DRAFT

ENVIRONMENTAL IMPACT STATEMENT

ESTABLISHMENT OF ENERGY CORRIDOR ON OAHU

JOB NO. H. C. 1084

By

Department of Transportation
State of Hawaii

September 28, 1971

CONTENTS

CONTENTS (continued)

INTRODUCTION

This study presents an evaluation of the environmental impact of the proposed Energy Corridor from Barbers Point to Honolulu, Oahu, Hawaii. The study is intended to procure data for fulfilling the Governor's Executive Order, dated August 23, 1971 which requires an environmental impact statement for "projects utilizing State funds and/or State lands." The environmental impact statement also is a requirement of the State Office of Environmental Quality Control. The study is consistent with the National Environmental Policy Act, 1969, Public Law 91-190, which encourages a systematic interdisciplinary study approach using elements of the natural and social sciences to provide the necessary preliminary environmental impact data.

In accomplishing this study, it was noted that the proposed Energy Corridor was sponsored by Act 33, 1970 Legislature, State of Hawaii. This Act declares the need for an Energy Corridor to transport fuel and other energy sources from places of manufacture or storage to distribution areas within the State of Hawaii. The Act generally authorizes pipeline transport of oil, its derivatives and manufactured gas. The Director of Transportation in the name of the State, and subject to the approval of the Governor, may, for the purposes of the Act, acquire, by purchase or eminent domain, private property in fee simple, or any lesser interest therein, including leases, all property necessary for establishment, maintenance, operation, management and control of the Energy Corridor. The Act was approved May 28, 1970.

PROJECT DESCRIPTION

GENERAL

The proposed Energy Corridor is generally based on implementation of objectives contained in Act 33, the General Plan of Oahu, and the Foreign Trade Zones Act. Environmental and ecological considerations of these require that certain industrial installations and activities be located in areas distant from residential and recreational areas of Honolulu. As shown on the General Plan, a large tract of industrial land has been set aside at Barbers Point in an area known as Campbell Industrial Park. An existing petroleum refinery with a production of 35,000 barrels per day and a proposed refinery of 29,500 barrels per day will provide petroleum products requiring transportation over the 20 mile distance from Barbers Point to Honolulu.

The alternates for transporting the petroleum products have included barge delivery, truck delivery and pipeline delivery. The convenience, dependability and economics of pipeline delivery have formed a basis for selection of the method and provided justification for the Energy Corridor concept. Pipeline transport also is amenable to intermediate delivery points for consumers in Pearl Harbor, Honolulu International Airport and Honolulu Harbor areas. The State-owned Energy Corridor concept provides a means for locating pipelines of several users in a common right-of-way which might otherwise be constrained or out of harmony with the development and ultimate use of traversed lands. Since all aspects of the Energy Corridor would be State controlled, optimization of land use will be assured.

The Energy Corridor generally will have a nominal 30-foot right-of-way over land and 100-foot under water. The preferred alignment

is shown on Plate 1. Alternate alignments considered in this selection are shown on Plate 2. Hawaiian Independent Refinery, Inc. has requested to be an initial user of the corridor. Other users would be provided with option for use as required in the future. As shown on Plate 1, the corridor would extend from the northeast property line of Campbell Industrial Park to terminal facilities at Pier 40 in Honolulu Harbor. This terminus was chosen in order to facilitate connections to the harbor pipeline system.

Intermediate Delivery Points shown on Plate 1 could be provided by users or consumers for Navy and Air Force facilities in Pearl Harbor, Waiau Power Plant and facilities at Honolulu International Airport. Intermediate facilities for pumping, re-heating, monitoring and measuring flow also are planned. These facilities would be provided by the users and/or the consumers and would not be part of the Energy Corridor.

PIPELINES

The Energy Corridor is presently planned to have an ultimate capacity of at least five pipelines. The corridor easement generally will be 30 feet wide with pipeline spacing of 5 feet. In certain confined areas such as through the Waiau Power Plant, the easement will be reduced to 15 feet with 40 feet of surface rights. A 100-foot easement is required for the underwater crossings of East Loch and Keehi Lagoon. This width will permit 20-foot pipeline spacing for ease of construction and maintenance. None of the pipelines are planned for the transport of unrefined products such as crude oil or wet gas. The first two pipelines presumably would carry white petroleum products such as diesel and aircraft fuels and black products such as Navy fuel oil and bunkers.

An initial application to install a 10-inch white fuel pipeline has been received from Hawaiian Independent Refinery, Inc.

Pipelines will be coated and corrosion protected with cathodes. Future heated black oil lines will be provided with thermal wrappings to minimize heat loss where appropriate.

RELATED FACILITIES

Future plans for the Hawaiian Independent Refinery, Inc. fuel transportation system contemplate a refinery pump station, an intermediate en-route pump re-heat station and related pipelines.

Pipelines will be augmented with a pipeline monitoring system. Present systems can provide telemetered information on flow rates and condition of the product transfer. The system will permit optimum control during delivery and provide the means for exercising immediate corrective action in the event of pipeline failure or incident. State and user contingency plans will be implemented in the event of pipeline failure for shut-off, containment, cleanup and repair of leakage.

Ultimately, users may require the addition of facilities for intermediate pumping and reheating. The stations would compensate for losses in pressure and heat during transport of certain products such as black oil. According to options provided in Act 33, natural gas also may be transported in the corridor. These stations and lines would meet with restrictions and standards established by the State.

CONSTRUCTION

The design and construction of pipelines in the Energy Corridor will be based on standards adopted by the State. The standards ultimately provide for safe operation and maintenance of pipelines consistent with regulations

established by the Federal Government and the trades involved. Standards presently adopted by the State include those outlined in Department of Transportation Rules and Regulations, Title 49, Part 195, American National Standards Institute, United States of America Standards Institute, National Fire Protection Association Codes, American Society of Mechanical Engineers Codes and local regulations where applicable.

Preliminary plans for initial pipeline construction call for both buried and short sections of overhead pipelines. Buried pipelines will have 30 to 48 inches of backfill cover (42 inches below bottom of furrows on cane land). Pipelines in the water crossing areas will have at least four feet of cover. Excess soils removed from trenches for these underwater lines will be removed from the area to prevent silting of the surrounding waters. Overhead pipelines at the Waiau Power Plant would be structurally supported. Some exposed piping also may be installed over stream or drainage channel crossings. The greater part of the pipelines will be buried along road and power easements, in cane fields and low density residential areas, in and along proposed highway rights-of-way, through the Naval reservation and in utility and road easements through light industrial and harbor areas.

Lines would be hydrostatically tested prior to installation. Testing would locate leaks and enable repairs prior to initial use. Corrosion protection would be provided to minimize corrosion during operations and enhance the life of the pipelines.

OPERATIONS

Normal operations will transfer refined and conditioned petroleum products through the pipelines. Black oils may require initial heating at the Campbell Industrial Park pump station. Preheating to 200 degrees Fahren-

heit may require that special consideration be given to pipeline insulation. However, initial segments of pipelines will traverse industrial property outside the Energy Corridor where heat loss into the environment will be of somewhat less concern. It is assumed that the soil backfill cover will provide sufficient added insulation through the cane fields and marine loch areas to prevent adverse effects on the cane and to prevent surrounding waters from rising more than 1-1/2 degrees Fahrenheit above ambient. However, this must be verified prior to construction.

In the event of leakage, both black oil and white refined products would tend to flow overland, percolate through subsurface soils or float as oil slicks. Leakage detected either by monitoring systems or pipeline patrol can be terminated almost immediately. Shut-off, repairs and clean-up would be initiated as required. Pipelines designed, constructed and tested in accordance with the State-adopted standards noted previously are not expected to present leakage problems under normal operating conditions.

Odors and noise may be associated with the terminal facilities, intermediate stations and delivery points. Since these are located in industrial areas, the overall effect on the surrounding environment is expected to be minimal. Present design practice permits installation of pumping and compressing facilities which reduce noise and vibration to nearly threshold levels. Odors due to minor spills can be minimized by proper maintenance and immediate clean-up.

The potential installation of a gas line presents possible fire hazards which can only be controlled by a careful design and maintenance program. Codes and standards are strict in regard to operation of gas lines and enforcements of these regulations will be an essential part of the Energy

Corridor operation. Routing of the corridor has been selected to avoid centers of populace concentration.

INCIDENT

In the event of a serious pipeline rupture, State and user contingency plans for shut-off, containment, repair and clean-up must be initiated. Fortunately, gross failures are immediately detected by pipeline monitoring systems. The impact of a major incident is therefore associated mainly with containment and clean-up. Black or white oil leakage from overland pipelines normally would be more manageable than leakage in water or shoreline areas. Adequate contingency plans must be developed to include provision for booms and skimming devices to contain and recover an oil spill. Absorbents, dispersents and other devices could be used as available and incorporated into the contingency plans. Such plans should be reviewed and updated frequently to keep abreast of the rapidly changing spill-related technology.

Failure of pressurized gas lines is normally associated with rupture and/or fire. Pressures less than 150 psi are anticipated. Historically, such failures are rare. Shut-off is a prerequisite to minimizing damage.

ENVIRONMENTAL IMPACT

GENERAL

This study is addressed to the State of Hawaii, Environmental Quality Control Act 132, SLH 1970 and the 1969 National Environmental Policy Act, Public Law 91-190. The intent is to encourage productive and enjoyable harmony between man and his environment; promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; and enrich the understanding of the ecological systems and natural resources important to the nation. Environmental impact statements are therefore required on projects affecting the quality of the human environment and to include the following:

"1) The environmental impact of the proposed action,

"2) Any adverse environmental effects which cannot be avoided should the proposal be implemented,

"3) Alternatives to the proposed action,

"4) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

"5) Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented;"

6) Where appropriate, a discussion of problems and objections raised by other Federal, State, Local agencies, private organizations and individuals in the review process and disposition of issues involved.

The Council on Environmental Quality established by the Environmental Act has responsibility for providing guide lines in preparation of the Environmental Impact Statement. These guide lines are contained in the Federal Register, Volume 36, No. 79 dated April, 1971 and are explicit in points to be covered. As contained herein, a description of the proposed action which includes information and technical data adequate to permit a careful assessment of the environmental impact by commenting agencies is provided. The use of maps and exhibits is encouraged. The probable impact of the proposed action would include assessment of land use, socio-economics, aesthetics, ecology and any of the systems related to the atmosphere, hydrosphere and lithosphere. In projecting the probable impact, it is important to define the conditions at or near the area prior to construction. For this reason, it is essential to collect base line data on the systems. Thereafter, monitoring programs may be planned and carried out to assess the actual environmental impact and modify the mitigating measures for contingency plans accordingly.

The State of Hawaii is in accord with the "Policies and Goals" of the Environmental Act and is committed to implementation of planning and operation for the proposed Energy Corridor which will minimize adverse environmental effects and restore or enhance environmental quality to the fullest extent possible. This study is therefore prerequisite to the statement and ultimate fulfillment of these goals.

LAND USE IMPACT

GENERAL

The Energy Corridor weaves through land areas bordered by several types of land uses. The major portion of the route is surrounded by agricul-

tural development and industrial and military activities. It is positioned to provide direct and convenient service from terminal and storage units to the major consumers, including Barbers Point Naval Air Base, military installations in Pearl Harbor, Waiau Power Plant, the Honolulu International Airport, the industrial district adjacent to Keehi Lagoon and Honolulu Harbor. The actual location of the line is placed to take advantage of existing physical features, such as highways and utility easements, so as to minimize its effect upon adjacent land uses. It maximizes the concept of multiple land use, and embodies the principles for Public Utilities and Terminals as stated in the City and County of Honolulu's General Plan.

