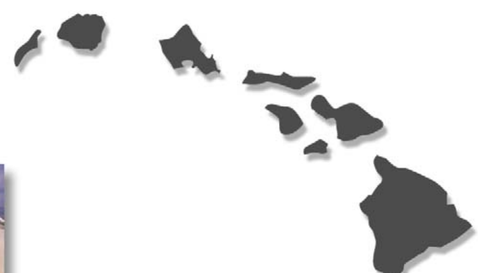
Statewide Fuel Facilities Development Plan

Proposed Fuel Facilities in Hawaii's Commercial Harbors



PDF of Report in Sections

PART 1 of 2 : Sections 1 through 6.3

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March 2009

DEPARTMENT OF TRANSPORTATION • STATE OF HAWAII •

PREFACE

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SECTION ONE

PREFACE

With Hawaii's oil dependency for all its energy needs at about 90 percent, Hawaii has by far the highest oil dependencies among all states. Hawaii's economy depends on a secure and un-interrupted supply of oil. Therefore, Hawaii is vulnerable to changes in cost and availability of crude oil and petroleum products.

Over the past two years, while this study was developed, the global oil markets have experienced far-reaching changes and have shown significant price volatility. Many oil analysts now agree that the era of "cheap-and-easy-oil" is over and that the world economy will have to face much higher oil prices because of possible supply constraints in the coming years.

As recent as in 2003, oil experts in Hawaii predicted stable oil market through the year 2015, with projected oil prices around $25 per barrel. Now, only five years later, many oil analysts concede the fact that the global oil supply has entered a new era, where short-term price-hikes between $150 and $200 per barrel are realistic scenarios, as proven by the oil price spike in summer 2008. The International Energy Agency (IEA), the Paris-based "energy watchdog" of the Organization for Economic Co-operation and Development (OECD), has recently warned in its World Energy Outlook 2008 that the world is facing a severe future "supply crunch" if future oil production projects that will provide an increase in net-supply gain are not implemented on schedule. Since no easy short-term solutions seem available or realistic, a tight supply-to-demand situation might then be likely for years to come. According to the IEA, the evolving credit crunch that started in the second half of 2008, will only have a limited effect on the future of the oil supply, although the global oil demand is showing some slacking as many economies slide into worsening recession. IEA sees the future energy world as very different from the current one and Hawaii's energy future might be also significantly different from the current status quo.

After the oil price spike of 2008, when the oil price approached the $150 per barrel mark, the oil price has retreated to a range of currently $40 to $50. While low oil prices are good in the short-term for the consumer and economies reeling under heavy financial burden they are problematic in the long-term. Safeguarding a secure future supply of oil, which is increasingly coming from oil fields that are costly to develop or are in areas that present harsh physical or political climates, will require very high investments. If the anticipated oil price will not guarantee a favorable return of investment many oil production projects might not be developed in time to avert an oil supply crunch down the road. The IEA suggests very high investments in new oil capacities and mitigating the accelerating decline in existing oil production capacities will be a crucial need of a securely supplied oil market. The recent "collapse" of the oil price might be a short-term indicator of the highly volatile global oil market; and prudent energy policies should keep an eye on the expected tight long-term supply outlooks.

Since Hawaii is so overwhelmingly dependent on imported crude oil and petroleum products the development of renewable energies and biofuels is a priority concern for the State of Hawaii to mitigate this high dependence of imported oil. Hawaii has already implemented many promising pilot projects over the past years and Hawaii will surely be an important center of alternative energy in the years to come. But even with an aggressive development of alternative fuels and renewable energies, Hawaii cannot stop its dependency on oil "overnight" and for many years petroleum will remain the main provider for its energy demands. In fact, while the new alternative energy systems will be implemented in Hawaii in the years ahead, Hawaii's conventional oil based infrastructure has still to be upgraded to allow for a continuing safe and secure supply chain.

As stressed in the findings of this report “Statewide Fuel Facility Development Plan”, flexibility in design and construction is deemed a key consideration for future fuel facilities in the commercial harbors, in order to accommodate Hawaii’s changing future fuel and energy needs.

The unprecedented recent changes in the global oil market and the evolving challenging long-term outlook for crude oil give the recommendations contained in this report a stronger and more urgent significance than was envisioned at the time when the study commenced, only two years ago.

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The purpose of this study is to provide an assessment of fuel facilities in the State of Hawaii's commercial harbors system and to provide recommendations of facility improvements to meet future needs. Petroleum is the main source of energy in Hawaii and its economy depends on a secure and uninterrupted supply of fuel for transportation and the generation of electricity. Because of this, the Hawaii Department of Transportation, Harbors Division, is conducting this study to plan for the future requirements of its commercial harbor fuel facilities with the goal of providing for an uninterrupted and secure movement of fuel through its facilities.

Because of the robust economic conditions in Hawaii during the mid-2000s and the resulting expanding cargo volume that was transported through the commercial harbors system, a number of harbors were coping with congested operating conditions and scarce berthing space. Also, because commercial piers are multi-use, liquid-bulk cargo operations (e.g., petroleum fuel shipments) are competing with containerized cargo for the finite berthing space available. Although liquid-bulk cargo has been historically treated as "another form of cargo," present fuel operations in the commercial harbors face future challenges, which are quite different from standard cargo handling operations.

Due to Hawaii's isolation from the continental U.S., its energy infrastructure and consumption are unique. While the per capita energy consumption in Hawaii is among the lowest in the U.S., its per capita petroleum consumption is almost double that of mainland U.S. The heavy dependency of Hawaii on oil is due to the facts that Hawaii has a very high per capita demand for jet fuel and that about 80 percent of the electricity generation utilizes petroleum (Hawaii also uses coal and synthetic natural gas for its energy generation needs).

Over the past decade, the demand for key petroleum products such as gasoline, jet fuel and distillates (e.g., diesel and residual oil) modestly increased. Inferring from these historical trends, a possible abrupt change in requirements in Hawaii's fuel system might seem unlikely; but there are indications that the Hawaii's fuel industry will face significant changes in the near future.

One of the looming challenges for Hawaii's fuel supply is the fact that the global oil supply situation has entered an era of structural change. While Hawaii uses only a minute amount of the global oil supply, any profound changes in the global oil market are magnified locally due to the heavy dependence of Hawaii's economy on petroleum. According to many oil analysts and industry leaders, the era of "easy-and-cheap oil" is over. The supply of oil in the future will increasingly come from unconventional sources and from potentially politically unstable regions; such oil exploration and production is inherently more expensive than conventional oil and potential supply interruptions could be more likely.

The price of oil has seen a dramatic swing during 2008. The oil price (New York Mercantile Exchange, Inc. (NYMEX) reported benchmark for light, sweet crude oils) increased from around $100 per barrel at the start of the year to a maximum price of about $145 per barrel in July 2008. After the hitting the maximum price, the oil price then literally "collapsed" to between $40 and $50 per barrel towards the close of the year 2008. There is a considerable range of suggested reasons for the price drop and differing estimates about how long the oil price will stay low. But though a low oil price seems attractive for Hawaii in the short-term, low prices bring the danger of dwindling investment into increasingly expensive and technologically challenging oil field developments in the future, and this could cause future supply bottlenecks when the global demand rebounds in the near future.

The sources of crude oil supply to Hawaii have changed significantly over the past decade. In 1994, Hawaii obtained over 86 percent of its crude oil supply from Alaska and Indonesia. Since then, these two oil regions have entered into production declines and in 2005 Hawaii imported only 21 percent of its oil from these formerly key suppliers. The supply shortfall has been made up by importation of crude oil from other countries, some of which might face the prospect of a decline in oil production themselves. It seems very likely that Hawaii's refineries will be faced with the need to continuously change their supplier countries, since more and more of the global oil supply will come out of the OPEC countries, which have not been typical crude oil providers for Hawaii.

While the substitution of supply countries might work to provide the required quantity of oil, the difference in quality of crude oil from different regions (e.g., the API density that refers to how "heavy" crude is or the sulfur contents) might have a significant impact on Hawaii's refineries. Currently, the local refineries are preferably using light and sweet crude to produce the petroleum products required in Hawaii.

Hawaii's refineries play a crucial role in the fuel and energy supply of the state. Under the present fuel supply system, crude oil is shipped to Hawaii and refined locally to the **output slate** (e.g., the composition and proportion of the petroleum products refined from the crude oil) that is specific for the Hawaii Islands. The proportional composition of demand for petroleum products in Hawaii differs significantly from the average U.S. demand. For example, the output slate that fits Hawaii's fuel demands has a very high percentage of heavier distillate fractions (i.e., residual oil), which is used in electric power generation.

In order to serve the unique petroleum fuel demand in Hawaii, the two local refineries located on Oahu produce significantly less gasoline and more residual fuel from crude oil input than a typical refinery on the continental U.S. or in Asia. A different output slate, however, would be required, if large quantities of biofuels were replacing gasoline or diesel for transportation or if large quantities of electric power were to be generated by natural gas, coal, biofuel or renewable energies, rather than by residual fuel oil or distillate.

The reality is that the local refineries would probably not be able to quickly change their production methodologies and equipment to process much heavier or sour crude oil as effectively as they do at this time. Projections in the global oil supply, however, suggest that the future supply will grow increasingly heavy and/or sour in the coming years. Significant changes in the operation of Hawaii's refineries would affect fuel shipments through the commercial harbors. Increased fuel imports in the form of refined products, rather than crude oil, would also require upgraded and expanded fuel facility infrastructure in the commercial harbors that can handle larger fuel quantities and a wider range of conventional and evolving fuel types.

Another challenge to Hawaii's fuel supply are biofuels. The State of Hawaii intends to assertively utilize biofuels as an important contributor to its energy supply. While the original scope of this study was to develop solutions only for petroleum fuel facilities, it became apparent during the study that biofuels have their own technical challenges to warrant a closer look at biofuel technologies and consider them in the development of fuel facilities for the State commercial harbors. In due course, this study has increased in scope to include various biofuels and fuel scenarios that will affect the fuel facilities in all of Hawaii's commercial harbors.

This study considers the future supply of biofuel only in a qualitative manner. A future expansion of this study would be required to develop quantitative predictions of biofuels and other fuel alternatives that will affect the fuel handling in the State commercial harbors through the planning horizon of 2030. With more exact quantitative predictions of future fuel demand for Hawaii, the design concepts for future fuel facilities proposed in this study may need some adjustments.

While quantitative predictions of future fuel demand in Hawaii are beyond the scope of this study, the following three design scenarios are planning for fuel facilities in the State commercial harbors. Since the purpose of the study is to develop guidelines for the development of fuel facilities in the commercial harbors through the year 2030, it was deemed necessary to consider multiple possible future fuel system scenarios, which will affect the design of fuel facilities in the State commercial harbors. The three future scenarios are briefly described in the following paragraphs:

FUTURE FUEL SYSTEM SCENARIOS:

Scenario 1: Status Quo

This scenario envisions the present petroleum based fuel system in Hawaii to continue into the future. Under this system, the refineries continue to import crude oil for local refining into the various petroleum products for local consumption. Under this design scenario, biofuel plays a minor role, such as the use of ethanol as a mandated oxidant supplement to motor gasoline. Changes in fuel facilities in the commercial harbors would primarily be to meet changing safety and environmental regulations, post-9/11 security requirements and evolving fuel transport technologies. Another aspect of a changing fuel industry would be a shift in demand for petroleum products, such as implementation of ultra-low sulfur diesel fuel or other evolving petroleum fuels (i.e., locally-specific fuel types or "boutique" fuels). All these changes would affect fuel-handling facilities in the State commercial harbors.

Scenario 2: Aggressive Development of Biofuels

This scenario assumes a more aggressive development of biofuels in Hawaii. Under Design Scenario 2, biofuels would be either imported to Hawaii or produced locally. Local production would either use imported feedstock or feedstock produced in Hawaii. Under this scenario, a portion of heavier distillates (e.g., for electricity generation) and lighter products (e.g., gasoline) would be replaced by biofuel, thus impacting refinery output. A more aggressive development of renewable energies or energy conservation (e.g., through higher mandated fuel efficiency of cars) would likewise result in reduced demand of gasoline, diesel and residual fuel, thereby changing the operation and economic scenario of Hawaii's refineries. Consequently, the anticipated increase of petroleum imports and exports through the State commercial harbors translates into the need for expansion of those fuel facilities.

Scenario 3: Significant Use of Natural Gas

This is a radical change from the status quo. Scenario 3 assumes that Hawaii would use natural gas, brought to the islands as liquefied natural gas (LNG), to power electricity generation and to provide utility gas and transportation fuel. In addition, Scenario 3, anticipates large volumes of biofuel to be used in electricity generation and/or transportation. Furthermore, energy conservation efforts and renewable energies would decrease the demand for distillate fuel for electricity production. All of these changes would significantly reduce petroleum demand in Hawaii, especially heavier fuel used in electricity generation. Hawaii's refineries would find it difficult or impossible to operate under the reduced petroleum demand scenario. Consequently, all or a significant portion of petroleum products for Hawaii would need to be imported through the commercial harbors system. Thus, fuel facilities in the commercial harbors would have to accommodate larger volumes of imported refined petroleum products as well as handle biofuel and LNG. Natural gas, in form of LNG, would be unloaded preferably at an offshore terminal, possibly close to Barbers Point, therefore not requiring LNG facilities in the harbors. The liquefied natural gas could be converted into compressed gas for shipments to the neighbor islands, where it could be used for electricity generation or other gas application, thereby substituting heavier fuel or Liquid Petroleum Gas (LPG), respectively. Interisland compressed gas shipments would require fuel facilities in the State harbors.

This study does not endeavor to speculate which of the three design scenarios is most likely to materialize in the future. Rather, these scenarios present a framework of possible fuel related facilities that will be required in the commercial harbors. Future developments of the global fuel supply and Hawaii's own preferred fuel system will determine what type of fuel shipment and handling technologies will be implemented. An important aspect in Hawaii's fuel supply future will be the ability to expeditiously implement fuel types that safeguard Hawaii's need for a secure and continuous supply. Consequently, we believe that the most important design guideline for future fuel facilities in commercial harbors will be the flexibility to handle different quantities and types of fuel.

The future fuel facilities in the commercial harbors are subject to stricter safety, security and environmental requirements than those standards that were in place when the present fuel facilities were built, many years ago. The change in fuel shipment technologies favors fuel vessels that are different in size, hull structure and propulsion than the current fuel barges. New fuel loading facilities will have to control displaced harmful or explosive vapors due to tighter safety and environmental standards. Loading arms, the current preferred industry standard for ship-to-shore fuel transfer connection, provide for safer fuel transfer operations than flexible fuel hoses, which are currently used in Hawaii's harbor. Future fire suppression systems for fuel facilities will have to deal with a much wider range of hazardous fuel products, such as fuel grade ethanol, which causes dangerous and difficult to control fires

Currently, fuel-handling operations in State commercial harbors take place along multi-use cargo piers built for handling general cargo operations. Piers that are dedicated to handle liquid-bulk cargo, however, can be fully operational using simpler docking facilities than containerized cargo. Fuel loading and offloading operations only need transfer pipes to connect to the mid-section of the fuel barge or ship. Therefore, fuel piers can be configured by structurally independent fuel transfer platforms and mooring and breasting dolphins. This form of pier structure, referred to as a "protruding pier" in this study, is typically less expensive than conventional bulkhead piers. In addition, protruding fuel piers can be built at locations in the harbors that would be marginal for general cargo piers. Thus, by separating fuel transfer from general cargo, dedicated fuel piers can increase the overall cargo handling capacity of the harbor in a cost effective manner.

While present pipeline installations in the commercial harbors were built "for the ages" (e.g., installed under thick layers of concrete or in concrete jackets and therefore not easily modified), it is recommended that future fuel pipeline installations in the commercial harbors should be in such a form that provides flexibility for modification. Pipeline installations that enable easy additions or modifications could use pipeline galleries or pipeline racks more effectively than installing pipelines below-ground. Therefore, pipeline systems in future fuel facilities in the commercial harbors might resemble pipeline systems in chemical or petrochemical plants, where pipeline installations on pipeline racks are standard system components and flexibility is an important economic consideration.

The seven State commercial harbors evaluated in this study are:

1. Honolulu Harbor, Oahu
2. Kalaeloa Barbers Point Harbor, Oahu
3. Kahului Harbor, Maui
4. Nawiliwili Harbor. Kauai
5. Port Allen Harbor, Kauai
6. Hilo Harbor. Hawaii Island
7. Kawaihae Harbor, Hawaii Island

With the exception of Honolulu Harbor, where no future changes are anticipated, the study formulates and presents alternatives for the other six State commercial harbors. Anticipation of no change for Honolulu Harbors is based on the assumption that the fuel facilities in Honolulu Harbor are adequate for the immediate future and that Kalaeloa Barbers Point Harbor will accommodate increases and/or changes in imported fuel or inter-island shipments of fuel.

A summary of design alternatives for the different harbors, with the exception of Honolulu Harbor, are briefly summarized in the following paragraphs:

<u>Kalaeloa Barbers Point Harbor - Oahu:</u>

The proposed design alternative for Kalaeloa Barbers Point Harbor would be developed to become the hub for Hawaii's fuel system. Besides loading fuel barges for shipping fuel to the neighbor islands, the harbor would accommodate increased import and export quantities of petroleum products or biofuels, including biofuel feedstock. In the future the harbor might also handle natural gas shipments, if Hawaii opts to use natural gas. Two new dedicated fuel berths are proposed at Piers P-3 and P- 4. At the present time, the proposed location for the new fuel berths is being used for a ship repair operation, which would have to be relocated to another site in the harbor. One of the proposed fuel berths could accommodate fuel tankers up to a size of a small Panamax tanker (~ 420,000 barrel capacity), while the other could accommodate a 400-foott fuel barge. Both fuel berths are built as protruding pier structures, composed of fuel transfer platforms and breasting dolphins. Main pier outfitting components of the two fuel berths would include fixed fire fighting systems and a vapor control system.

Three options for ancillary facilities are proposed, which would provide support functions to the two new fuel berths. The first option for the ancillary facilities would provide a tank farm, typically for biofuel or other evolving fuels, on a site adjacent to the new fuel pier. The second and third options for the ancillary facilities would convey the fuel through transfer pipelines installed in pipeline galleries or on pipeline racks, respectively.

