within the EEZs of various Pacific countries and areas. Both research studies rank the Marshall Islands among the top two areas in the Pacific with the largest crust potential. Due to the uncertainty of these estimates, it is suggested that the Marshall Islands is

Table 1

Estimated Total Resource Potential of
Crusts in Various Pacific Island Countries and Areas

Pacific Area	Relative Ranking[1]	Potential[1]
Marshall Islands	1	High
Micronesia	2	High
Northern Marianas	3	Medium
Kingman-Palmyra	4	Medium
Johnston Island	5	Medium
Hawaii-Midway	6	Medium
Belau (Palau)	7	Medium
Wake	8	Low
Guam	9	Low
Howland-Baker	10	Low
Jarvis	11	Low
Samoa	12	Low

Pacific Area	Relative Ranking[2]	Potential[2]
Kiribati Islands	1	High
Marshall Islands	2	High
Micronesia	3	High
Johnston Island	4	High
Kingman-Palmyra	5	High
French Polynesia	6	Medium
Hawaii-Midway	7	Medium
Wake	8	Medium
Howland-Baker	9	Medium
Northern Marianas	10	Low
Jarvis	11	Low
Samoa	12	Low
Belau (Palau)	13	Low
Guam	14	Low

[1]Johnson et al. 1986.
[2]Hein et al. 1987.

among the top three most important areas for crust deposits in the Pacific and probably the world.

Estimates have been made of the crust potential of the Marshall Islands based on the limited available data. As such, the specific estimates of total potential, average crust thickness, and metal grade should be used with caution, because these estimates will change as more exploration data become available. The estimates in this report should be useful in examining the overall potential of the Marshall Islands. Two models have been used to provide estimates. The first model was used to estimate the in-place resource potential (which is not an indication of the economic potential of these resources). The second model attempts to define the characteristics and size of a possible commercial mine site that might occur within the Marshall Islands.

Figure 2 is a schematic cross section showing the locations of crust and nodule occurrences of possible commercial interest. Nodules commonly occur as small potato-shaped concretions on the soft sediment-covered seabed at depths greater than 4,000 meters.[1] Crusts are widespread throughout the marine environment

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[1]It should be noted that recent reports of concentrations of nodules at depths of approximately 2,000 meters on the Horizon Guyot (Hein et al. 1985) and 1,200 meters on a seamount in the Minami-Torishima area (Masuda, personal comm. 1988) suggest that substantial nodule fields may occur at depths comparable to crusts within the EEZs of Pacific countries and have similar compositions. Because of the lack of data and the scope of the present study, no attempt was made to estimate the potential for nodule deposits within the Marshall Islands EEZ, even though

(Footnote continued)

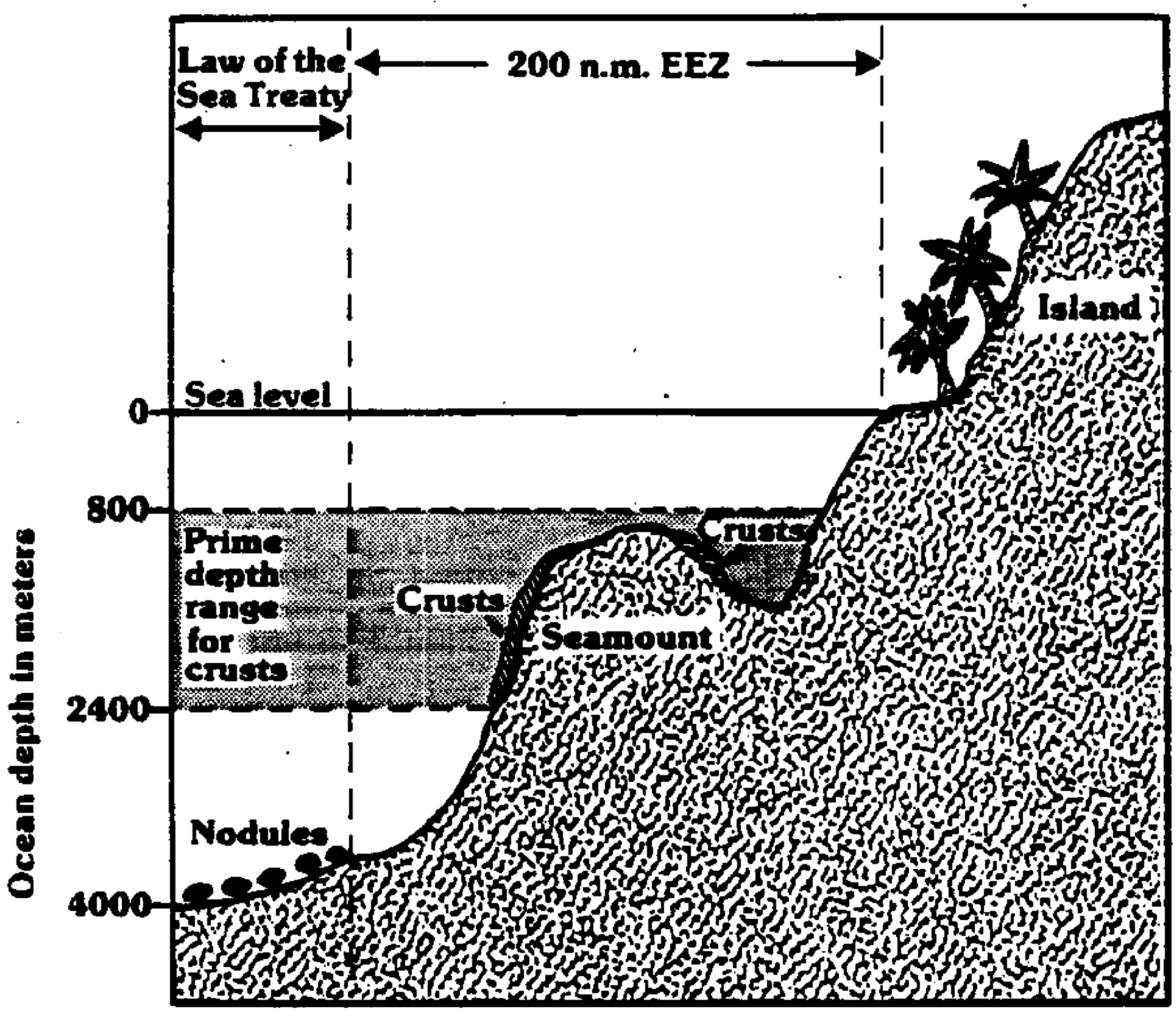

Figure 2. Schematic cross-section showing the locations of crust and nodule occurrences of possible commercial interest.

wherever a solid substrate occurs. Most exposed rock surfaces appear to be associated with higher than average ocean currents and sloping topography. Therefore, as shown in Figure 2, the sides of seamounts are prospective sites for crust deposits.

Model Parameters for Estimating Crust Resources

A simple resource estimation model was developed by Clark et al. (1984) to estimate crust resources. This model was used in a 1985 study (Clark et al. 1985) that included the Marshall Islands. The same model is used in this study but includes additional exploration data. Eight important parameters for estimating crust resources are discussed below.

1. Favorable Geographic Areas

To date, the most important occurrences of crusts have been found between 15°S and 20°N latitudes in the Pacific Ocean. The Marshall Islands EEZ falls approximately between 4°N and 17°N latitudes and therefore is totally within the most favorable latitudes for thick crust accumulations.

2. Age of Seamounts

Crusts appear to grow at widely different rates depending on a number of physical and chemical factors; however, a range of

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[1](continued)
nodule deposits are expected to occur. Therefore, although the focus of this study is on crust processing in the Marshall Islands, it should be assumed that either crusts or nodules might be mined and processed in the Marshall Islands.

2.5 to 5.0 mm per million years has been reported by Hein et al. (1987). To obtain crusts of possible commercial interest of 5 cm (50 mm) would require 10 to 20 million years. To date the best crust deposits have been located on seamounts greater than 25 million years in age. Within the Marshall Islands, most or all of the seamounts are believed to have ages substantially older than 25 million years. Crusts examined to date have had ages less than 20 million years.

3. Favorable Depth Range

At least half the value of crusts is accounted for by its cobalt content. A number of researchers have observed that the cobalt content varies inversely with depth (Cronan 1977; Halbach et al. 1982; McKelvey et al. 1983; Hein et al. 1987). The highest cobalt grades and thickest crusts found to date have been recovered from between 800 and 2,400 meters. Therefore, the resource estimates for the Marshall Islands include only crusts between 800 and 2,400 meters, even though substantial resources of lower quality crusts are expected to occur below 2,400 meters.

4. Permissive Area

The total permissive area of the 89 seamounts in the Marshall Islands was estimated from the best publicly available bathymetric maps. Estimated areas for individual seamounts are shown in Appendix A. The total permissive area between 800 and 2,400 meters, adjusted for slope, is estimated to be approximately 58,200 km^2. Given the uncertainty of the maps used for the estimates it should be assumed that there may be a ±20 percent error in the 58,200 km^2 estimate. Therefore, the total permissive area might be as low as approximately 45,000 km^2 or as high as approximately 70,000 km^2. The best estimate of 58,200 km^2 is assumed for all resource estimates in this study.

5. Average Metal Content

Table 2 shows recently published estimates of average metal contents of crusts from selected areas of the Central Pacific, including the Marshall Islands, plus the average for the Central Pacific and the total Pacific.

Based on the limited number of sample analyses to date (55 to 63 depending on the metal analyzed), for the critical metal cobalt the average metal grades for the Marshall Islands are slightly lower than the average for the Central Pacific. The highest percent cobalt reported from Marshall Islands crust samples is 1.42 percent (Hein et al. 1987). Samples from individual seamounts have cobalt contents substantially above the average grade indicated in Table 2.

In the following resource assessment, the values in Table 3 are used, except for platinum which is an estimate based on limited analyses on crusts from other areas of the Pacific. Low and high subjective estimates are shown and are based on the range of values throughout the Central Pacific. The author's subjective estimate is that there is a 90 percent probability that the metal grade will be as high or higher than the low

Table 2

Average Metal Content for Crusts from the
Marshall Islands, Central Pacific and the Total Pacific
(weight percent of samples from less than 2,500 m)

Areas	Cobalt	Nickel	Copper	Manganese
Central Pacific				
Hawaii-Midway[1]	0.69	0.37	0.06[2]	20
Johnston Island	0.70	0.43	0.11	22
Palmyra-Kingman	1.10	0.51	0.06	27
Marshall Islands	0.74	0.45	0.08	21
Average Central Pacific	0.78	0.44	0.08	22
Average Total Pacific	0.63	0.44	0.08	22

[1]Johnson et al. 1985
[2]Estimate

(Hein et al. 1987)

Table 3

Metal Grade Assumptions for
Crusts from the Marshall Islands
(weight percent)

Metal	Low	Best Estimate	High
Cobalt	0.68	0.75	0.95
Nickel	0.40	0.45	0.55
Copper	0.06	0.08	0.09
Manganese	21.00	21.00	24.00
Platinum (g/t)	0.25	0.4	0.65

estimate, and a 10 percent probability that metal grade will be as high or higher than the high estimate.

6. <u>Average Crust Thickness</u>

A critical element in preparing a resource assessment of the Marshall Islands is the determination of the average crust thickness. The present technologies for sampling crusts result in preferential collection of loose cobbles and slabs that usually have thinner crusts than underlying crust pavements (Johnson et al. 1985). Second, scientists have not yet systematically measured the thicknesses of the recovered crusts. Third, friable crusts tend to be broken during dredging, resulting in underrepresentation of crusts in some dredge hauls.

The most important factors controlling crust thickness appear to be (1) age of the seamount, (2) location relative to the equatorial zone, (3) depth of crust accretion, (4) substrate, and (5) currents.

Previous resource assessments in the Central Pacific have used average thicknesses of 2.0 to 2.5 cm (Clark et al. 1984; Clark et al. 1985). Scientific cruises to the Marshall Islands areas have recovered a few exceptionally thick crust samples--up to about 15 cm in thickness (Duennebier and Schlanger 1988). However, such thicknesses do not indicate average thicknesses. It was reported that the average thickness on one seamount appeared to be at least three cm (Halbach, personal comm. 1988). It will require much more sampling to establish a reliable average crust thickness for the Marshall Islands. Based on limited available information on crust thicknesses, the likely age of the seamounts, and location in the Pacific, the following subjective estimates of average crust thicknesses are used in this study: low--2.0 cm, best estimate--2.5 cm, and high--3.25 cm.

7. Average Percent Crust Cover

Seamounts are usually partially covered by sediments--particularly on the flat tops of seamounts where sediments can readily accumulate. In earlier studies it has been assumed that 40 percent average crust cover will occur over seamounts in the central Pacific. This is a subjective estimate based on discussions with various research scientists and observations of bottom photographs over seamounts. In the present study SeaMARC II side-scan image data (an acoustic equivalent of an aerial photograph of the seafloor) of a seamount in the Marshall Islands were examined in detail. The estimated crust coverage for this seamount is shown in Appendix B. The resulting quantitative estimate is 42 percent probable crust cover. This is close to the previous subjective estimates of a 40 percent crust cover, and the average estimate of 40 percent crust cover appears reasonable for an assessment in the Marshall Islands.

8. Crust Density

Crust densities for wet crusts recovered from seamounts vary from about 1.85 to 2.10 gm/cm^3 with a typical density of about

1.95 gm/cm^3. Metal grade estimates are based on dry crusts. Dry crust densities vary from about 1.15 to 1.55 gm/cm^3 with a typical density of 1.34 gm/cm^3 (Johnson et al. 1985). An average density of 1.34 is assumed in the resource estimates for the Marshall Islands.

Resource Assessment

The total crust potential within the 800- to 2,400-meter depth range of the Marshall Islands is estimated to range between about 625 and 1,015 million tonnes with a best estimate of 780 million tonnes.