GENERAL PLAN

The environmental considerations implemented by the General Plan are inclusive of locating noxious industrial facilities away from Honolulu's urban areas. Specifically, with regard to Public Utilities and Terminals, the General Plan proposes:

1. "To locate the necessary facilities and utilities so as to cause a minimum of inconvenience and no adverse effect on property values, if possible, and to assure that the improvements complement the surrounding development or area."
2. "To encourage the installation of underground utilities, to eliminate ugly poles and wires on existing and proposed streets, where scenic views and vistas exist."
3. "To protect the water reserve areas."

The Energy Corridor concept therefore coordinates the land use objectives and consolidates the routing of required energy transmission systems. Additionally, it strengthens the major industrial districts at the

Campbell Estate Industrial Park and the Keehi Lagoon area in providing essential energy sources to the industrial districts. The placement of the corridor further emphasizes the General Plan principles in serving the military areas and the Honolulu International Airport. Finally, the Energy Corridor maximizes the utilization of land as so designated in the City and County General Plan, and permits a continued strengthening of these specific districts by providing a convenient, efficient and economical system for transporting fuels between places of manufacture or storage and the consumer.

TRAVERSED AREAS

The western terminus of the corridor is the northeast corner of the Campbell Estate Industrial Park. At this point, the line extends eastward paralleling Farrington Highway and an existing power easement to Waipahu, where the highway intersects Kunia Road. Close coordination with Campbell ownership permits the agricultural area bordering the corridor to experience little deleterious effects because of the pipeline easement.

From Waipahu or the northwestern end of West Loch, to its intersection with the Interstate Highway at Pearl City, the corridor follows an abandoned railroad right-of-way most of the way, which also encompasses existing petroleum fuel lines. The land north of the easement through this segment is occupied largely by residential uses and related community service facilities. The south side of the corridor is utilized in part by several small farm plots.

The corridor continues eastward along the Interstate Highway until it enters the northwest corner of East Loch. The corridor then traverses across the East Loch, extending eastward to the edge of the proposed Halawa Stadium grounds. South of Halawa Stadium, the pipeline parallels the pro-

posed right-of-way of the H-1 Interstate Route, and continues to the Honolulu International Airport.

From the International Airport, the route extends eastward at the rear of the Industrial Development, through Keehi Lagoon Beach Park, entering the water at Keehi Lagoon, and then extending into the Kapalama Industrial District, where the route terminates on the eastern end at Pier 40.

SPECIAL CONSIDERATIONS

Recreational areas, historical monuments, and wildlife habitats have generally been avoided in the planning of the proposed route so as to minimize the impact on areas of community interest and aesthetic value. However, all such areas could not be avoided completely and the corridor passes within the vicinity of Waipahu Intermediate and Senior High Schools, Leeward Community College, the proposed Halawa Stadium, Pearl Harbor Elementary School, and Keehi Lagoon Beach Park. The least distance between any major structure at these facilities and the corridor is 200 feet, and in all cases, pipelines will be buried. In most instances, the corridor is separated from these community facilities by being placed at lower elevations, but exceptions exist near the proposed Halawa Stadium, Pearl Harbor Elementary School, and Keehi Lagoon Park where the terrain is flat.

The physical impact on these localities during the construction phase of the project should be minimal. It can be anticipated that long-term detrimental impact upon these facilities will be essentially non-existent since the line will be buried and out-of-sight. Long-term adverse effects can be avoided by careful construction and prudent operation of the project.

FUTURE DEVELOPMENT

The Energy Corridor has been carefully chosen to avoid significant impingement upon existing and expected growth patterns adjacent to the easement in accordance with the General Plan. Easement restrictions will be no greater than those normally required for regular utility easements. The industrial development along the Corridor is proposed to remain. It can expand and grow in the future without curtailment by the presence of the line. In the agricultural area, the facility will not destroy or restrict the continued use of this property for agricultural activities. The route, as it parallels the Interstate Highway, will not cause any detrimental effect upon the highway or use of adjacent property. The corridor is not a barrier to the development of existing or future land areas. The administration of the corridor will come under the jurisdiction of the State of Hawaii, which has the ability to coordinate the use of the easement and to control its effects upon adjacent lands during and after construction.

SHORELINE SETBACK

Elements of the Shoreline Setback Act in relation to beach or water access, use and view at the Keehi Lagoon crossing will be strictly observed. The area affected is 40 feet inland from the upper reaches of wash waves. Because of pipeline burial beneath the lagoon banks and bottom, there will be little evidence of the corridor once it is installed. Additionally, no surface structures, fences, or the like are required at the crossing. During construction, some temporary effects may be experienced. However, these are not expected to be of major significance.

AESTHETIC IMPACT

The installation of pipelines, in the long run, will not have any detrimental impact on the aesthetics of the adjoining area. There will be some temporary or transient aesthetic evidence during the construction since the ground surface will be scarred by trenching and backfill. The noise and dust resulting from construction can be minimized by careful and prudent construction practices. After the construction period, the easement will be fully graded and re-seeded as soon as practicable. In the few potentially erosive areas, special stabilization such as jute mats may be placed. With careful landscape planning, the significance of long-term detrimental impact can be minimized. Odors are not expected to be associated with the pipelines during normal operation.

SOCIO-ECONOMIC IMPACT

The construction and subsequent operation of the proposed Energy Corridor is not expected to have a disruptive impact upon existing or future land use patterns in adjacent areas. This can be seen in the objectives and goals of the City and County's General Plan and Act 33 of the 1970 Legislature. Additionally, the existence of the corridor does not require any amendments to the General Plan. Instead, it will strengthen the existing industrial areas by providing a convenient and efficient energy source for the consumers.

The corridor is preferable to the alternatives of overland transport and close-in barging. The first alternative would create additional congestion and hazards on the streets and highways. The second alternative poses a stronger spill potential than the pipelines. A barge transport spillage incident probably would be of greater magnitude and would be more difficult to contain and clean up.

The full socio-economic impact of the corridor upon Oahu and the State of Hawaii cannot be completely assessed at this time, because the number and types of energy sources and uses which ultimately will utilize the Energy Corridor are not known. In this regard, the Energy Corridor is a potential planning tool for controlling socio-economic effects. Although Hawaiian Independent Refinery, Inc. is primarily concerned with international fuel requirements, domestic fuels, such as gasoline, are potential products which can be transported in the corridor.

On a short-term basis, it has been estimated that a typical 50,000 barrel per day refinery would require 1,000 construction workers to build the facility. Permanent employment would require 250 people, with an annual payroll and local services demand of five million dollars.

The corridor and its pipelines can be considered as long-term features. Pipelines designed to present standards have an indefinite lifetime, but normally are depreciated over a 40-year period.

ECOLOGIC IMPACT

GENERAL

This evaluation of the ecological impact is concerned with identification of the principal ecological communities which the Energy Corridor traverses. Special references also are made to flora, fauna and any rare or endangered species. Impact considerations are discussed separately.

It is apparent that certain background data are lacking and need to be developed by subsequent evaluations. A thorough biological base line survey is necessary to establish the existing conditions in the vicinity of the Energy Corridor. Unless base line conditions are established, it will be impossible to monitor and assess the later effects for updating any remedial plans.

ECOLOGICAL COMMUNITIES

Six ecological communities can be identified traversing eastward from Campbell Industrial Park to the Honolulu Harbor Terminal. The communities are associated with both natural and man-made environments. As discussed below, the communities have been designated as the Sugar Cane Plantation, West Loch Marsh, Middle and East Lochs, Naval Reservation and Harbor Facility. During more thorough studies, additional communities may be designated.

Sugar Cane Plantation - The first ecological community is a sugar cane plantation. This is an agricultural monoculture with other vegetation being suppressed. The deep irrigation ditches and fields support some small animal life. Among these are the Kentucky cardinal, Mynahbird, English sparrow, rice bird, mongoose, various rats and mice, the barred dove, the lace-neck dove and the ring-necked pheasant.

The primary impact considerations are agricultural, requiring that crops be disturbed as little as possible during both construction and operation of the corridor.

West Loch Marsh - This marsh community is located at the upper end of the West Loch. A portion of the marsh is in waters presently classified as AA in regard to water quality. On-going elimination of existing pollution may provide opportunity for an ultimate community of prolific wildlife, both terrestrial and marine. As a result, the marsh can be classified on a preliminary basis as the most important natural community adjacent to the Energy Corridor.

The marsh base is formed by the confluence of the Pacific Ocean waters and the silt laden waters of Waikele Stream. The resulting delta has

been colonized by mangroves. This type of mangrove marsh is a very productive area biologically, with an enormous number and variety of organisms living among the mangrove roots. The outwash from this productive area contributes some food to the filter-feeding oysters (crossostrea virginica) which line the shores of West Loch.

The AA water classification for elimination of pollution is designed ultimately to reestablish the oyster production in this bay. These oysters, while presently quarantined for human consumption, still are used as seed oysters for other parts of the islands. The outwash of biological material in this water also feeds the young of the Nehu fish (stalethorus purpureus) and mullet (mugil cephelus) which breed extensively in the West Loch. The Nehu fish is the principal bait fish of the very important Hawaiian tuna industry. In addition, the biologic outwash feeds and supports a very large and diverse biotic community which includes the top predators and various kinds of marsh fowls. These include the endangered ae'o or Hawaiian stilt (Himantopus h. Knudseni) and the Keolkeo or Hawaiian Coot.

When the mangrove swamp and marshland is viewed exclusively as the habitat of man, it is generally conceded to be a potential area for development. It offers flat land for ease of construction and ready access to aquatic recreation. However, the marsh also is conceived of as an area suitable for other indigenous species. Therefore, it should be preserved and left undisturbed for these species. The Navy, seeing this need, has set aside some 330 acres for wildlife refuge areas in the upper end of West Loch. The result is to preserve the West Loch as one of the few remaining areas on Oahu where an extensive marsh habitat can propagate the wildlife species.

On an impact basis, the West Loch marsh must be given special considerations during both construction and operations of the corridor to disturb the area as little as possible. In particular, silting considerations will preclude the disposal of excess backfill into West Loch waters, and construction during water fowl breeding season should be planned and conducted to minimize disturbance to the birds.

Middle and East Lochs - The Middle Loch is not as critical an area biologically as the West Loch marsh. Some Hawaiian Galimule have been observed near the west side of Waiau Power Plant. Also, there is a bird refuge a few hundred yards south of the Energy Corridor. Fresh water springs provide some local agriculture. Essentially, the same impact considerations apply here as to West Loch, with regard to construction and operations. It is believed, however, that the Galimule may be rare and/or endangered, and therefore require special consideration.

The East Loch is without mangrove marshes, and there appear to be no concentrations of wild fowl or oysters. There is, however, some bait fishing which primarily supports the sport-bank fishing. It is understood that a bird refuge is planned for a part of the Pearl Harbor Park. The corridor at this point is several hundred feet offshore and underwater. Construction conceivably could be disruptive during bird migration and breeding. Any operational or major incident leakage would have impacts of variable consequence which would require immediate correction.

Naval Reservation - The corridor next crosses the Navy reservation and related industrial area. Some of the routing is through untended cane fields and residential planting which includes mature trees. The trees are an integral part of the environmental culture and will be preserved where possible.

Keehi Lagoon - The Keehi Lagoon crossing involves a buried routing through a public park and across the lagoon. Some Nehu are fished here as well as much sport fishing done from banks and bridges.

The Oceanic Institute did a thorough ecological survey of Keehi Lagoon from June through September, 1970. Their final report is available and may be consulted for further detailed information. The conclusion reached was that Keehi Lagoon at present is a biologically poor area.

Harbor Facility - The balance of the corridor traverses commercial developments related to Honolulu harbors. Generally, the area is of little ecological significance. There are sea waters at adjacent wharves and at least one small stream traversed by the corridor. Except in the instance of leakage, the impact on these will be insignificant.