Kahului Commercial Harbor - Maui:

The initial development and selection of fuel facility alternatives for Kahului Harbor was coordinated in conjunction with efforts for the *Kahului Commercial Harbor 2030 Master Plan.* Master Plan stakeholders evaluated initial design scenarios and the most promising design scenarios were developed under the present study into five conceptual design alternatives. All alternatives provide berthing space for 400-foot fuel barges at a new fuel pier and for 600-foot tankers at an existing pier, which is equipped with upgraded fuel transfer systems.

A. Kahului Commercial Harbor - Conceptual Design Alternative A
Proposes a new piled fuel pier structure perpendicular to Pier 3, which would protrude into the inner harbor basin. The new pier structure could accommodate one fuel barge and a RO/RO cargo barge (which would load or offload cargo over the stern, thereby increasing the cargo capacity in Kahului Harbor). The fact that the pier would protrude into the inner harbor basin may affect navigation.

B. Kahului Commercial Harbor - Conceptual Design Alternative B
Proposes to build a new protruding pier structure, which would be dedicated to fuel transfer. The new pier would be located at a presently undeveloped site in the harbor, next to existing Pier 1D. The new fuel pier would be composed of a piled fuel transfer platform and several breasting and mooring dolphins. The new piled fuel pier would be connected to land by means of a roadway, which would also support fuel transfer pipelines. Since the new fuel facilities would be located about 2,400 feet away from the present fuel storage tanks, new interconnecting pipelines would have to be installed to convey the fuel to the existing fuel storage facilities. The long interconnecting pipelines could be installed on pipeline racks providing for cost-effective installation and maintenance. Since the required investments for the long interconnecting fuel pipelines would be considerable, two alternatives that use different pipeline technologies are proposed.

C. Kahului Commercial Harbor - Conceptual Design Alternative C
Proposes to build a new multi-cargo pier next to the existing Pier 1D by using a conventional bulkhead pier structure. As with Conceptual Design Alternative B, long interconnecting pipelines would have to be installed to connect the new fuel berths with existing tank facilities.

D. Kahului Commercial Harbor - Conceptual Design Alternative D
Proposes to expand the existing Pier 3 to be used as a multi-use cargo and fuel pier. The pier expansion would create 57,000 square feet of additional space for cargo handling operations.

E. Kahului Commercial Harbor - Conceptual Design Alternative E
Proposes to add a sheet pile apron around the pier structure of existing multi-use cargo Pier 3 to allow dredging of the harbor basin at Pier 3 to 30 feet, without compromising the existing pier structure. One breasting dolphin would be installed to extend the breasting line of Pier 3, thus allowing berthing of a large fuel-barge at the pier while retaining the cargo handling capacity of Pier 2.

Nawiliwili Commercial Harbor - Kauai:

Alternatives are developed based on previous recommendations concerning the proposed location for new harbor developments at the jetty area. Two new design alternatives would be developed for the jetty area and one alternative is proposed as an improvement of existing fuel transfer installations at Pier 2. These alternatives would provide berthing space for 400-foot fuel barges.

A. Nawiliwili Commercial Harbor - Conceptual Design Alternative A
Proposes to build a new bulkhead pier at the jetty. The new fuel facility would be connected to the existing fuel pipeline system in the harbor.

B. Nawiliwili Commercial Harbor - Conceptual Design Alternative B
Proposes to build a new protruding fuel pier with a fuel transfer platform and breasting dolphins at the jetty. The new fuel facility would be connected to the existing fuel pipeline system in the harbor.

C. Nawiliwili Commercial Harbor - Conceptual Design Alternative C
Proposes to consolidate fuel transfer terminals into one location in existing Pier 2. The Conceptual Design Alternative C would not create new fuel transfer berths, as Conceptual Design Alternative A and B do, but would streamline fuel transfer operations. Currently fuel barges have to unload for different clients at two different locations at the pier. The scope of Conceptual Design Alternative C is therefore significantly less than Alternatives A and B.

Port Allen Commercial Harbor – Kauai:

Port Allen Harbor has only one design concept for future fuel facilities. The proposed future fuel pier is planned as a protruding pier at a presently undeveloped site in the harbor, alongside of the existing breakwater. The pier alignment would fit into the harbor layout that is proposed by the Kauai Commercial Harbors 2025 Master Plan. The fuel pier would therefore be the first phase of the new harbor development. A long piled roadway would connect the new fuel berth with land and also would support long fuel transfer pipelines that are leading to existing fuel storage facilities. The conceptual design would provide berthing space for 400-foot fuel barges and 600-foot tankers.

Hilo Commercial Harbor - Hawaii Island:

Hilo Harbor is the main harbor for fuel shipments to the Island of Hawaii. Fuel for West Hawaii, which is shipped through Hilo Harbor, is currently trucked to West Hawaii. The rapidly developing economy of West Hawaii favors fuel supplies to be shipped through Kawaihae Harbor. This will result in stagnation or decline of fuel volume, shipped through Hilo Harbor and therefore the existing fuel transfer capacity of Hilo Harbor is deemed sufficient. The new Pier 4 cargo pier will necessitate the relocation of several fuel hatches and pipelines at Pier 3 and/or Pier 2, resulting in Pier 2 offering an extra fuel berth

Kawaihae Commercial Harbor – Hawaii Island :

As described in the Hilo Harbor summary above, Kawaihae Harbor will likely see increased and diversified fuel shipments in the future. Two concept design alternatives are proposed to develop new fuel transfer facilities and to alleviate the worsening congestion in the harbor. Both conceptual design alternatives would provide berthing space for 400-foot fuel barges and for 600-feet tankers.

A. Kawaihae Commercial Harbor - Conceptual Design Alternative A
   Proposes a new fuel transfer station on the northern end of Pier 2. The barges or tankers would protrude beyond the northern end of Pier 2. Two breasting dolphins would extend the breasting line of Pier 2, while the actual fuel transfer would still be carried out on the existing Pier 2.

B. Kawaihae Commercial Harbor - Conceptual Design Alternative B
   Proposes extension of the breasting line of Pier 2 further than proposed by Alternative A. The fuel transfer would be carried out on a newly installed piled platform that would be located between Piers 1 and 2. Three breasting dolphins would allow the fuel barge or tanker to protrude far beyond the northern end of Pier 2. Under Conceptual Design Alternative B the fuel barge or tanker would protrude into the mooring envelope of Pier 1.

Upgrading fuel facilities in all the commercial harbors is an important investment to ensure an uninterrupted flow of fuel supplies to Hawaii and between in Hawaiian Islands. The level of importance and urgency, with which the fuel facilities should be improved, is different between the six commercial harbors, for which the report proposes fuel facilities upgrades or expansions.

Different levels of priorities are assessed in quantitative terms using a two-tier scoring approach. Initially five priority criteria are defined, which are each assigned specific overall weights. The sum of all overall weights is 100%, thus the overall weight assigned to one priority criterion reflects its relative importance. In the second tier the six commercial harbors are assigned scores in relation to each criterion. The final ranking, expressed as the priority index of the harbor, is the product of the overall weights multiplied with the individual score for the harbor. The proposed fuel facilities in the commercial harbors with the highest Priority Index refer to the highest priority and should be realized first.

Ranking No.	Fuel facilities in commercial harbors	Priority Index
1	Kalaeloa BPCH, Oahu	90
2	Port Allen Commercial Harbor, Kauai	59
3	Kawaihae Commercial Harbor, Hawaii Island	59
4	Hilo Commercial Harbor, Hawaii Island	48
5	Kahului Commercial Harbor, Maui	37
6	Nawiliwili Commercial Harbor, Kauai	26

Thus the proposed fuel facilities in Kalaeloa Barbers Point Commercial Harbor on Oahu are assigned the highest priority index and therefore these fuel facilities should be realized first. The fuel facilities in the other commercial harbors should be realized in the ranking number as indicated.

For three of the six commercial harbors, Kahului Commercial Harbor, Nawiliwili Commercial Harbor and Kawaihae Commercial Harbor, multiple conceptual design alternatives of fuel facilities were developed. An analysis was performed to select of the preferred conceptual design alternatives in these three commercial harbors. The resulting proposed priority, with which fuel facilities should be realized are:

Ranking No.	Fuel facilities in commercial harbors	Preferred conceptual design alternative for harbor
1	Kalaeloa BPCH, Oahu	Only one design proposed
2	Port Allen Commercial Harbor, Kauai	Only one design proposed
3	Kawaihae Commercial Harbor, Hawaii Island	Design Alternative A
4	Hilo Commercial Harbor, Hawaii Island	Only one design proposed
5	Kahului Commercial Harbor, Maui	Design Alternative D
6	Nawiliwili Commercial Harbor, Kauai	Design Alternative B

It should be noted that the ranking and determination of the Priority Index for the realization of fuel facilities in the six commercial harbors does not consider the pace and scope of future biofuel production capacities on the different islands and future inter-island biofuel shipments. Such determination would have to be carried out in a different study. The overall Priority Index would then be assessed on the basis of combined needs for petroleum fuel and biofuel facilities in the commercial harbors.

Preliminary costs for the proposed fuel facilities in the six commercial harbors were determined. The summaries of these preliminary cost estimates are presented in Section 8 of this study. The detailed breakdowns of cost estimates of the proposed fuel facilities in the six harbors are presented in Appendix A.

A summary of the total costs for all proposed fuel facility alternatives is as follows:

Island of Oahu:
- Kalaeloa Barbers Point Harbor:
  - Pier structures and outfitting for two fuel berths ….. $19,700,000
  - Pier with Ancillary Facilities - Alternative A ……….. $38,000,000
  - Pier with Ancillary Facilities - Alternative B ……….. $32,900,000
  - Pier with Ancillary Facilities - Alternative C ……….. $32,100,000

Island of Maui
- Kahului Harbor:
  - Conceptual Design Alternative A ………………….. $16,300,000
  - Conceptual Design Alternative B –
    - only cost for pier structure ……………………… $14,300,000
    - - Alternative B with transfer pipe config. T1……. $18,200,000
    - - Alternative B with transfer pipe config. T2 …… $15,900,000
  - Conceptual Design Alternative C –
    - only cost for pier structure ……………………… $46,100,000
    - - Alternative C with transfer pipe config. T1 …… $50,000,000
    - - Alternative C with transfer pipe config. T2 ….. $47,800,000
  - Conceptual Design Alternative D ………………….. $30,900,000
  - Conceptual Design Alternative E ………………….. $13,700,000

Island of Kauai:
- Nawiliwili Harbor:
  - Conceptual Design Alternative A ………………….. $16,000,000
  - Conceptual Design Alternative B ………………….. $10,300,000
  - Conceptual Design Alternative C ………………….. $ 500,000
- Port Allen Harbor:
  - Conceptual Design ………………………………….. $12,700,000

Island of Hawaii:
- Hilo Harbor:
  - Conceptual Design ………………………………….. $ 2,000,000
- Kawaihae Harbor:
  - Conceptual Design Alternative A ………………….. $ 4,800,000
  - Conceptual Design Alternative B ………………….. $ 7,000,000

SECTION ONE

INTRODUCTION

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SECTION ONE

INTRODUCTION

Hawaii's commercial harbors fuel facilities were constructed many decades ago and, by and large, have not been significantly modified and upgraded since. Presently, Hawaii's fuel system infrastructure has not been subject to significant changes and has historically served the islands in a reliable and stable manner. Recent developments in Hawaii's fuel sector, however, suggest that its fuel industry will face a period of significant changes in the coming years.

With the continuing growth of cargo activity, Hawaii's commercial harbors are reaching higher levels of utilization and, in some cases, are at capacity. In an effort to alleviate congested conditions, the Hawaii Department of Transportation, Harbors Division, has completed this study to plan for the future requirements of its commercial harbor fuel facilities with the goal of providing for an uninterrupted and secure movement of fuel through its facilities. The planning horizon for this plan is to the year 2030.

Hawaii, because of its geographic isolation and energy system, is very highly dependent on petroleum products for virtually all of transportation needs and most of electricity generation. Without a reliable and secure supply of petroleum, Hawaii's economy cannot function. Since it is not connected to the nation's pipeline system or power grid, all of the required fuel has to be shipped to the islands. While the majority of the imported crude oil is received by offshore terminals, nearly all of the petroleum supply to the neighbor islands and some of the fuel imports require fuel facilities in the commercial harbors.

Although coal is an important fuel contributor to the state's energy system, this study does not include it. Rather, only liquid fuels are considered (liquid petroleum gas and liquefied natural gas, in their typical gaseous state, are also treated as liquid fuel, since their transport is preferable in liquid form).

While petroleum consumption in Hawaii has been increasing at a very slow pace, most of the changes in Hawaii's fuel situation will arise from changes in global oil market and the fact that State of Hawaii supports the introduction of alternative fuels and renewable energies on a significant scale.

The original scope of this study was confined to the development of maritime transport of conventional petroleum products. Recent developments in Hawaii's energy policies and active engagements of the biofuel industry in projects, however, have underlined the importance that biofuels are given in Hawaii. Since biofuels or its feedstock will have to be transported through the fuel facilities in the commercial harbors, the scope of this study was expanded to encompass biofuels as well. In addition, this study evaluates what likely effects the use of natural gas would potentially have on the fuel facilities in the commercial harbors system.

In the course of the study, it became apparent that the future energy situation couldn't be sufficiently described with one fuel scenario alone. Therefore, three energy scenarios are defined to address the different challenges that will be faced by fuel facilities in the commercial harbors system in the coming years. While the defined energy scenarios are described in a qualitative manner, a subsequent study must estimate anticipated quantities of the different petroleum and biofuels, which will likely be powering Hawaii's economy in the future. The safe and reliable transport of these fuels through the commercial harbors will be of critical importance to Hawaii; therefore sufficient transport and transfer capacities have to be available to safeguard the required fuel supply to the islands.

The handling of liquid-bulk cargo is quite different from containerized or other cargo types. Liquid-bulk cargo can be transported via transmission pipelines to remote storage tanks that do not necessarily have to be adjacent to the fuel piers, but can be located outside the harbor, adding flexibility to liquid-bulk cargo operations. Containerized cargo requires staging and storage areas that are close to the docks, in order to avoid long logistic transport modes and costly operations. Liquid-bulk cargo on the other hand, requires fixed piping infrastructure with a secure ship-to-shore fuel transfer systems. This system however, cannot be easily changed.

Fuel facilities at the following seven commercial harbors were assessed:

1. Honolulu Harbor, Oahu
2. Kalaeloa Barbers Point Harbor, Oahu
3. Kahului Harbor, Maui
4. Nawiliwili Harbor - Kauai
5. Port Allen Harbor, Kauai
6. Hilo Harbor, Hawaii Island
7. Kawaihae Harbor, Hawaii Island

<u>This study uses the following methodologies.</u>

First, previous planning documents, such as master plans, development plans etc., were reviewed and applicable conclusions were used in the concept design of future fuel facilities.

Second, site visits were made to determine the individual harbor's situation and were assessed collaboratively with the Harbors Division.

Third, interviews were conducted with stakeholders of Hawaii's fuel industry, including fuel shipping companies, refineries, fuel companies and shipping agents. Results of these interviews helped to formulate short- and long-term recommendations to improve the fuel transfer and fuel shipping operations in the commercial harbors.

Fourth, interviews were conducted with agencies responsible for fuel spill response and environmental remediation. Response and cleanup of fuel spills are key functions that safeguard high environmental awareness and readiness to curb possible environmental impact through fuel spills.

Fifth, interviews were conducted with individuals and agencies that are engaged in energy planning for Hawaii. Such individuals and agencies are active in the areas of conventional petroleum fuel, renewable energy and alternative fuels. The outcome of these interviews provided guidance on the anticipated development of Hawaii's energy needs and growth patterns, as well as challenges and opportunities of renewable energies and alternative fuels (including liquefied natural gas) to replace part of the petroleum fuel supply to the islands. The information gained through interviews and reviews of reports and other planning information revealed the need to define possible future fuel supply scenarios, which are different from the today's scenario based primarily on petroleum.

Sixth, historical and forecasted data for fuel and energy demand in Hawaii was used as a comparison to the U.S. mainland and the world. This data was obtained from comprehensive web sites of the U.S. Energy Information Administration; the Hawaii State Department of Business, Economic Development and Tourism and the International Energy Agency.

Seventh, as an addition to the scope of this study, numerous interviews were conducted with representatives of companies engaged in the emerging biofuel sector of Hawaii. During the study, it became apparent that the development of concept designs for future fuel facilities in the commercial harbors could not be complete without incorporating emerging shipping technologies and operational procedures for biofuels.

Eighth, new developments in fuel shipping technology and fuel transfer and storage operational procedures were assessed in their potential to increase the capacity, safety and security of fuel operations in the commercial harbors. Recommended future changes of fuel transfer technologies and shipping procedures include such aspects as advanced ship-to-shore fuel transfer systems, multi-product capable pipelines operations and new generations of fuel transport vessels.

Ninth, the special requirements of a post-9/11 planning environment in respect to security of fuel supply are incorporated into the various alternatives within the proposed concept designs in this study.

In addition, various regulations for security as well as for operational and environmental safety for marine fuel terminals, fuel storage and fuel transport in transmission pipelines have become significantly more stringent than they were at the time when most of the fuel facilities in the harbors were built. Such regulations now include new measures to control fuel vapor, increased fire protection and improved fuel transfer procedures.

While developing alternatives for design concepts of future fuel facilities in the harbors, initial design approaches were discussed with the Harbors Division. In addition, initial feedback on the design approaches was sought from selected stakeholders of Hawaii's fuel industry. Therefore, the presented alternatives for future fuel facilities in the harbors represent refined concept designs that have passed through initial design discussions and reviews.

Preliminary cost estimates regarding the alternatives presented in various concept designs for future fuel facilities were developed. The unit costs used in these estimates are based on actual budgetary quotes (for selected pier structure and fuel infrastructure components) and historical unit costs. The concept fuel pier design and preliminary pier outfitting specifications determine the quantities for the computation of cost items and total costs.

SECTION TWO

HAWAII ENERGY DEMAND

SECTION TWO

HAWAII ENERGY DEMAND

The Hawaiian Islands are geographically isolated from the continental United States (U.S.) and are not connected to the nation's electrical grid or to the petroleum pipeline systems. Given this unique energy situation, Hawaii relies on imported crude oil for virtually all of its energy needs.

2.1 Total Energy Consumption in Hawaii

Historically, Hawaii has an extraordinarily high dependence on petroleum for its energy needs. Presently, approximately 90 percent of its energy comes from petroleum products. In terms of per capita oil consumption, Hawaii far exceeds the average per capita oil consumption of its U.S. mainland counterparts. Besides using oil products for its energy needs, Hawaii also uses small amounts of coal and natural gas, which is a synthetic natural gas produced locally from imported petroleum feedstock.