An estimate of the amount of in-place crust resources was estimated by the following formula:

Crust Resources = (Area)(Cover)(Thickness)(Density)(Units)

= (58,200)(0.4)(2.5)(1.34)(10,000)

= 780 million tonnes

Where:
- (a) Area = km^2 of permissive area for crusts between 800 and 2,400 meters.
- (b) Cover = share of permissive area covered by crusts.
- (c) Thickness = average thickness of crusts in cm.
- (d) Density = density of crusts.
- (e) Units = standard adjustment for different units in equation.

Metal Resources

Table 4 gives the crust and metal resource estimates for the Marshall Islands. As shown in Table 4, the best estimates of the in-place resources are as follows: 780 million tonnes of crust, 5.9 million tonnes of cobalt, 3.5 million tonnes of nickel, 160 million tonnes of manganese, and 310 tonnes of platinum. Copper is not shown but is estimated at less than one million tonnes.

MINE SITE

The resource estimates discussed above do not indicate the amount of crusts that may be eventually mined. The small amount of scientific sampling of crusts is inadequate to define the parameters of a mine site--no mine site has yet been found in the Pacific. The best crust deposit examined to date is south of Johnston Island. However, sufficient information is available to make a rough estimate of the parameters of a mine site that could exist in the Marshall Islands and might be of commercial interest. The deposits of greatest commercial interest will be those deposits with metal grades and crust thicknesses substantially above the averages used in the resource estimates.

Land-based deposits may provide some guidance as to the percentage of total resources that may be commercially mined. For most mineral commodities, between 1 and 5 percent of the deposits examined are of significant commercial interest. For the Marshall Islands it is assumed that between 1 and 5 percent of the 58,200 km^2 of permissive area will support mining activities by the first generation of marine mining technologies.

Table 4

Crust and Metal Resource Estimates for the Marshall Islands[1]
(million tonnes except platinum in tonnes)

Commodity	Low[2]	Best[3]	High[4]
Crust[5]	625	780	1,015
Cobalt	4.3	5.9	9.6
Nickel	2.5	3.5	5.6
Manganese[5]	130	160	240
Platinum[6]	155	310	660

[1] Estimated total in-place resources, not recoverable reserves.

[2] Estimate assumes an average crust thickness of 2.0 cm and the low percent estimates for individual metals.

[3] Estimate assumes an average crust thickness of 2.5 cm and the metal content shown in Table 2 for the Marshall Islands.

[4] Estimate assumes an average crust thickness of 3.25 cm and the high percent estimates for individual metals.

[5] Rounded to the nearest 10 million tonnes.

[6] Rounded to the nearest 5 tonnes.

This is equal to an area of 582 to 2,910 km2, with a mean of 3.0 percent or about 1,750 km2. This assumption is based on the assumption that the distribution of high quality deposits will be similar to the distribution on land.

Mine Site Parameters

Table 5 presents the author's estimates of the parameters that may exist for a mine site in the Marshall Islands.

Assuming 3 percent of the permissive area within the Marshall Islands contains deposits having the assumed parameters shown in Table 5, then the production levels shown in Table 6 could apply. An estimated 87.5 million tonnes of dry crust is contained in the 1,750 km2 of mine sites (and would probably include a number of seamounts). Therefore, each square kilometer contains about 50,000 tonnes of in-place crust and will produce about 33,500 tonnes of mined crusts assuming two-thirds of in-place crust is recovered. Therefore, 30 km2 would be mined each year to produce one million tonnes of dry crust per year, and if 3 percent of the permissive area in the Marshall Islands could support mining, mining would last for about 60 years.

Value of Production

The market value of the final products produced from crusts will depend on metal prices, which fluctuate widely from year to year. Therefore, estimated long-term prices of metals in constant 1988 U.S. dollars are used in Table 7 to obtain

Table 5

Mine Site Parameters of Possible Commercial Interest in the Marshall Islands

Parameters		Possible Range in Parameters	Assumed Parameter
1. Mean crust thickness		3.5-6.5 cm	5.0
2. Crust specific gravity 1.34 (dry)		1.95 (wet) 1.34 (dry)	1.95 (wet)
3. Mineable area		700-3,400 km^2	1,750 km^2
4. Crust grade	Co	0.8-1.1%	0.9%
	Ni	0.5-0.65%	0.55%
	Mn	22-25%	23%
	Cu	0.06-0.09%	0.08%
	Pt	0.4-0.8 g/t	0.6 g/t
5. Seamount slope		5-20°	5-20°
6. Crust coverage		60-90%	75%
7. Substrate types hyaloclastics phosphorite		basalt hyaloclastics phosphorite	basalt
8. Depth		800-2,400	1,000-2,000
9. Crust recovery		50-75%	66.7%
10. Production ('000 dry t/y)		700-1,500	1,000

Revised estimates from Table 3-18 in State of Hawaii, Department of Planning and Economic Development and U.S. Department of Interior, Minerals Management Service, 1987.

Table 6

Annual Production Levels from a Hypothetical Mine Site*

Parameter	Thousand Tonnes Metal In Ore	Thousand Tonnes Metal Recovered to Metal Product
1. Cobalt	9.0	8.1
2. Nickel	5.5	4.8
3. Copper	0.8	0.4
4. Manganese	230.0	200.0
5. Platinum ('000 troy ounces)	19.3	9.6

*Assumes one million dry tons of crust is mined per year.

Table 7

Market Value of Metals Produced from a One-Million-Tonne Crust Mining and Processing Operation[1]

Commodity	Price per Unit (1988 US$)[2]	Sales Value per Year (1988 US$ millions)	Percent of Total
Cobalt	8.00/lb	143	50
Copper	0.75/lb	1	nil
Nickel	3.50/lb	37	13
Ferromanganese	0.23/lb	101	35
Platinum	400/troy oz.	4	2
Total		286	100

[1]See Table 5 for quantities of metals.
[2]Author's estimates.

estimates of the annual sales value of a one-million-tonne-per-year crust operation.

As shown in Table 7, cobalt accounts for half the metal value assuming that five metals are recovered. Ferromanganese accounts for 35 percent of the value, assuming the process used can recover the manganese (most of the process options considered for nodules do not assume recovery of manganese). Nickel contributes about 13 percent to total revenues, and both platinum and copper contribute an insignificant amount to total revenues.

Mining Technology

It is too early to define with confidence the mining technology that will be developed to mine crusts. A possible mining system has been proposed by Halkyard in the Draft Final Environmental Impact Statement (U.S. Department of Interior, Minerals Management Service and the State of Hawaii, Department of Planning and Economic Development, 1988). The proposed mining system is illustrated schematically in Figure 3. The miner would be self-propelled and would crawl along a seamount surface breaking up the friable crusts using a rotating cutter head similar in concept to cutters used in the coal mining industry. There would probably be some form of gravity separation at the mining site; then the crusts would be pumped in a water slurry to the mine ship.

The proposed mining machine would weigh about 100 tonnes out of the water and have dimensions of about 8 meters in width, 13 meters in length, and 6 meters in height.

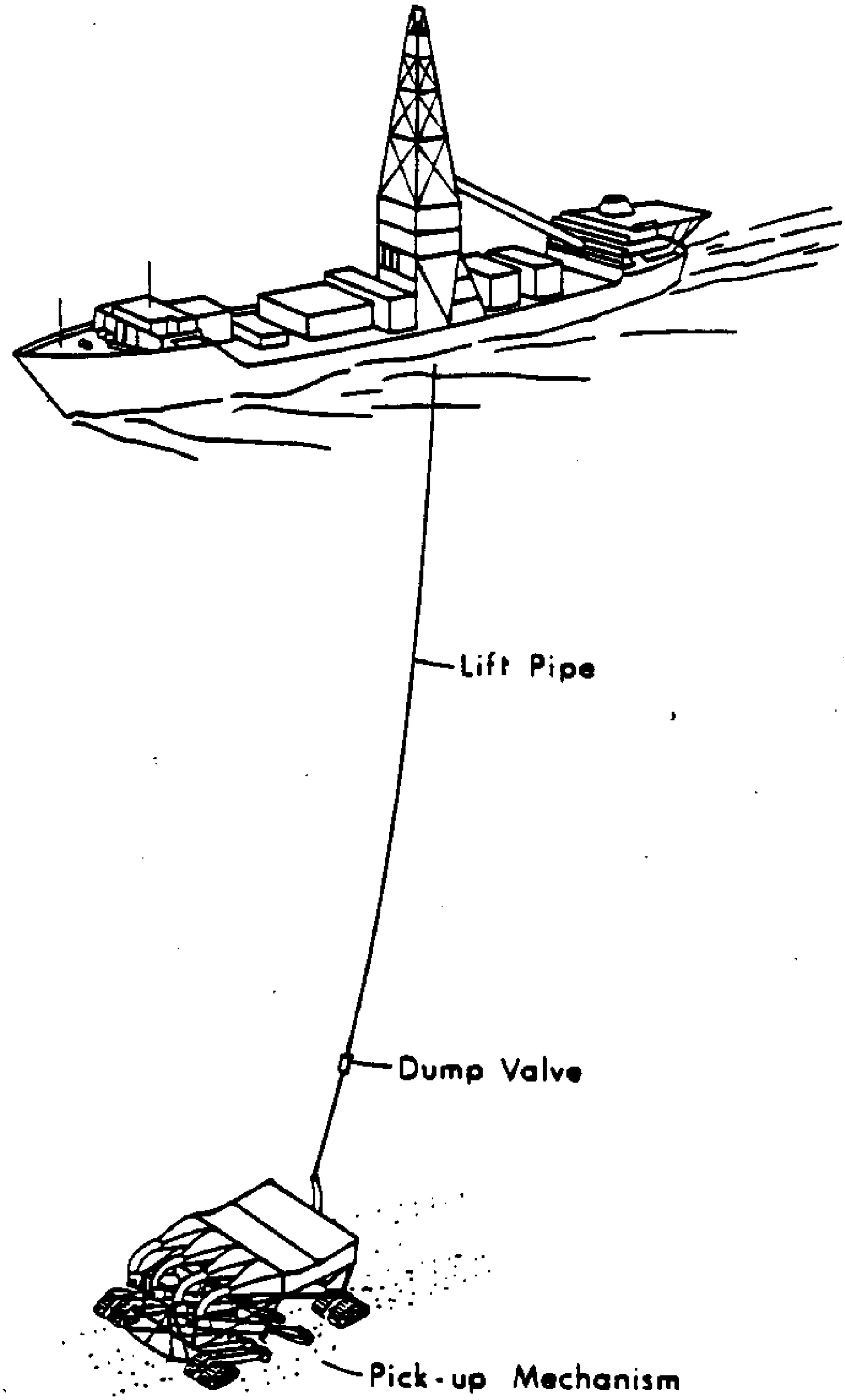

Figure 3. Schematic diagram of a plausible crust mining system.

Source: Figure 4-1 from State of Hawaii, Department of Planning and Economic Development, and U.S. Department of Interior, Minerals Management Service, 1987.

PROCESSING PLANT

This section is abstracted from the Draft Final Environmental Impact Statement: Proposed Marine Mineral Lease Sale U.S. Exclusive Economic Zone Adjacent to Hawaii and Johnston Island, 1988, U.S. Department of Interior, Minerals Management Service and the State of Hawaii, Department of Planning and Economic Development; and a document derived from this EIS research titled Mining Development Scenario for Manganese Crusts in the Exclusive Economic Zones of the Hawaiian Archipelago and Johnston Islands, 1987, State of Hawaii, Department of Planning and Economic Development, and U.S. Department of Interior Minerals Management Service. These studies are the only known public documents that examine metallurgical processing options for crusts.

A metallurgical processing facility will be required that will process 1.0 to 1.8 million tonnes of wet crust per year (or about 0.7 to 1.25 million tonnes dry crust), plus an indeterminate amount of barren substrate (say, 0.1 to 0.5 million tonnes wet substrate). It should be noted that the scale of operation assumed in the previous section on mining assumes an operation of 1.0 million tonnes dry crust per year. However, the scale assumed in this processing chapter is only 0.7 million tonnes per year of dry crust. Therefore, the estimates in this section should be considered the minimum necessary, as a larger size project is more likely.

There are numerous options that will need to be considered in selecting a best-process option and site for the processing facilities. The two main process options that are likely to be considered are pyrometallurgical and hydrometallurgical processing plants. Figure 4, which shows two processing options, gives a simplified overview of crust mining, transport, processing, and marketing. In the pyrometallurgical option, large amounts of energy are required to smelt the ore, but the nonairborne waste products may be more manageable from an environmental perspective. In the hydrometallurgical option, the metals are recovered through high pressure leaching that requires much less energy but produces much larger quantities of waste water that may be more difficult to dispose of in an environmentally acceptable manner.

Ore Transport and Preparation

As mined, crust will probably include 20 to 40 percent barren substrate (waste) that can either be separated on the seamount, on the mining ship (providing an environmentally acceptable disposal method can be developed), or onshore. Ore transport ships are assumed to carry 24,000 tonnes of ore (including 25 percent substrate). About 60 deliveries will be required each year for 1.4 million tonnes of wet crust and substrate. An ore transport ship will arrive at the port approximately every five days. The ore will be reslurried at the port and pumped to the adjacent ore storage area. A stockpile area of about 25 acres will be needed at the port.