RARE OR ENDANGERED SPECIES

On a national basis there are many rare or endangered species which are protected by law. None of these species have been noted during a brief evaluation of the corridor. There are, however, several local species indigenous to Hawaii which warrant careful attention from an environmental impact viewpoint. The West Loch marsh community is known to support at least two locally endangered species. These are the ae'o or Hawaii stilt and the alee Keolkeo or Hawaiian coot. The Hawaiian Galimule (alai) is notable in the Middle Loch.

Since marsh habitats are becoming rarer and endangered by encroachment from urban areas, on a national basis they must receive special attention. The West Loch marsh is a particular example which should be carefully protected from detrimental environmental impact. In addition, there are probably several other important species in this West Loch area

which would be noted in further study. Therefore, this area will be treated with care and caution during adjacent corridor construction and operation.

IMPACT CONSIDERATIONS

The impact of pipeline construction, operation and potential incident is considered in terms of the alteration of the existing environment. Certain temporary alterations to be considered are the disposal of excess backfill during construction, noise and traffic disruption. In the excavation of the section adjacent to West Loch, no excess backfill material can be wasted in the water to create a silting or turbility problem. Also, construction should be conducted so as to avoid situations critical for wild fowl and fish.

During operation, it is anticipated that at least one pipeline will be carrying heated black oil. In this regard, the temperature of adjacent waters must not be changed more than 1-1/2 degree Fahrenheit. It is assumed in this study that the minimum of four feet of cover in the underwater crossing will provide an adequate thermal barrier between the pipe and water, and the small amount of heat transmitted would be quickly dissipated in the heat sink provided by the covering water. These assumptions should be verified during design of any heated pipeline. Shallow water areas might require special attention such as thermal insulation.

Any leakage from pipeline operation is expected to be small in quantity and of short duration, pending repair. A monitoring and patrol system will be planned for the corridor and should minimize general contamination by leakage.

A large-scale incident such as pipeline rupture would do considerably more damage than minor corrosion leakage, particularly if the spill occurred in vegetated areas or in a marine loch. Contingency plans must

provide for early detection and shut-off, and rapid cleanup will be required to minimize deleterious effects.

Under conditions of large-scale pipe leakage, clean-up is possible in the cane fields. However, it would be difficult without removal of the crop and rehabilitation of the area. In the mangrove swamp of West Loch, complete cleanup would be nearly impossible. This is because the mangrove roots would trap and hold any black oil and require tree-to-tree cleanup. In addition, the shallowness of the area would greatly inhibit or preclude the use of mechanical skimmers operated from boats.

BASE LINE SURVEY AND MONITORING

The time constraints imposed on this ecological study limited it to a review of existing data and a brief field trip. In order to properly assess the short- and long-term ecological effects, it will be necessary to obtain base line data relative to species, populations and communities. Such a base line biological survey should include all ecological communities which actively will be disturbed by the corridor and those aquatic communities downstream of the corridor in the creeks and ditches, West Loch and Keehi Lagoon which could be affected by incidents. Having established base line biological conditions, it will be necessary periodically to sample the important and critical ecological areas in order to assess short- and long-term ecological effects of the corridor as well as all other projects that may affect these areas. Such monitoring surveys should be conducted on a routine basis until an assessment of biological effects can be made and may be required on a periodic basis indefinitely.

GEOLOGIC IMPACT

GEOLOGIC ZONES

The proposed alignment of the Energy Corridor traverses four general geologic zones as described below.

Zone 1 - Campbell Industrial Park to West Loch. This zone is underlain primarily by older consolidated alluvium, which consists mainly of reddish clayey silt soils. On the areas of higher relief, small outcrops of weathered basaltic bedrock are found. At the beginning of the alignment, coralline reef rock is exposed at the surface.

Zone 2 - West Loch to Halawa. Much of this area has been reclaimed by land filling. Underlying soils consist primarily of soft silts and sands of alluvial and estuarine origin. The granular soils are relatively permeable.

Zone 3 - Halawa to Keehi Lagoon. Geologic materials in this area are primarily tuff and coralline reef rock. The tuff is a cemented volcanic ash erupted from the craters of Makalapa and Salt Lake. This material is found primarily on the inland side of Kamehameha Highway. The coralline reef rock is exposed primarily on the seaward side of the highway.

Zone 4 - Keehi Lagoon to Honolulu Harbor. Geologic materials in this zone are similar to those in Zone 2. The land areas are primarily recent fill overlying soft marine sediments. Materials in the area of the Keehi Lagoon crossing are soft silts and sands overlying denser coralline deposits.

SURFACE ALTERATION

Alterations to the ground surface caused by the proposed corridor generally will be temporary in nature. Because the pipelines within the corridor will be buried, trenching and backfilling will be required. Essentially no areas of extreme topographic relief will be crossed. Thus, the ground

surface can be restored to its original form.

Excavation will be almost entirely in soils so that blasting will not be required along any section of the corridor.

SUBSURFACE EFFECTS

The effects of the corridor to the subsurface will be negligible. Loads imposed by the pipelines will be extremely light, and settlement will not occur except to a minor degree in the soft soils in and adjacent to the water crossing areas. Oceanographic and soils engineering studies have been conducted of these areas to provide the pertinent data for adequate pipeline design and depth of burial.

In the event of minor leaks, little percolation of petroleum products into the subsurface is anticipated in most of the geologic materials encountered because of their relatively low permeability. The potential exceptions to this would be in coralline reef rock and sand. Effects of major leaks on the ground water are discussed in the section on Hydrologic Impact.

EROSION AND LANDSLIDING

All the soil materials encountered along the alignment are readily erodable, particularly when disturbed by construction operations. However, pipeline construction can be accomplished in a short time, and the period for potential erosion problems thus will be short. Additionally, the areal extent of construction operations will be small. Prompt revegetation of disturbed areas will adequately protect the corridor area from erosion after construction has been completed. Steeper ground slopes than those encountered along the corridor would be necessary for erosion to pose any permanent problems.

The proposed alignment crosses no existing natural landslide areas. A slope failure did occur several years ago along the shore of West Loch near the proposed corridor alignment and ruptured the Standard Oil pipeline. However, this failure was associated with land filling after the pipeline had been constructed. Therefore, the only potential soil stability problems in the corridor would be in those areas underlain by soft soils if future large landfills were allowed immediately adjacent to the corridor.

CORROSIVE SOILS

Galvanic corrosion of steel pipelines is possible in low, moist areas particularly adjacent to the saline waters of Pearl Harbor. To control this corrosion potential, special pipe coating will be required in addition to cathodic protection.

EARTHQUAKES

Historical earthquake activity in the vicinity of the Island of Oahu has been moderate. No major earthquakes centered near the Island have been recorded, although one in 1948 is reported to have broken windows in downtown Honolulu (Macdonald, 1970, p. 252). The largest historical earthquake in the state, estimated at a magnitude of 7.75, occurred on the Island of Hawaii in 1868 (Furumoto, 1965). All other recorded major earthquakes have occurred on or near the Islands of Hawaii and Maui.

The effects of the 1868 earthquake on Oahu have been estimated at an intensity of V on the Modified Mercali scale (Furumoto, 1965). This intensity has been defined as "Felt by nearly all, many awakened, some fragile objects broken, and unstable objects overturned; a little cracked plaster; trees and poles notably disturbed; pendulum clocks may stop; some damage to stone walls." (Macdonald, 1970, p. 255) A slightly higher

maximum intensity of 6.0 has been estimated on Oahu for an earthquake of unknown magnitude off Molokai in 1871 (Furumoto, 1971).

The adoption of the Uniform Building Code made by the City and County of Honolulu requires that structures be designed for Zone 1 seismic conditions. This designation means that seismic design is required, but only for the least severe conditions. State structures require design in accordance with Zone 3 criteria regardless of location.

Earthquake activity of the greatest intensity recorded in over 100 years will not pose a hazard to the proposed Energy Corridor since the pipelines will be designed and constructed to resist the seismic forces.

TSUNAMIS

Damage on all the Hawaiian Islands has been caused by tsunamis, or seismic sea waves. However, the proposed corridor alignment lies outside any of the potential tsunami damage areas on Oahu. In the sections adjacent to Pearl Harbor and Keehi Lagoon, the maximum effect of a tsunami has been predicted as a four-foot rise in the sea level, but with no actual wave formed. Such a rise in the water surface will have no effect on the corridor.

HYDROLOGIC IMPACT

SURFACE DRAINAGE

The Energy Corridor traverses the southwestern part of Oahu in an area of relatively low rainfall. Therefore, the development of a surface drainage pattern is generally poor except where runoff from higher rainfall areas intersects the corridor. In the sections from Campbell Industrial Park to near Waipahu and from the Halawa area to Keehi Lagoon, no major drainages are crossed by the corridor.

In the vicinity of Pearl Harbor, the corridor crosses eight streams which drain into the harbor. Four of the streams are classified as perennial and four as intermittent. They are listed below:

1) Draining into West Loch
   a) Honouliuli Stream west of Waipahu, (intermittent)
   b) a small drainage in the Waipahu Industrial area, (intermittent)
   c) Waikele Stream (perennial)
   d) Kapakahi Stream (a distributary of Waikele Stream)

2) Draining into Middle Loch
   a) a small drainage near the base of Waipio Peninsula in Waipahu, (intermittent)
   b) Waiawa Stream near Pearl City, (perennial)

3) Draining into East Loch
   a) Waimano Stream west of the Waiau Power Plant in Pearl City, (intermittent)
   b) Halawa Stream, (perennial)

Crossings of all other streams which run into East Loch from the northeast are avoided because the corridor lies offshore within East Loch. Similarly, crossings of Moanalua and Kalihi Streams are avoided because the corridor lies in Keehi Lagoon offshore from their outlets.

Crossings of surface drainages will be made by either bridging or by trenching with burial of the pipelines in the stream beds. Thus, no permanent obstacles to stream flow will be imposed, and the pipelines will be protected from the effects of stream flow and scour.

In the section between Campbell Industrial Park and Waipahu, the corridor runs near or adjacent to a number of cane field irrigation ditches and flumes. When these features are crossed, the pipelines normally will pass underneath them.

The corridor will lie adjacent to the shoreline at the head of West Loch. The pipeline will be buried below the existing ground surfaces. Where the corridor passes through East Loch and Keehi Lagoon, pipelines will be buried in the bottom soils. Thus, disturbance and possible damage to the pipelines by the action of currents, waves and anchors will be avoided.

GROUND WATER ZONES

The corridor lies almost entirely within areas underlain by artesian ground water. The artesian aquifer is basaltic bedrock which generally is covered by several tens to hundreds of feet of relatively impermeable "caprock" sediments interlayered with coralline deposits. In those sections near the shoreline, the water table which exists within the "caprock" sediments and coral normally is so brackish as to be suitable only for industrial use. The underlying artesian water is of much better quality; sources near the coast are used mainly for irrigation and sources further inland for domestic purposes.

Five areas of very large springs issuing from the basalt aquifer exist near the heads of the Pearl Harbor lochs. The corridor passes on the landward side of one of them, Waiawa Spring, and passes through a second, Waimano Spring. Both of these are near Pearl City. Effects of the corridor on the springs are discussed subsequently.

A number of known ground water sources exist at present near the proposed Energy Corridor alignment. Those closest to the corridor are listed on the following page:

1) U. S. Navy shaft and galleries near Makakilo - Domestic supply from near sea level in basalt. Located at least 400 feet north of the alignment.

2) Ewa Plantation wells near Honouliuli - Agricultural supply from basalt below sea level. The nearest is approximately 2000 feet south of the corridor.

3) Three wells near the head of West Loch - Presumably agricultural and/or industrial sources from basalt below sea level. Two are located a few hundred feet south of the corridor and one about 500 feet north of the corridor.

4) Numerous wells near the Waiawa and Waimano Springs - Presumably agricultural sources. Depths of production not known, but presumably shallow.