The State economy in general is not energy intensive, but rather, the aviation industry is a large consumer of jet fuel and the generation of electricity is highly dependent on petroleum. These facts are responsible for its very high per capita usage.

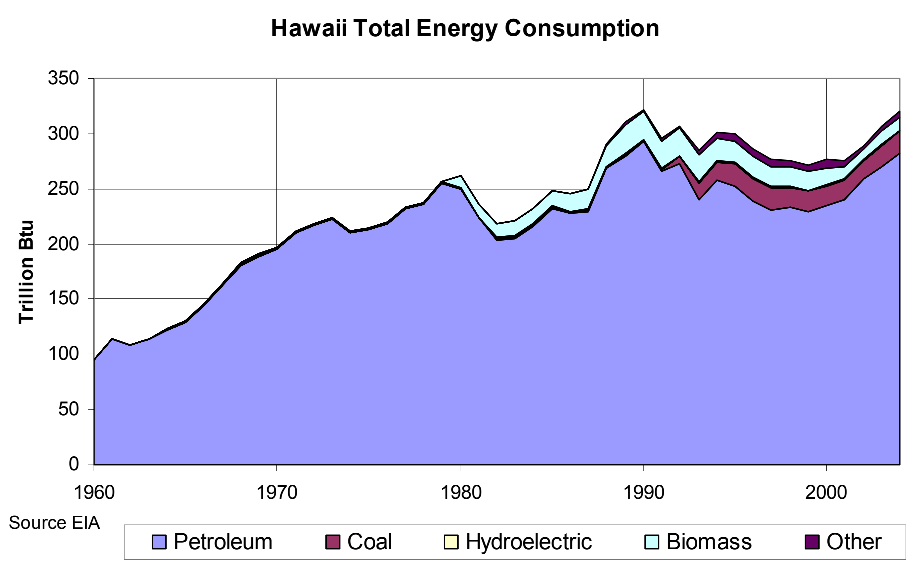

Figure 2-1: Total Energy Consumption in Hawaii by Source

Figure 2-1 shows the total energy consumption of Hawaii, grouped by energy sources. Up to about the year 1980, Hawaii was almost entirely dependent on petroleum for all its energy needs. Before 1980, hydroelectric and biomass contributed less than one-half of one percent. Starting in the late 1970s, biomass, then coal and other indigenous energies sources (geothermal, wind, solar and ocean) were introduced.

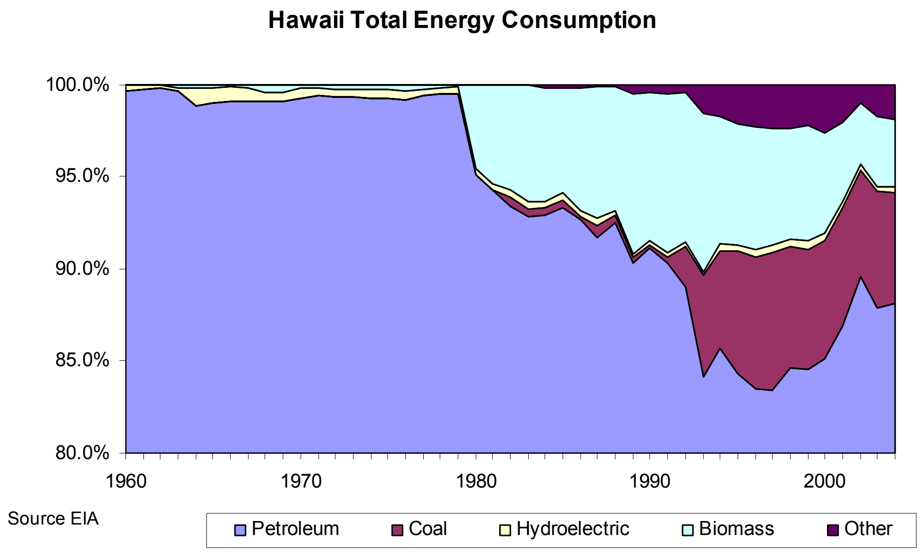

Figure 2-2: Total Energy Consumption in Hawaii by Source

Figure 2-2 shows the contribution of the different sources of energy to the total energy supply of Hawaii, expressed in percentage of total energy. The minimum contribution by petroleum occurred between 1996 and 1997, which was about 84 percent of total energy consumption. By 2004, the portion of energy provided by petroleum was back up to 88 percent.

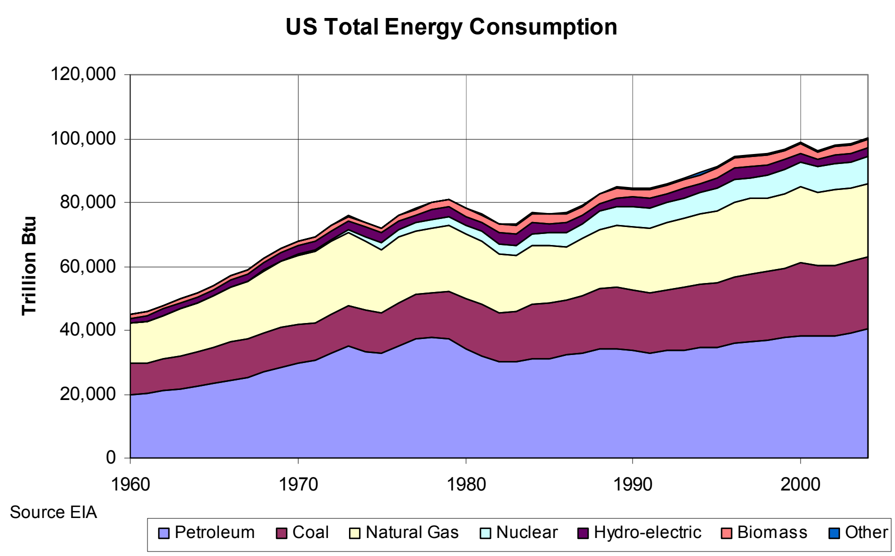

Figure 2-3: Total Energy Consumption in the US by Source

Figure 2-3 shows the total energy consumption of the U.S. Differences for Hawaii are the contribution of the three fossil fuels to the total energy supply. For the U.S., petroleum is the biggest single contributor of total energy consumption, which is currently about 40 percent, followed by natural gas and coal, which contribute about 23 percent and 24 percent, respectively. Starting in the 1970s, nuclear energy became a significant energy source with currently about 8 percent of total energy supply. Renewable energies (including, hydroelectric and biomass) contribute about 6 percent of total supply.

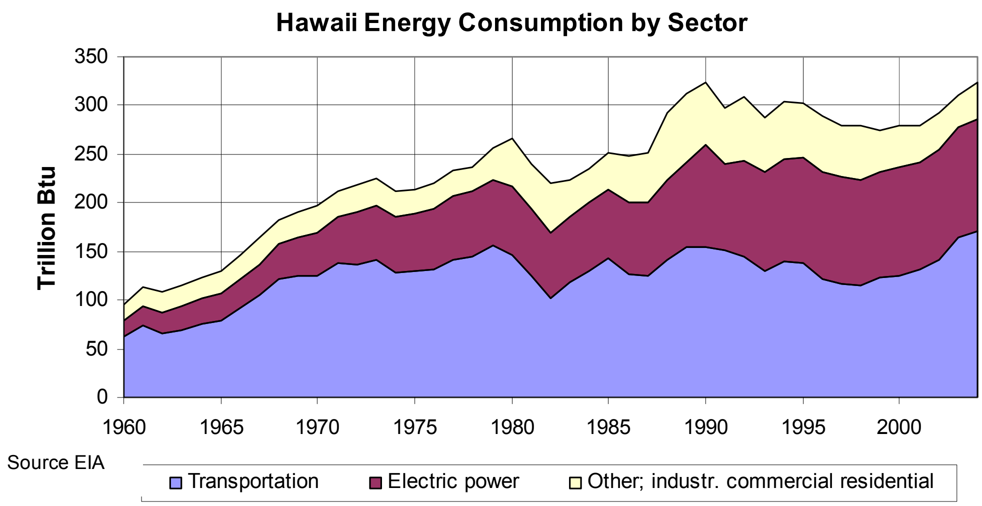

Figure 2-4: Total Energy Consumption in Hawaii by Sector

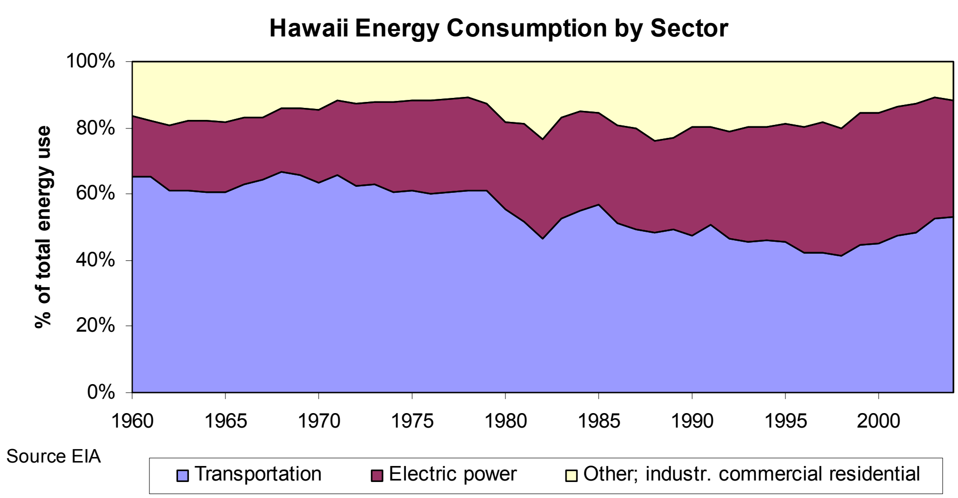

Figure 2-5: Total Energy Consumption in Hawaii by Sector

Figures 2-4 and 2-5 illustrate Hawaii's energy consumption in the main three sectors: transportation, electric power generation and other (i.e., commercial, industrial and residential energy demands).

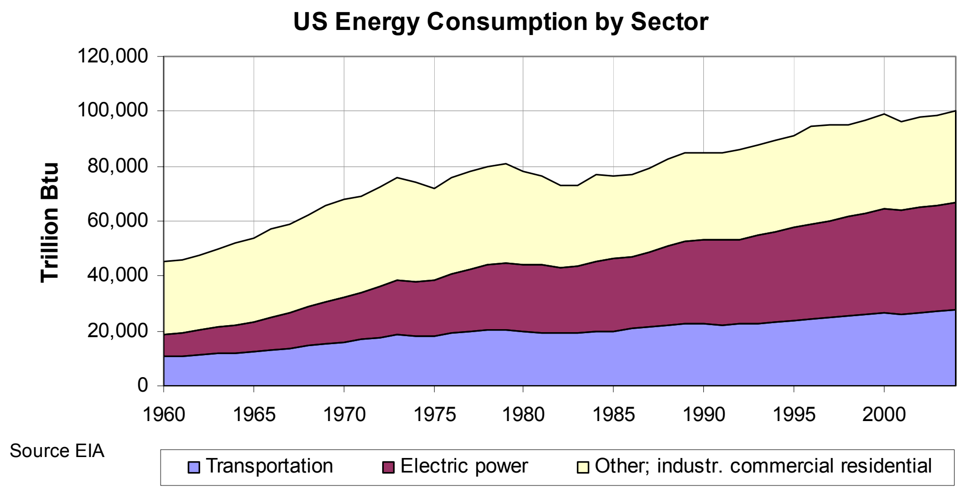

Figure 2-6: Total Energy Consumption in US by Sector

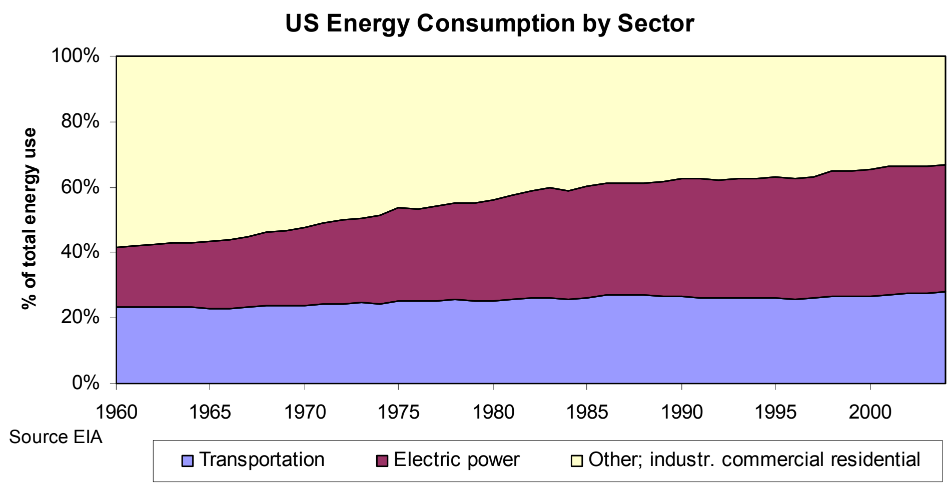

Figure 2-7: Total Energy Consumption in US by Sector

As a comparison, Figures 2-6 and 2-7 illustrate energy consumption for the entire U.S. in the three main sectors: transportation, electric power generation and other.

There are fundamental differences of energy consumption per sector between Hawaii and the entire U.S. Hawaii is characterized by a high contribution of the transportation sector, with 53 percent of total energy consumption in the year 2004, as compared to the entire U.S.'s transportation sector contribution at about 27 percent. The sum of the transportation and electricity sectors is about 88 percent in Hawaii versus 66 percent for the entire U.S. For the sector described as "other, industrial, commercial and residential, Hawaii's consumption is substantially lower at 12 percent than the total U.S. at 34 percent. Over the past 15 years the energy consumption in total US has gradually increased by an average of 1.3 percent per annum. Hawaii's energy consumption has shown consumption patterns have that followed pronounced periods of decrease and increase in energy use, depending on how well the economy is doing.

2.2 Future Outlook for Hawaii's Energy Situation

The outlook for Hawaii's energy situation has two major drivers:

1. The anticipated energy situation in the U.S.
2. Hawaii's unique energy situation based on its oil dependency.

<u>First,</u> although the development of energy consumption in the entire U.S. is not a reliable indicator of future energy consumption in Hawaii (compare Figures 2-4 and 2-6), the forecasted U.S. trends can provide important clues for Hawaii. The latest forecast of future U.S. total energy use is presented the *Annual Energy Outlook 2007* by the Energy Information Administration (EIA).

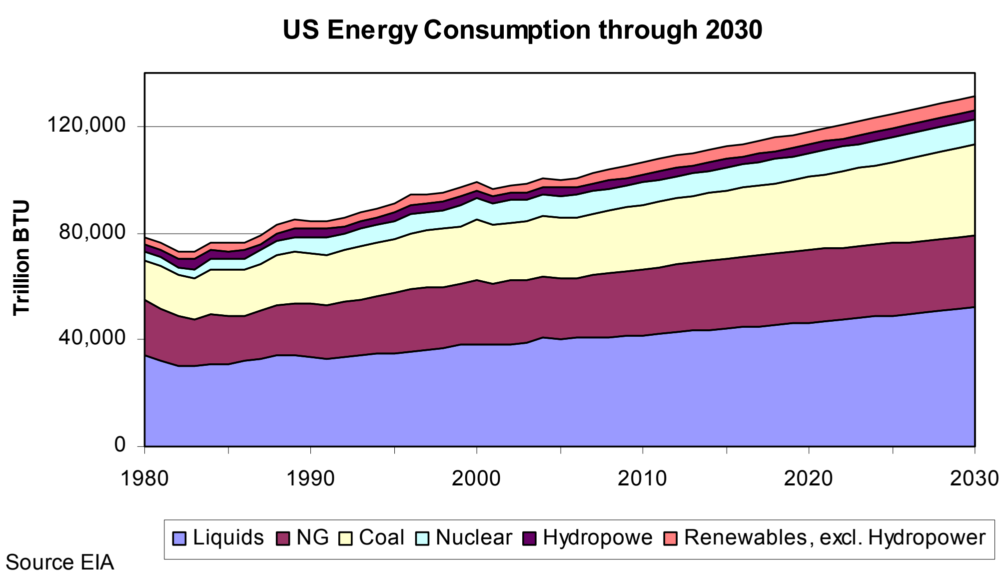

Figure 2-8 Predicted Total Energy Consumption in US by Source

Figure 2-8 illustrates the anticipated U.S. energy consumption. By 2030 the total energy consumption is predicted to increase about 30 percent from 2007 levels. Coal and renewable energies (excluding hydropower) will have the highest anticipated growth rates of 47 percent and 40 percent, respectively. Nuclear power at 13 percent, natural gas by 15 percent and hydropower at 9 percent will grow at a rate lower than total energy. Liquids will grow at the same rate as total energy consumption. It should be noted that in 2007, the EIA for the first time used the term “liquids” in lieu of petroleum, suggesting the growing importance of biofuels, gas-to-liquid fuels and other derived types of fuel.

Second, Hawaii’s high oil dependency can provide clues to its future use. Figures 2-1 and 2-2 illustrate Hawaii’s high dependency on petroleum. Considering Hawaii’s geographic isolation, petroleum is an ideal fuel in terms of portability and logistics. It is easily transported and stored under ambient pressures and temperatures. It has a high-energy content and does not require sophisticated process equipment for its conversion into usable products. Other fossil energy sources, such as natural gas or coal require more sophisticated and costly means for transport and/or handling.

A major drawback of petroleum is its carbon emissions during the conversion process and use. Petroleum also induces other environmental concerns associated with exploration, production, transport, storage and conversion.

A major concern of Hawaii’s high petroleum dependency is energy security. Energy security requires measures to weather long-term and short-term petroleum supply shortfalls or interruptions. Short-term interruptions can be handled by a petroleum infrastructure that features sufficient reserves, robust transport system and redundancies. Possible long-term supply shortfalls can only be accommodated by inter-fuel fuel substitution (e.g., by increasing coal use or by introducing natural gas or biofuels into the energy system), increasing indigenous energy sources and lowering energy consumption through demand side management measures. Efforts that improve the long-term energy security situation of Hawaii require significant investments of capital and considerable time to implement.