The ore materials will be processed with hot process water (90°C) to remove salt that would be detrimental in processing the

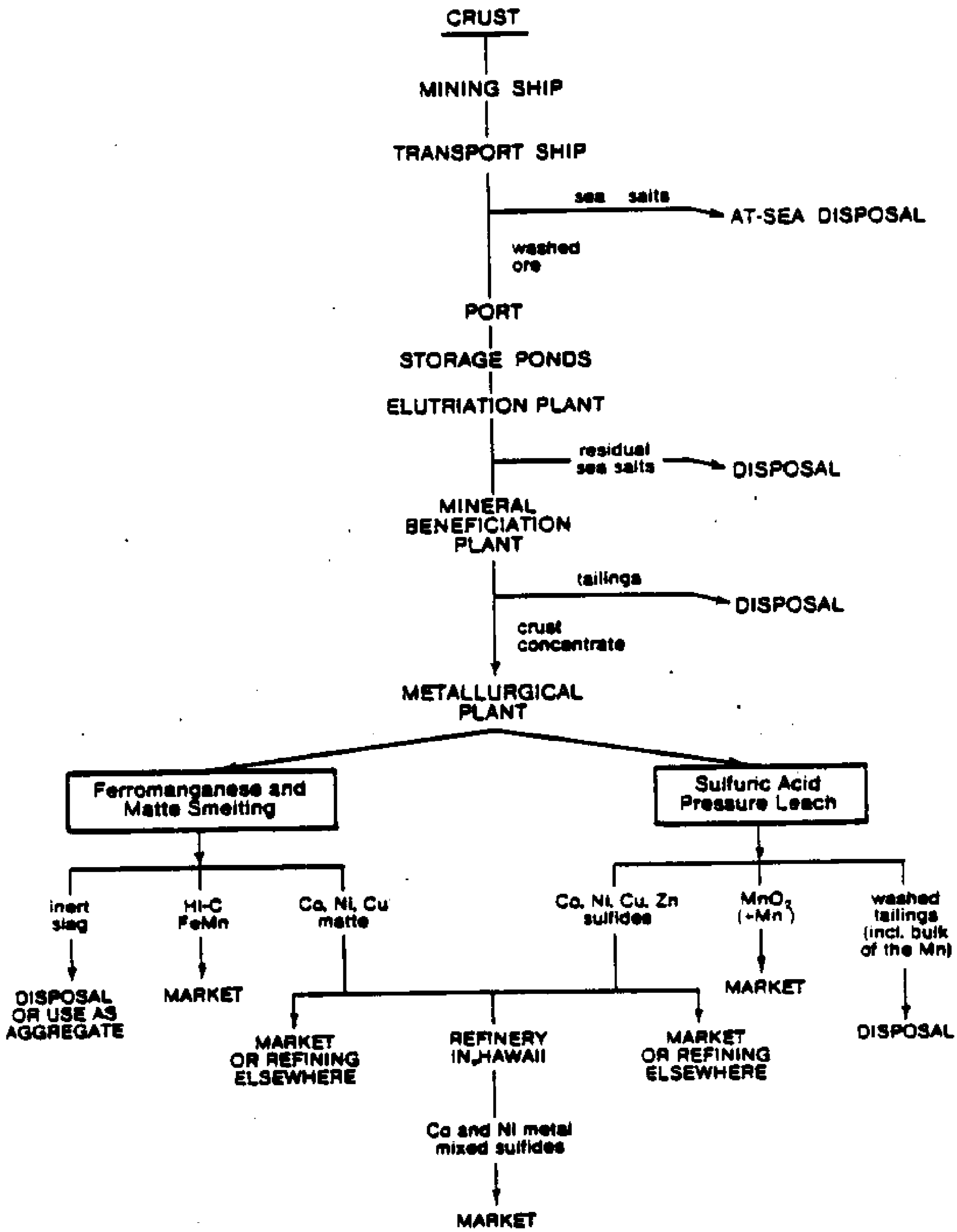

Figure 4. Simplified overview of crust mining, transport, processing and marketing system.

Source: Figure 5-1 from State of Hawaii, Department of Planning and Economic Development, and U.S. Department of Interior, Minerals Management Service, 1987.

crusts. The substrate will be removed in a subsequent step by flotation--either the crust or the substrate will be preferentially floated and separated.

Figure 5 is a schematic diagram of ore preparation for 700,000 dry tonnes of crust per year.

Pyrometallurgical Processing Plant

Figure 6 is a schematic of a pyrometallurgical plant that will smelt and refine the prepared ore from the ore preparation facility. The following description of the energy, other input requirements, and waste streams is from the Draft Final Environmental Impact Statement, U.S. Department of Interior, Minerals Management Service, and the State of Hawaii, Department of Planning and Economic Development, 1988:

> The fuel and energy requirements of the fully integrated smelting process are very large. For the plant without ferromanganese production, they are annually about 290,000 megawatt hours (MWh) of electricity, 260,000 t of coal for various uses, and 75,000 t of coke for reduction. There are also substantial requirements for silica flux (about 290,000 t) and sulfiding agent (about 21,000 t of anhydrous gypsum). Depending upon the quantity of substrate assumed to be present in the mined ore, process water and total steam requirements are 3-4 million cubic meters (m^3) and 250,000-420,000 t, respectively. With or without ferromanganese production, cooling water requirements for smelting are appreciable, estimated at 13 to 14 million m^3 annually for once-through cooling, or roughly 0.7 in the same units for cooling tower make-up.
>
> The annual consumption of coal for all uses would be more than doubled by the production of ferromanganese. In addition, electrical energy consumption would be increased to as high as 780,000 MWh. The greatly increased lime requirement (about 200,000 t for maintaining a suitable slag composition in the

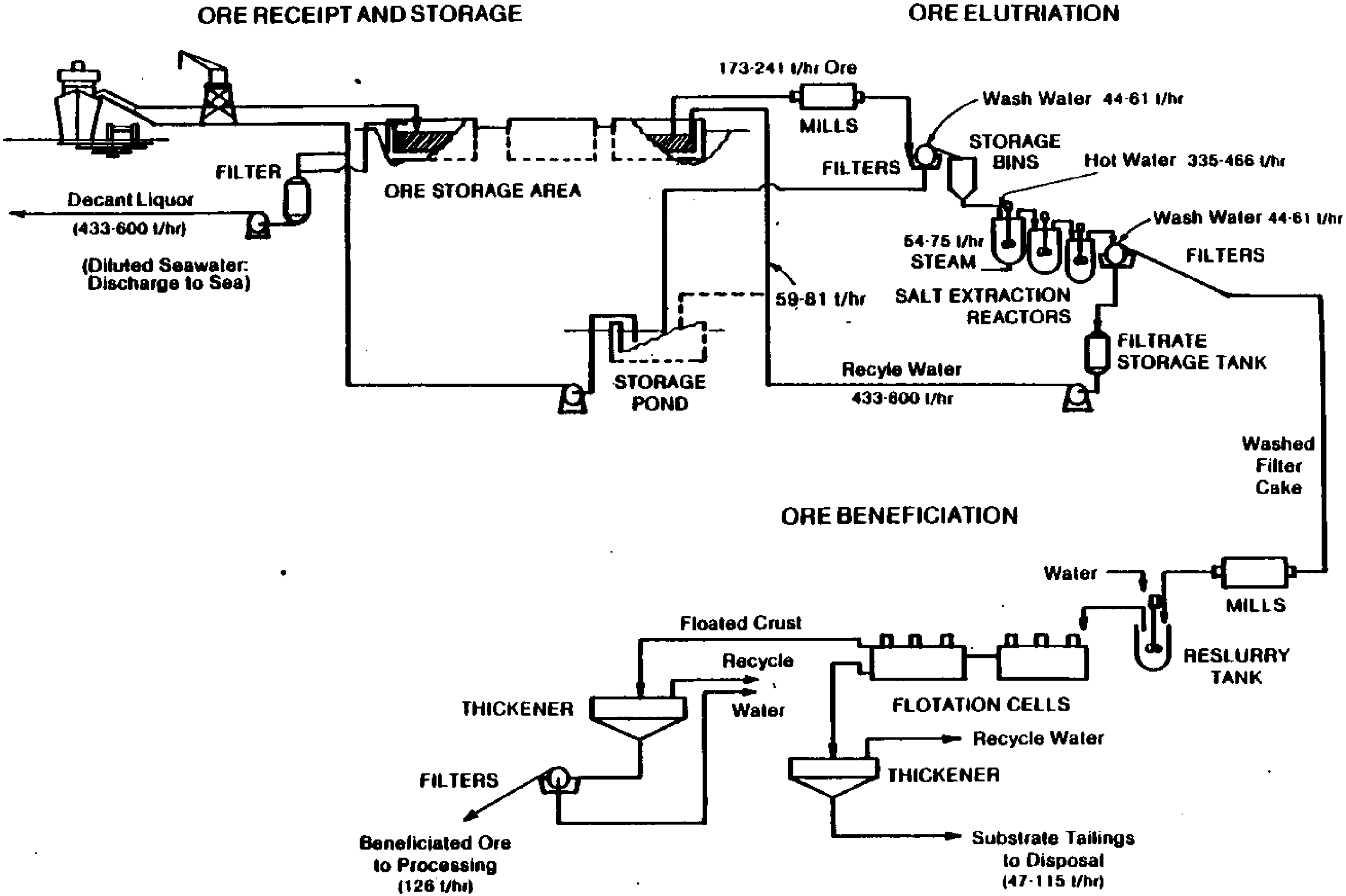

Figure 5. Schematic diagram of crust ore preparation stage.

Source: Figure 5-5 from State of Hawaii, Department of Planning and Economic Development, and U.S. Department of Interior, Minerals Management Service, 1987.

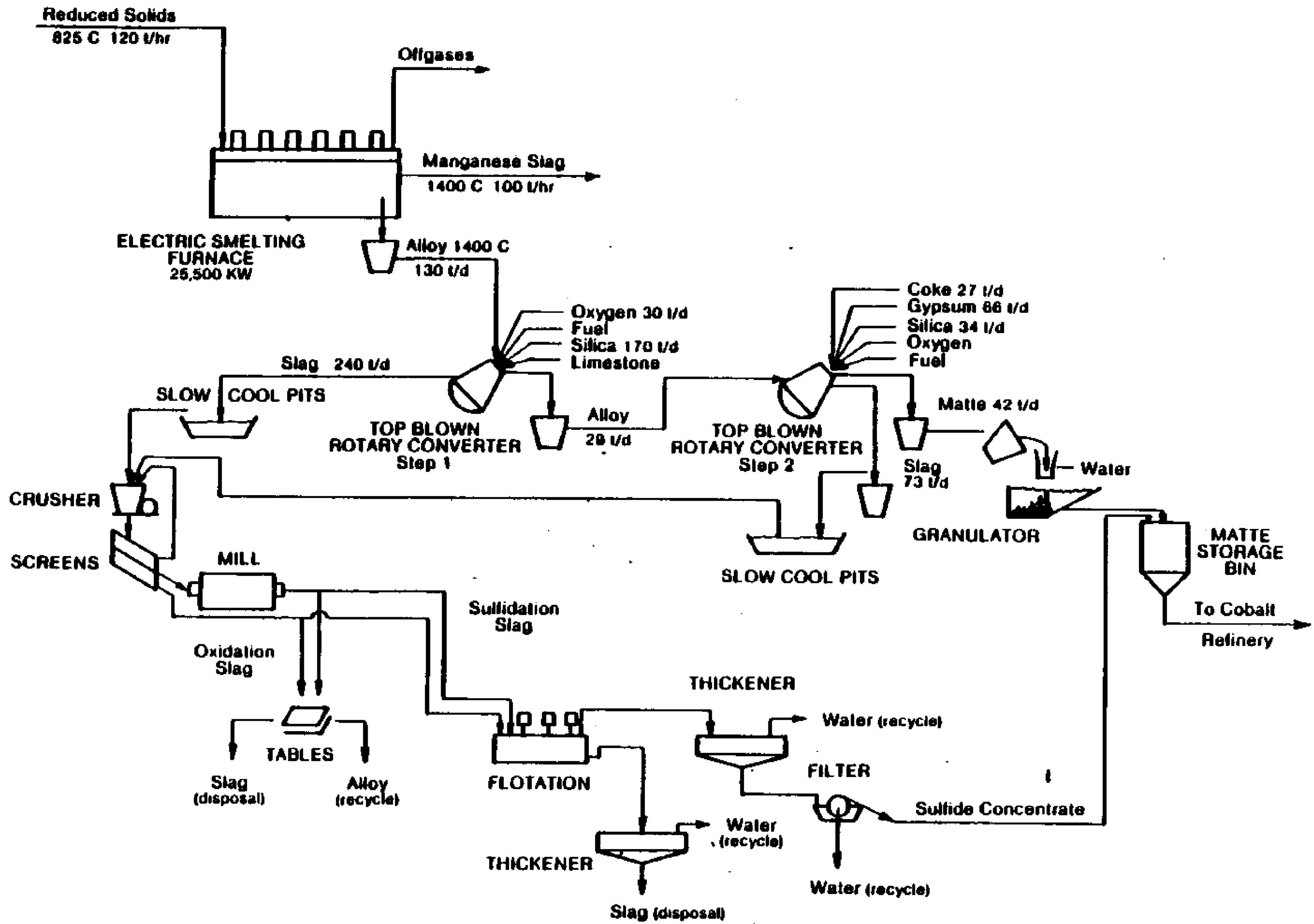

Figure 6. Schematic diagram of a pyrometallurgical plant (smelting and refining).

Source: Figure 5-7 from State of Hawaii, Department of Planning and Economic Development, and U.S. Department of Interior, Minerals Management Service, 1987.

ferromanganese furnace) would dictate installation of a lime kiln to calcine about 390,000 t of limestone/yr.

Waste streams from smelting/refining would consist mainly of smelter and converter slags, about 900,000 t annually, and small amounts of collected smelter dusts and of iron oxide precipitate (from the cobalt refinery). Disposal of these materials is assumed to take place on site. In addition, about 55,000 t, including accompanying water, of gypsum sludge would be produced in neutralization and would require-appropriate treatment for dispoal on land. The slags, however, would most likely be inert, vitreous substances that might find use as aggregate in road construction, as land fill, etc. Assuming that slags will pass the EPA toxicity test and other applicable leachability tests (EPA Elutriation tests for toxic metals were performed on glass generated at the Bureau of Mines Avondale Laboratories recently. No significant metal releases were detected, and the slags passed the EPA requirement for sanitary landfill...), they could probably be stored on land without further treatment. On the order of 1.6 hectares (ha) (4 acres) of land would be required for storage of one year's production of slag. If the local situation is not atypical, land so used could be reclaimed. The feasibility of disposal of the slag at sea could also be considered, in logistic as well as environmental aspects....