5) Waiawa Spring - Partially diverted for agricultural use. Watercress farming in the spring area. Located a few hundred feet south of the corridor.

6) Waimano Spring - Partially diverted for industrial use and recycled for agricultural use. Watercress farming in the spring area. Corridor crosses upper spring area.

7) Hawaiian Electric Company wells - Industrial source from basalt about 15 to 20 feet below sea level. Located a few hundred feet north of the corridor.

8) Young Laundry well near Keehi Beach Park - Apparently an industrial source from basalt several hundred feet below sea level.

WATER QUALITY

Generally, all surface drainage waters crossed by the corridor are designated Class 2. The head of West Loch has been classified as AA water. Chapter 37-A of the State Public Health Regulations classifies Middle and East Lochs as Class B. Keehi Lagoon is classified as Class A except for marina areas which are Class B. Although the streams and estuaries crossed by the corridor do not now meet water quality standards, remedial measures being implemented would allow no additional contamination by the corridor products.

Significant flow in the surface drainages is sporadic and no use is made of the water in the lower reaches of the drainages. A certain amount of waste disposal has been accomplished in the past down the drainages, but this is being phased out.

The waters of Pearl Harbor have been devoted almost entirely to Naval use in the recent past. Recreational use has been minimal, partially for security reasons and partially because of the pollution in the waters. Numerous sources of pollution from military, governmental and private sources have been documented, and the state of water quality in the harbor has been estimated. Some commercial bait fishing is conducted in Pearl Harbor; minor sport fishing occurs along the shore; and commercial oyster harvesting will be permitted in West Loch when the waters meet acceptable health standards.

The waters of Keehi Lagoon presently are used for commercial bait fishing and offshore recreational uses, although contamination of the water has been measured. At present, some industrial waste disposal has been noted in the upper reaches of the lagoon.

POTENTIAL CONTAMINATION FROM LEAKAGE

Possible effects on the hydrologic regime may be evaluated by considering two types of leakage: 1) a sudden failure, easily identified by releasing a large quantity of fuel in a short time, and 2) a slow leak, more difficult to detect because of limited volume of leakage, but releasing a significant amount of fuel over an extended period of time. The probability of either type of leak occurring is believed to be very low for pipelines designed to Energy Corridor standards. Small leaks of short duration would have little environmental effect.

Contamination of stream water would be most severe from large, sudden leakage. Appropriate monitoring of pipeline operations should limit this leakage to a short time span so that the waters would not remain contaminated for long. However, cleanup of the stream shoreline and the resulting slick in Pearl Harbor would be necessary. Since stream waters downstream from the corridor are not used, secondary effects of contamination should be minimal. Small leaks will have little impact on flowing stream waters, but frequent inspection of the stream crossings will be appropriate to search for slicks which could indicate such leakage.

Any leakage reaching the cane field irrigation system could cause some damage to the crops. However, immediate cleanup operations in the event of a large leak would minimize the damage.

Contamination of the uppermost water table is possible by pipeline leakage, particularly if the fuel is of a lighter grade. Either a large short-term leak or a small long-term leak could reach the ground water table. Unfortunately, this possibility has been demonstrated recently by a leak in a Navy gasoline pipeline. However, for such contamination to have disastrous

consequences, the leakage would have to be very large and in most cases would have to reach the artesian aquifer.

Ground water sources in the basalt aquifer normally are protected from contamination by the overlying relatively impermeable "caprock." Additionally, any shallow water table within the "caprock" would intercept the leakage which would float on the surface of the uppermost water. However, at the Navy shaft near Makakilo and at Waiawa and Waimano Springs, "caprock" protection is very thin or completely missing. No ground water sources within the "caprock" itself are known to exist in the immediate vicinity of the corridor. The normal direction of ground water flow is in a seaward direction. Thus, areas of most concern with regard to potential contamination will be those seaward or down-gradient from the corridor.

Possible effects of major leakage from pipelines in the Energy Corridor on known water sources closest to the corridor are evaluated as follows:

1) U. S. Navy shaft near Makakilo - Contamination of the ground water source is theoretically possible. However, seepage would have to penetrate more than 150 feet vertically through basalt and migrate at least 400 feet horizontally against the normal ground water gradient.

2) Ewa Plantation wells near Honouliuli - Ground water sources are protected by at least 60 feet of "caprock" sediments, and the closest well is about 2000 feet from the corridor. No effect is anticipated.

3) Three wells near the head of West Loch - Wells produce from the basalt aquifer which is protected by several tens of feet

of "caprock" sediments. Also, one of the wells is up-gradient from the corridor. Contamination is not likely.

4) Wells near Waiawa and Waimano Springs - Details on these wells are lacking, but they are assumed to be shallow and contamination is distinctly possible.

5) Waiawa Spring - The corridor is on a bluff above the spring area, but any large volume of leakage could reach the spring. Contamination of the agricultural water supply and damage to the watercress grown in the area could result.

6) Waimano Spring - Contamination of the spring would be immediate in this area with potential damage to the watercress crop and possible contamination of industrial water.

7) Hawaiian Electric wells - These wells presumably are shallow so that contamination of the water sources is theoretically possible. However, the wells lie up-gradient from the corridor, and the pipelines will be elevated so that leakage will be easily detected. Therefore, no effect is anticipated.

8) Young Laundry well - This well produces from the basalt aquifer which is protected by several hundred feet of "caprock" and probably a shallow water table. Also, the well is up-gradient from the corridor. No effect is anticipated.

Although the springs adjacent to Pearl Harbor represent one of the largest untapped water sources in the vicinity of Honolulu, their direct development is not planned for the foreseeable future. Because of the relatively high salinity of the springs, any development for municipal use of the resources represented by them probably will take place in the form of

wells further inland. Thus, it is not likely that in the event of oil leakage, contamination of any future domestic water supply will occur. However, contamination of the springs still would be serious, and special leak-prevention and leak-detecting measures may be appropriate.

Because most petroleum products are lighter than water, any leakage from pipelines adjacent to or within Pearl Harbor or Keehi Lagoon would create slicks at the water surface. These slicks would tend to be concentrated immediately adjacent to the Energy Corridor, and their direction of movement would be determined primarily by the surface currents and prevailing winds at the time of leakage. Extensive data regarding these currents are generally lacking. However, studies which have been conducted indicate that currents are weak, with maximum velocities of approximately 0.2 knots generally directed seaward during ebbing tides and landward during flooding tides.

There are some indications that in the section of Keehi Lagoon crossed by the corridor, surface currents tend to be directed primarily seaward during periods of the prevailing northeasterly trade winds. Wind direction probably is the dominant factor in controlling the direction of surface currents on relatively protected bodies of water such as Pearl Harbor and Keehi Lagoon. Fresh water inflow also would tend to create currents in a seaward direction.

Measurements of currents a few feet below the water surface in East Loch and Keehi Lagoon were made in connection with studies for the corridor. They indicated a relatively random pattern of current direction with peak velocities of approximately 0.2 knots.

In Pearl Harbor, the effects of an oil slick would be primarily biological at present and have been discussed previously within this Statement. In the future, contamination within and along the shores of Pearl Harbor also would be more objectionable for aesthetic reasons, particularly when the water quality of Pearl Harbor is improved.

In Keehi Lagoon, effects of leakage could include pollution of the shoreline adjacent to the Keehi Lagoon Beach Park. Additionally, an oil slick on the water surface would be particularly objectionable because of the recreational uses of Keehi Lagoon.

POTENTIAL CONTAMINATION FROM SILTING

Pipeline construction activities will necessarily involve disturbance of the soft bottom soils. However, every effort to minimize siltation and turbidity will be made. Because of the relatively weak and variable currents in Pearl Harbor and Keehi Lagoon, the area of silty water is expected to be very limited. Effects of any siltation would be most pronounced in the biological regime, but because of the temporary duration of construction, no significant impact is anticipated.

METEOROLOGIC IMPACT

PREVAILING WINDS

Prevailing winds on the Island of Oahu are Trade Winds which blow from the east and northeast approximately 70 percent of the time. Winds from other directions are relatively uniformly distributed about the compass for the remainder of the time. The winds are important to dispersion of odors and gases and would contribute to dust problems. In addition, the wind would affect surface water currents and tend to move or spread any oil slicks.

DUST

In the drier areas, construction of the pipelines could create a certain amount of dust in the air which would be transported by any winds blowing at the time. Because of the restricted width of the corridor, the amount of dust at any one location would be limited and would be easily controlled by such simple methods as sprinkling.

ODORS AND GASES

Since the pipelines will be buried along almost the entire route, odors are not anticipated except in the event of a leak at the surface.

No plans exist at the present time for transporting manufactured or natural gas within the Energy Corridor. However, it is conceivable that one or more manufactured gas lines might be installed in the future. The manufactured gases normally do not contain toxic gases such as hydrogen sulfide.

PIPELINE LEAKS

Any vapors and gases which escape from the pipelines during leakage would be expected to rise and dissipate relatively rapidly since the gases are lighter than air. The probability of significant odor pollution is slight since the pipeline will generally be buried. In the event of major leakage, local contamination of the air could be significant but would be temporary. The dangers inherent in a gas leak, such as fire or explosion, are obvious and will be carefully evaluated prior to allowing any gas lines in the corridor.

Areas which would be most affected by air pollution would be those downwind immediately adjacent to the corridor. During prevailing wind conditions, most of the corridor runs on the downwind side of existing developed areas. Major exceptions to this are in the Waipahu and Hickam/Airport areas. In these locations, any temporary air pollution would be most noticeable.

SURFACE CURRENTS

Surface waters and floating materials normally would move in the direction of prevailing winds. Thus, any uncontained oil slicks in the Keehi Lagoon would tend to be blown out to sea and thence along the coast. Slicks within the lochs generally would migrate south and southwesterly. Early containment and cleanup would help prevent these slicks from spreading due to wind and surface currents.

UNAVOIDABLE ADVERSE EFFECTS

GENERAL

The Environmental Policy Act requires inquiry into any unavoidable adverse effects such as water or air pollution, damage to life systems, threats to health, undesirable land use patterns or urban congestion. Aspects of land use and congestion are not believed to be adverse. Therefore, those probably adverse environmental impacts which cannot be avoided normally will be associated with construction, operation and incident of the Energy Corridor. It is sufficient to identify these effects wherever possible and propose either mitigating measures or contingency plans to minimize the adversity.

In the context of short-term or long-term effects, it can be assumed that those effects due to construction and probably to incidents would be short-term and of a temporary and quickly remedied nature. Long-term effects would be associated with operation of the Energy Corridor, but by careful planning and design, the adverse effects also can be minimized. It is proposed that by initiation of monitoring programs, certain aspects of operation can be modified to eliminate or reduce effects anticipated or encountered at the outset of the project. Because the environment is constantly changing, it is impossible to predict all of the adverse effects. However, in recognition of past experience, the following are proposed at this time.

CONSTRUCTION EFFECTS

Probable construction effects will be associated with right-of-way clearing, trenching and backfilling, transportation, fabrication, installation and testing of Energy Corridor components. Noise, dust, silting, turbidity

and wasting of excess earth must therefore be anticipated as heavy construction equipment is brought into use along the alignment. Fortunately, pipeline construction normally proceeds at a fairly rapid rate and therefore these adverse effects will be localized and of short duration. After installation and backfill of the pipeline, a temporary land scar will be evident. Also, erosion could be a temporary problem. However, specifications would be worded to include appropriate planting and/or cover to minimize this effect.

HYDROSTATIC TESTING

To reduce the probability of leakage, the pipelines will be hydrostatically tested prior to backfilling. Normally, local waters are used to perform this testing. In the event that salt water were used, the fluid would be evacuated and returned to its source to prevent damage to local vegetation or animal life.