Hawaii’s future energy situation will hinge around the following governing criteria:

1. Availability and price of crude oil.
2. Introduction of alternative transportation fuels such as biofuels and natural gas.
3. Extent of using coal for electricity generation.
4. Introduction of alternative fuels for electricity generation, such as natural gas and biofuels.
5. Increase of indigenous energies for electricity generation, such as geothermal, wind, solar, and ocean energies.
6. Extent of increases in energy savings through improved technology and change in consumption patterns.

At the present time Hawaii’s energy infrastructure is unequivocally based on petroleum and is a product of decades of building and improving its existing energy infrastructure. Any changes in the status quo of the energy supply to the islands will have a significant and far reaching impact on the petroleum supply system and therefore on the fuel transport system in the commercial harbors.

SECTION THREE

HAWAII FUEL SYSTEM

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SECTION THREE

HAWAII FUEL SYSTEM

Section Three describes Hawaii's current fuel system based on the operation of two refineries on Oahu. Section Three also introduces evolving challenges and opportunities that will probably affect and shape the future Hawaii's fuel system. Finally, this section discusses in detail three future energy scenarios: the status quo that assumes no major changes from the heavy dependence on petroleum going into the future and two alternate fuel supply scenarios, which consider the emergence of biofuels and natural gas as key contributors to Hawaii's fuel supply. These three scenarios illustrate likely future fuel facilities needs in Hawaii's commercial harbors.

3.1 Current Fuel System

This section discusses the current fuel supply system in Hawaii. It has to be pointed out that coal, although an imported fuel used for electricity generation, is not considered for the development of fuel facilities in the commercial harbors system. The handling of coal in Kalaeloa Barbers Point Harbor is only considered in respect to cargo capacity for harbor operations (e.g., berthing scheduling conflicts for ship in the harbor).

3.1.1 Hawaii's Fuel Supply System

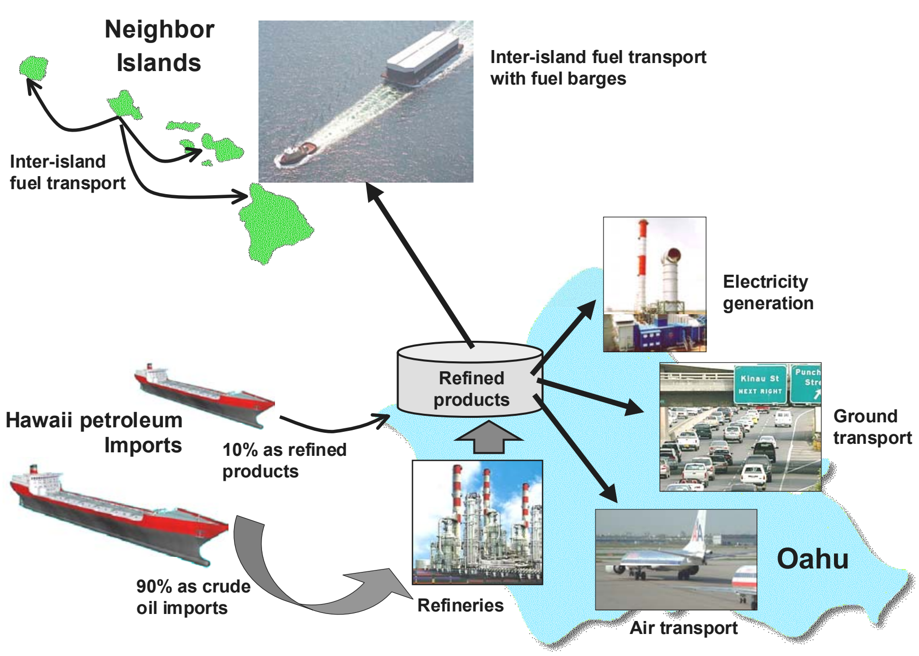

Figure 3-1: Hawaii's Fuel Supply System

The current fuel supply system of Hawaii is depicted in Figure 3-1. Petroleum fuel is mostly imported in the form of crude oil and refined locally into petroleum products. Specifically, approximately 90 percent of liquid-bulk cargo imports are crude oil and 10 percent are refined products. The majority of the fuel supply to Hawaii thus passes through the two petroleum refineries on Oahu, which makes the refineries important links in Hawaii's fuel supply system.

The refineries receive crude oil and convert it to a specific output slate of petroleum products. The output slate of petroleum products are balanced and optimized based on the demands of energy sectors in Hawaii, such as electricity generation, ground transport and air transport. The unloading of crude oil from the large tankers is by means of two offshore mooring systems (one single-point mooring and the other multi-point mooring) owned by the two local refineries. The crude oil is pumped from the tankers to receiving tank farms, which can hold several weeks of reserves.

The refined products are stored in large holding tank farms before they are distributed on Oahu or on the neighboring islands. The transport to the neighboring islands is by fuel barges. Both Kalaeloa Barbers Point Harbor and Honolulu Harbor have fuel transfer facilities to load fuel barges for distribution to the neighboring islands.

3.1.2 Crude Oil Supply to Hawaii

The origin and quantity of Hawaii's crude oil imports in 2005 are depicted in Table 3-1. The supply of crude oil to Hawaii is of prime importance for the fuel supply system. In 2005, Hawaii received about 89 percent of the crude oil from foreign sources. Among the main foreign suppliers of crude oil, Middle East suppliers accounted for 24 percent, while suppliers from Asia accounted for 67 percent. All of the domestic supply comes from Alaska.

Table 3-1: 2005 Crude Oil Imports to Hawaii

Origin	crude supply BPD average	%		Origin Country/Region	crude supply % of total
Domestic	15,900	11%		Alaska	11%
Foreign	123,600	89%		Saudi Arabia	18%
				China	16%
				Vietnam	14%
				Indonesia	13%
				Brunei	8%
				Malaysia	4%
				Australia	4%
				Yemen	2%
				UAE	2%
				Others	7%

source: DBEDT

Main contribution of foreign crude	
Middel East	24%
Asia & Oceania	67%

3.1.3 Consumption of Petroleum Products

The historical consumption pattern of the four main petroleum products in Hawaii between 1980 and 2004 is depicted in Figures 3-2 and 3-3 (Refer to Section 4.9 for a description of fuel types pertinent to Hawaii's fuel system). The main petroleum products depicted are residual fuel (used for electricity generation), distillate fuel (e.g., diesel), motor gasoline and jet fuel.

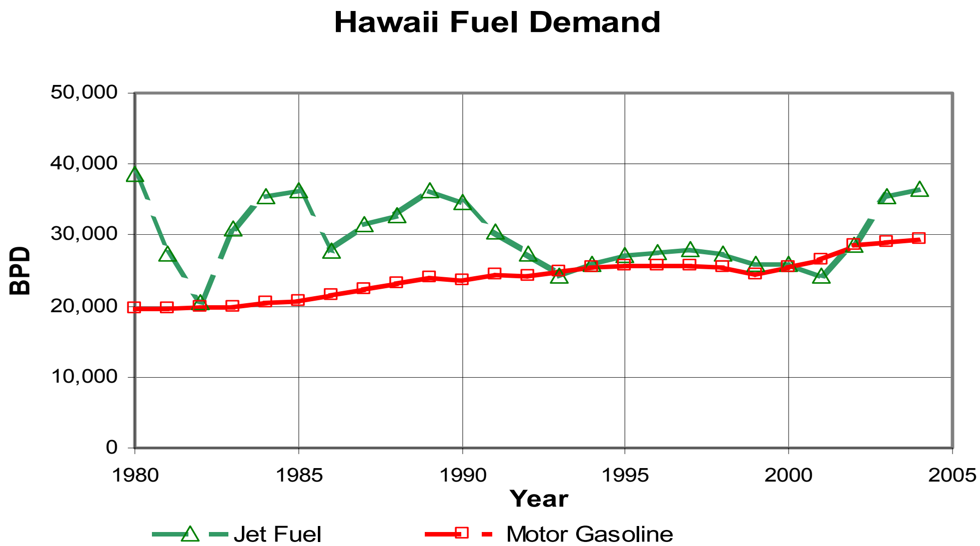

Figure 3-2: Historical Jet Fuel and Motor Gasoline Consumption in Hawaii

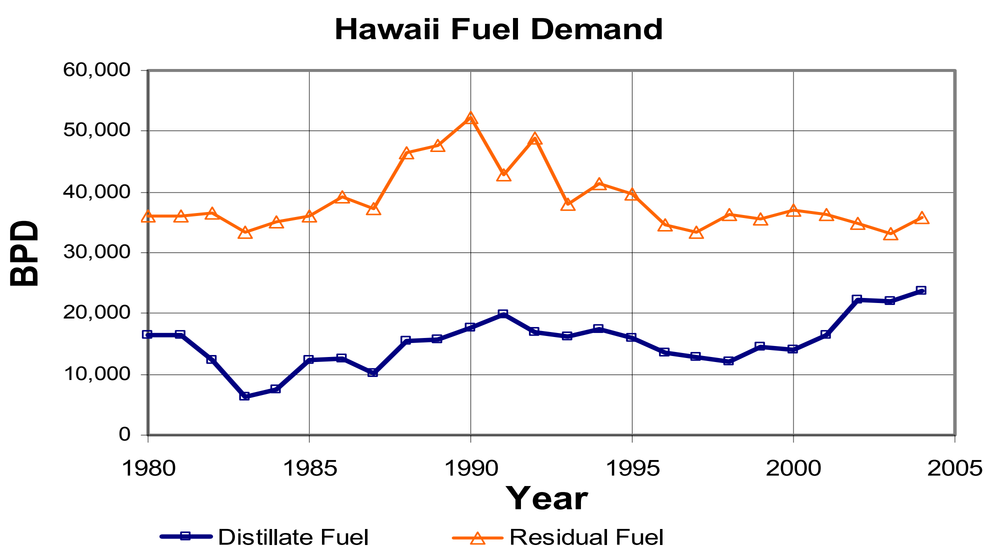

Figure 3-3: Historical Distillate Fuel and Residual Fuel Consumption in Hawaii

For jet fuel (See Figure 3-2) and residual fuel (See Figure 3-3), no clear trends can be deduced. Historical data for both fuels suggests a somewhat constant consumption level between 1980 and 2004, with periodic ups and downs. Using linear regression, the consumption trends indicates gasoline growing by an average of 1.9 percent per year and distillate fuel growing by an average of 2.7 percent per year.

Figure 3-4 compares the fuel consumption of main petroleum products between Hawaii and the entire United States (U.S.). All five major petroleum products depict significantly different consumption pattern for Hawaii and the entire U.S. Gasoline represents about one-half of all petroleum used in the U.S. but represents only about one-quarter in Hawaii. The amounts used for residual fuel and jet fuel are significantly larger in Hawaii than in the entire U.S.

Figure 3-5 shows the fuel consumption by sector for Hawaii and the U.S. While fuel needs for ground transport in Hawaii is about one-half compared to the entire U.S., fuel required for air transport is more than three times higher than in the U.S. The amount of petroleum fuel used for electric power generation in Hawaii is about 15 times higher than the U.S. average.

Figure 3-4 and 3-5 show the unique demand pattern in Hawaii when compared to the rest of the country. The significant differences are Hawaii's high jet fuel demand, resulting from significant military and civilian airline consumption, and Hawaii's power generation that to a large extent is based on petroleum.

Hawaii's unique demand pattern for petroleum determines the operation and the product output slate of the two refineries, which is discussed in Section 3.1.4.

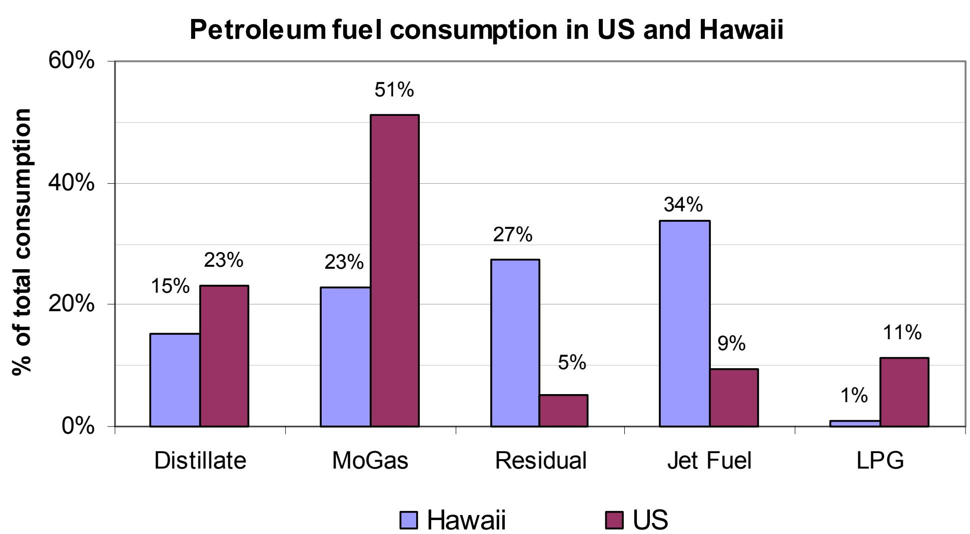

Figure 3-4: Fuel Consumption by Product for the Hawaii and Entire U.S.

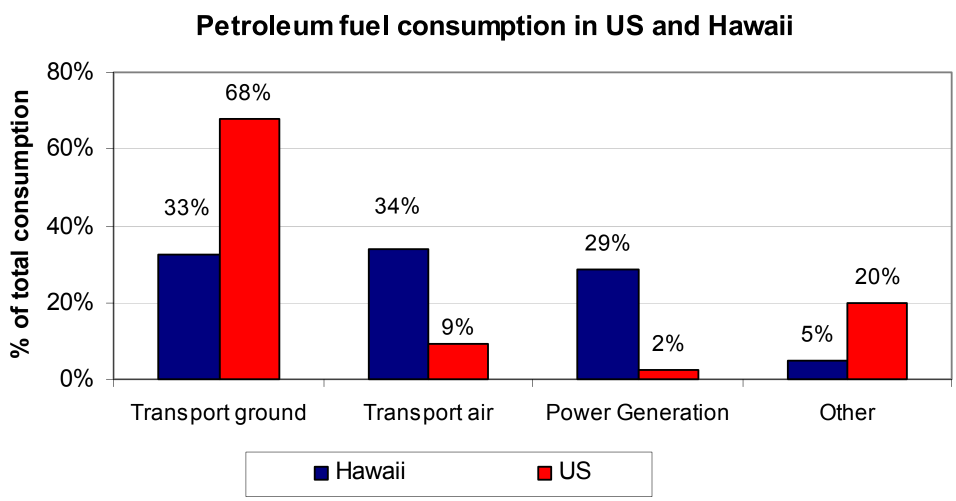

Figure 3-5: Fuel Consumption by Sector for the Hawaii and Entire U.S.

3.1.4. Refinery Operations

Hawaii's two refineries, both located on Oahu, were built decades ago and have since been upgraded. Their petroleum product output slate matches the historical and current demand pattern in Hawaii. The fact that transport of crude oil is less costly than importing refined products provides an economic incentive for the refineries to process petroleum locally. Since the refineries match their output slate to the unique consumption pattern in Hawaii, the operational processes of the refineries also differ from refineries on the continental U.S.

Figure 3-6 compares the output slate of Hawaii's refineries to the average output slate of a typical refinery in the U.S. The refineries in Hawaii produce a slightly higher portion of middle derivatives (e.g., diesel, jet fuel, kerosene) than their U.S. counterparts. On the other hand, Hawaii's refineries produce significantly less motor gasoline and much more residual fuel.

Figure 3-6 also suggests the degree of downstream process sophistication of Hawaii's two refineries in comparison to typical U.S. refineries. The refinery process is basically divided into two stages, the primary distillation process and the downstream processes. The primary distillation process yields an output slate that maps the quality and consistency of the crude oil that is processed. Heavy crude oil yields more residual fuel and less gasoline than light crude. In the diverse downstream (secondary) process, the products of the primary distillation are converted to higher value products such as gasoline. Refineries on the U.S. mainland have more downstream process capacities in order to maximize the gasoline yield from crude oil.

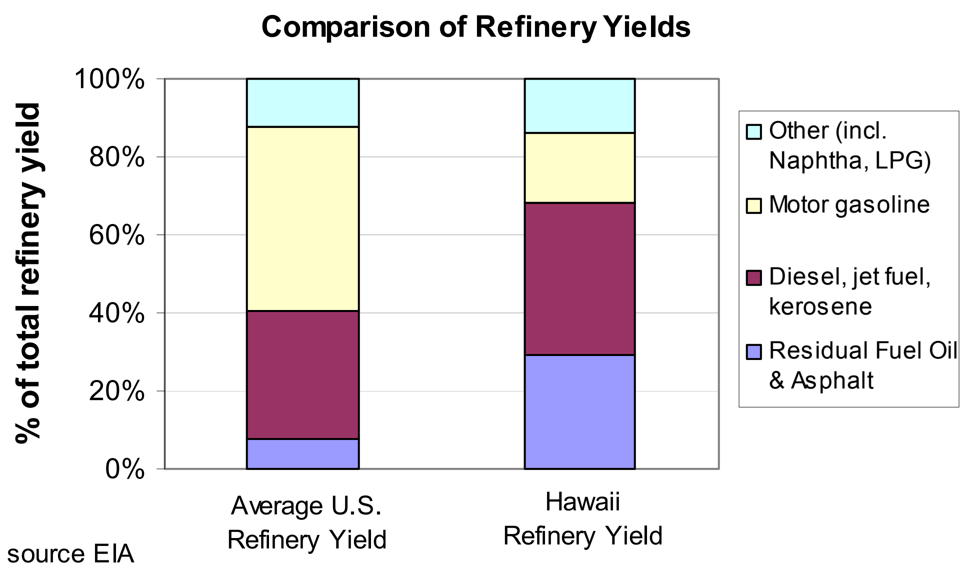

Figure 3-6: Average Refinery Yields of Refineries in Hawaii and in the U.S.

If Hawaii's refineries can continue to provide the established fuel output slate to match its economy, the operational processes of both refineries will require minimal adjustments provided that the quality of the crude available remains constant. If, however, the consumption slate differs from current conditions or if refinery yield from the type of crude is significantly different from current yield, refineries will have to make changes to their operational procedures. Such operational procedure changes might include adding downstream process capacities, the importation of deficient petroleum products or the exportation of surplus products. Future challenges to the refineries, which will also have effects on the fuel facilities in the commercial harbors system will be discussed later in this study.