Disposal on land of the large quantity of substrate tailings (0.7-1.8 million t, including accompanying water) from ore beneficiation would entail 3-4 times the land requirement as for the granulated slags. The main impediments to returning substrate tailings to the sea are their relatively fine state of subdivision and the possible presence of residual flotation reagents. In this, as in other significant aspects, it would be highly desirable to reject as much substrate as possible on the ocean floor during mining of the crust.

Table 8 summarizes the above process requirements, production, and waste for a pyrometallurgical plant processing 1.1 million tonnes of wet crusts and 0.27 million tonnes of substrate per year. Options with and without ferromanganese recovery are included in Table 8. There may be substantial problems in producing commercial ferromanganese because of

Table 8

Annual Process Requirements and Waste Products from a Pyrometallurgical Process Plant

('000s)

Item	Units	Three Metals Recovered (no ferro-manganese)	Four Metals Recovered (with ferro-manganese)
Major raw materials			
Ore (crust and substrate)	t	1,370	1,370
Beneficiated crust	t	1,000	1,000
Coke	t	75	75
Silica	t	287	287
Calcium sulfate	t	21	21
Lime	t	9	--
Limestone	t	--	390
Oxygen	t	12	19
Carbon electrodes	t	*	4
Coal	t	259	593
Other	t	*	*
Utilities			
Electricity	MWh	285	<780
Steam	t	250	250
Cooling water	m^3	14,000	15,000
Process water	m^3	3,500	3,500
Waste			
Tailings (solids and water)	t	740	740
Slag	t	880	880
Smelter dust and iron oxide precipitate	t	*	*
Gypsum (solids and water)	t	55	55
Process gases	m^3	2,400,000	3,400,000
Ventilation gases	m^3	1,900,000	2,500,000

* Less than 1,000 tonnes.

Source: Derived from Table A-7, U.S. Department of Interior Minerals Management Service, and State of Hawaii, Department of Planning and Economic Development, 1988.

probable impurities of phosphorous, alkaline metals, and copper. If manganese recovery proves to be uneconomic, then the manganese will have to be discarded as a waste product and the gross revenues from metal products will be reduced by about one third.

Hydrometallurgical Leaching Plant

Figure 7 is a schematic diagram of a hydrometallurgical leaching plant for processing manganese crusts. The following description is from the U.S. Department of Interior, Minerals Management Service, and the State of Hawaii, Department of Planning and Economic Development, 1988:

> The process materials requirements and metal production and waste generation rates are summarized for the sulfuric acid pressure leach plant in Table [9]. The quantities shown were estimated on the basis that only the nonferrous metal values (cobalt, nickel, copper, and zinc) are recovered.
>
> Of the major process materials, elemental sulfur is used to produce sulfuric acid on-site for leaching the beneficiated ore and to generate hydrogen sulfide for selectively precipitating the nonferrous metals from the pregnant leach solution. An estimated 58,000 t of limestone (shown as 32,500 t of equivalent lime) is used mainly to neutralize residual sulfuric acid in the acid leach liquor and in the barren solutions after precipitation of the metal sulfides. The remainder is converted to slaked lime (calcium hydroxide slurry) and used to recover ammonia from the raffinate of the cobalt refinery. In these uses, the limestone becomes converted into gypsum, which is ultimately discarded from the plant with the pressure leach residue, or tailings.
>
> A small quantity of anhydrous ammonia is required as make-up in the cobalt refinery. Relatively small quantities of hydrogen (for on-site manufacture of hydrogren sulfide), solvent extraction reagents (make-up for the cobalt refinery), and flotation reagents are also consumed in the hydrometallurgical complex.

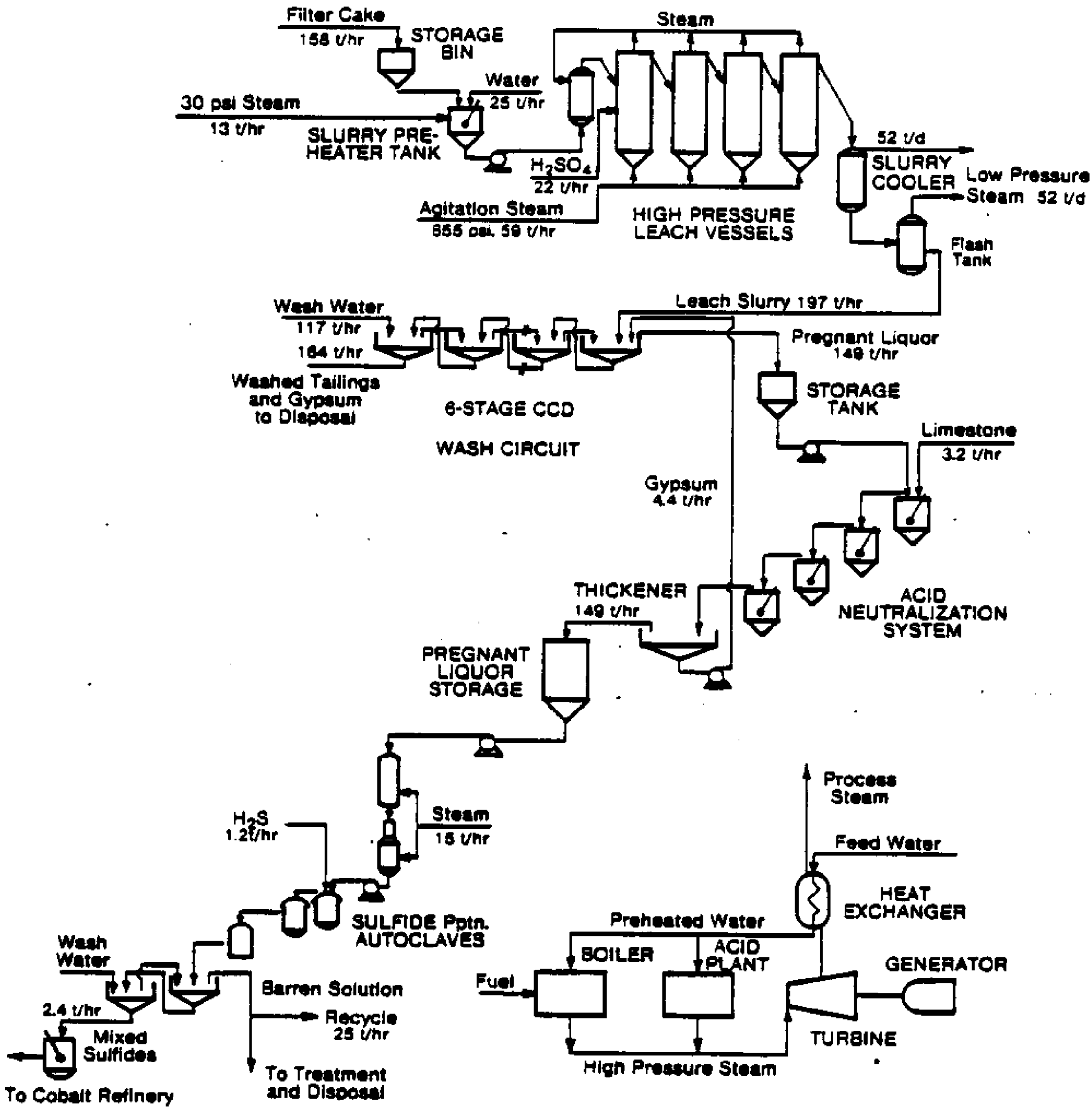

Figure 7. Schematic diagram of a hydrometallurgical plant--leaching and sulfide precipitation.

Source: Figure 5-9 from State of Hawaii, Department of Planning and Economic Development, and U.S. Department of Interior, Minerals Management Service, 1987.

Table 9

Annual Process Requirements and Waste Products from a Hydrometallurgical Process Plant

('000s)

Item	Units	Three Metals Recovered (no manganese)
Major raw materials		
Ore (crust and substrate)	t	1,370
Beneficiated ore	t	1,000
Sulfur	t	66
Lime	t	33
Hydrogen	m^3	100
Coal	t	83
Other (ammonia, solvent and flotation reagents)	t	*
Utilities		
Electricity	MWh	86
Cooling water	m^3	3,300
Process water	m^3	5,410
Waste		
Substrate and water	t	740
Leach tailings and water	t	1,200
Gypsum and water	t	80
Iron oxide precipitate	t	*
Process gases	m^3	500,000

* Less than 1,000 tonnes.

Source: Derived from Table A-9, U.S. Department of Interior Minerals Management Service, and State of Hawaii, Department of Planning and Economic Development, 1988.

> Fuel is required for the generation of electric power and steam. It is estimated that about 83,000 t of coal would be consumed annually for these purposes at the lower ore delivery rate of 1,370,000 t/yr and that 99,000 t of coal would be needed for 1,910,000 t/yr of ore. The increase in coal consumption is attributed to the steam energy needed to heat the larger quantities of ore and process water.
>
> Electricity ... is employed in the hydrometallurgical plant primarily to drive pumps, mechanical agitators in reactor tanks, and mechanical equipment such as thickeners, flotation cells, sulfuric acid plant, etc. At 86,000 MWh/yr, the electrical energy consumption is only about 30 percent of that for the pyrometallurgical process without manganese recovery. Net steam consumption, mainly for the pressure leaching step and for the elutriation (salt extraction) step is estimated at 510,000 and 680,000 t for the lower and higher ore delivery rates, respectively.

ENVIRONMENTAL ISSUES

Environmental impacts occur at the mining, transportation, and processing stages. Substantial work has been done on environmental impacts associated with manganese nodule projects. However, the only study pertaining to crusts is the Draft Final Environmental Impact Study, 1988, prepared for the U.S. Department of Interior, Minerals Management Service, and the State of Hawaii, Department of Planning and Economic Development.

With respect to the mining environment, mining is expected to occur between depths of 800 and 2,400 meters on hard seamount surfaces. Densities of bottom-dwelling organisms in this depth range are quite low compared to shallower depths (less than about 500 meters). There are a range of biological resources that have been identified on crust surfaces in the Hawaiian Islands, including corals, anemones, starfish, several species of fish, precious coral, and deep-sea shrimp. Although preliminary studies indicate low concentrations of biological life on crusts below 800 meters, it will be necessary to undertake baseline studies of prospective mine sites within the Marshall Islands prior to commercial mining activities. Such studies should be included in the Environmental Impact Studies. Mining activities will probably disturb from 20 to 40 km^2 of seamount surface each year. Over a 20-year period of commercial mining, 0.7 to 1.4 percent of the estimated seamount surface area within the depth range of 800 to 2,400 meters will be disturbed.

Separation of crusts from rock substrate may occur at the seamount surface, on board the mining ship at the ocean surface, or on shore at the processing plant. At each of these sites substantial nontoxic substrate will be produced that may require special handling to reduce detrimental impacts on the environment.

During transportation, there should be minimal environmental impacts unless a ship sinks. As the crust ore and substrate are relatively nontoxic, it should not pose a widespread or long-term environmental problem if such an accident occurred. However, there might be a substantial local impact.

The largest potential environmental impact could occur during processing. These potential impacts will vary considerably depending on the process option chosen. Tables 8 and 9 provide estimates of the quantities of waste products that are anticipated from pyrometallurgical and hydrometallurgical process options. Basically, the pyrometallurgical option emits much larger waste streams into the atmosphere, and produces a large tonnage of relatively stable, inert slag that appears suitable for landfill. The hydrometallurgical option produces much less air pollution but generates a much larger amount of liquid wastes that may not be inert, as well as limited amounts of material suitable for landfill. Appendix C provides a detailed description of the waste products and potential hazards associated with the two process options.

CRUST PROJECT ECONOMICS

It is important to emphasize that it is premature to make accurate estimates of the economics of crust mining and processing operations. However, very preliminary estimates have been prepared for the Final Environmental Impact Statement prepared for the State of Hawaii. These estimates indicate that crust mining and processing is <u>not</u> economic under the assumptions used in the study. Table 10 shows the estimated capital and operating costs of pyrometallurgical and hydrometallurgical plants in 1984 U.S. dollars. Table 11 shows the annual revenues and cash operating costs for a crust mining and pyrometallurgical processing project producing 700,000 dry tonnes per year of crusts with the grades assumed for a mine site in Table 5. The <u>mimimum</u> required return on investment of US$750 million in a mining and pyrometallurgical processing project is on the order of US$100 million per year, plus tax obligations. Table 12 shows the annual revenues and cash operating costs for a crust mining and hydrometallurgical project processing operation.

Table 10

Estimated Capital and Operating Costs
for Crust Mining and Processing Project
(1984 US$ millions)

Costs	Pyro-metallurgical Process	Hydro-metallurgical Process
Capital costs		
Mining	193	193
Ships/terminal	173	163
Processing plant	366	201
Other	18	18
Total capital	750	575
Operating costs		
Labor	26	26
Maintenance and repair	14	8
Operating materials	13	38
Utilities and fuel	91	12
Insurance and other	16	9
Total cash operating costs	160	93

Source: Appendix C, U.S. Department of Interior, Minerals Management Service, and State of Hawaii, Department of Planning and Economic Development, 1988.

Table 11

Estimated Annual Revenues and Costs for a
Crust Mining and Pyrometallurgical Processing Project*
(assumes 700,000 dry tonnes of crust per year)

Revenues/costs		Output (tonnes)	Long-term prices in 1988 US$	Total revenues (US$ millions)
Revenues:	Cobalt	5,670	8.00/lb.	100
	Nickel	3,500	3.50/lb.	27
	Copper	140	0.75/lb.	nil
	Ferromanganese	133,000	0.23/lb.	67
	Platinum	6,752	400/tr.oz.	3
Cash operating revenues				197
Direct operating costs				160
Operating profit before taxes and return on investment				37

Note:
*Assumed mined grades and (metallurgical recovered grades) are as follows: cobalt 0.9% (0.81%); nickel 0.55% (0.50%); copper 0.08% (0.02%); ferromanganese 23% (19%); and platinum 0.6 g/t (0.3 g/t).