EXCESS EARTH

Although little excess earth material normally remains after backfilling, such excess will have to be removed in areas which cannot tolerate local wasting. These areas would include those where revegetation would be impeded or where excessive silting and turbidity would contribute to local waters. Replaced soils also must be prevented from eroding by use of planting and jute mats wherever erosion would occur before the planting could take root.

CONSTRUCTION TIMING

Because construction schedules are usually controlled by strict time commitments, it is probable that the noise and activity will overlap certain wild life or marine biological cycles. These adverse effects would

be of short duration, however, and it is unlikely there would be any significant long-term impact. Construction timing also may affect the normal cycle of terrestrial or marine harvesting. In these instances, it is reasonable to assume that schedules could be modified slightly on a local basis to minimize the effect.

OPERATIONAL EFFECTS

The normal construction effects will be associated with conditioning, transport and delivery of the energy products. In the case of viscous petroleum products, heating and pumping will require stations which locally may result in noise, vibrations and odors. Some unwanted heat loss also may be experienced near the source. Less viscous petroleum products such as diesel fuel and gasoline do not require heating and therefore heat loss will not present any problems. Both manufactured and natural gases also do not require heating for pipeline transport.

PRODUCT TRANSPORT

In the pipeline transport of petroleum products, some form of minor leakage may occur. This leakage may be contrasted to significant leakage as would occur due to a pipeline incident or failure. Hydrostatic testing of the pipeline will help to prevent multiple instances of leakage in either the pipeline or related fittings and valves. Small penetrations which could result from vandalism or localized corrosion imperfections therefore seem the most likely source of minor leakage. This form of leakage could easily be recognized in water areas and repaired with minimal damage. Leakage below the ground surface may be more difficult to detect and in some instances be degraded before causing any damage. However, wherever leak-

age was detected, either in the form of seepage or water supply contamination, remedial measures would be initiated.

PRODUCT DELIVERY

Noise, odor and spill may be associated with delivery points along the corridor. Present plans call for locating these points within confined areas. These areas normally would be closed to the general public and surrounding environment. Therefore, the effects would be minimal except in the instance of vandalism. Minor leakage from this cause can be remedied on a local basis with little effect. Major leakage would fall in the incident category.

MAJOR INCIDENT EFFECTS

Major incident effect or major pipeline failure would cause the greatest adverse effect on the environment. The occurrence of such incidents would be problematical and due to such triggering events as fire, landsliding, support failure, overhead collision or vandalism. Any one of these modes of failure can be minimized by adequate design, safety precaution and policing. Probability of a major incident is extremely low for pipeline transport.

The U. S. Coast Guard has classified spills as:

Spill	Inshore Waters (gallons)	Offshore Waters (gallons)
Minor	1 to 100	1 to 1,000
Moderate	100 to 10,000	1,000 to 100,000
Major	10,000 plus	100,000 plus

The corridor routing is fortunate in that it does not cross any geologic faults and is outside of any potentially damaging earthquake zone.

Pipeline spacing and burial generally will preclude failure of adjacent lines in the event of a companion pipeline break.

A major fire as a result of a pipeline leak would occur most readily in gas lines which may or may not ever be installed in the corridor. The next most easily ignited fuel is gasoline. The probability of fires from these fuels is much higher in feeder gas mains or around gasoline stations than in the Energy Corridor where a line will be relatively protected. However, gas and gasoline fires of any description are essentially unknown in Honolulu. Thus, the probability of a major fire caused by a leak in the Energy Corridor appears to be acceptably low.

MITIGATING MEASURES

The unavoidable adverse effects can be minimized by application of mitigating measures which will assure prudent design, good workmanship, proper construction, maintained operations, corridor patrol, enforced policing and contingency plans.

Technology regarding spill prevention, containment, dispersal and cleanup is changing and improving rapidly. Incorporating the changes into contingency plans will be required.

ALTERNATES INVESTIGATED

GENERAL

The Environmental Policy Act requires the responsible agency to "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." An exploration and objective evaluation of alternative actions that might avoid some or all of the adverse environmental effects is therefore essential. Analysis of such alternatives and their costs and impact on the environment are required in order not to foreclose prematurely options which might have less detrimental effects.

Alternates for the Energy Corridor have been investigated both in regard to alternate corridor routes AA, BB, A, B, C, F, G, and 1 to 5 shown on Plate 2, and in regard to individual pipelines, barge delivery, truck delivery and harbor refinery. Results of these studies are as follows.

INDIVIDUAL PIPELINES

Consideration was given to the alternative of each user finding his own route for pipeline(s) through southern Oahu. It was quickly determined that this would be a very unsatisfactory alternative for the public. As a consequence, legislation resulting in Act 33 was developed to discourage individual users from installing any more pipelines that were not under close control of the State.

Obvious disadvantages of individual pipelines included: 1) use of more land to accommodate the same number of pipelines, 2) a dispersion over a greater area of those environmental effects associated with pipelines, and 3) inefficient methods of land acquisition which would increase pipeline costs.

ALTERNATE ROUTES

Alternate Energy Corridor routes have been investigated through the Honouliuli Area, Suburban/Industrial Areas, Marine Lochs, Naval Facilities and Honolulu Harbor Areas. Co-locating the corridor facilities with highways and Standard Oil of California (SOCAL) pipelines was also explored. Highly improved and populated areas were avoided because of the effects on improvements, displacements of families and businesses and safety precautions. Investigations indicated that certain sections were feasible for highway co-locating. These were:

1. Farrington Highway, immediately south of Palalai interchange to vicinity of Kunia Road, and
2. Interstate Route H-1 under portions of the Pearl City Viaduct.

Highway co-locating could not be accommodated in:

1. Portions of Interstate Route H-1 not included in #2 above,
2. Farrington Highway, vicinity of Kunia Road to Waiawa Interchange,
3. Kamehameha Highway, Waimano Home Road to McGrew Point, and
4. Geiger Road, Main Street and South Street.

The adequacy of co-locating with an existing SOCAL route also was investigated. According to the Standard Oil Company of California, SOCAL has an 8-inch black oil line, a 4-inch hot water tracer and an 8-inch white oil line within a 15-foot right-of-way. The three pipelines were installed in such a manner that inclusion of additional pipelines in the right-of-way cannot be accommodated without considerable relocation of their existing pipelines. This relocation would disrupt the present supply of petroleum and would be costly. Relocation of their existing lines and/or working close to the heated line also would constitute a safety hazard.

HONOULIULI AREA ROUTES

Four alternate AA- and two BB- routes were considered in the Honouliuli area. The route lengths and estimated costs for three pipelines in the corridor were prepared. The costs are not presented herein.

AA1 - This route follows the SOCAL pipeline route along the old railroad right-of-way and was rejected as too expensive. AA1 is in very heavy coral rock which creates serious problems in regard to construction time, and to safety when working close to SOCAL's operating lines, particularly the heated line.

AA2 - This route follows a cane field road and is acceptable although not as good as the more direct route AA3.

AA3 - This route has the lowest construction cost in that it follows a direct line through undeveloped agricultural lands. All of the property except for a number of small parcels is owned by the Estate of James Campbell.

AA4 - This route borders the Farrington Highway except for a short portion near point AA. This route was favored by the Campbell Estate Trustees because it is least disruptive to the agricultural operations and their long-range development plans.

BB1 - This route followed AA1 and then branched to Geiger Road. Thence it crossed Pearl Harbor at Iroquois Point and terminated in delivery points for the Navy, Airport and Harbor.

BB2 - This route was an alternate to BB1 for crossing the Naval reservation and delivering to facilities near Pearl City.

SUBURBAN/INDUSTRIAL ROUTES

AA to A - At point AA the corridor enters the old railroad right-of-way and the new pipelines will have to be installed alongside the existing

SOCAL lines. However, there are no feasible alternates as the area is very congested. The area is potentially corrosive and special coating will be required on the hot line. This segment is 8,700 feet long.

A to B - Two routes were considered along this segment. Route AB continues along the old railroad right-of-way. This section of the right-of-way contains a Navy 8-inch fuel line as well as the three SOCAL pipelines. It is 8,500 feet long and progress would be very slow. Subsurface conditions would be very corrosive, and working close to the existing lines would be hazardous.

The second and preferred route, AB Alternate, parallels the railroad right-of-way to the north. This route is 9,500 feet long. There will be some inconvenience to property owners for about ten days, but overall it is a better route than along the railroad.

At point A this route leaves the old railroad right-of-way and follows along a planned new street alignment adjacent to Leeward Community College. It then crosses under and turns parallel to the Pearl City Viaduct portion of Interstate Highway to the east end of Second Street. The corridor then crosses under Pearl City Viaduct again and parallels the railroad right-of-way to Hawaiian Electric Company property, through the Waiau Power Plant property, where it enters Pearl Harbor in East Loch.

The corridor width through most of Hawaiian Electric Company property has been reduced to 15-foot width and goes overhead on structural supports. Also included in this segment is a spur line to the Pearl City Peninsula tankage.

MARINE LOCH ROUTE

Four routes were considered in the Marine Loch areas between points B and C. Routing along Kamehameha Highway was not considered feasible due

to the extensive development along that highway. A routing parallel to the H-1 freeway was discarded for the same reason. The railroad right-of-way (SOCAL route) is full of utilities and existing lines. The cost of installing pipelines in this route is excessive.

A water route appears to offer the best solution. The direct length from B to C through East Loch is 11,000 feet. A portion of the eastern end would have to drop down under a channel area to a total depth of perhaps 30 feet to 35 feet below sea level. The line across East Loch can be laid in water north of operational and anchorage areas.

NAVAL FACILITY ROUTES

The general area of the Pearl Harbor Naval facility and reservation from C to F-1, or Aiea Bay through the Honolulu International Airport, has been thoroughly investigated with six routings as discussed below.

Alternate 1, C to F - After the loch area crossing, the route turns and follows the railroad right-of-way toward the Hickam Air Force Base. Numerous Navy fueling lines will be crossed. However, the Navy lines are deep and will not receive any interference from any additional pipelines installed in the corridor. The route continues past the Makai-Honolulu corner of the Navy Publication and Printing Office where it turns toward Kamehameha Highway, continuing in a straight line until opposite the Navy drum fueling facility. At this point, the route turns and continues adjacent to Kamehameha Highway to F.

Some of the area traversed is very tight and it will be necessary to reduce the right-of-way width from 30 feet to as little as 15 feet. The intersection of Kamehameha Highway, Plantation Drive and Center Drive is very complex and reduced right-of-way width will be required. The area

traversed between Weather Central and F is open and available except for buildings occupied by a Navy contractor.

Alternate 2, C to F - This route follows Alternate 1 to the future dental clinic, where it turns and crosses Kamehameha Highway. The route continues to Palmyra Drive and Midway Drive intersection, and then across the Interstate H-1 Highway right-of-way (future) where it continues adjacent to the highway complex and joins the Alternate 1 route.

A commissary warehouse near Kamehameha Highway and four Dependent Public Quarters would be affected by the route. Housing for the tenants and warehouse space would be required to replace these affected improvements.

Alternate 3 - This route considers an alternative to the Alternate 2 route in the Johnson Circle area and does not affect any residences.

Alternate 4 - This route considers an alternative to the Alternate 1 route on the Mauka side of Kamehameha Highway and generally opposite the six Navy storage tanks and future dental clinic areas.

Alternate 5 - After the loch area crossing, the route continues generally in a straight line crossing Kamehameha Highway between Houston and Essex Streets. The route continues adjacent to Salt Lake Boulevard toward the Honolulu International Airport. It continues in a straight line passing Dickson Circle and following the existing SOCAL line adjacent to Kamehameha Highway to points near the Honolulu Airport Road and Keehi Lagoon Seaplane Runway.