3.1.5 Inter-Island Fuel Transport

Most of the refined petroleum supply for the neighbor islands is shipped from Oahu by fuel barges. Currently, two shipping lines have regularly scheduled inter-island fuel barge services. There are a few exceptions when petroleum products are shipped directly from out of State to the neighbor islands, such as direct shipments of Liquefied Petroleum Gas (LPG), typically propane.

Figure 3-7 shows the amount of fuel consumption by major islands. It represents the average of different estimates of the fuel consumed in Hawaii, using several reported sources and years (e.g., DBEDT, DOT, FACTS, and Stillwater). This also shows that on average, about two-thirds of the state's petroleum fuel consumption occurs on Oahu and the remaining one-third is distributed to Hawaii Island, Maui and Kauai.

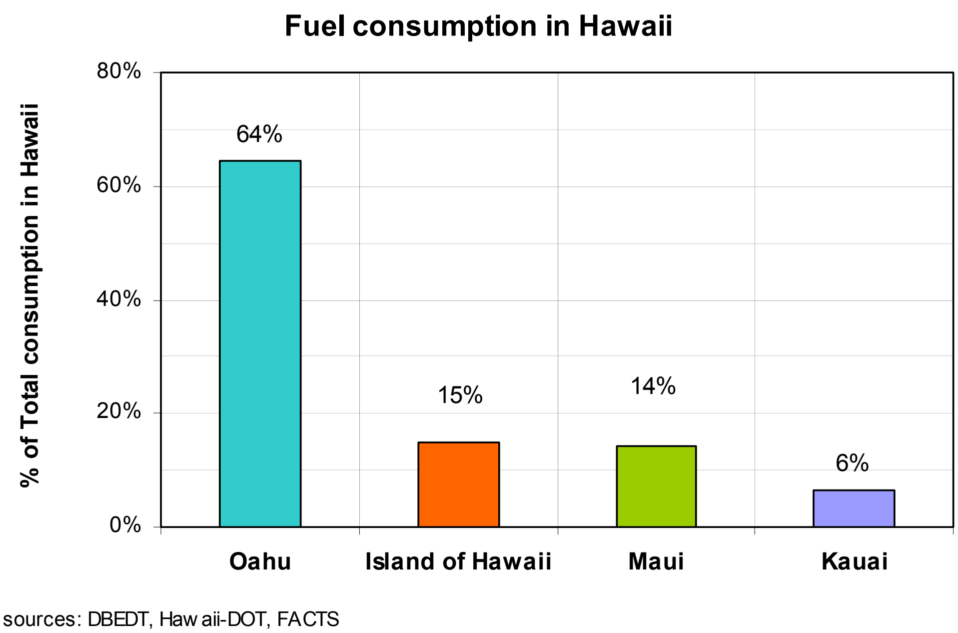

Figure 3-7: Petroleum Fuel Consumption in Hawaii by Island

3.2 Evolving Challenges and Opportunities

Recent events in the energy sector, and specifically the oil industry, suggest major structural changes are unfolding. Using high oil prices volatility over the past several years as an indication, the recent trends suggest that unprecedented change is upon us. Between 2003 and today, the price per barrel for light and low-sulfur crude has increased more than fivefold before retreating to a lower price level. Because the energy supply to Hawaii is largely dependent on an uninterrupted supply of petroleum products, future fuel facilities will be affected by a changing global oil supply and consumption patterns.

This section provides an overview of several evolving challenges and opportunities that confronts Hawaii's fuel supply and consumption. However, it is beyond the scope of the study to quantify in detail the effects of these challenges and opportunities. Rather, this section briefly describes these challenges and opportunities, and provides an estimate on how the evolving markets could potentially affect Hawaii's fuel system.

3.2.1 Changes in Oil Supply to Hawaii

A recent authoritative study conducted in Hawaii (FACTS, 2003) compares the forecasting of the future oil supply to looking into a "crystal ball." At the time of the study, the future price of oil for the time around 2015 was estimated in the order of $27.50 per barrel. As this writing (December 2008), the price of light sweet crude oil had reached almost $150 per barrel mark during the summer of 2008 and before the per barrel price retreated to a mark between $40 and $50 per barrel. There has been much speculation about the extraordinary drop in oil price and the economic downturn in 2008 has been named as a major contributor. While lower oil prices are welcome by the consumer and particular to the Hawaiian economy in the short term, the longer-term consequences could be a supply “crunch”, which would logically result in higher oil prices and supply shortfalls in the future.

Issues, such as major supply interruptions, vanishing spare capacities, political unrests in some of the oil producing countries and a volatile international financial market all contribute to the high volatility of the oil price. The quest to turn oil resources into actual production is increasingly subject to costly exploration and production technologies. Lost production capacity due to field depletion must be replaced by new production capacity. The recent 2008 World Energy Outlook by the IEA, suggests that depletion rates of oil fields are increasing at a rate much higher than expected. Therefore a significant and increasing amount of new oil production capacity has to be developed, just to keep the production at current level. Adding to the challenge is that fact that many of the countries, which are in the position to increase oil production are situated in politically volatile regions, like the Middle East and certain regions in South America and West Africa.

Hawaii’s oil consumption is relatively small when compared to the international oil market. It will always be vulnerable to the developments of the global oil market. The fact that about 89 percent of the overall energy demand of Hawaii is based on petroleum highlights the urgency and importance to factor in the changing oil market, when planning the future fuel infrastructure in Hawaii’s commercial harbors.

Figure 3-8 shows countries from where the oil supply to Hawaii originates. As will be discussed later, crude oil from different countries or production regions varies in quality and composition. As pointed out in section 3.1.5, Hawaii’s refineries depend on an input quality of crude oil that matches their process capabilities, in order to maintain the current output slate and to meet current local market needs.

Figure 3-8 also highlights changes to the crude oil supply that Hawaii’s refineries received over the past decade. In 1994, 93 percent of the crude slate for Hawaii’s refineries was comprised of the then three main suppliers: Alaska, Indonesia and Australia. While the total crude input has remained approximately constant over the past decade, the contributions of these three suppliers have declined to 32 percent of the total crude input. Since Alaska is the only domestic supplier of crude oil, the foreign portion of the crude slate of Hawaii’s refineries has grown from 61 percent to 89 percent by 2005. As Alaska’s oil production is expected to continue its decline (unless new regions like the Arctic National Wildlife Refuge (ANWR) are opened for oil production), Hawaii’s reliance on foreign crude oil is expected to increase in the coming years.

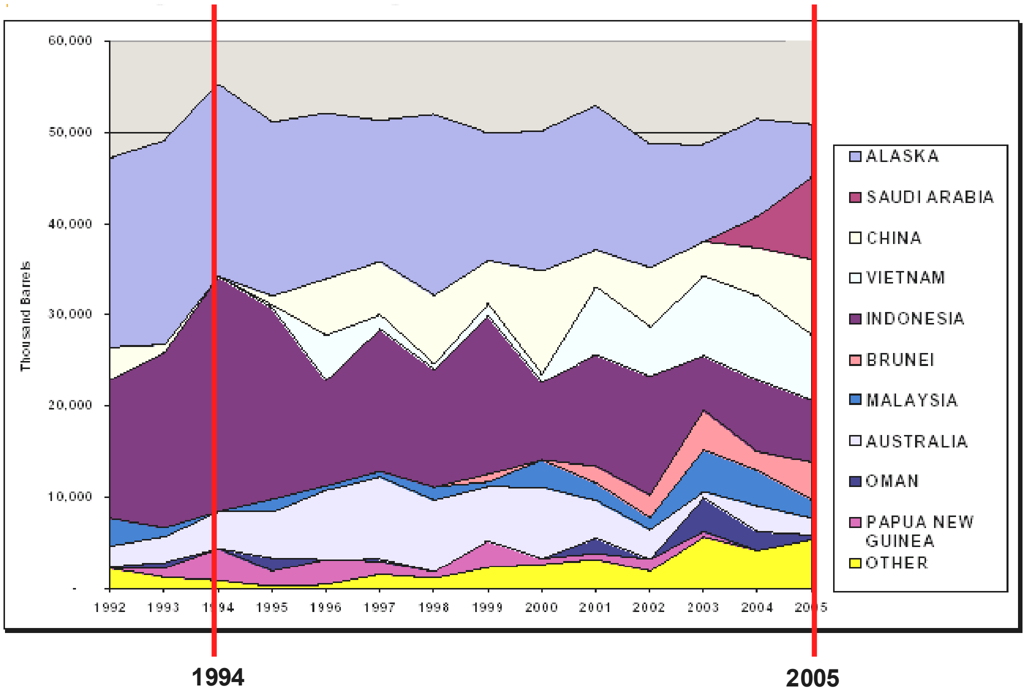

Figure 3-8: Changes in Origins of Hawaii's Crude Oil

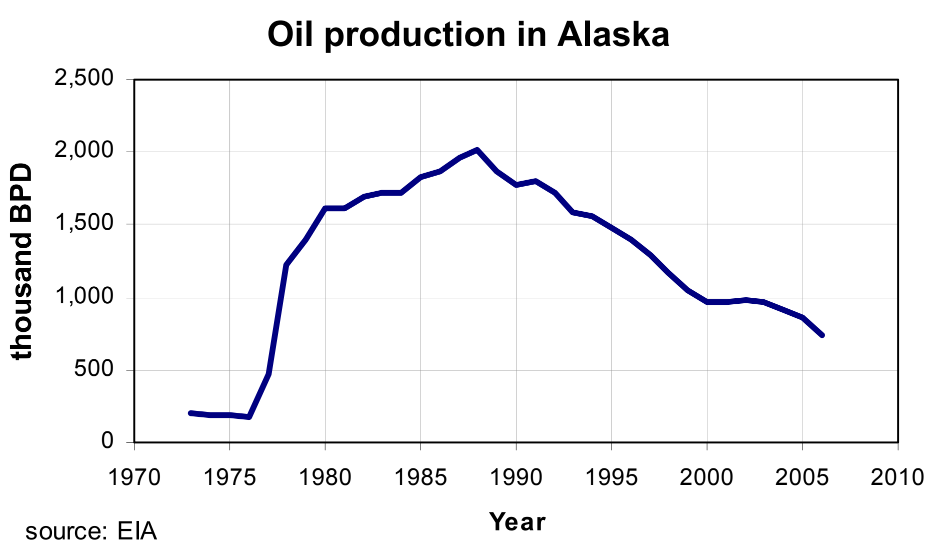

Figure 3-9: Oil Production in Alaska

The decline of the three suppliers: Alaska, Indonesia and Australia must be seen in conjunction with oil production profiles of these countries. Figure 3-9 shows the production history and the outlook for the crude production in Alaska. Oil production in Alaska peaked in 1987 and is now in steep decline. Future production rates will depend on successful exploration and development of new oil fields. Figure 3-10 shows the total crude production in Alaska, Indonesia and Australia. Indonesia's oil production had a historical maximum in 1977, then has shown an average annual decline of 3.6 percent per year in the past 10 years. In fact, Indonesia, as an OPEC member, is now a net importer of petroleum.

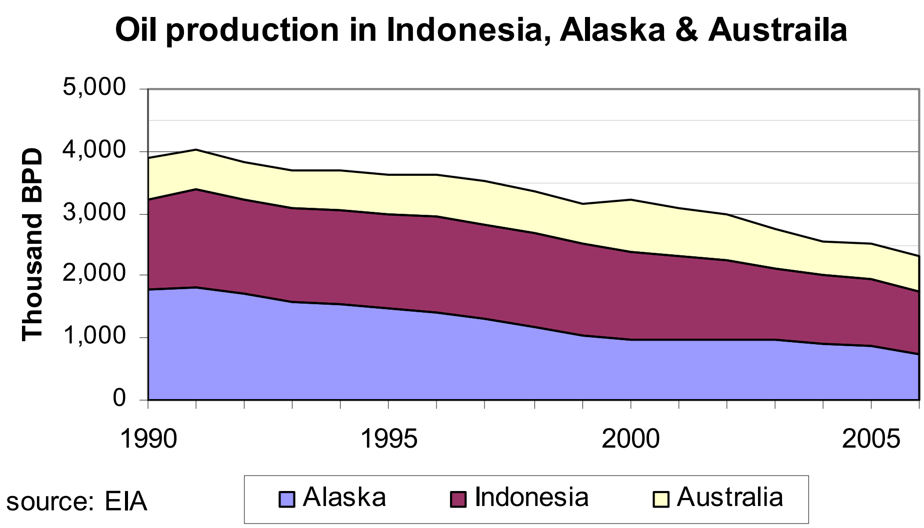

Figure 3-10: Oil Production in Alaska, Indonesia and Australia

In the past several years, more and more crude oil is coming from the Middle East. In 2005, about 25 percent of the foreign supply came from this potentially unstable region. As depicted in Figure 3-11, the Middle East has close to 60 percent of all global oil reserves. Asia, on the other hand, which represents the bulk of the present supplies to Hawaii, has very little reserves. Exxon Mobile predicts that oil supply from OPEC Middle East will have to increase from about 30 percent of the world oil production in 2005 to over 50 percent in 2030 in order to satisfy projected global demand.

Besides the fact that future concentration of crude oil production in the Middle East will present energy security concerns for Hawaii, the decreasing quality of the crude oil is also an issue. According to a recent OPEC report (OPEC, 2007), non-OPEC light crude oil has peaked and is now in decline. While a number of oil production projects that are planned in the Middle East will come on line through 2010 and will add some light oil processing capacity, production capacities planned after 2010 will mainly add heavier crude. As a general trend, it can be deduced that future crude world supply will be more "heavy" (i.e., lower API [American Petroleum Institute] density) and more sour (i.e., higher in sulfur).

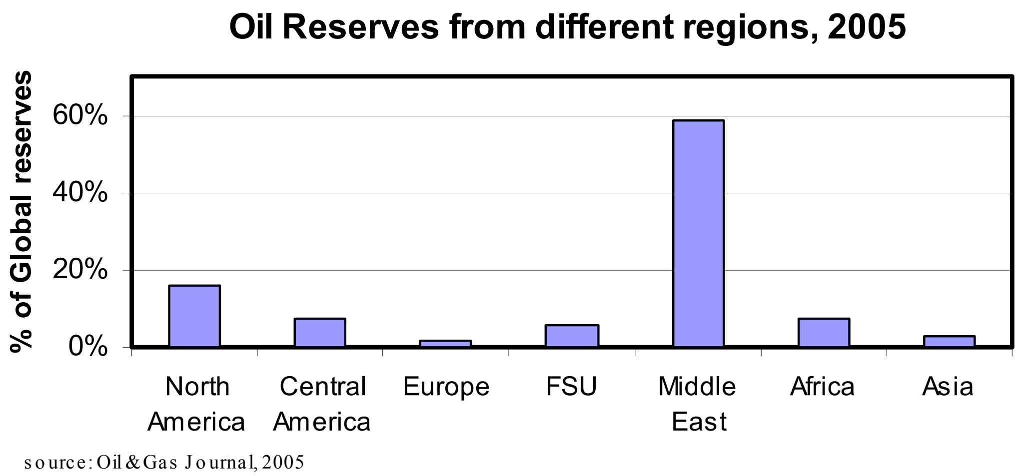

Figure 3-11: World Oil Reserves by Regions

To summarize, in future years, Hawaii's refineries will be faced with the problem of having to replace established crude oil suppliers, whose oil production rates will continue to decline, with new providers. Since sweet and light crude oil is favored by Hawaii's refineries and appears to be a shrinking global commodity and coupled with the fact that international competition for this type of product is intensifying, Hawaii's refinery most likely will be faced with higher future crude oil prices or a shrinking availability of crude oil of such high quality.

3.2.2 Fuel Replacement through Biofuels

The State of Hawaii supports the introduction of biofuels in a range of energy applications. Biofuels will be either imported as finished products or produced from feedstock that is either imported or grown locally. Since Hawaii has mandated the use ethanol as an oxidant in motor gasoline, it replaces about 10 percent of gasoline. At the present time, ethanol is being imported as a finished fuel. In the future, there are plans to produce ethanol in Hawaii by using feedstock such as sugar cane grown on the islands.

In addition, there are plans to build biodiesel production facilities in Hawaii. For the immediate future, biodiesel feedstock would be imported, although feedstock could also be produced locally. Since fuel facilities for biofuel are practically non-existing in the commercial harbor system, new facilities would have to be developed.

The addition of biofuels in electrical production and transportation would result in inter-fuel replacement of petroleum fuels. In this scenario, distillate and residual fuel used in electrical generation would be replaced by biofuels. Same with the transportation sector in that biofuels would replace gasoline and diesel to some extent.

3.2.3 Fuel Replacement through Coal and Natural Gas

The Energy Information Administration (EIA) predicts that over the next 20 years, the importance of coal will increase significantly for energy generation. Since coal is already used for electricity generation on Oahu, the production capacity of the existing coal power plant could be increased. Coal would then replace either distillate or residual fuel. However, with the recent concerns over carbon emissions, coal is being re-evaluated as a fuel source to augment electrical production in Hawaii.

There have been previous investigations into the possibility of implementing natural gas (NG) into Hawaii's energy system. Using NG for electrical generation and for other activities such as in the transportation sector could result in a significant diversification of Hawaii's energy system. From the fuel resource availability standpoint, NG has significant worldwide reserves. The bulk of the NG reserves are distributed over more countries than is the case of crude oil. In addition, NG produces less carbon emissions during the electrical generation process. These important facts make NG a strong candidate as a prime fuel candidate for Hawaii's energy future.

The disadvantage with NG when compared to crude oil and petroleum products is that it requires more sophisticated means of transport and storage. While the most efficient means to transport NG is as continuous streams through transmission pipelines, it is not feasible to install transmission pipelines that connect Hawaii to production areas. Therefore NG has to be imported batch-wise, either as Liquefied Natural Gas (LNG) or Compressed Natural Gas (CNG).

The worldwide market for LNG has expanded significantly in the past decades and there are available supplies of it that could be tapped by Hawaii. The supply of LNG to Hawaii would require specialized and costly super-insulated cargo vessels and dedicated unloading facilities with cryogenic process transmission pipelines and landside storage tanks. The high costs and sophisticated operation of these installations would require a large enough supplied volume of LNG in order to achieve the necessary economies of scale to make this a viable alternative. If implemented, it would replace significant amounts of distillate and residual fuel for power generation and possibly some diesel and gasoline fuels for transportation. In addition, it could replace a significant portion of Hawaii's utility gas supply that is presently produced locally from petroleum products.