Table 12

Estimated Annual Revenues and Costs for a
Crust Mining and Hydrometallurgical Processing Project*
(assumes 700,000 dry tonnes of crust per year)

Revenues/costs		Output (tonnes)	Long-term prices in 1988 US$	Total revenues (US$ millions)
Revenues:	Cobalt	5,250	8.00/lb.	93
	Nickel	3,360	3.50/lb.	26
	Copper	420	0.75/lb.	1
	Platinum	6,752	400/tr.oz.	3
Total revenues				123
Direct operating costs				93
Operating profit before taxes and return on investment				30

Note:
*Assumed mine grades and (metallurgical recovered grades) are as follows: cobalt 0.9% (0.75%); nickel 0.55% (0.48%); copper 0.08% (0.06%); and platinum 0.6 g/t (0.3 g/t).

The minimum required return on an investment of US$575 million in a mining and hydrometallurgical processing project is on the order of US$75 million per year, plus tax obligations.

Both the pyrometallurgical and hydrometallurgical project options would not be commercially viable under the assumptions used in Tables 10, 11, and 12. It is important to note that the project's economics might be considerably improved by considering a larger operation (perhaps 50 to 100 percent larger than the 700,000 dry tonnes per year project selected for the Hawaii study). Also, operating cost assumptions would change substantially if the plant were located near a low-cost energy source (i.e., Queensland, Australia, or British Columbia, Canada).

It is important to emphasize that there has been very limited R&D on mining technologies for crusts, and therefore all economic analyses at this early stage of R&D should be considered speculative. In addition, processing technology development has not focused on designing technologies that would be best suited to tropical island environments.

SUITABILITY OF THE MARSHALL ISLANDS FOR A PROCESSING PLANT

TNC investors will consider a range of factors in determining the suitability of the Marshall Islands for processing crusts. In this section, important physical, economic, and political factors are examined in the context of the Marshall Islands. An attempt is made to consider these factors from the perspective of the TNC, because it is the TNC that will probably determine whether or not a processing plant will be located in the Marshall Islands.

Physical Considerations

1. Location. Locating a processing plant in the Marshall Islands would be the best option with respect to crust transport distances and costs. Transport would probably be under 500 km versus a few thousand km to a processing site in Japan, Australia, Canada, or the United States (see Figure 8). The transport savings per tonne of wet ore shipped to a site in the Marshall Islands would probably range from US$5 to US$15, depending on the size of ships used and distances to the processing site.

2. Suitability of Port Sites. It is probable that a new port would have to be dredged in the Marshall Islands to handle the large amounts of crust and raw materials inputs to the processing plant. Ships of up to at least 60,000 deadweight tonnes, with a draft of about 12.0 meters, would be required for the processing plant and power station. This would result in substantial port development costs that may not be necessary at some of the alternative sites in Australia and Canada where deep-water ports already exist.

3. Availability of Electricity. Electrical generating capacity in the Marshall Islands is quite inadequate for a crust processing plant. The capital and most populated island, Majuro, presently has about 13 MW of electrical capacity. For a pyrometallurgical plant, the requirements are about 35 MW without

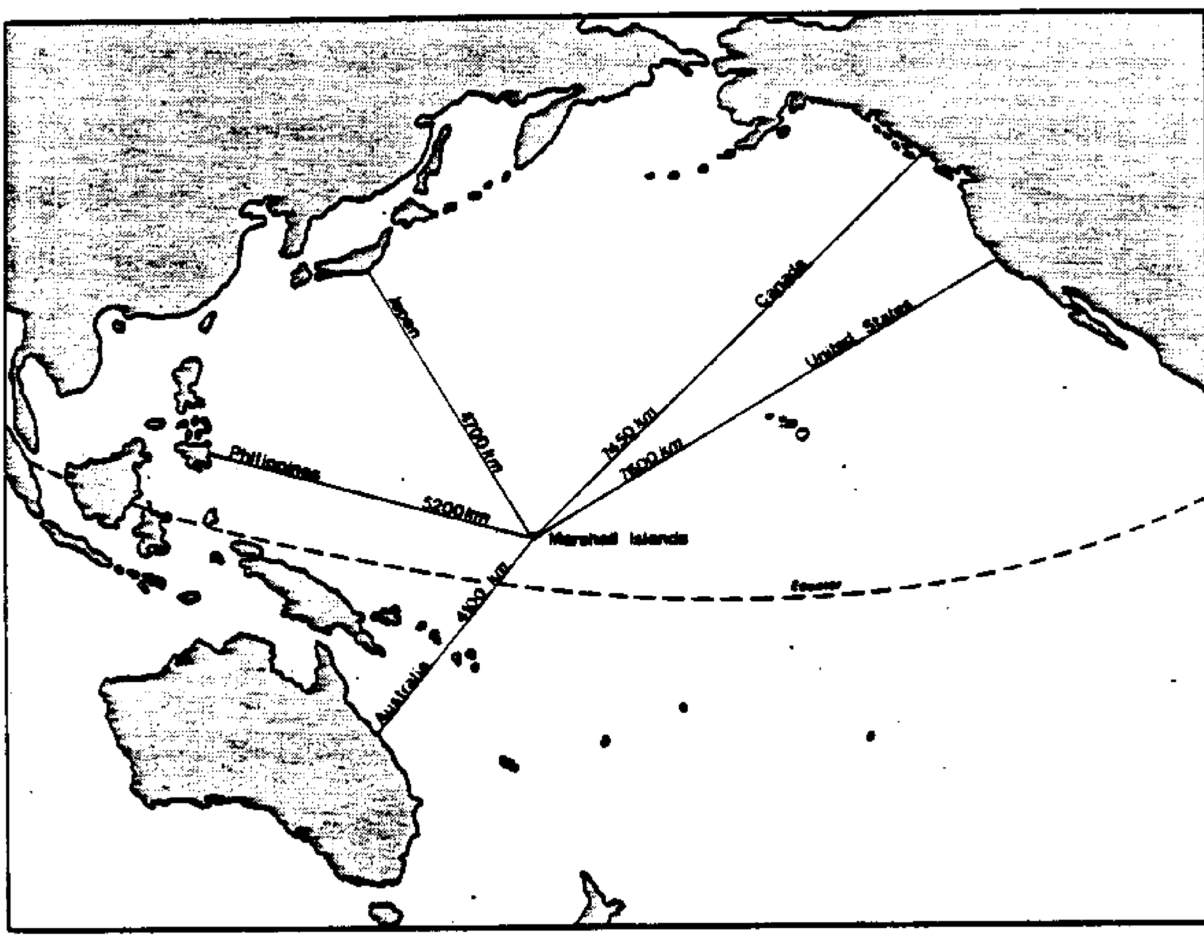

Figure 8. Approximate distances to processing sites outside of the Marshall Islands. Processing sites within the the Marshall Islands will probably be 50-500 km from mining operations.

ferromanganese recovery and 115 MW with ferromanganese recovery, not including standby capacity. In contrast, a hydrometallurgical plant would use only about 11 MW of electricity. The most efficient power plant that could be considered for the Marshall Islands would have electricity costs of two to four times the costs for electricity in Queensland (Australia) or British Columbia (Canada). Costs to large industrial users in Queensland and British Columbia vary from about 1.5 to 3.0 U.S. cents per kilowatt hour. Costs for a new efficient power plant in the Marshall Islands would probably be from 7 to 12 U.S. cents per kilowatt hour.

4. Water Availability. There is limited water availability on all atolls of the Pacific. However, there is high rainfall in the Marshall Islands averaging over 170 inches per year in the south and 70 inches per year in the north.

On Majuro, the airport runway rainwater collection system provides an average of 630,000 gallons of water per day. The problem is that annual variations in rainfall can be quite large, resulting in a need for large water storage facilities. In addition, groundwater sources in the Laura area of Majuro are being developed to produce a sustainable yield of 400,000 gallons per day. The total of about one million gallons per day to be produced on Majuro, could possibly be developed on some of the other large atolls. Given the wide range of uncertainty about the total amount of water available, a range of 500,000 to 1,500,000 gallons per day appears plausible on some atolls in the Marshall Islands. This is equivalent to about 1,900 to 5,700 meters per day or about 0.7 to 2.1 million m^3 per year. Population demands for water would probably substantially reduce the total availability of water for a crust processing plant on any of the larger atolls.

The water demands for a processing plant will include both salt water and scarce fresh water. It is assumed that the cooling water requirements could be met by salt water, but the process water would be fresh water. Cooling towers are assumed, but the efficiency in the warm, humid climate of the Marshall Islands would probably be lower than in more temperate areas. Table 13 summarizes possible freshwater availability and water requirements for two processing plant options. As previously noted, the optimum commercial size plant might be at least 50 percent larger than the size used in this study. If all process water is fresh water, then there will be serious problems in meeting the water requirements under the assumptions used here. Clearly, larger freshwater sources would need to be established in the Marshall Islands than are assumed in this study. The problems appear particularly serious with regard to the water requirements of a hydrometallurgical plant. The cost of a distillation plant to produce fresh water would probably be prohibitive.

5. <u>Land Availability</u>. The entire land area of the Marshall Islands, which spreads over 31 atolls and islands, is only 171 km^2. The land area of individual atolls varies from less than 1 km^2 to several km^2. This can be contrasted to a land

Table 13

Possible Water Availability and Water Requirements for a Crust Processing Plant in the Marshall Islands (assumes 700,000 tonnes of dry crust per year)

	Million m^3
Possible water availability	
Salt	no limits
Fresh water*	0.7-2.1
Pyrometallurgical plant water requirements**	
Salt water (cooling)	13.9
Fresh water (process)	2.9-4.1
Hydrometallurgical plant water requirements**	
Salt water (cooling)	3.4
Fresh water (process)	5.4-7.0

Notes:
*Author's estimates.
**From Tables 8 and 9.

requirement of 1.1 to 2.2 km^2 for a pyrometallurgical plant and 1.9 to 3.5 km^2 for a hydrometallurgical plant, including disposal area.

With respect to a pyrometallurgical plant, the requirements for existing land may be substantially lower than the 1.1 to 2.2 km^2 indicated--perhaps as low as 0.5 to 0.75 km^2. The large tonnage of (probably) inert slag produced each year could be used for landfill. However, for planning purposes an area of at least 1 km^2 in close proximity to suitable port facilities should be assumed.

6. Waste Disposal. The issue of environmentally safe disposal sites is particularly important for small, ecologically fragile coral atolls such as those found in the Marshall Islands. The large amounts of liquid wastes associated with a hydrometallurgical plant could pose a serious environmental problem. If stored on land in large ponds, there would be the danger of seepage into porous coral bedrock. If treated and dumped into the ocean, there could be substantial danger to the fragile reef environment and perhaps humans.

The large amount of solid slag waste (apparently environmentally safe) from a pyrometallurgical plant might reduce the size of the waste disposal problem. However, stack gas emissions would be much greater. (See Appendix C for a more detailed discussion of wastes.)

7. Labor Requirements. The labor requirements of from 450 to 600 people for mining and processing are small relative to most economies but would be significant for the Marshall Islands.

The present population of the Marshall Islands is about 40,000 with an annual high growth rate of about 4.0 percent per year. Within the active employment age group of 20 to 54 years, there are about 13,000 people, 51 percent of whom are men. A mining and processing plant employing 85 percent Marshallese would account for 3 to 5 percent of the total potential active workforce. However, because of the large percentage of youths and high population growth rates, the impact on employment during the period 1995-2015 (when the first commercial mining crusts or nodules might occur) would be much smaller.

In the Marshall Islands, there is very little employment in any export-oriented industrial activity, and one crust project could become the largest employer of any export-oriented industry.

Political and Legal Environment

These issues are discussed in detail in the legal section of this study. However, it is clear that the uncertainty associated with land ownership would be considered a substantial risk factor to potential TNC investors.

With respect to political stability, the Marshallese government is pro-Western and strongly encourages foreign investment. But the following underlying risk factors might be considered significant by most TNC investors.

- The government is young (only a few years old) and inexperienced in dealing with major investments.

- o The nation is overly dependent on funds from the U.S. government to keep the economy growing.
- o The present strong role of the president in pushing projects forward could change with future leaders who might have less power.
- o Some Pacific island nations are in a state of political change that could extend through the 1990s. Investors are concerned that political unrest might spread to other Pacific island countries, including the Marshall Islands.

Investors considering a 25-year investment in the Marshall Islands must assume substantially higher risks than similar investments in countries such as Australia, Canada, and Japan. This is reflected in economic terms in a requirement for higher required profitability for investments in the Marshall Islands. Put another way, the economic benefits from processing crusts in the Marshall Islands must be greater than elsewhere.

<u>Tax Environment</u>

The present tax rates in the Marshall Islands are lower than most other countries in the world. At present, taxes are at a rate of 3.0 percent of gross revenues. Basically, this tax is similar to a sales royalty. The tax system has recently been reviewed and a company tax rate of about 15 percent (assume on taxable profits) has been suggested by a United Nations consultant to the government.

A major investment, probably exceeding a half billion dollars, will have a negotiated tax regime. The tax rate that would come out of such negotiations would probably be substantially higher than existing rates, but lower than competing sites in Australia, Canada, and the United States. Most mining and processing agreements have tax regimes that are heavily profit-based rather than royalty-based. Potential investors are likely to argue for a profit-based tax regime.

The government's tax revenue from the mining and processing of crusts is dependent on the economics of the operations and the form and level of taxes. A broad indication of plausible tax revenues is that the government might obtain the "equivalent" of 5 to 15 percent of total gross revenues. Therefore, for a crust operation of 700,000 dry tonnes per year, the government might obtain tax revenues within the ranges shown in Table 14.