The City and County of Honolulu are formulating improvement plans for Salt Lake Boulevard. Also, the stadium project will have a bearing on the future of Salt Lake Boulevard which is being improved to fit growth and local traffic conditions. Scheduling of plans and road reconstruction does

not permit positive coordination of this project with the Energy Corridor. Timing is an unknown quantity. Any facilities installed in Salt Lake Boulevard at this time would require relocation at some future date when final plans for Salt Lake Boulevard are complete. Relocation would require extensive modification or complete replacement of the pipelines at a high cost.

The portion of this route adjacent to Kamehameha Highway is questionable because of timing relative to design of Interstate H-1 Highway. Also, there may be a conflict with the future mass transit system.

Alternate 6 - This route considers an alternative to Alternate 5 to the point where Interstate H-1 Highway and Salt Lake Boulevard intersect. At this point, the corridor turns and continues adjacent to Interstate H-1 Highway to the point where the Alternate 2 route is joined. Alternate 6 continues as either Alternate 2 or 3 routing. Refer to their descriptions for other affected areas.

HONOLULU HARBOR ROUTES

Airport Vicinity - Two general routes have been investigated. One is a continuation of Alternate 1 route from F to F-1.

Alternate 1 route through this area crosses airport property. Airport traffic may necessitate pipeline construction during off hours.

The second route follows Kamehameha Highway and may conflict with the future mass transit system. Timing of highway design activities in this area has not been established. If all problems can be resolved, the shorter route is desirable.

Airport to Pier 40 - The route F1 to G follows the routing of other pipelines. The alternate route through Keehi Beach Park is a shorter water crossing and is not adjacent to any existing pipelines.

Any of the water crossings will require approval of the Honolulu District Engineer, U. S. Army Corps of Engineers, who in turn will have to obtain approval of the Department of Interior, Fish and Wildlife Service, Bureau of Outdoor Recreation, Division of River Basin Studies and Federal Water Control.

The route F2 to G parallels Sand Island Road to point G near the bascule bridge. A terminal is planned at point G. From point G the route narrows to 15 feet in width since fewer pipelines are anticipated. The route skirts the boundary between Kapalama Military Reservation and the planned Oceanographic Research Center where it terminates at Pier 40. Pipelines extending as far as Pier 40 can tie into existing pipeline distribution systems for Honolulu Harbor and Iwilei storage areas.

TRUCK DELIVERY

The use of a fleet of trucks to deliver the petroleum products was considered. This alternative would have a serious impact on Hawaii's already crowded highways and on air quality. To handle the product of Hawaiian Independent Refinery, Inc. (HIRI), a fleet of twenty-three 7,000-gallon tank trucks would be required working round the clock and making eight trips per day. For the approximately 20-mile trip into the city, a total of 2,700,000 miles per year would be driven by the fleet.

If additional producers of energy products are situated at the Campbell Industrial site, additional tanker fleets of sizes varying according to the volume of production would be required. The tanker fleet would not be as economical as either the pipeline or barge delivery. The additional hazards due to the operation of tank trucks containing highly flammable liquids using the same road as pedestrians and vehicles also are apparent. Collisions

with such vehicles could cause explosions and fires. The additional noise and air pollution due to a truck fleet would have a significant environmental impact.

BARGE DELIVERY

The use of barges as a permanent solution to delivery of the completed refinery products from Campbell Industrial Park to intermediate distribution centers near and in Honolulu has been considered as another alternative transporting method. Economically, it is more feasible than trucking but less attractive than a pipeline. Barging, when compared to trucking, would eliminate the long truck hauls from Barbers Point to the major areas of consumption in and near the city.

BARGE SUPPORT

Barging would not eliminate all trucking and/or piping requirements. Barge delivery would be most feasible from the refinery to depots in the harbor. From the harbor, it would be either trucked and/or piped to the users. For the product of the first energy corridor user, the HIRI Refinery, one 40,000-barrel barge operating five to six runs per week theoretically could be used to transfer the 29,500 barrels per day of petroleum products.

SPILL POTENTIALS

Hawaiian waters at times bring relatively high seas, strong winds and offshore currents which can be a hazard to shipping. Running aground in/and due to such seas is at least conceivable, and a barge could create a serious oil spill problem. Spill potential also exists in the vicinity of the refinery's mooring buoy during approach, while docking and during transfer.

The use of Honolulu Harbor for discharging petroleum products would present some additional hazards. Although traffic within the harbor

is closely controlled, there would be the possibility of a collision with an accompanying spill. In off-loading the oil at the dock, there also would be the possibility of some small leaks going unnoticed and leaking oil into the harbor.

STORAGE REQUIREMENTS

If barges were to be used, greater storage than is currently planned for petroleum products would have to be provided at the off-loading point to handle the barge volume. Such additional tank storage in the city is undesirable from an aesthetic viewpoint.

The use of barges presents a storage problem at the refinery. High seas or delays may prevent barges from loading at the refinery dock. Therefore, additional holding storage may be required at the plant site.

SUMMARY

Should additional plants producing energy products come into the Barbers Point area, additional barges would be required. A fleet of such tankers introduced into Hawaiian waters increases the potential problems discussed previously. Although barging cannot be entirely eliminated, its use as a permanent Barbers Point-to-Honolulu transport system for petroleum products is less desirable and efficient than pipelines.

HARBOR REFINERY

Fifteen years ago, the State of Hawaii considered the construction of a harbor refinery as an alternative to the present Barbers Point refinery. At that time, there was a proposal to build a refinery on Sand Island adjacent to the Honolulu Harbor waterfront. The state and city governments jointly decided that the refinery should be located outside of urban Honolulu. The reasons for this decision were safety, potential pollution, and the value of

land. The General Plan was adopted accordingly with Campbell Industrial Park at Barbers Point being set aside for the location of future oil refineries. Thereafter, the Standard Oil of California refinery was constructed. Hawaiian Independent Refinery, Inc. is now constructing the second refinery at this location. A third new refinery by Continental Oil/Dillingham also is being considered for construction in this area.

SHORT-TERM/LONG-TERM RELATIONSHIPS

GENERAL

The Environmental Policy Act requires that the environmental statement address itself to "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity." The Guidelines issued by the Council on Environmental Quality further state that: "This in essence requires the agency to assess the action for cumulative and long-term effects from the perspective that each generation is trustee of the environment for succeeding generations." Pursuant to these guidelines, a short-term/long-term use relationship has been considered under the four separate headings which follow.

INDUSTRIAL SEPARATION

The general plan of industrial separation is to separate any "noxious" industry from the more congested urban area of Honolulu and place these industries in a special industrial park on Barbers Point. This plan has the intent of avoiding even greater congestion, noise and air quality problems in an already crowded area. This plan is currently being implemented by the construction of industrial facilities in the Campbell Industrial Park on Barbers Point. The benefit to the community would be to avoid the kind of congestion, noise, and traffic problems in other cities where heavy industry was built in urban areas.

CORRIDOR CONCEPT

The Energy Corridor concept permits the products generated in a separated industrial area to be transported to delivery points. The corridor will be owned by the State to permit uniform control by the people but will be operated and ultimately financed by private industry. The long-term advantage

of the corridor will be to avoid separate or rivalling easements and permit coordinated pipeline transport. A long-term disadvantage exists regarding Civil Defense in that a concentrated set of pipelines would be more easily disrupted by acts of war or sabotage.

EASEMENT RESTRICTIONS

There are some restrictions on easement involved in the construction and use of the Energy Corridor. Buildings which are habitable or which enclose overhead space cannot be built over the corridor unit for safety reasons. The easement also may involve some covenants which will limit encroachment by residential, commercial or industrial development.

FUTURE DEVELOPMENT

Ultimately, some residential, commercial or industrial developments will be planned for present low yield areas. The building restrictions imposed for compatibility with the corridor will affect the planning of these developments. Areas of populace concentration such as schools and shipping centers, which were avoided by the proposed routing as much as possible, should not be developed immediately adjacent to the corridor. There also may be parallel routes of energy corridors in the future. The impact of these constraints must be recognized.

In assessing the Energy Corridor with respect to very long-term development, it is clearly part of an emerging pattern of industrial urbanization on Oahu. This industrial urbanization probably will contribute to a change in the traditional quality of life which has given Hawaii its distinctive flavor. Also, in respect to industrial and urban development, it is clear that some portions of the native natural environment will suffer in the process. These impacts must be weighed in regard to the corresponding changing times.

The Energy Corridor and associated refineries reflect the trend toward a substantial and continued growth in the demand for petroleum products. Economically, this demand will justify the cost of the refinery and pipeline facilities. Military jet fuel demand is expected to rise from about 16,000 barrels per day in 1972 to 28,000 barrels per day in 1980. This predicted growth results from continued conversion to jet aircraft and from the introduction of larger aircraft. In civilian products, demand is projected to rise in much the same manner.

The long-term relationship of this is that of a continuing rise in combustion products and the related undesirable side effects. These include several forms of pollution such as air, noise, crowding and the disposal of used automobiles. All of these problems will tend to be increased rather than decreased by the use of the Energy Corridor products. Although the Energy Corridor could conceivably create a certain demand for its products by being the most efficient mode of transport, use of the Energy Corridor will be made primarily in response to a pre-existing demand. Thus, while the corridor shall be built, maintained and operated in such manner as to minimize the adverse impact to the environment, all long-term effects cannot be predicted with certainty at this time.

IRREVERSIBLE RESOURCE COMMITMENT

GENERAL

The Council on Environmental Quality requires that any "irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented must be stated. This requires the agency to identify the extent to which the action curtails the range of beneficial uses of the environment." In the case of the Energy Corridor, three irreversible resource commitments have been identified on a preliminary basis. These are alignment fixity, building restrictions, and incident potential.

ALIGNMENT FIXITY

The concept of burying several energy pipelines in a 20-mile long corridor and the easements required thereof generally precludes any relocation of the corridor. The result is an alignment fixity which is irreversible during the life of the pipelines except as it might be modified by State requirements of higher priority.

BUILDING RESTRICTIONS

If this Energy Corridor contains in the future any gas transmitting pipelines, there are certain restrictions upon building which must be observed. No habitable structure nor space confining structure may be built over such gas lines. Consequently, industrial and residential encroachment upon the Energy Corridor is limited. Although not different from other utility easements, this is important in regard to future development.

INCIDENT POTENTIAL

An irreversible and irretrievable commitment is made to the possibility of incidents with respect to this pipeline corridor. If the corridor were not present, there would be no additional potential for spill incidents along

the proposed corridor alignment. The construction of this corridor irretrievably commits an understanding of the potential of spill incidents, no matter how small the probability. All contingency plans must provide for the necessary shutoff, containment, cleanup and repair.

LOCAL GROUPS AND VIEWS

Consistent with the National Environmental Policy, an effort has been made on a preliminary basis to identify local groups which may have an interest in the Energy Corridor. The time-frame for this document has precluded contacting any groups to obtain their views. During the public hearing, these views can be presented. Written testimony for the Shoreline Setback public hearing on September 15, 1971 was submitted on that date by Life of the Land.

At the present time, the following have been preliminarily identified in regard to environmental interest: Life of the Land, Outdoor Circle, Conservation Council, Save Our Surf, The Bishop Museum, Sierra Club and The Audubon Society. In addition, certain civic and community groups exist along the route of the Energy Corridor. These include the community groups of Ewa Beach, Waipahu, Pearl City, Aiea, and Kalihi-Palama.

CONCLUSIONS

On the basis of an evaluation by the engineering, scientific and social disciplines considered, it is concluded that the proposed Energy Corridor, as an alignment, can be constructed along the preferred route as shown herein with minimum damage to the environment. Further, if construction is followed by carefully planned operating procedures and contingency for incident, the corresponding environmental impact also will be minimal. In selecting the routing, it is noted that it generally: 1) follows existing pipelines, road and railroad right-of-way, 2) avoids hazardous geological areas, 3) minimizes potentially damaging hydrologic and marine effects, 4) goes around ecological sensitive areas, 5) reduces, but does not eliminate, the overall expected sociological reaction and impact, and 6) is the most environmentally acceptable alternative available, with respect to both alignment and mode of transport.