An alternative to liquefied natural gas (LNG) is compressed natural gas (CNG). The past years have seen significant developments of marine CNG vessels. The ocean-born transportation of CNG is now technically and economically feasible and is an interesting market application for natural gas (NG). Some of the world regions with stranded NG have too low production volumes to economically justify installation of a LNG liquefaction plant. In these instances, NG could be brought to the market through CNG ships, which require much less costly and sophisticated infrastructure than LNG. CNG shipment from Alaska or Asia could be economically feasible for Hawaii. Another interesting possibility would be to distribute the re-gasified LNG, which is received on Oahu, to the neighbor islands using CNG barges. As in the case of CNG, NG would replace distillate or residual fuel for electricity generation.

<u>To summarize,</u> increasing coal and implementing natural gas in Hawaii's energy system would replace a significant portion of petroleum fuel, particularly residual fuel for power generation.

While the scope of petroleum fuel replacement by coal is limited, implementing NG would have a much greater effect on the petroleum fuel supply and consumption situation in Hawaii.

3.2.4 Opportunities Through Renewable Energies and Energy Conservation

Renewable energies other than biofuels can generate electrical power, thereby replacing power generating facilities that are powered by fossil fuels. Significant implementation of renewable energies, if technically feasible and achievable in the coming years, could significantly reduce the demand distillate and residual fuels.

Energy conservation measures could contribute to all three main areas of Hawaii's energy system: electrical power generation, ground and air transports. Conservation of electric energy would reduce the demand for distillate and residual fuel. Conservation in ground transports such as through a change in driving patterns or through a growing number of fuel efficient cars, increased use of public transport or redesign of urban areas, would mainly reduce the consumption of gasoline and some diesel. Conservation measures in air travel, achieved through a new generation of energy efficient airplanes, larger planes or fewer flights would reduce the demand for jet fuel.

3.2.5 Ramifications for Hawaii's Refineries

The present output slate of Hawaii's refineries closely matches the local demand for petroleum products. At present, the two refineries on Oahu produce about 90 percent of the petroleum products consumed in Hawaii. As pointed out in Section 3.1.4, the current process capabilities of Hawaii's refineries require a certain crude oil quality to produce the current output slate. This unique output slate is characterized by a large portion of residual fuel, which is significantly higher than the average portion of residual fuel produced in refineries in the U.S. or Asia. In Hawaii, electricity generation creates a ready market for residual and heavy distillate fuel. U.S. mainland refineries have optimized their operation to maximize gasoline output and minimize the less lucrative residual and distillate fuel fractions. This requires the U.S. mainland refineries to operate sophisticated downstream process facilities, where the lower yield product residual fuel is converted to lighter products.

The anticipated future decrease in API density and increase in sulfur content of the world crude oil supply would require increasing downstream process capacities, in order to meet the rising demand for gasoline. In implementing such a costly process infrastructure, economies of scale favors the large refineries. Hawaii's refineries are small in size when compared with the typical refineries on the U.S. West Coast or in Asia. Hawaii's refineries might have to invest in significant process revamping if future available crude oil cannot be economically processed to the required output slate to meet the needs of Hawaii. This would result in export and importation of selective petroleum products, which cannot be sold in Hawaii or that cannot be met by Hawaii's refineries, respectively.

Inter-fuel replacement or significant reductions in demand for certain fuel types might force the refineries to change their overall output capacities to match the required fuel demand in Hawaii or force them to export products that cannot be sold locally. As an example, if LNG replaces large amounts of residual and distillate fuel, while the demand for gasoline stays high, the refineries would be faced with surplus volumes of residual fuel that must be shipped to offshore markets. This might result in a negative return, and in turn burdening the viability of Hawaii's refiners.

From the standpoint of future fuel facilities in commercial harbors system, and while purposely not addressing potentially far-reaching economic and political ramifications of future changes in petroleum refining in Hawaii, the following possible options of Hawaii's refineries have to be considered in the context when planning fuel facilities:

Option 1. Hawaii's refineries would carry out significant investments in upgrades of downstream process capacities to reduce the amount of residual and distillate fuels for power plants, which would be replaced by biofuels, NG, coal, or would not be required due to gains in renewable energies and energy conservation measures.

Option 2. Hawaii's refineries would continue using crude oil quality required for existing refining operations and would incur future higher oil price differentials, since the world crude oil supply becomes increasingly heavy and sour, making light and sweet crude more expensive. In this case, the price for locally produced fuel might be higher than imported fuel, thereby deteriorating the competitiveness of local fuel production.

Option 3. While using current refinery operations, refineries would decrease refining production levels to match lower residual and distillate fuel demand, thereby causing an undersupply of gasoline and lighter distillate fuels, resulting in increased needs for importation of refined petroleum fuels.

Option 4. Terminating portions or all refining operations in Hawaii, resulting in the need to import all petroleum fuel as refined products through the commercial harbors system.

Assuming that the future fuel supply situation for Hawaii will encounter significant changes, all four scenarios above would require changes to the fuel-handling infrastructure in the commercial harbors. In the case of increased imports of finished petroleum products, fuel facilities in the harbors would have to be adjusted to match the demand for berthing and storage. Biofuels and feedstock facilities would have to be installed in order to handle higher quantities of biofuels and its feedstock.

3.3 Description of Current and Possible Future Energy Systems for Hawaii

This section describes the current energy system of Hawaii and suggests three possible future energy systems that might evolve within the 2030 timeframe of this study.

3.3.1 Continuation of Status Quo

The current energy system is anchored in Hawaii's high dependency on imported crude oil and assumed to continue into the future.

Figure 3.12 shows the per capita consumption for specific petroleum products and the per capita consumption for all petroleum. Hawaii has a lower per capita energy demand compared to the U.S., but has a significantly higher per capita demand for energy derived from oil. Hawaii's per capita consumption for gasoline is only 75 percent of the consumption in the entire U.S., suggesting the average driver in Hawaii consumes considerably less than the average American driver. The biggest differences in per capita consumption are residual fuel and jet fuel, where the Hawaii per capita consumption is nine times and six times higher than in the entire U.S., respectively. Although per capita total liquids consumption in Hawaii is significantly higher than in the total US, this does not mean that Hawaii's residents are consuming more energy than their mainland counterparts, but that Hawaii needs much more oil to satisfy demand than the mainland does.

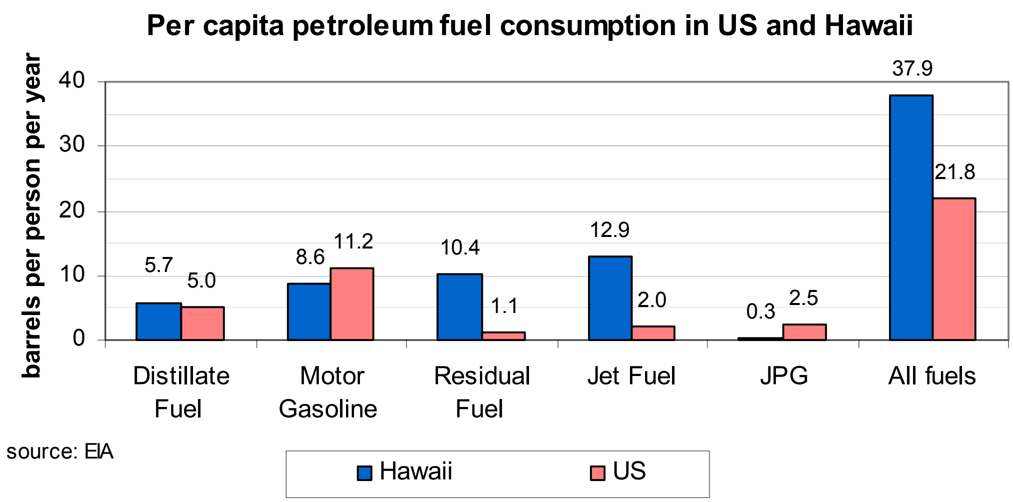

Figure 3-12: Per Capita Petroleum Fuel Consumption

Figure 3.13 indicates that Hawaii's high dependence on oil is due to the high use of petroleum for power generation and the high demand of airborne transport to the islands.

The existing energy system of Hawaii is schematically depicted in Figure 3-14. The energy vectors that are depicted in RED are affecting the petroleum fuel related operations in the commercial harbors system. The vectors in BLACK represent the energy vectors that do not affect the petroleum fuel related operations in the commercial harbors.

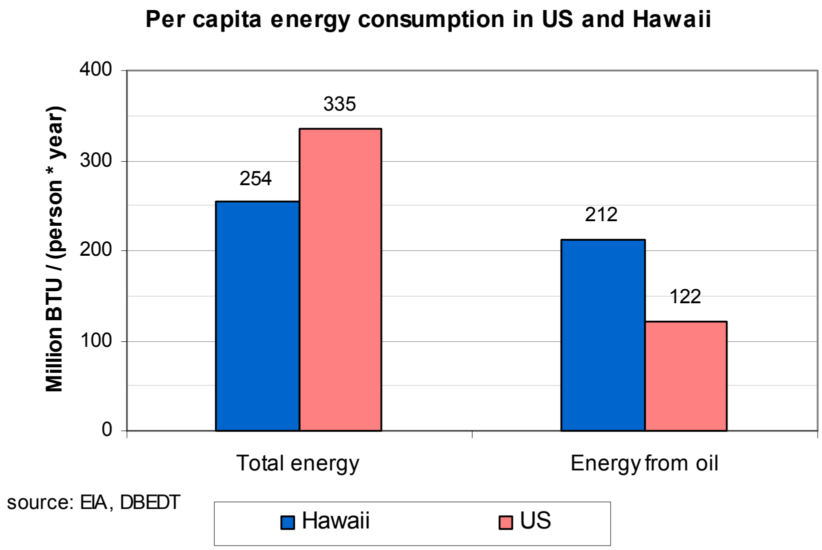

Figure 3-13: Per Capita Energy Consumption for Hawaii and the U.S.

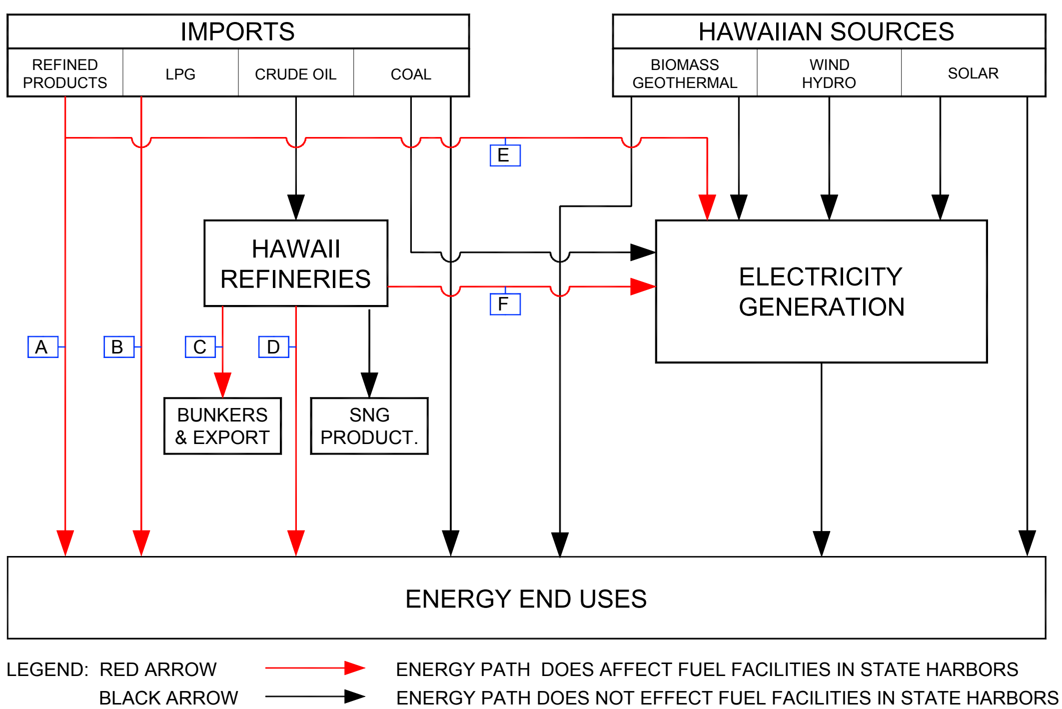

Figure 3-14: Current Energy System of Hawaii

The import of crude oil and export of selected refined petroleum products (e.g., residual fuel) is currently carried out through the offshore moorings south of Kalaeloa Barbers Point Harbor and does not affect the fuel operations in the commercial harbors system. Coal, though an important fuel for Hawaii, is likewise not considered in the scope of the present study.

Vector A: Refined petroleum products (except LPG) are imported from refineries outside of Hawaii. Currently direct imports of refined petroleum products can only be handled in the two harbors on Oahu: Honolulu and Kalaeloa Barbers Point Harbors. A portion of the imported fuel is shipped to the neighbor islands

Vector B: Import of LPG happens through Oahu and also directly to neighbor islands.

Vector C: Bunker oil is mainly distributed on Oahu.

Vector D: Examples of petroleum products for transportation are gasoline, light distillates and jet fuel. The main portions of these products are consumed on Oahu. The rest of the fuel output is shipped to the neighbor islands.

Vector E: A small portion of the imported distillate fuel is used for power generation.

Vector F: The residual oil and distillate fuel produced by Hawaii's refineries used for power generation, either on Oahu or on the neighbor islands.

All other elements of the current energy system, such as geothermal, biomass, solar and wind energies do not directly affect the fuel handling operations in the commercial harbors. However, though they affect the fuel facilities indirectly by replacing fuel that would otherwise have to be imported or shipped between the islands.

3.3.2 Emergence of Biofuels

The State of Hawaii supports the production of biofuels and its use in a range of energy applications. The two biofuels currently being implemented or under considerations are ethanol and biodiesel.

Hawaii requires a 10 percent blend of ethanol in gasoline, where it is the preferred oxygenate to reduce carbon emissions from motor vehicles. Currently, ethanol is imported to Hawaii but there are plans to produced ethanol locally and replace imports. Local production of ethanol requires different types of organic feedstock, depending on the production process. This feedstock must either be imported or can be produced in Hawaii.

The present state-of-the-art biodiesel production technologies require feedstock from oil-based sources, such as virgin oil feedstock, waste vegetable oil or animal fats. Production of biodiesel in Hawaii requires either the importation of feedstock or production of the local feedstock.

Adding biofuels to Hawaii's energy system requires fuel facilities in the commercial harbors system that include storage tanks, transmission pipeline systems, environmental protection infrastructure such as vapor control systems and loading/offloading facilities for barges and tankers. In addition, fuel barges will need to be configured for the inter-island transport of biofuels and biofuels feedstock.

Hawaii's energy system that is based on petroleum fuel and significant amounts of biofuels is schematically depicted in Figure 3-15. The energy vectors that are depicted in RED in Figure 3-15 are affecting the petroleum fuel and biofuels related operations in the commercial harbors. The vectors in BLACK represent the energy vectors that do not affect the petroleum fuel or biofuel related operations in the commercial harbors.

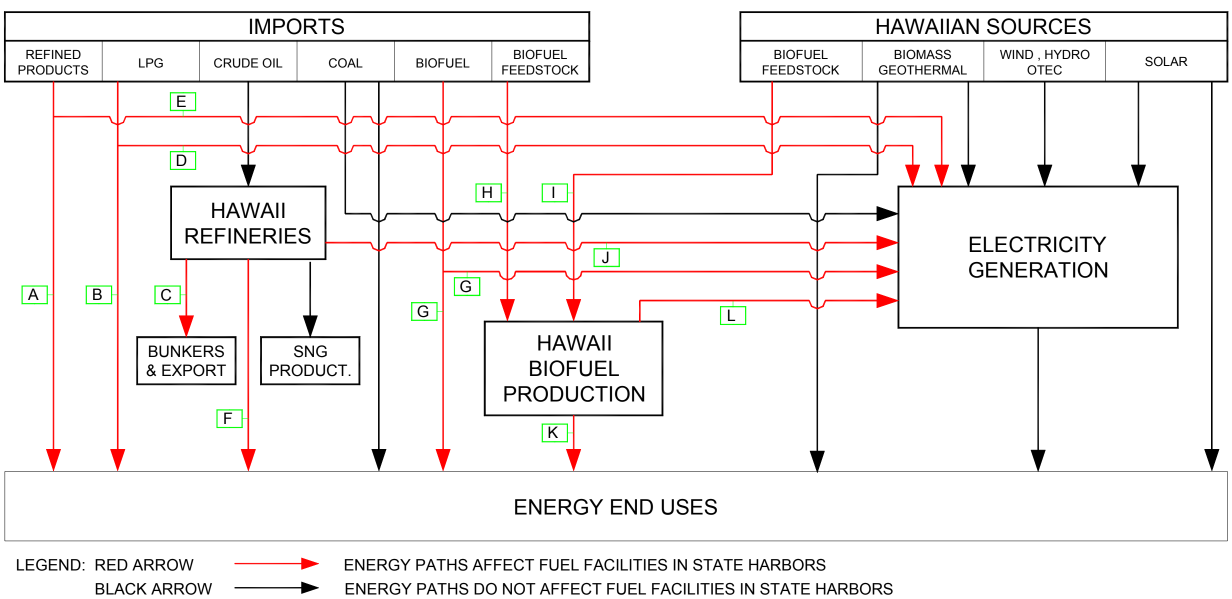

Figure 3-15: Energy System Scenario Using Petroleum and Biofuels

The import of crude oil and export of selected refined petroleum products (e.g., residual fuel) is currently carried out through the offshore moorings located south of Kalaeloa Barbers Point Harbor and does therefore not affect the fuel operations in the commercial harbors system. Coal is not considered for fuel facilities in the commercial harbors. Renewable energies, such as geothermal, biomass, solar and wind energies do not directly affect the fuel handling operations in the commercial harbors system. However, they would affect the fuel facilities indirectly, by replacing fuel that would otherwise have to be imported or shipped between the islands.

Vector A: Refined petroleum products (except LPG) for energy end uses are imported from refineries outside of Hawaii. Imports occur through Oahu and on the neighbor island's commercial harbors

Vector B: LPG for energy end-uses are imported through Oahu and on the neighbor island's commercial harbors.