STRATEGIC MINERALS SIGNIFICANCE OF THE MARSHALL ISLANDS

The strategic minerals significance of seabed minerals is commonly emphasized by those who would benefit from a "strategic classification"--scientists wanting federal research funds, companies wanting government protection and assistance, political leaders, and the news media. However, there are lower-cost, land-based alternatives for all of the metals contained in crusts and nodules. Most minerals industry analysts would agree that the supply of cobalt is more uncertain than other crust metals because of the high level of production coming from Zaire (57 percent) and Zambia (11 percent) (U.S. Department of Interior, 1988). This uncertainty has caused industry to design away from cobalt--resulting in only modest growth in the cobalt market over

Table 14

Plausible Range of Government Tax
Revenues for a Crust Mining and Processing Plant*
(assumes 700,000 tonnes dry crust per year)

Type of operation	Plausible range in average annual tax revenue (1988 US$ millions)
Mining in the Marshall Islands, processing elsewhere	3-10
Mining and pyrometallurgical processing (with ferromanganese) in the Marshall Islands	10-30
Mining and pyrometallurgical processing (without ferromanganese) in the Marshall Islands	7-20
Mining and hydrometallurgical processing in the Marshall Islands	6-18

Note:
*The above estimates are not based on a formal cash flow analysis of a mining and processing plant but are the author's estimates of plausible, effective tax take that might occur.

the past decade and generally low cobalt prices. If substantial alternative sources of supply were developed (such as in the Marshall Islands), there would be a greater incentive to design cobalt back into products and expand this market.

The significance to the United States of mining crusts in the Marshall Islands is: (1) it would probably delay commercial crust developments within the United States' EEZ; (2) the United States would have alternative sources of supply other than the more volatile African environment; and (3) U.S. companies would be likely candidates for participation both as equity partners and in supplying mining and processing equipment. These three points are briefly examined below.

The reason that development of commercial crust mining in the Marshall Islands would probably delay developments within the United States' EEZ is because only one operation could be added without substantially depressing the market price of the key metal cobalt. One crust mining operation would add 15 to 20 percent to world supplies of cobalt. In addition, the company that established a commercial operation would probably be able to expand existing operations at much lower costs than a new entrant to the industry. That is why the author has sometimes used the term "first in, last in," with respect to crust mining in the Pacific.

A plausible scenario would have a Japanese-U.S.-European consortium becoming involved in the first commercial development. In order to obtain financing for the project, it is probable that long-term sales contracts would be necessary for cobalt. These contracts are likely to be with companies in the host countries of the consortium members. In addition, because of the risky nature of the first project and its strategic significance, host governments, including the United States, might provide some form of project guarantees in exchange for guaranteed access to the metal products from the projects. The West German government has used such a strategy for certain land-based projects producing critical metals needed by West Germany.

The original technologies for seabed mining were developed primarily in the United States, and the leaders of the major consortiums planning seabed mining of nodules in the 1970s were U.S. companies. The U.S. mining industry had a comparative advantage in mining technology and experience throughout the 1970s. However, this industry advantage may be rapidly eroding as the U.S. mining industry has had no significant interest in ocean mining for most of the 1980s.

The Japanese government, through MITI and other government agencies, has had an active US$160-million program to explore seabed deposits and develop nodule mining technologies for trial mining in the early 1990s. In addition, there is significant research on both crusts and seabed sulfide deposits in Japan. France has a significant program pertaining to nodule exploration and mining. There has been substantial government support of scientific research related to crust and sulfide deposits during the 1980s; however, industry participation remains quite low.

In conclusion, the strategic significance to the United States of commercial crust or nodule developments in the Marshall

Islands is positive from the perspective of broadening the sources of supply. However, the economic and strategic importance of more sources of supply to the United States is probably modest. The U.S. government already has a large strategic stockpile of cobalt and is insulated from major damage resulting from disruptions in supply of cobalt.

More important than strategic minerals considerations is that the United States may be losing its lead in ocean technology and may not be a major player in commercial crust or nodule developments in the Marshall Islands or elsewhere in the Pacific in the 21st century.

PREPARING FOR THE FUTURE

The future commercial potential for crust and/or nodule mining in the Marshall Islands is yet to be demonstrated. Optimists can paint a bright future, while others believe the large size and low costs of mining land-based deposits will delay commercial crust and nodule mining until far into the next century or later.

With respect to the strategies that might be followed by the Marshall Islands government, the following point is important. If the Marshall Islands government prepares for the management of exploration, mining, and processing of crusts and it does not occur, there would be a modest loss because the resources and expertise expended on the project could have been used on other projects. However, if the Marshall Islands fails to prepare for exploration, mining, and processing of ocean minerals and it does occur, then much larger costs to the nation could result.

Mistakes could include giving control of all of the best resources to one company, failure to develop a solid data base of research results to guide decision making, unacceptable levels of environmental damage in both mining and processing, and consumption of most of the available water on the major atoll where processing is located. The government might also simply get a poor agreement and minimum economic benefits through ignorance of what constitutes a good agreement for large minerals projects.

Successful mining developments from both the investor's and government's perspective do not occur without a great deal of effort and specialized knowledge. At present, there is little indication that within the government there is sufficient expertise to manage future exploration and commercial development of crusts or nodules. Because of the long period of time from the commencement of exploration to commercial mining (7 to 15+ years), the government could phase in its involvement and costs. The following is a brief outline of the types of activities that the Marshall Islands government might undertake.

Phase 1: Scientific Exploration

Scientific exploration of crust deposits in the Marshall Islands has been under way for a number of years. This exploration activity has been funded by the U.S. and West German governments. With respect to government-funded scientific exploration activities, the Marshall Islands government does not need to give up any commercial rights to their marine resources. The main responsibilities of the government are to ensure that research cruises are legitimate and that all of the survey results, as well as representative crust samples, are turned over to government. This will require storage facilities for samples and a small scientific library, neither of which appear to exist to date in the Marshall Islands.

Second, approval and monitoring of all research activities should be under the ministry responsible for resources. There should be at least one government person, with a geological background, responsible for scientific research, data, and sample storage. In addition, in reviewing requests for scientific expeditions, the government should suggest modest additional sampling that it believes is necessary to better define the crust and nodule potential within its EEZ. Under this proposal, the role of the Ministry of Foreign Affairs would shift more to security issues.

The Marshall Islands government should consider the possibility of obtaining outside aid funding, specifically for one or more expeditions, to systematically sample crusts and nodules within the Marshall Islands EEZ.

During the scientific exploration stage, the main activities that will occur include: detailed mapping of seamounts using echosounder and sidescan sonar surveys; sampling crusts using dredges (primarily) and core devices; bottom photo coverage of portions of seamount surfaces; samples of the water column; and analysis of crusts and substrates for constituents including metals. It may also include collecting biological information that could be useful in future Environmental Impact Studies.

At the end of each scientific cruise an "Expedition Report" is prepared describing all major shipboard activities. In addition, scientists usually prepare a number of professional papers and/or "open file reports." Samples are often shared with scientists in a number of different universities and research facilities, and results from their research will be published over a number of years.

Dredges are commonly about one to two meters in width at the mouth. Individual expeditions recover a few tonnes of crust and substrate. In advanced stages of scientific exploration, manned submersibles may be used for closer observation and sampling of seamount surfaces.

Common problems are a lack of attention to systematic measuring of the thicknesses of crusts, a tendency for dredges to recover nonrepresentative samples, and loss of crust information when the focus of the scientific cruise is not on crusts. Also, potentially valuable baseline biological information may not be systematically collected.

<u>Phase II: Exploration by TNCs (4-10 years)</u>

Although TNCs are not at present active in exploration for crusts or nodules, these resources appear to have sufficient long-term commercial potential to attract some TNC activity over the next decade. It should be anticipated that TNCs will approach the Marshall Islands government for exploration and mining rights. The Marshall Islands government has no experience in dealing with companies involved in mineral exploration and mining and therefore should seek professional experience from lawyers and mineral economists who have been actively involved in minerals legislation and agreements in developing countries. For example, the United Nations Centre on Transnational Corporations provides such assistance to governments.

The following four issues are of particular importance in considering exploration licenses to a TNC:

1. The company should be a legitimate one with financial and technical resources to carry out the proposed exploration program. This will probably be a medium-to-large mining company--companies with annual minerals sales of at least US$250 million.
2. The company should submit a realistic exploration program and expenditure commitment. A minimum exploration expenditure of US$200,000 to US$500,000 per year is probably required to undertake a significant crust exploration program.
3. There should be a relinquishment plan to ensure active exploration and to prevent one company from holding all prospective crust areas.
4. There should be clearly defined reporting procedures to the government, with a minimum of biannual reports covering all exploration and analyses. In addition, a portion of all exploration samples should be retained by the government.

A plausible scenario for leasing would be to give limited exclusive rights to the entire EEZ for a maximum 1 1/2 years, providing a minimum annual expenditure of, say, US$100,000 to US$500,000 on exploration, and a nominal annual license fee of US$10,000 to US$25,000 per year is paid to the government to cover a portion of the costs of monitoring activities and analyzing research results. At the end of the 1 1/2 year period the company would have to relinquish a minimum of 50 percent of the areas held, and after an additional two years, a minimum of 50 percent of the remaining area would have to be relinquished.

With a total estimated area of 58,200 km2, the maximum areas held by an exploration company might be as shown in Table 15. The estimates in Table 15 are based on a situation where there is no active bidding for exploration areas. If there was active bidding by a number of companies, then the initial license areas should be much smaller. In the example shown in Table 15, the requirement to progressively relinquish areas is an incentive to continue active exploration.

Although not examined here, there is a need to consider the shapes of license areas and how these can be subdivided when relinquishments occur--otherwise, a company may reserve the best area on each seamount and effectively block the entry of any new exploration companies.

Exploration by TNCs will probably result in substantially larger crust and substrate sampling programs than scientific cruises can provide. Each cruise might recover tens of tonnes of crust and substrate.

Table 15

Plausible Lease Areas and Relinquishment Schedule for the Marshall Islands*

Year	Maximum Permissive Area Held by a Company	
	thousand km²	% of total area
0-2	58,200	100
3-4	29,100	50
5-6	14,550	25
7-10	2,910	5

Note:
*This table applies in the case of one investor only and would not apply if there were applications from more than one investor.

At the stage where prototype mining activities are undertaken on an identified mine site, the total amount of crust and substrate material recovered will probably be between a few hundred and a few thousand tonnes.

Phase III: Commercial Development

After a commercial deposit has been proven and a prototype mining system developed and tested, a full feasibility study will be prepared that will include:

1. the geology of the deposits to be mined, including reserve estimates;
2. the mining technology to be used, recoveries and production rates;
3. the processing method, metallurgical recoveries, and location of the processing facilities;
4. the transportation plans and related infrastructure;
5. the utilities required (most important if processing is to occur in the Marshall Islands);
6. services and infrastructure (most important if processing is to occur in the Marshall Islands);
7. personnel requirements, and training ahd localization plans;
8. environmental impacts associated with all phases of mining, transport, and processing of crusts and substrate;
9. capital and operating costs of the project;
10. market analysis for metals to be produced; and

11. economic evaluation of the project (includes cash flows out to 20 years' production, the estimated internal rate of return of the project, and risk analysis).

The government will probably have to negotiate a "mineral development agreement" before commercial development will proceed. Such arrangements lay out the detailed terms and conditions for commercial development and operation of mining and processing projects. For large projects in developing countries these agreements usually fix the tax regime for the life of the agreement; include guarantees that the investor can repatriate aftertax profits; include an agreement for arbitration by a neutral third party in the event of major unresolved disputes between the investor and the government; include training and localization plans; and define requirements pertaining to the environment, and a range of other issues.

The tax regime is of critical importance to the investor and the government, as this lays out the formula for dividing the profits from the project. The present gross revenue-based tax regime in the Marshall Islands is not appropriate for taxing large mineral projects. Most tax regimes in mining and processing are heavily based on profits, plus a modest sales royalty. The Marshall Islands will need to obtain expert advice in developing a tax regime for crust mining and processing. The tax regime should be primarily profit based.

A key requirement for any commercial mining and processing development in the Marshall Islands should be a full Environmental Impact Study.

The duration of mining and processing licenses in developing countries rarely exceeds 25 years, as the economics of projects are ignored by investors beyond this period. There often are provisions for renewal of licenses, but there are usually no guarantees that the conditions will be the same.

CONCLUSIONS

The Marshall Islands ranks among the top three Pacific Island areas with respect to its prospectivity for deposits of crusts that may have commercial potential. The government of the Marshall Islands is clearly interested in promoting exploration and development of crust deposits and probably will encourage processing in the Marshall Islands.

However, the Marshall Islands, like most other Pacific Islands, does not appear to be as favorable a site for processing as either Australia or Canada. The transportation disadvantage to distant processing sites would probably be more than offset by the advantages of good port sites, low-cost energy and water, and available land for plants and waste disposal. In addition, investors will have concerns about major investments of over a half billion dollars in a young nation with no history of large private investments. Finally, the complicated land ownership problem in the Marshall Islands will be of concern to any potential investor. On the positive side, the Marshall Islands government would probably negotiate a favorable tax regime for a major crust mining and processing project.

The outlook is for some TNC exploration for crusts in the Marshall Islands over the next decade. If commercial developments do occur in the Pacific, the Marshall Islands will be one of the top candidates. With respect to processing of crusts, both technical and economic factors appear to favor transport of crusts to a site in one of the major countries around the Pacific (Australia, Canada, or the United States). Options for encouraging processing crusts in the Marshall Islands should be actively examined when private investors have located a possible crust mine site. Environmental baseline studies should begin during the exploration period. Commercial mining of crusts or nodules is unlikely to occur anywhere in the Pacific before the year 2000.