Certain features and characteristics tentatively identified during this study such as water quality, corrosive soils, unique species, wind patterns and sociological aspects require detailed study for a more comprehensive environment impact evaluation. However, it is believed that on the basis of present knowledge, the construction and normal operation of the Energy Corridor will have a minimal and temporary impact. Further, as based on the satisfactory performance of recently constructed pipelines elsewhere, and the fact that contingency for incident can be realized, a continuing safe operation can be expected.

In using the information presented herein, it should be recognized that some will be essentially unaltered over time. However, other data such as related to sociological aspects and to some extent ecology, are fairly

unstable and may be changed, depending on events which cannot be foreseen. Therefore, all conclusions are based on judgment and assessments of information available at this time.

- oOo -

The following Plates and Bibliography are attached and complete this Statement.

Plate 1 - Preferred Corridor Alignment

Plate 2 - Alternate Corridor Alignments

Bibliography

BIBLIOGRAPHY

American Petroleum Institute Research Project OS-1, Systems Study of Oil Cleanup Procedures, Status Report, October 15, 1969.

Bathen, K. H., 1970, "The Circulation in Keehi Lagoon, Oahu, Hawaii, During July and August, 1968", Hawaii Institute of Marine Biology Tech. Rep. No. 17, University of Hawaii.

Board of Water Supply, 1963, "Oahu Water Plan", City and County of Honolulu.

Board of Water Supply, 1971, "2020 Plan", City and County of Honolulu.

Cox, D. C., 1961, "Potential Tsunami Inundation Areas in Hawaii", HIG Report No. 14.

Dale, R. H., 1967, Land Use and Its Effect on the Basal Water Supply, Pearl Harbor Area, Oahu, Hawaii, 1931-65", USGS Hydrologic Investigations Atlas HA-267.

Dames & Moore, 1971, "Soils Investigation, Proposed Energy Corridor, West Loch Section, for the State of Hawaii," Honolulu, Hawaii.

Dames & Moore, 1971, "Oceanographic, Geophysical and Soil Investigation", Proposed Energy Corridor, East Loch and Keehi Lagoon Sections, for the State of Hawaii", Honolulu, Hawaii (in preparation)

Environmental Science and Technology, 1971, "Oil Spill Technology Makes Strides", Vol. 5, No. 8.

Federal Water Pollution Control Admin., 1969, "Report on Pollution of the Navigable Waters of Pearl Harbor", U. S. Dept. of the Interior.

Federal Water Pollution Control Admin., 1971, Supplement to reference cited above.

Furumoto, A. S., 1965, "Seismicity of Hawaii", HIG Technical Report.

Furumoto, A. S., 1971, Personal Communication.

Harvey, G. W., 1970, "Keehi Lagoon Ecological Survey, June to September, 1970, Final Report", Makapuu Oceanic Center, Waimanalo, Hawaii.

Honolulu Building Code Service, 1969-1970 Edition, Trade Publishing Co., Honolulu.

Laevastu, T., Avery, D. E. and Cox, D. C., 1964, "Coastal Currents and Sewage Disposal in the Hawaiian Islands", HIG Report, University of Hawaii.

Macdonald, G. A., and Abbott, A. T., 1970, "Volcanoes in The Sea", University of Hawaii Press, Honolulu.

BIBLIOGRAPHY (page 2)

Oil & Gas Journal, 1970, "Industry Gets Some Oil-Spill Answers", Vol. 68, No. 23, pp. 66-67.

Oil & Gas Journal, 1971, "Oil-Spill Control: A hard fight but industry is slowly winning", Vol. 69, No. 34, pp. 69-87.

Oil & Gas Journal, 1970, "Oil Spills: Where we are and where we're going," Vol. 68, No. 22, pp. 91-107.

Oil & Gas Journal, 1970, "New System to Tattle on Channel Leaks", Vol. 68, No. 34, pp. 34-35.

Sparks, A. K., 1963, "Survey of the Oyster Potential of Hawaii", State of Hawaii, Dept. of Land and Natural Resources.

State of Hawaii, Civil Defense Division, January 1971, "Marine Oil Spill Disaster Plan".

State of Hawaii, Dept. of Health, 1968, "Public Health Regulations, Chapter 37-A, Water Quality Standards", (Amended in 1969 and 1971)

Stearns, H. T. and Vaksvik, K. N., 1935, "Geology and Ground Water Resources of the Island of Oahu, Hawaii", Bull. 1, Hawaii Division of Hydrography.

Stearns, H. T. and Vaksvik, K. N., 1938, "Records of the Drilled Wells on the Island of Oahu, Hawaii", Bull. 4, Hawaii Division of Hydrography.

Stearns, H. T., 1939, "Geologic Map and Guide of Oahu, Hawaii", Bull. 2, Hawaii Division of Hydrography.

U. S. Coast Guard, 12th District, November 1970, "Region Nine Pollution Contingency Plan".

U. S. Navy; OICC, Mid Pac and Comfourteen District Civil Engineer Staffs, 1971, "Pearl Harbor Pollution Model Study", sponsored by Commander PACDIV, Naval Facilities Engineering Command.

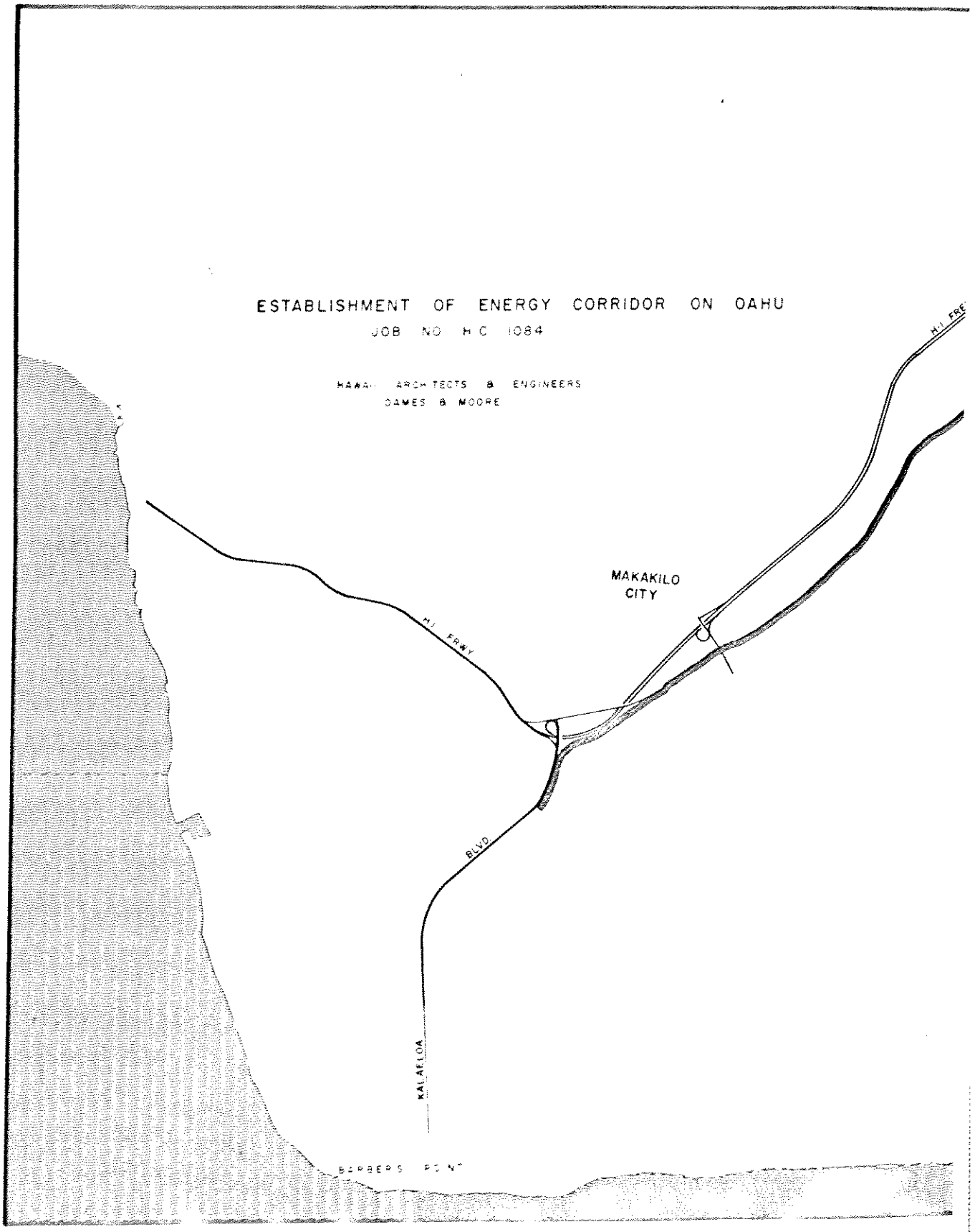
Visher, F. N. and Mink, J. F., 1964", Ground Water Resources in Southern Oahu, Hawaii", USGS Water Supply Paper 1778.

Wentworth, C. K., 1951, "Geology and Ground Water Resources of the Honolulu - Pearl Harbor Area, Oahu, Hawaii", Board of Water Supply, City and County of Honolulu.

Department of Transportation, Office of Hazardous Materials, February 28, 1969, Summary of Liquid Pipeline Accidents Reported on D. O. T. Form 7000-1 from January 1, 1968 through December 31, 1968.

Department of Transportation, Office of Hazardous Materials, February 13, 1970, Summary of Liquid Pipeline Accidents Reported on D. O. T. Form 7000-1 from January 1, 1969 through December 31, 1969.

Department of Transportation, Office of Pipeline Safety, April 1, 1971, Summary of Liquid Pipeline Accidents Reported on D. O. T. Form 7000-1 from January 1, 1970 through December 31, 1970.


ESTABLISHMENT OF ENERGY CORRIDOR ON OAHU
JOB NO HC 1084
HAWAII ARCHITECTS & ENGINEERS
DAMES & MOORE
MAKAKILO CITY
H1 FWY
BLVD
KALAELOA
BARBERS PT