Vector C: Bunker oil, primarily of residual and distillate fuel oil for ships, is produced by Hawaii's refineries and is mainly distributed on Oahu.

Vector D: LPG for electricity generation (e.g., distributed smaller co-generation units) are imported through Oahu and the neighbor island's commercial harbors.

Vector E: Refined petroleum products (except LPG) for electricity generation are imported from refineries outside of Hawaii. Imports occur through Oahu and on the neighbor island's commercial harbors.

Vector F: Refined petroleum products (including LPG) from Hawaii's refineries are distributed on Oahu and the neighbor islands.

Vector G: Biofuels for energy end uses and for electrical generation would be imported from refineries outside of Hawaii. Imports occur through Oahu and on the neighbor island's commercial harbors.

Vector H: Biofuel feedstock would be imported from suppliers outside of Hawaii. Imports would occur through the commercial harbors on Oahu and the neighbor islands. The feedstock will be converted to biofuel in refineries in Hawaii.

Vector I: Biofuel feedstock grown in Hawaii would be distributed throughout the Hawaiian Islands, (e.g., biofuel feedstock would be transported between the islands.) The feedstock would be converted to biofuel in refineries in Hawaii.

Vector J: Residual fuel and distillate fuel used in electricity generation is produced by Hawaii's refineries is distributed to the neighbor islands.

Vector K: Biofuel for energy end uses and produced by refineries in Hawaii would be shipped between islands.

Vector L: Biofuel for electricity generation and produced by refineries in Hawaii would be shipped between islands.

3.3.3 Introduction of Natural Gas

Previous studies have investigated the addition of NG to Hawaii's energy system (e.g., FACTS, 2003). Natural gas (NG) could be a cost effective and environmentally superior fuel for Hawaii because of its cleaner thermal conversion characteristics and lower greenhouse gas emissions.

In this scenario, NG would be imported as liquefied natural gas (LNG). The primary use of imported NG would be in Hawaii's power plants. NG would also supply industrial, commercial and residential applications that are currently served by the Synthetic Natural Gas (SNG) supply. In addition, NG might also find entry into the transportation sector, thereby replacing a portion of motor gasoline.

The LNG infrastructure in Hawaii would include:

1. Offshore unloading terminal with cryogenic transmission pipelines connecting to shore.

2. Cryogenic storage tank with adequate capacity to accommodate the Liquid Petroleum Gas (LPG) volume supplied by the LPG tankers plus an adequate safety margin.

3. Re-gasification plant to convert LNG to CNG.

Under the LNG scenario, which was proposed for Hawaii in previous studies (e.g., FACTS, 2003), NG use was confined to Oahu since LNG re-gasification installations would only be located on Oahu. The neighbor islands were not included in Hawaii's NG system, because LNG installations are too costly for the relatively small market on the neighbor islands.

Using recent technology, developments in CNG shipping (e.g., ABS [American Bureau of Shipping Ship Classification Society] classed CNG ships and barges are now available) would make it technically and economically feasible to transport NG in form of CNG either to Oahu or directly to the neighbor islands or inter-island between neighbor islands. Therefore CNG could be added to a future Hawaii energy system, either to replace LNG imports (and avoid the significant investment in technically advanced and operationally difficult LNG components) or to increase the volume of LNG imports by opening the neighbor islands to NG energy, thus decreasing system unit costs by increasing the economies of scale.

Under the energy system scenario proposed in this section, LNG (or CNG) imports are substituting either all or most of the residual and distillate fuels used for electrical generation. NG would also substitute LPG gas for larger energy conversion applications. It would furthermore replace some of the gasoline or diesel for ground transportation. Biofuels would be used for energy generation and for ground transport applications. Furthermore, the scenario assumes that selective renewable energies and energy conservation measures would noticeably reduce the electricity energy demand and further reduce residual and distillate fuel for power plants.

As a result of the inter-fuel substitution and energy savings, the energy scenario in this section assumes that the resulting petroleum market in Hawaii would change to such an extent that its refineries would find it hard to compete. The energy system thus assumes that the refineries might decide to cease operations. Therefore, all petroleum products would be imported to Hawaii, which would require the installation of appropriate fuel handling infrastructure in the commercial harbors system.

Figure 3-16 illustrates the energy system scenario comprised of petroleum fuel, biofuels, NG and other energy sources. The energy vectors in Figure 3-16 that relate to coal imports, import of LNG and supply of re-gassed CNG on Oahu do not affect the fuel facilities in the commercial harbors system. Likewise energy vectors associated with renewable energies would not directly affect the fuel facilities in commercial harbors.

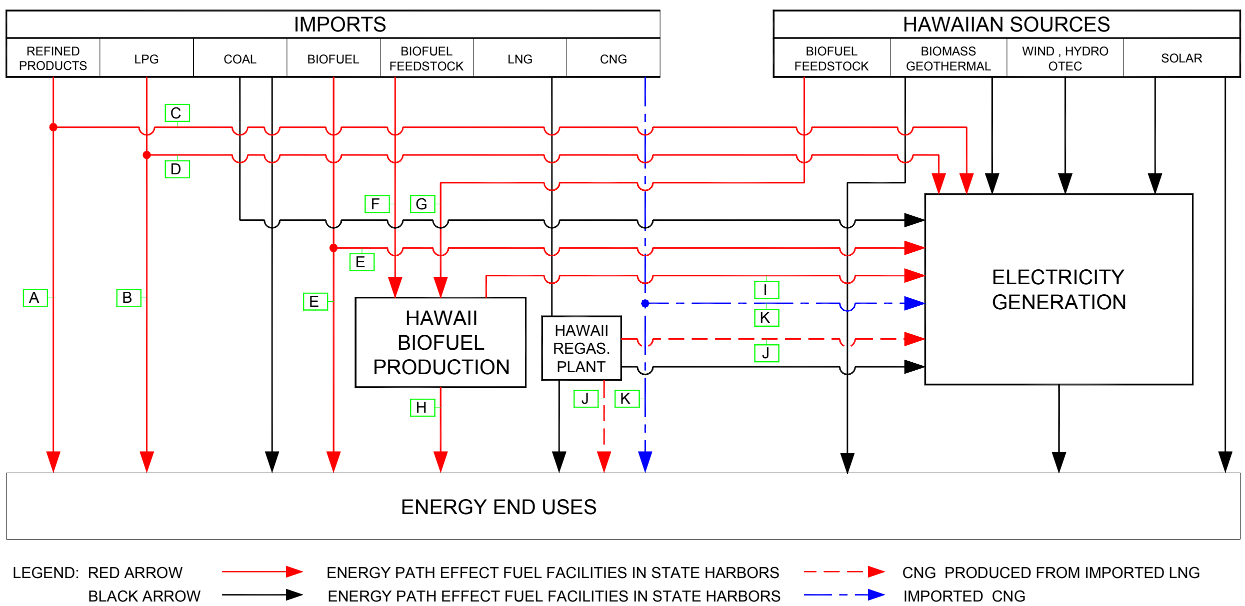

Figure 3-16: Energy System Scenario Using Petroleum, Biofuels and Natural Gas

<u>Vector A</u>: Refined petroleum products (except LPG) for energy end uses are imported from refineries outside of Hawaii. Imports occur through Oahu and the neighbor island's commercial harbors.

<u>Vector B:</u> LPG for energy end-uses would be imported through harbors on Oahu and on the neighbor islands

<u>Vector C:</u> Refined petroleum products (except LPG) for electricity generation would be imported from refineries outside of Hawaii. Imports occur through Oahu and the neighbor island's commercial harbors

Vector D: LPG for electricity generation (e.g., distributed smaller co-generation units) would be imported through Oahu and the neighbor island's commercial harbors.

Vector E: Biofuels for energy end uses and for electricity generation would be imported from refineries outside of Hawaii. Imports would occur through Oahu and the neighbor island's commercial harbors.

Vector F: Biofuels feedstock would be imported from suppliers outside of Hawaii. Imports would occur through Oahu and the neighbor island's commercial harbors. The feedstock would be converted to biofuel in refineries in Hawaii.

Vector G: Biofuels feedstock that is grown in Hawaii would be distributed throughout the Hawaiian islands, e.g., biofuel feedstock transports between the islands. The feedstock would be converted to biofuel in refineries in Hawaii.

Vector H: Biofuels for energy end uses and produced by refineries in Hawaii and shipped between islands.

Vector I: Biofuels for electricity generation and produced by refineries in Hawaii and shipped between islands.

Vector J: CNG for electricity generation and energy end uses would be produced in the LNG re-gasification on Oahu and is shipped to the neighbor islands.

Vector K: CNG for electricity generation and energy end uses would be imported to Hawaii in CNG ships through Oahu and the neighbor islands commercial harbors.

SECTION FOUR

DESIGN APPROACH FOR FUEL FACILITIES

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SECTION FOUR

DESIGN APPROACH FOR FUEL FACILITIES

Section Four presents fuel related technologies and port planning strategies being considered for the commercial harbors system's future fuel facilities. Based on the three energy scenarios described Section Three, a design schemes was developed for each energy scenario: (1) Status Quo, (2) emergence of biofuel and (3) introduction of natural gas. Each design scheme identifies the basic infrastructure requirements for fuel transfer operations within the commercial harbors system. In addition, this section provides details of fuel-related environmental regulations and safety requirements that were considered when developing each conceptual design scheme.

4.1 Design Schemes for Fuel Transport

This section discusses the conceptual fuel design schemes that are proposed for each energy scenario described in Section Three. The three fuel design schemes describe the modes of transport of fuel from out-of-state sources to Hawaii, and the fuel distribution between the Hawaiian Islands. Assuming a wide range of possible changes to the energy system of Hawaii, all three conceptual design schemes are considered possible within the planning horizon of 2030. Also, consideration was given to the scope and speed of changes of world oil markets and inter-fuel substitution that might occur in Hawaii's energy system.

Future commercial harbors improvements of fuel facilities correlate directly with the anticipated volumes and types of fuels distributed (e.g., petroleum products or alternative fuels that will be shipped through Hawaii's commercial harbors). It is important, however, to emphasize that all aspects of Hawaii's energy system affect the commercial harbors system's fuel facilities, at least indirectly. Even though, for example, renewable energies are not supplying fuel to Hawaii's energy system, the increasing use of it would reduce the amount of selected petroleum products used locally and would indirectly affect the mode of fuel supply to the islands. Likewise, a large scale introduction of liquefied natural gas (LNG), though off-loaded at an offshore location and outside the commercial harbors system would still greatly affect the fuel facilities in the commercial harbors by requiring fuel facilities to import refined petroleum products.

4.1.1 Design Scheme 1: Status Quo

Figure 4-1 shows the fuel facilities under Design Scheme 1. Under this scheme, the supply pattern of petroleum and other fuels that are presently used in Hawaii would continue into the future; only the absolute amount of fuel used and the relative proportions would vary. For example, demand for Liquid Petroleum Gas (LPG) might increase due to favorable demand and price situation, since LPG can be produced from both oil and natural gas production. In another example, ethanol mixed with gasoline might be used in higher proportion than the 10 percent blend, which is currently mandated in Hawaii. Furthermore, less gasoline might be used due to a more efficient car fleet and less residual oil might be used in power generation. In such cases there would be changes in the transportation volumes of the established fuels in fuel transports through the commercial harbors.

Under Design Scheme 1, the fuel facilities in the commercial harbors system would have to handle three types of fuel:

1. Liquid petroleum products, including gasoline, jet fuel, light and heavy distillates (residual fuel for power generation and bunker oil is not being considered).
2. Liquid petroleum gas (LPG), is a mixture of propane and butane.
3. Biofuels: ethanol is currently used as an oxidant in motor gasoline.

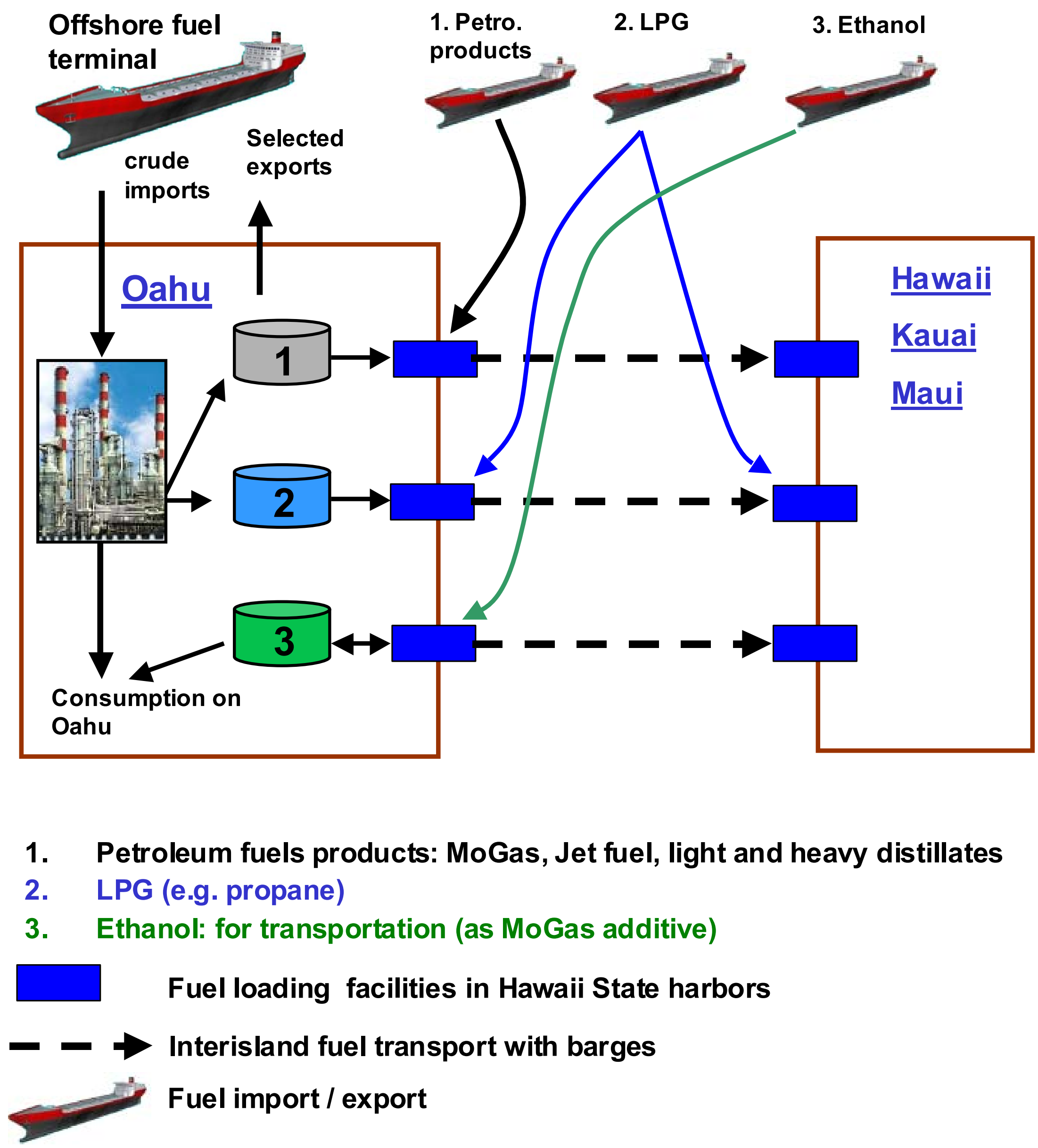


Figure 4-1: Fuel Transport Methodology of Design Scheme 1

Figure 4-1 shows crude oil being supplied to the refineries on Oahu that produces refined petroleum products and LPG for consumption in Hawaii. Some quantities of refined petroleum products would be directly imported through the two commercial harbors on Oahu. Some refined products (e.g., Naphtha or residual fuel) would be exported from Hawaii. The majority of the refined products would be consumed on Oahu. The rest would be distributed to the neighbor islands via inter-island fuel barges.

The main portion of LPG is produced by Hawaii's refineries on Oahu as a byproduct of crude oil distillation. Some LPG is also occasionally imported directly to Oahu or to the neighbor islands when the refineries cannot supply it.

Ethanol is the only biofuel of significant volume imported to Hawaii. Currently, ethanol is mixed with motor gasoline to decrease unwanted emissions in internal combustion engines. The current ethanol imports to Hawaii are transported to Oahu's commercial harbors, then distributed locally and to the neighbor islands. Since ethanol is corrosive, hygroscopic (i.e., a strong affinity to absorb water) and acts as a strong solvent, it is transported separately from gasoline and is usually blended with gasoline close to the point of consumption.

Table 4-1 summarizes the types of fuel transport vessels used under the Design Scheme 1. This are basically the same fuel vessels used in the current fuel transport scenario.

Table 4-1: Required Fuel Transport Vessels under Design Scheme 1

	1 Petroleum fuel products	**2** Liquid petroleum gas (LPG)	**3** Ethanol or biofuel
OAHU			
Fuel tankers receiving	**X**	**X**	**X**
Fuel barges loading	**X**	**X**	**X**
Neighbor islands			
Fuel tankers receiving		**X**	
Fuel barges receiving	**X**	**X**	**X**

4.1.2 Design Scheme 2: Emergence of Biofuels

Figure 4-2 shows the fuel facilities considered under Design Scheme 2. Under this scheme, biofuels would be added as a significant energy source for Hawaii's electrical generation (i.e., replacing distillate and residual fuels) and ground transportation (i.e., replacing gasoline and diesel). Biofuels would attain significant market share, both as imported, refined fuel and fuel that is produced in Hawaii from feedstock that is either imported or produced locally. In addition, it is assumed that energy conservation programs and renewable energies would result in reducing demand of fuels for transportation and electrical generation.

Design Scheme 2 anticipates changes in the operation of Hawaii's refineries. Specifically, it makes an assumption that the local refineries would either not be able or not opt to match their output slate to Hawaii's anticipated demand structure. This would require an increase in the importation and/or exportation of selected petroleum products through Oahu's commercial harbors.