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APPENDIX A

PERMISSIVE AREAS OF KNOWN SEAMOUNTS IN THE MARSHALL ISLANDS EEZ

Number	Name or Water Depth (fathoms)	Location Latitude	Location Longitude	Area (km^2)
01	1,000	17°00'N,	168°30'E	111
02	635	16°30'N,	167°00'E	393
03	1,125	15°00'N,	167°00'E	23
04	950	15°20'N,	168°40'E	32
05	Taongi/Sybilia	14°30'N,	169°00'E	567
06	720	14°00'N,	167°30'E	2,133
07	530	14°30'N,	166°00'E	704
08	649	13°30'N,	164°30'E	2,953
09	903	14°00'N,	163°15'E	544
10	1,000	14°00'N,	162°00'E	45
11	600	14°30'N,	161°10'E	550
12	1,250	13°08'N,	161°45'E	11
13	624	13°00'N,	162°45'E	330
14	750	13°00'N,	164°30'E	67
15	1,100	12°00'N,	161°20'E	62
16	645	12°00'N,	161°25'E	164
17	810	12°20'N,	162°15'E	84
18	700	11°40'N,	163°00'E	195
19	750	13°00'N,	164°30'E	184
20	Bikini/Sylvania	12°00'N,	165°00'E	2,407
21	490	12°10'N,	166°20'E	628
22	680	12°10'N,	166°40'E	147
23	Rongrik/Mellu	11°50'N,	163°00'E	5,933
24	900	12°40'N,	168°10'E	72
25	830	13°10'N,	169°30'E	318
26	930	14°40'N,	169°30'E	68
27	Dawson	12°15'N,	170°05'E	509
28	1,260	11°55'N,	170°05'E	23
29	520	12°15'N,	168°50'E	502
30	Utrik/Taka	11°10'N,	169°45'E	1009
31	780	11°00'N,	170°05'E	80
32	1,234	11°20'N,	170°00'E	9
33	980	11°25'N,	171°00'E	45
34	1,100	11°20'N,	171°00'E	29
35	Mejit	11°15'N,	171°00'E	180

(continues)

Appendix A, continued

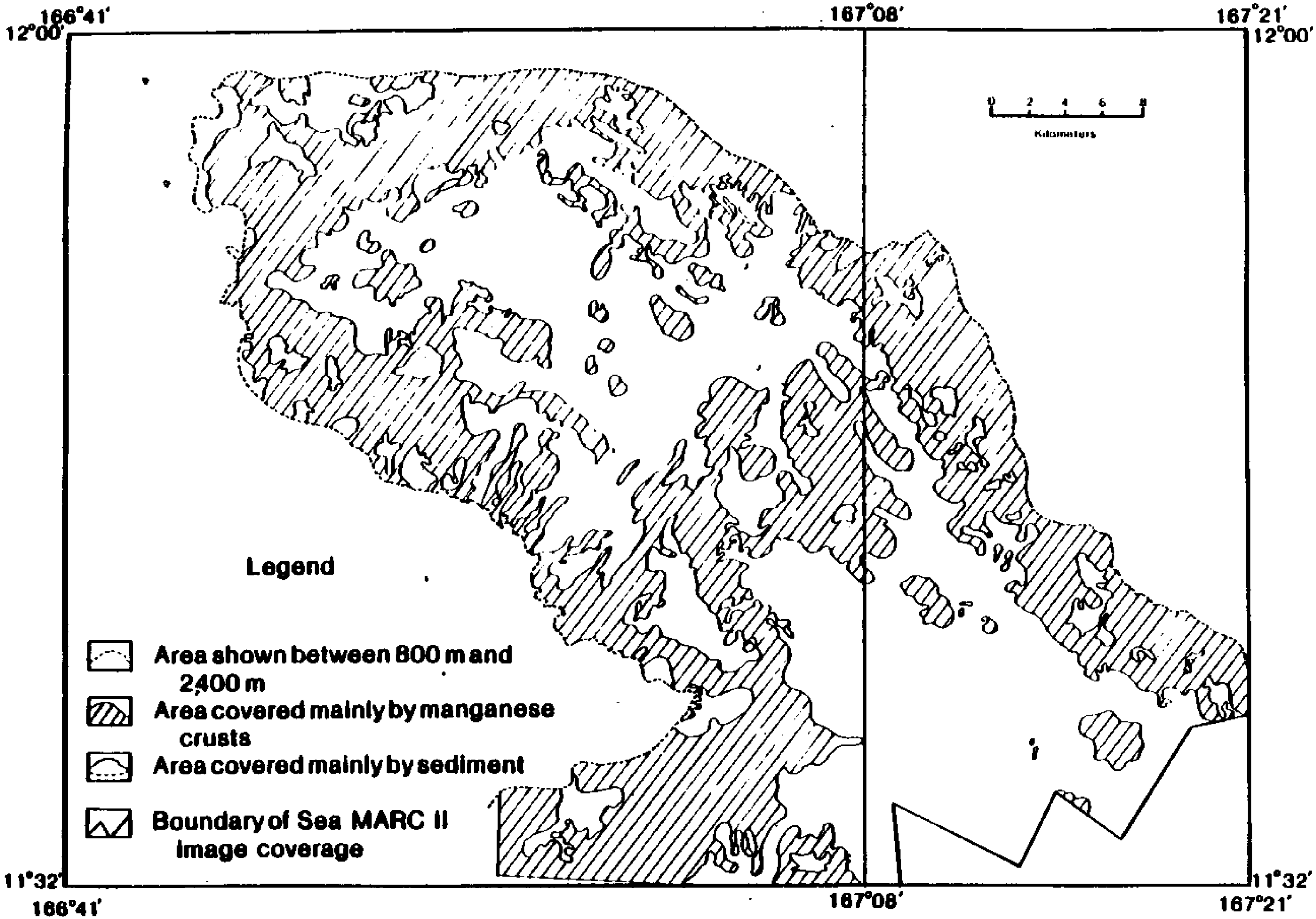
Number	Name or Water Depth (fathoms)	Location Latitude	Location Longitude	Area (km^2)
36	Ailuk	10°50'N,	170°00'E	713
37	Jemo	10°10'N,	169°30'E	257
38	700	10°50'N,	166°20'E	617
39	1,265	10°50'N,	166°35'E	10
40	Wotho	10°00'N,	166°00'E	378
41	580	10°10'N,	162°00'E	3363
42	1,240	10°25'N,	163°00'E	7
43	Enewetak	11°30'N,	162°15'E	2064
44	800	11°45'N,	161°35'E	353
45	870	11°30'N,	161°05'E	325
46	1,000	11°15'N,	159°10'E	82
47	900	11°10'N,	160°10'E	33
48	940	11°10'N,	161°00'E	408
49	825	10°50'N,	161°30'E	772
50	840	10°30'N,	160°40'E	1676
51	760	10°05'N,	160°30'E	446
52	800	9°40'N,	160°35'E	209
53	1,000	8°20'N,	160°40'E	563
54	Ujelang	9°50'N,	161°00'E	909
55	950	10°10'N,	162°00'E	592
56	650	9°50'N,	162°20'E	837
57	1,230	9°45'N,	162°05'E	10
58	1,091	9°20'N,	162°20'E	145
59	1,000	9°00'N,	162°15'E	25
60	1,100	8°30'N,	162°40'E	10
61	650	7°40'N,	163°00'E	746
62	600	8°45'N,	163°10'E	568
63	Ujae	9°00'N,	165°35'E	674
64	880	9°30'N,	166°10'E	389
65	Lae	9°00'N,	166°10'E	281
66	Kwajalein	9°00'N,	167°30'E	1,679
67	Lib	8°20'N,	167°20'E	350
68	Namu	8°00'N,	168°00'E	1,033
69	842	8°45'N,	168°45'E	68
70	Likiep/Wotje/Erikub	10°00'N,	169°00'E	3,689

(continues)

Appendix A, continued

Number	Name or Water Depth (fathoms)	Location Latitude	Location Longitude	Area (km^2)
71	770	8°50'N,	169°45'E	477
72	1,000	9°20'N,	170°45'E	73
73	Aur/Maldelap	8°15'N,	171°00'E	1,839
74	1,000	7°50'N,	171°00'E	471
75	674	7°30'N,	169°30'E	933
76	Jabwot/Ailinglaplap	7°25'N,	168°50'E	1,762
77	Namorik	5°30'N,	168°00'E	587
78	Ebon	4°40'N,	168°40'E	269
79	Kili	5°40'N,	169°10'E	95
80	Jaluit	6°00'N,	169°30'E	798
81	Mili	6°00'N,	172°00'E	1,014
82	665	5°30'N,	172°20'E	1,115
83	680	4°40'N,	172°35'E	188
84	Keats	6°00'N,	173°15'E	235
85	950	6°40'N,	172°20'E	93
86	1,150	6°50'N,	171°55'E	87
87	678	7°20'N,	172°20'E	279
88	Majuro/Arno	7°00'N,	171°20'E	2,457
89	720	7°20'N,	171°20'E	70
Total				58,229

APPENDIX B



The seamount has a measured area of 1,370 m^2 between 800 and 2,400 meters. Forty-two percent of the seamount (cross-hatched areas) is estimated to be free of sediment and probably covered by manganese crust. Estimates based on Sea MARC II side-scan image map.

Source: 1988 R/V Moana Wave Cruise; Hawaii Institute of Geophysics.

APPENDIX C

WASTE PRODUCTS AND POSSIBLE ENVIRONMENTAL IMPACTS OF CRUST PROCESSING

Solid Waste Treatment from a Hydrometallurgical Plant

The following description is from the U.S. Department of Interior, Minerals Management Service, and the State of Hawaii, 1988.

> The major wastes of the hydrometallurgical process ... are the substrate tailings, the pressure leach residues, or tailings, gypsum, $CaSO_4 \cdot H_2O$, and spent process liquor. Treatment and disposal strategies are proposed ... for the last-named, aqueous waste stream. The other three waste streams contain solids in the form of a washed slurry. The type of treatment required for disposal on land will be determined by whether the wastes are considered hazardous by virtue of the content and leachability of toxic or otherwise environmentally deleterious constituents.
>
> Any hazardous designation of the substrate tailings would likely be a consequence of reagents added during the beneficiation step for removal from the desired crust. It is likely that waste substrate, if disposed of on the land, would be kept separate from the leach tailings and the waste gypsum. Here and there, gypsum produced in sulfuric acid neutralization is utilized as a by-product for such end-uses as wallboard, retarder in cement, and soil conditioner and nutrient. For the most part, however, natural gypsum is employed for these uses, and waste gypsum is discarded. In general, one cannot count on finding beneficial uses for the gypsum that would be produced by the hydrometallurgical plant. Thus, land disposal is indicated for at least a major portion of the waste gypsum, as well as for the leach tailings. Indeed, unless a beneficial use, or an economical treatment making possible at-sea disposal, might be developed for either or both solid wastes, they would probably be disposed of together.
>
> The severity of problems associated with disposal of these solid wastes on land will be affected very much by weather and by how much the intended disposal sites are net evaporation, or transpiration, areas. This site-specific characteristic is determined by climatic conditions: temperature, relative humidity, rainfall, wind, and seasonal variations thereof. In the phosphate regions of central Florida, which are flat

and experience heavy rainfall, the waste gypsum of phosphoric acid production is commonly stored on the ground in huge, long heaps, or "stacks."

In the same Florida phosphate regions, the voluminous clay wastes of phosphate rock beneficiation are impounded within big earthen "dams." The environmental drawbacks to this disposal method are equally as obvious as for the gypsum stacks. It would appear, then, that the land-fill method of disposal is the most appropriate for solid wastes generated by the conceptual hydrometallurgical plant and for which at-sea disposal is not feasible. [This option may be difficult in the Marshall Islands where land is scarce.] The stringency of the regulations governing construction and maintenance of the disposal facilities depends, of course, on whether the waste is considered hazardous.

The minimum treatment of the solid wastes prior to disposal is thorough washing so as to remove to acceptable levels any possibly deleterious solutes from the associated slurry water. The major solid wastes from the hydrometallurgical processing of cobalt-rich crust should be sufficiently stable toward degradation and further leaching by slurry water and rainwater as to avoid an official hazardous classification. This view is suggested by their composition and chemistry and supported by leachability tests performed on similiar wastes from manganese nodules processing (Haynes and Law, 1982). Should this favorable result be confirmed on actual crust processing wastes, a simple land-fill technique should suffice. Disposal areas would then be relatively simply constructed and maintained and subsequently reclaimed by distribution of removed top-soil, recontouring as appropriate and revegetating.

For the worst-case situation, where one or more of the wastes unexpectedly does not qualify for classification as innocuous, disposal requirements would be more stringent, as summarized in the following excerpt (Kahane et al., 1985):

- o Incorporate liner to prevent migration of waste out of facility during its active life.
- o Collect and remove leachate from the facility and ensure that leachate depth over the liner does not exceed 1 ft (0.45 m).
- o Design to control flow during at least 25-yr storm.

- o Cover waste or manage unit to control wind dispersal.
- o Prevent overtopping or overfilling.
- o Install system to monitor groundwater in uppermost aquifer.
- o Implement compliance monitoring program if hazardous constituent is detected.
- o Upon closure, design final cover (cap) over waste unit to minimize infiltration of precipitation,
- o Maintain effectiveness of final cover.
- o Operate leachate collection and removal system.
- o Maintain groundwater monitoring system (and leak detection system where double liner is used).
- o Continue 30 years after closure.

Accidental Release

Process plants for cobalt-rich ferromanganese oxide crust will be large and complex industrial facilities through which large quantities of material in solid, liquid and gaseous form will pass. While much of this material is innocuous and is transferred or processed at ambient conditions, some is processed at high temperatures and/or pressures. Accidental release, or discharge, of more than an insignificant quantity could result in its widespread dispersion and the development of a hazardous situation. Hazards could also result from the uncontrolled release of flammable or toxic liquids or gases, or of other materials that could cause environmental damage if dispered. Chronic releases of smaller amounts of material, as from undetected accidents, improperly designed equipment, or misoperation of the process, could also create hazardous situations.

The possibility of the release of such materials and the consequences of their release are recognized in the detailed plant design, and measures are taken to decrease the risks to an acceptable level. Since the present analysis is based on conceptual designs of crust processing plants, it is not possible to describe in detail the measures that would be taken to reduce risks or to quantify the consequences of an accidental release. However, it is possible to describe the amounts and types of materials that would be of concern if accidentally released from crust processing plants. These are specific to the process used, e.g., pyrometallurgial or hydrometallurgical, while the other categories apply to any type of process plant.