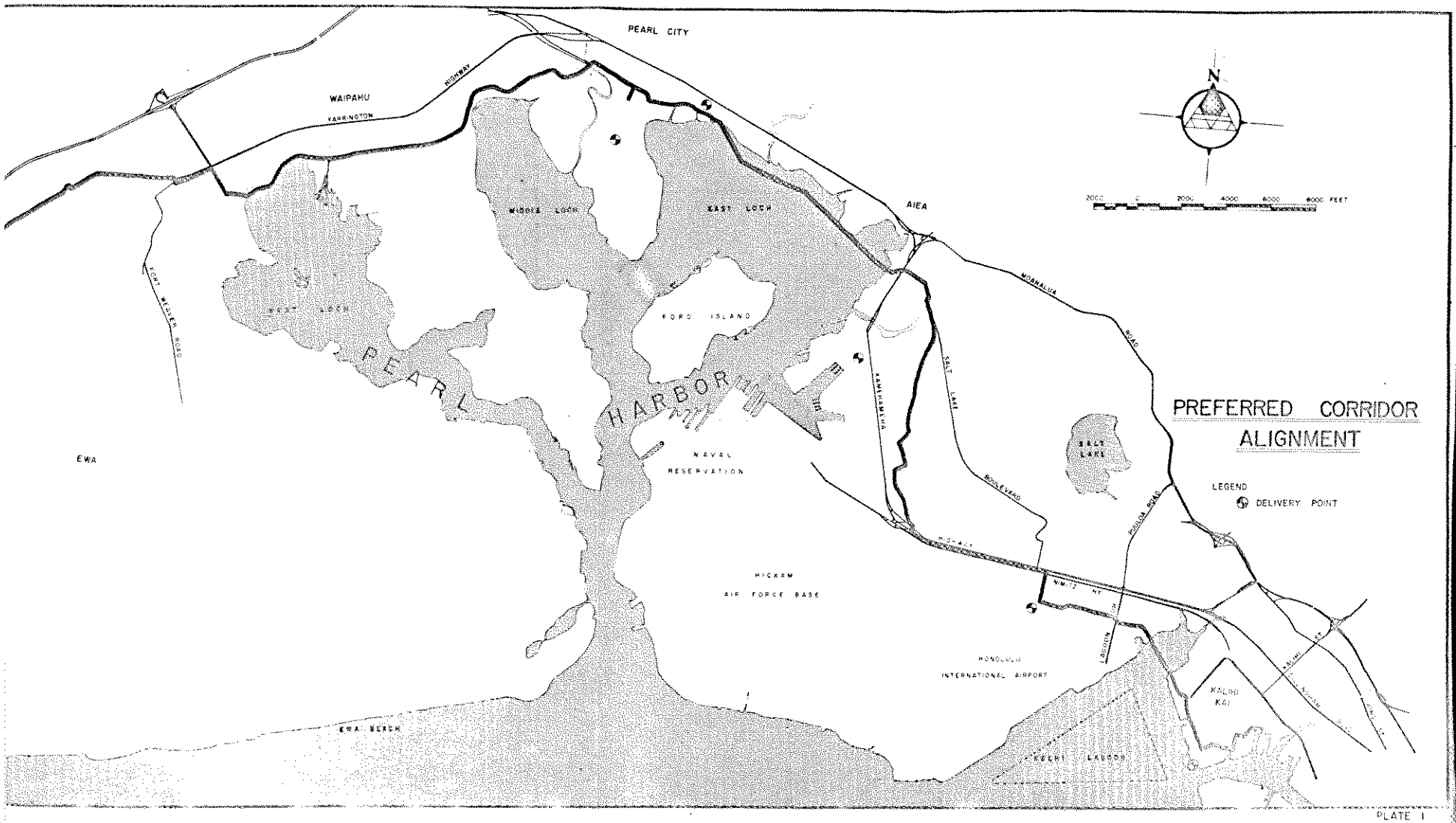
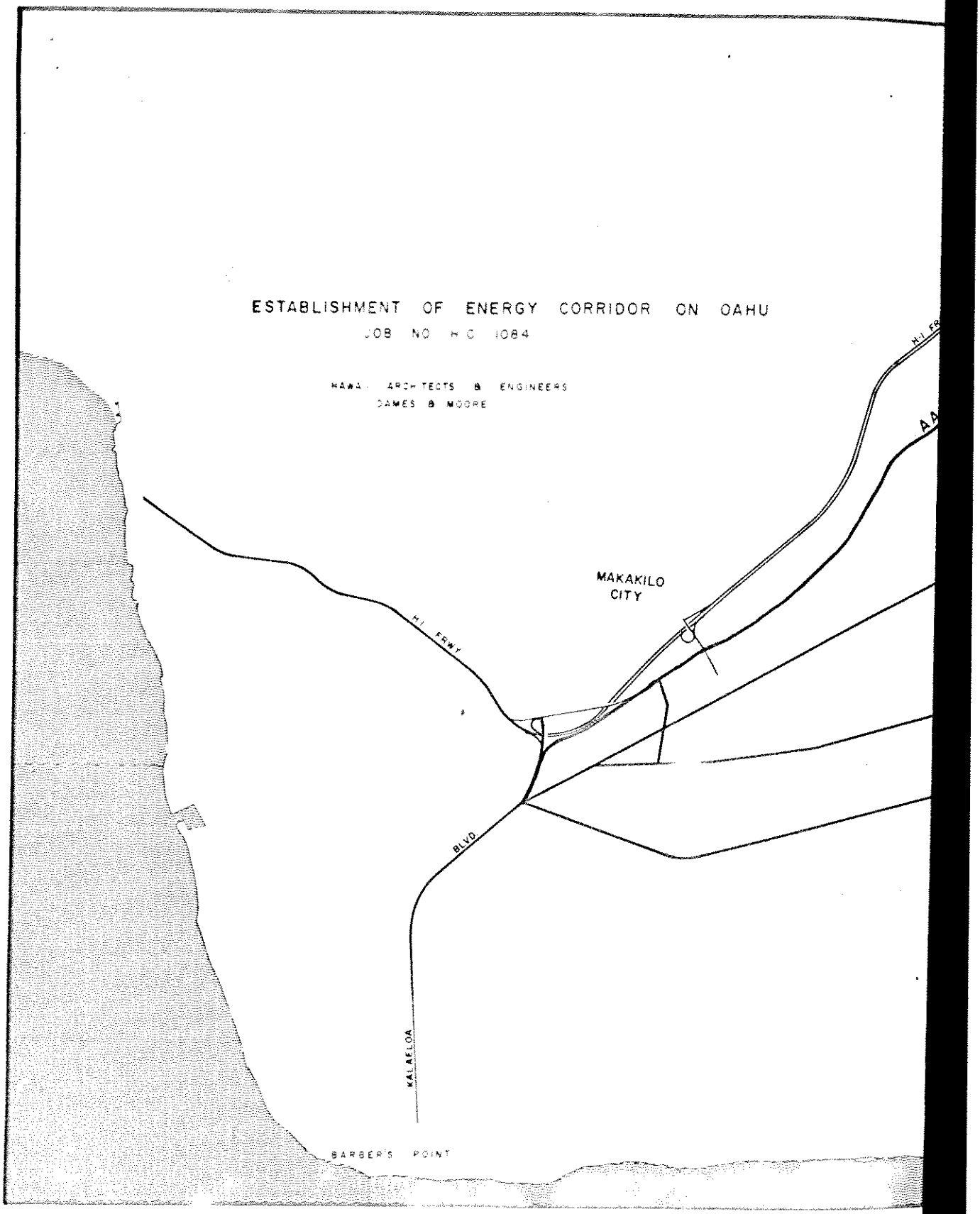

PEARL CITY
WAIPAHU
FARRINGTON
HIGHWAY
AIEA
MOANALUA ROAD
WEST LOCH
MIDDLE LOCH
EAST LOCH
FORD ISLAND
PEARL HARBOR
FORT WEAVER ROAD
NAVAL RESERVATION
SALT LAKE
SALT LAKE BOULEVARD
PUULOA ROAD
HICKAM AIR FORCE BASE
HONOLULU INTERNATIONAL AIRPORT
KALIHI KAI
KALIHI LAGOON
EWA
EWA BEACH
N
2000 0 2000 4000 6000 8000 FEET
PREFERRED CORRIDOR ALIGNMENT
LEGEND
DELIVERY POINT

PLATE 1


ESTABLISHMENT OF ENERGY CORRIDOR ON OAHU
JOB NO H C 1084
HAWAII ARCHITECTS & ENGINEERS
JAMES & MOORE
MAKAKILO CITY
H-1 FRWY
BLVD
KALAELOA
BARBER'S POINT

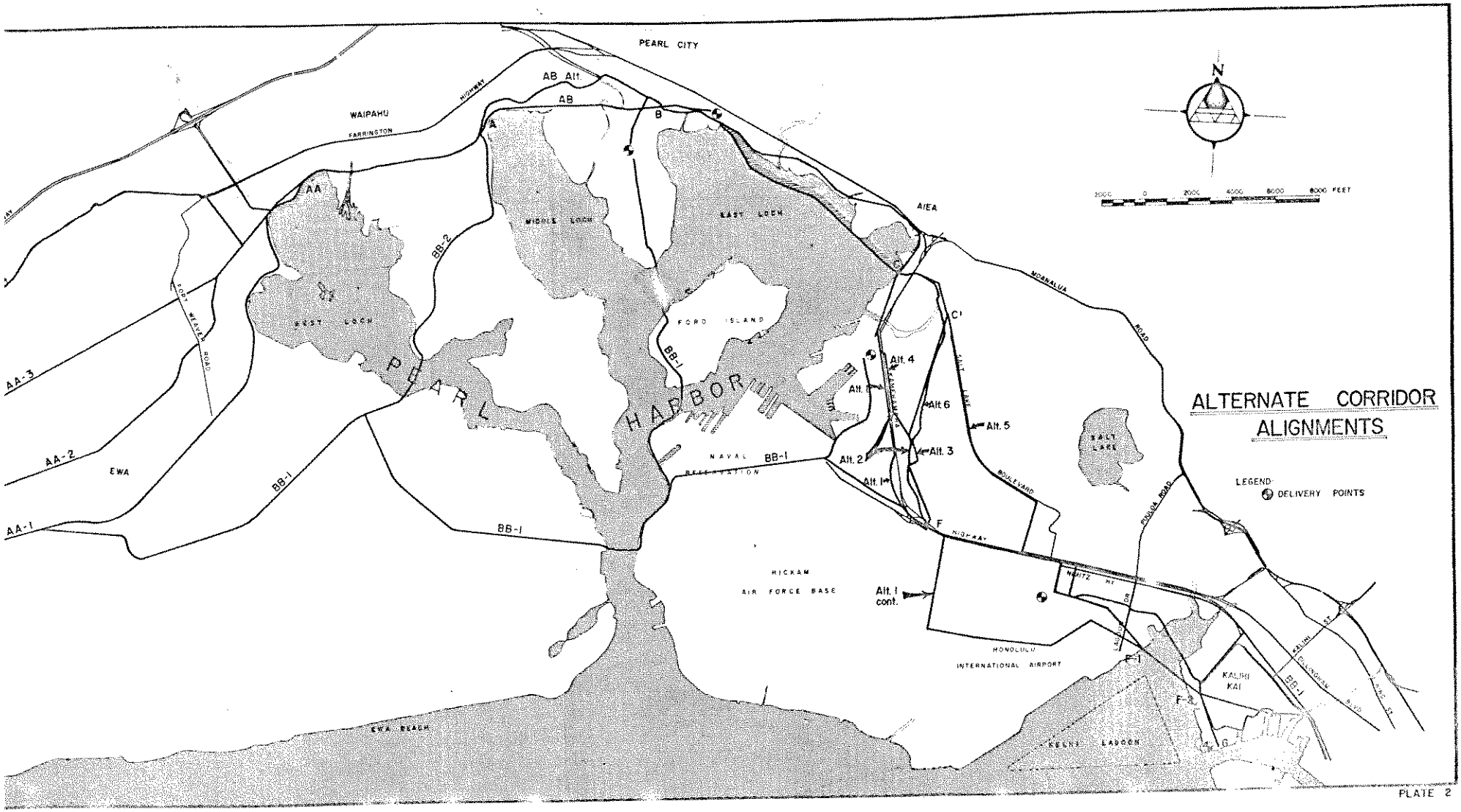

PEARL CITY
AB Alt.
AB
WAIPAHU
FARRINGTON HIGHWAY
AA
AA Alt.
MIDDLE LOCH
EAST LOCH
AIEA
MOANALUA ROAD
FORD ISLAND
WEST LOCH
FORT WEAVER ROAD
BB-2
BB-1
AA-3
AA-2
AA-1
EWA
PEARL HARBOR
NAVAL RESERVATION
Alt. 4
Alt. 6
Alt. 5
Alt. 3
Alt. 2
Alt. 1
SALT LAKE BOULEVARD
PUUHALE ROAD
F
HIGHWAY
HICKAM AIR FORCE BASE
Alt. 1 cont.
NIMITZ HWY
HONOLULU INTERNATIONAL AIRPORT
KALIHI KAI
KALIHI
KAMEHAMEHA HWY
SAND ISLAND
KEEHI LAGOON
EWA BEACH
N
200C 0 2000 4000 6000 8000 FEET
ALTERNATE CORRIDOR ALIGNMENTS
LEGEND
DELIVERY POINTS

PLATE 2