Ore Storage, Elutriation and Beneficiation

Although about 150,000 t of wet mined ore is inventoried in the ore storage area, the probability of its accidental release would be very low for a properly designed plant and selected site. The storage pond would be in-ground; dusting would not be troublesome, because the solids would be covered with water. About 2500 t of ground solids are inventoried in the salt-extraction reactions in slurry form, but uncontrolled release of this amount of material is highly unlikely, since the elutriation area would be diked to contain spillage. Comparable amounts of material are inventoried in bins as filter cakes, and about 200 t/hr of coarsely milled ore could be moved as moist solids to and from the elutriation tanks by enclosed conveyors. Good maintenance and careful housekeeping would be required to prevent dispersal of manganese and other oxide constituents of the ore, in the form of dusts emitted from the equipment or resulting from spillage and drying. The reactors and filters would be hooded to control steam emissions, for operational as well as for environmental reasons.

Approximately 10,000 t of finely ground ore is inventoried in the ore beneficiation plant with about two-thirds of the total being held as slurries in in-ground thickener tanks and, therefore, not of major concern. The separated substrate wastes are pumped to disposal in slurry form, while the washed, beneficiated crusts are filtered and transported as filter cake to the metallurgical plant for recovery of the metal values. The previously mentioned techniques would be used to control dusting and spillage. Relatively small amounts, possibly of the order of 10 kilograms per hour (kg/hr), or liquid flotation agents will be added to the pulp to effect separation of crust from substrate. While odorous, and hazardous by virtue of flammability, these reagents are generally either absorbed on the solids or dissolved in the slurry water and, or, are not likely to be dispersed in their original form in the event of a release in the flotation area.

The major environmental and health hazards in the ore storage, elutriation, and beneficiation sections of the plant would be chronic releases of fine manganese oxide and other oxide-containing dusts. Chronic releases can generally be prevented or substantially reduced by proper plant design, operation, maintenance and housekeeping.

Pyrometallurgical Plant

In keeping with the original stipulation, the pyrometallurgical plant proper is considered, for purposes of this analysis, not to include a cobalt refinery. The in-plant inventories or consumption rates of hazardous materials and the conditions under which they are stored or processed are summarized for the pyrometallurgical process in Table 16. This list is not intended to be fully comprehensive since it does not include minor or incidental materials commonly used in processing, such as anti-dusting agents, chemicals for process water treatment, chlorine used for potable water purification, etc. While release of these minor materials could be hazardous, their in-plant inventory is small and their properties are well known; accordingly, they are usually considered to be of less concern than major process materials.

Molten slags or alloys pose an obvious immediate hazard. However, they generally cannot be transported beyond the plant boundaries by accidental discharge, because they solidify rapidly. They are innocuous as solids and, therefore, are not included. The solids which are listed in Table 16 are included because they can be dispersed as airborne particulates.

Although hot, dusty, and toxic by virtue of their composition, carbon monoxide and sulfur-containing gases produced in the dryers, furnaces and converters are present in relatively small amounts. The equipment in which they are produced is normally maintained at slighly subatmospheric pressure, so that the production of these gases can be stopped rapidly if a release is detected. Reducing gases, containing carbon monoxide, would be burned in waste heat boilers for energy recovery prior to release. All off-gases would be scrubbed, if necessary, to meet emission limits on nitrogen and sulfur oxides.

Oxygen is included in the hazardous materials inventory, because it supports combustion of other materials. Significant amounts of oxygen are held in inventory as pressurized liquid and would vaporize and disperse rapidly if the containment vessel were ruptured or if leaks developed in transfer piping. Fuels are included for obvious reasons, although the in-plant inventory of liquid fuels for vehicles and process uses is small, and its storage is conventional.

The movement of large amounts of fine, dry solids through a pyrometallurgical process plant results in the generation of substantial amounts of dusts and presents a possible hazard from either sudden chronic

Table 16

Hazardous Materials Inventory, Pyrometallurgical Process

Material/Origin/Use	Composition (particulates)	Condition	Amount
A. Gases (STP)			
1. Prereduction kiln	CO	~1 atm, 900° C	900 m^3/min
2. Smelting furnace	CO	~1 atm, 1,400° C	250 m^3/min
3. Sulfiding converter	CO, S	~1 atm, 1,400° C	100 m^3/min
4. FeMn furnace	CO	~1 atm, 1,500° C	300 m^3/min
5. Oxygen to process		3 atm, 50° C	15 m^3/min
B. Liquids			
1. Oxygen		10 atm, -150° C	200 t
2. Fuels		Ambient	50 t
C. Solids			
1. Coke		Ambient	20 x 10^3 t
2. Coal		Ambient	60 x 10^3 t
3. Dried crust (ore)		150° - 200° C	2 x 10^3 t
4. Pre-reduced solids		825° C	3 x 10^3 t
5. Process dusts		150° - 825° C	500 t
6. Fume		Variable	5 t

Source: U.S. Department of Interior, Minerals Management Service, and State of Hawaii, 1988.

releases of particulates. Solids conveyors would be enclosed, and transfer points would be hooded and ventilated to reduce emission to the plant environment. Careful housekeeping would prevent spills from being dispersed. All process exhaust streams (such as dryer or furnace off-gases) and fugitives control streams (as from transfer-point hoods) would be passed through baghouses, electrostatic precipitators or other devices to remove particulates.

The discontinuous, ferroalloy phase of the pre-reduced crust solids is pyrophoric. Ignition is prevented by maintaining it under reducing conditions. Transfer of molten materials from the smelting furnaces, converters, and ferromanganese reduction furnaces via ladles or launders will result in the production of fine particulates or sulfurous gases fumed from the very high temperature fluids. For process reasons, the furnaces themselves, including charging ports, penetrations for electrodes or lances, etc., would be carefully sealed and hooded to minimize infiltration of air. Tap holes and skim bays would be hooded and provided with high-volume ventilation for control of fugitives; exhaust gases would be passed through baghouses or precipitators to remove dust, which would be recycled to the extent possible. Slag and matte granulators and cooling pits would also be hooded and ventilated to control vapors and particulate emissions.

The inventory of dried solids, dusts and fume in the plant is relatively small, and the probability of massive release and dispersal is quite small, since these materials are held at atmospheric pressure and mostly within buildings. The major concerns in a pyrometallurgical plant would be the release of noxious gases during upset conditions and/or the chronic release of particulates from a variety of sources.

Coal and coke storage requirements are modest and would be handled in a conventional manner. Anti-dusting agents would be used to control dispersion of particulates during storage and retrieval.

The properties of all the materials listed in Table 16 are well known, and all operations in the pyrometallurgical process plant are known from practice for analogous terrestrial ores. It is not likely that new or untested designs would be required or that new standards would need to be developed for the design or operation of the plant described. Based on historical data, expected failure rates of equipment or systems that would lead to uncontrolled releases of these materials would be of the order of 10^{-3} to 10^{-6} events per year. ... Therefore, the probability of an accidental release occurring during the 20-year plant operating life is very low.

Hydrometallurgical Plant

For the purpose of this analysis, the hydrometallurgical treatment is considered to be carried out as an integrated process, from ore leaching to metals refining. The in-plant inventory or consumption rate of hazardous materials and the conditions under which they are stored or processed is summarized for the hydrometallurgical process in Table 17. The list is not fully comprehensive, since minor and incidental materials commonly used in processing are excluded, as for the pyrometallurgical process. Partially processed crust material is included although, based on analogy with similar types of tailings, the leached solids themselves are not likely to be toxic.

The large flow of sulfur dioxide, trioxide-containing gases occurs in the on-site sulfuric acid plant, and the small flow of hydrogen, sulfur, hydrogen sulfide occurs in the on-site hydrogen sulfide plant. The hydrogen sulfide is compressed and used to precipitate the value metals as sulfides; ammonia is used in the cobalt refiners; and hydrogen is generated and stored on site for use in the production of hydrogen sulfide. The gas inventories in the sulfuric acid and hydrogen sulfide plants are small; operating pressures are near ambient; and the production processes are easily controlled. Accordingly, massive releases of these gases are very unlikely. Gas generation can be halted quickly if a release is detected in any of these plants.

Substantial inventories of leach liquors are in process under pressure and at moderately high temperatures in the leaching operations of the hydrometallurgical plant and cobalt refinery. Loss of vessel integrity or failure of piping components would result in rapid depressurization, with the release of boiling acidic, metal-bearing liquors and the generation of vapors containing acid mists.

Since the leach liquors at reaction temperatures are highly corrosive, the large reaction vessels and their appurtenances would be inspected regularly. The area surrounding the vessels would be diked to contain spills. All components of process piping would be maintained carefully to prevent leakage of these liquors, which would be very corrosive to unprotected equipment.

Table 17

Hazardous Materials Inventory, Hydrometallurgical Process

Material/Origin/Use	Composition	Condition	Amount
A. Gases (STP)			
1. Sulfuric acid plant	SO_2, SO_3, N_2	~1 atm, 550° C	900 m^3/min
2. H_2S plant	H_2, S_2, H_2S	~1 atm, 400° C	20 m^3/min
3. Hydrogen plant	H_2, CO_2, CO	20 atm, 600° C	20 m^3/min
4. H_2S to process		10 atm, 50° C	13 m^3/min
5. Hydrogen		20 atm, 50° C	3 x 10^3 m
6. NH_3 to process		3 atm, 50° C	1.5 m^3/min
B. Liquids			
1. Leach solution (ore leach plant)	H_2SO_4 dissolved salts	35 atm, 255° C	500 m^3
2. Leach solution (cobalt refinery)	H_2SO_4 dissolved salts	10 atm, 170° C	75 m^3
3. Pregnant liquor	H_2SO_4 dissolved salts	1 atm and 100°–50° C	17 x 103 m^3
4. Neutralized pregnant liquor	dissolved salts	1 atm, 50° C	165 m^3
5. Precipitated sulfide slurry	H_2SO_4 dissolved salts	10 atm, 120° C	165 m^3
6. Neutralized effluent	dissolved salts	1 atm, 50° C	160 m^3
7. Manganese sulfate	$MnSO_4$	1 atm, 50° C	45 m^3
8. Ion exchange	kerosene, reagents	1 atm, 50° C	105 m^3
9. Co tankhouse electrolyte	H_2SO_4 dissolved metal	1 atm, 50° C	1500 m^3
10. Ni tankhouse electrolyte	H_2SO_4 dissolved metal	1 atm, 50° C	750 m^3
11. H_2SO_4		Ambient	200 t
12. H_2S		10 atm, 25° C	25 t
13. NH_3		10 atm, 25° C	50 t
14. Fuels		Ambient	650 t
C. Solids			
1. Sodium hydrosulfide	$NaHS \cdot 2H_2O$	Ambient	20 t
2. Sulfur		Ambient	2.5 x 10^3 t
3. Coal		Ambient	8.5 x 10^3 t
4. Ore undergoing leaching		35 atm, 255° C	200 t
5. Leach residue		1 atm and 50° –100° C	12 x 10^3 t
6. Sulfide precipitate		10 atm, 120° C	1 t
7. Precipitates undergoing leaching		10 atm, 170° C	2 t
8. Sulfide leach residues		1 atm and 50° –100° C	20 t

Source: U.S. Department of Interior, Minerals Management Service, and State of Hawaii, 1988.

Much larger inventories of acidic, metal-bearing pregnant liquors, tankhouse electrolytes and other aqueous streams and of organic liquid-ion-exchange solutions, reagents and solvents are contained in the plant, but are held at ambient pressure and near-ambient temperatures. Most of these liquids would be in equipment located within individually bermed, sumped, or diked areas or, in the case of thickeners, in in-ground tanks. Therefore, seepage of small amounts is a more likely occurrence than is a large uncontrolled release. Since most of these fluids are flammable or corrosive, as well as toxic to some degree, inspection and maintenance would be carried out on a regular schedule to prevent spillage.

Storage and containment of liquid fuels and sulfuric acid would be in conventional tanks located within diked areas. Hydrogen sulfide and ammonia, stored as liquids under pressure, would vaporize and disperse rapidly, if storage vessel integrity were lost. Both of these materials are very toxic, especially the former. However, they are widely used, and design and operating practices for their safe use are well known.

Except for the inventory of leach residues, or tailings, held in in-ground thickeners, the amount of solids in the hydrometallurgical process plant would be substantially less than in the pyrometallurgical plant. Furthermore, solids within the former are produced and transported as slurries and, so, are not as likely to be dispersed as are dry dusts. Spillage or leakage of small amounts of slurries could, if allowed to dry, result in the release of particulates.

The leach residues (washed free of attendant liquors) are not likely to be hazardous. The smaller amount of precipitated sulfides, on the other hand, will be very finely divided and subject to oxidation and possible combustion. This could lead to the release of fumes or metal-bearing particulates.

Coal storage would be conventional. Sulfur is considered as a hazardous material because it is combustible and, in powder form is subject to dispersal by dusting. Sodium hydrosulfide is toxic and additionally hazardous because it can generate hydrogen sulfide on hydrolysis or, particularly, if contacted with acidic solutions.

In contrast with the pyrometallurgical plant, normal emissions of gases, dusts and fumes would be very low for the hydrometallurgical plant. Small amounts of acid mist, generated in the cobalt and nickel tankhouses, would be controlled by directed high-volume ventilation. Other process vents and exhausts, being small, would be scrubbed or treated as required. The major concerns in the hydrometallurgical plant would be the uncontrolled release of pressurized, boiling leach liquors or toxic liquids stored under pressure, due to equipment failure or misoperation. Undetected seepage of acidic, metal-bearing solutions would also be of concern, although the hazard would be less immediate.

As in the case for the pyrometallurgical process, the properties of the identified hazardous materials are well known, and no unusual or new processing operations are involved. Based on historical data, failure rates of equipment or systems leading to uncontrolled releases would be expected to be on the order of 10^{-3} to 10^{-6} per year.