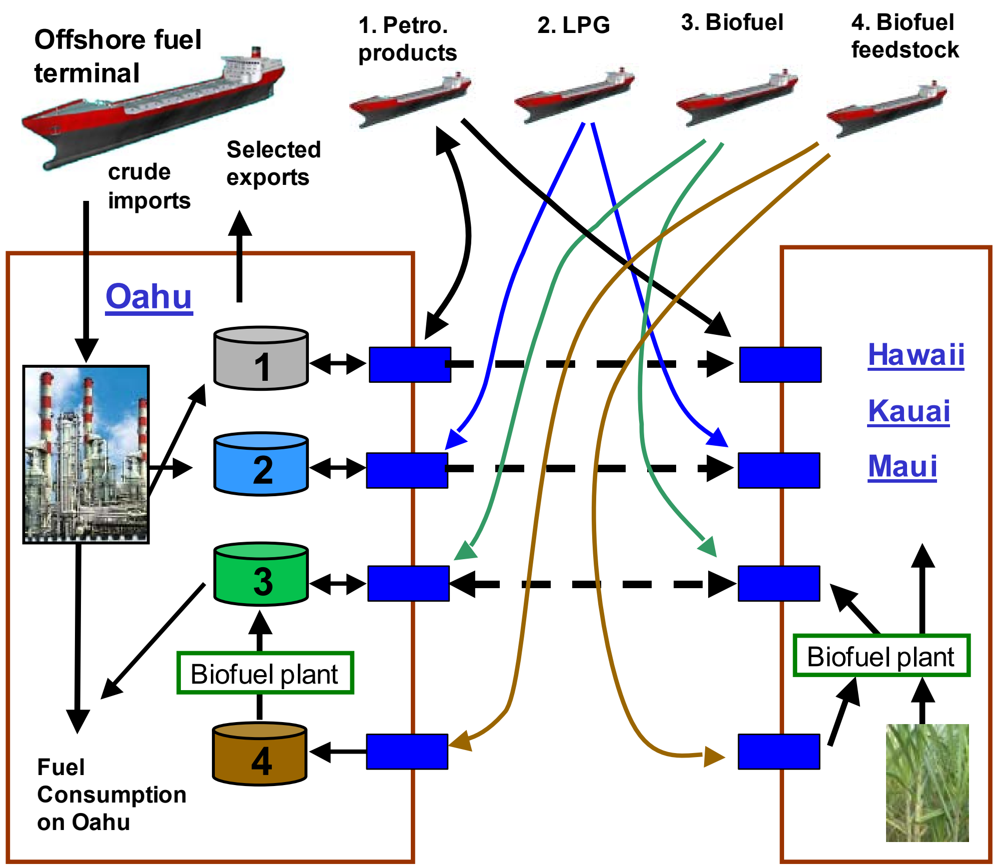
This scheme is illustrated in Figure 4-2 and suggests the following required fuel shipping modes between Oahu and the neighbor islands:

1. The petroleum refineries on Oahu would continue to receive crude oil shipments through the current offshore fuel terminal. Exports of selected fuel products, which cannot be sold on the islands, would be loaded at a new fuel terminal in the Kalaeloa Barbers Point Commercial Harbor that would be able to accommodate suitable tanker sizes.

2. Fuel imports to the islands would primarily be carried out through the new fuel terminal in Kalaeloa Barbers Point Commercial Harbor. Since some commercial harbors on the neighbor islands would have fuel piers that could accommodate Handysize Tankers for biofuels feedstock importation, these tankers might also dock at there, thus bypassing Oahu and avoiding transport of petroleum products from Oahu with fuel barges.

3. Imports of LPG would be shipped to Oahu and to those harbors on the neighbor islands that could accommodate suitably large tankers.

In addition, Figure 4-2 illustrates the possible range for future biofuels shipping schemes. Biofuels could be imported to Oahu or directly to the neighbor islands. Fuel barges are likewise envisioned to distribute biofuels between the Hawaiian Islands, either biofuels that is imported through Oahu or biofuel that is produced on Oahu or on the neighbor islands. Lastly, feedstock for biofuels production could be imported to either Oahu or directly to the neighbor islands.



1. **Petroleum fuels products: MoGas, Jet fuel, light and heavy distillates**
2. **LPG (e.g. propane)**
3. **Ethanol: for transportation (as MoGas additive)**
4. **Biofuel feedstock**

Figure 4-2: Fuel Transport Methodology of Design Scheme 2

Table 4-2 illustrates the different types of fuel shipments that are anticipated under Scheme 2.

Table 4-2: Required Fuel Transport Vessels under Design Scheme 2

	1 Petroleum fuel products	2 Liquid petroleum gas (LPG)	3 Ethanol or biofuel	4 Biofuel feedstock
OAHU				
Fuel tankers receiving	X	X	X	X
Fuel barges loading	X	X	X	
Fuel barges unloading			X	
Neighbor islands				
Fuel tankers receiving	X	X	X	X
Fuel barges unloading	X	X	X	
Fuel barges loading			X	

4.1.3 Design Scheme 3: Introduction of Natural Gas

Design Scheme 3 would move Hawaii's energy system further away from the current high dependency on petroleum. Under this scenario, natural gas (NG) would be added as a significant component to Hawaii's energy supply. In addition, biofuels would be an equally significant contribution to Hawaii's energy system as stated in Design Scheme 2.

NG would be transported to Hawaii as liquefied natural gas (LNG). In what seems to be the most feasible method, it is assumed that LNG carriers would be unloaded at a mooring location offshore from Kalaeloa Barbers Point Harbor. LNG would then be transferred to a land based storage facility via cryogenic transmission pipelines. The LNG would be stored in the super-cooled and liquid state and would be conveyed to a re-gasification plant on Oahu before being used in electrical generation and being distributed as compressed natural gas (CNG) throughout Oahu.

Previous studies that analyzed the use of LNG suggested that natural gas in Hawaii would only be used on Oahu for electrical generation, utility gas and minor ground transportation applications. The neighbor islands were not considered viable candidates for natural gas since expenditures for the LNG infrastructure required for the neighbor islands appeared to be economically unjustifiable.

The use of CNG for Hawaii was not considered in previous studies. Recent developments in CNG marine transport technology opens up a new energy supply opportunity for Hawaii. Shipment of CNG to Hawaii from the continental United States (U.S.) or Asia could now use state-of-the-art CNG technology and such shipment could be economically viable. The economical merits would deserve more analysis in a follow-up study.

The CNG scenario would avoid the costly cryogenic and storage infrastructure requirements for LNG shipments and would make the natural gas supply to Hawaii more flexible. If, after a more in-depth analysis, LNG is still the preferred way to ship natural gas to Hawaii, CNG technology could be used to supply the neighbor islands, thereby increasing the amount of LNG shipments and improving the economies of scale of this system. In this case, LNG would be re-gasified on Oahu and a part of the CNG would be shipped to the neighbor islands using innovative CNG barges. The required CNG fuel shipment infrastructure and loading and unloading facilities in the commercial harbors would require innovative approaches, which are different from existing fuel facilities in Hawaii's commercial harbors. But such loading and unloading facilities would preferably be located at dedicated and specially secured fuel piers, because of stringent safety requirements for such fuel facilities.

Also, under Design Scheme 3, natural gas would be used in electrical generation, utility gas and ground transportation, thus replacing volumes of petroleum fuels such as residual fuel, heavy and light distillates, synthetic natural gas (SNG) (as produced from feedstock provided by the refineries) and motor gasoline. LPG consumption would be reduced because of the fuel substitution by NG. As a consequence, this scheme does not assume direct shipments of LPG to the neighbor islands. Instead, LPG would be shipped to Oahu and distributed to the neighbor islands by LPG barges.

Under this scenario, the significance of biofuels would be comparable to the scenario in Design Scheme 2. Refined biofuels would be imported to Hawaii through commercial harbors on Oahu and the neighbor islands. Biofuels would likewise be produced in Hawaii from feedstock that is either imported or produced locally. Thus the envisioned biofuel consumption and production scenarios would require fuel facilities in commercial harbors that could handle biofuels and its feedstock.

Design Scheme 3, addresses a fuel supply scenario for Hawaii that is purely hypothetical at this point in time. The much contemplated introduction of a large amount of natural gas to Hawaii would have significant ramifications to the energy system of Hawaii, in general, and the local refineries, in particular, since the demand for petroleum fuel would be greatly reduced by the replacement of natural gas and biofuels. As demand would drop for residual fuels, heavy and light distillates, motor gasoline and LPG and the remaining demand for petroleum products in Hawaii would no longer match the output slate of Hawaii's oil refineries. Under the assumptions of Design Scheme 3, the refineries would decide how to align their business strategies. Since this study investigates the ramification on the fuel facilities in the commercial harbors, the worst-case scenario is assumed where both local refineries would cease operation. Therefore all petroleum products would have to be imported using fuel facilities in the commercial harbors, rather than importing most of the petroleum using offshore moorings at Barbers Point on Oahu.

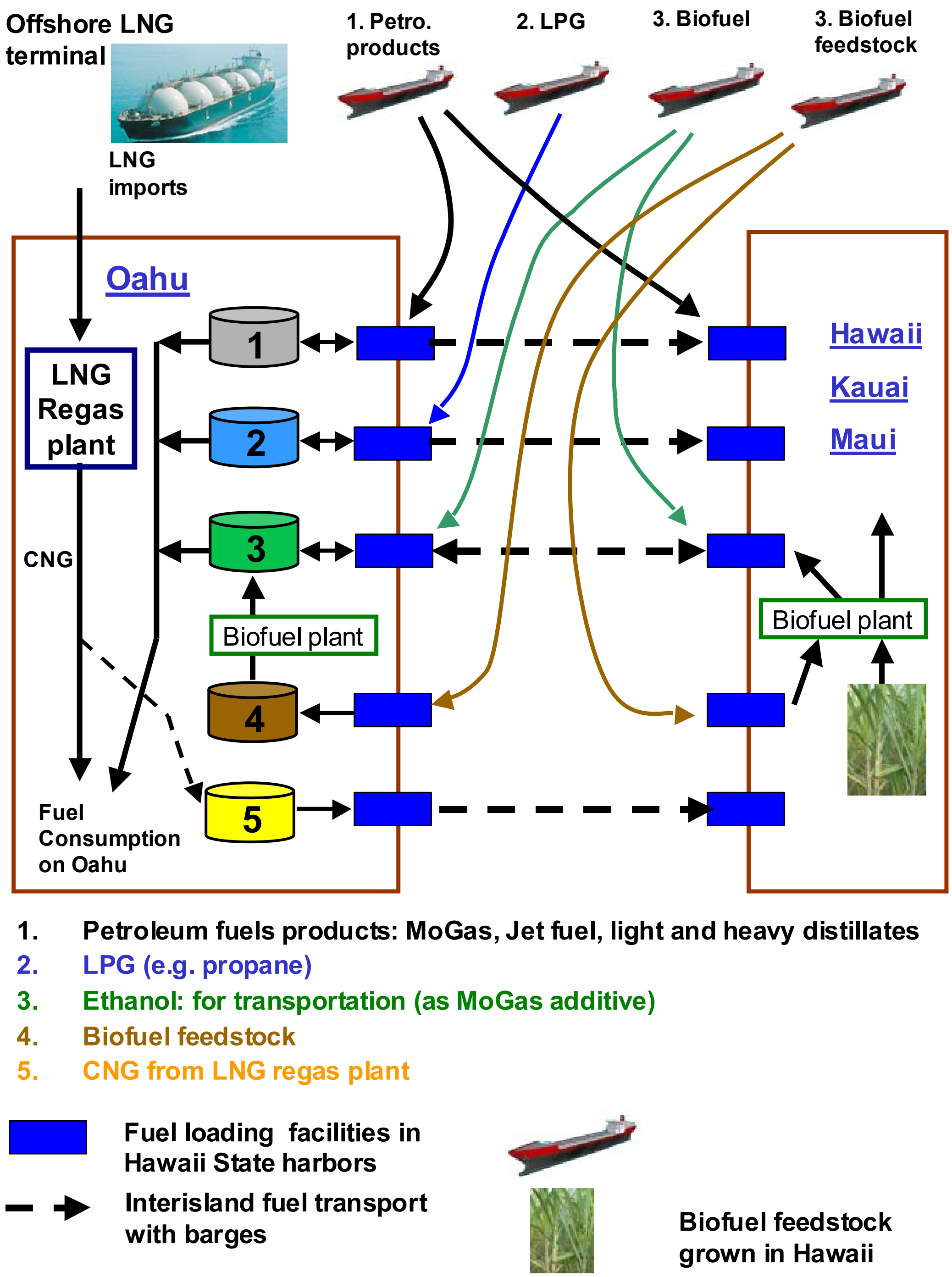


Figure 4-3: Fuel Transport Methodology of Design Scheme 3

Table 4-3 illustrates the different types of fuel shipments that are anticipated under Scheme 3.

Table 4-3: Required Fuel Transport Vessels under Design Scheme 3

	1 Petroleum fuel products	2 Liquid petroleum gas (LPG)	3 Ethanol or biofuel	4 Biofuel feedstock	5 Natural gas as CNG
OAHU					
Fuel tankers receiving	X	X	X	X	
Fuel barges loading	X	X	X		X
Fuel barges unloading			X		
Neighbor islands					
Fuel tankers receiving	X		X	X	
Fuel barges unloading	X	X	X		X
Fuel barges loading			X		

4.1.4 Discussion of Design Schemes 1 through 3

Recent developments in the energy sector (e.g., the extreme volatility in the price of oil) and the prospect of initiatives to mitigate climate change strongly suggest that significant changes in the global energy situation are forthcoming in the coming years. This is especially true for petroleum as the era of “easy and cheap oil” appears to be over and future oil supplies will be more limited and expensive (e.g. IEA, 2008).

Although changes in established energy technologies are typically not introduced “over night,” it is important to develop a flexible fuel supply system in order to accommodate changes in the world energy situation that occur faster than established energy thinking might suggest. For example, the use of biofuels is deemed an important contributor to Hawaii’s energy system in the years to come.

Design Schemes 1 through 3 provide a broad range of possible future energy supply scenarios for Hawaii. The three design schemes were defined solely in a qualitative manner, while anticipating types, but not volumes of fuels to be handled in Hawaii’s commercial harbors in the future. It is beyond the scope of this study to assess possible fuel quantities for the different fuels to be shipped under the three design schemes. Such determination will have to be carried out in a different study. The salient features of each scheme are described below:

- Design Scheme 1 basically follows the established fuel transport system in Hawaii with its refineries on Oahu being the hub of the local petroleum economy. Certain changes in the world crude oil market are considered under this design scheme. It is anticipated that there is a need of increasing the importation and/or exportation of refined petroleum products.

- Design Scheme 2 assumes the emergence of biofuels in Hawaii. In due course, this scheme envisions the need to transport refined biofuels or biofuel feedstock to Hawaii or transport it between the Hawaiian Islands. While this scheme deviates from the status quo, such as illustrated in Design Scheme 1, plans to increase biofuels and renewable energy in Hawaii are not hypothetical, but rather represents existing State of Hawaii policies that support this emerging industry.

- Design Scheme 3 assumes the currently hypothetical introduction of NG in substantial quantities. The scheme significantly departs from the assumption of Hawaii's petroleum refineries remaining the backbone of Hawaii's energy system. Natural gas could become an environmentally friendly and economically attractive fuel to substitute a significant volume of petroleum fuels in Hawaii. The LNG world market is presently expanding rapidly and Hawaii could profit from NG as a clean and effective energy source. While replacing a significant amount of petroleum, the local refineries would have to adjust their output accordingly. Design Scheme 3 assumes the worst-case scenario where a significant portion of petroleum imports is imported through fuel facilities in the commercial harbors that would require significantly expanding the present fuel facilities.

Which of the three design schemes or a combination thereof, will eventually become reality in the years to come will depend primarily on the future world oil and energy market conditions and evolving energy use in Hawaii. Judging from the wide range of predictions of future availability for oil, a wide range of oil supply scenarios is possible; ranging from abundant oil availability through the year 2030 to the assumptions of tight supplies with a peak in world oil production before or around the year 2010. As of now, the world oil market forecasts a shrinking of spare capacities, where a rapidly increasing oil demand (i.e., surging demand from rapidly developing economies in China, India and the Middle East) cannot be satisfied with an abundant supply of conventional oil.

Because Hawaii will have to adjust to fundamental fuel supply changes in the future, this study considers the **flexibility of the fuel facilities as the most important design criterion.** As the types and quantities of fuels that are shipped through the commercial harbors are changing, the fuel facilities have to be able to swiftly follow changes in technology and capacities.

The following are governing design criteria, which have been deduced from Design Schemes 1 through 3:

1. Fuel has been regarded as one of many bulk cargos handled in commercial harbors. Under this premise, fuel facilities share pier space with other cargo. While fuel will increase in value and its timely delivery gains in importance (e.g., just in time delivery to safeguard stocks), fuel shipments must be regarded as a unique form of cargo that requires priority treatment within the commercial harbors system.

2. Since the future energy market will most likely undergo significant changes in the near- and long-term future, future fuel facilities will have to be built and operated in a flexible way to allow for swift changes in fuel transport technology and capacities.

3. Fuel transfer infrastructure in the commercial harbors system is most flexible when the fuel facilities do not have to share pier space with other types of cargo. Therefore, wherever possible, dedicated fuel piers are preferable, where fuel installation configurations can be optimized for fuel transfer. For example, transmission pipelines that connect dedicated fuel piers with land-based fuel storage facilities should be installed in such a way as to allow expeditious additions or modifications.

4. Fuel barges have been the preferred or sole form of fuel transport vessel for inter-island applications to date. In the future, there will also be a need to accommodate small or medium size product tankers at the fuel piers in Hawaii's commercial harbors.

5. Although the present study does not address storage facilities in detail, the storage aspect plays an important role to optimize the entire fuel system and to enhance energy security for Hawaii.

4.2 Overall Design Components of Fuel Facilities

Typical fuel facilities in commercial harbors comprise of the following components:

1. Pier structures, mooring equipment and dredged area to accommodate fuel barges and tankers. The Harbors Division provides these components.

The following four components are provided by the terminal operator:

2. Ship-to-shore fuel transfer equipment such as flexible hoses

3. Interconnecting pipelines to convey the fuel from the vessel to storage facilities, and vice versa. These transmission pipelines are either owned by a single fuel company or in some cases a consortium of them (i.e., Kahului).

4. Fuel booster pumps. Normally the fuel vessels can discharge the fuel under the pressure and capacity using on-board pumps. If the pressure were not sufficient, then booster pumps would have to be used to assist in the transfer of fuel to the storage tanks.

5. Landside fuel storage tanks. The storage facilities are located outside of Harbors Division's property except in two locations: Nawiliwili Harbor on Kauai and Kawiahae Harbor on Hawaii Island.

This study assesses the commercial harbors system fuel facilities' components 1 through 4 above. Item number 5 is discussed where appropriate.

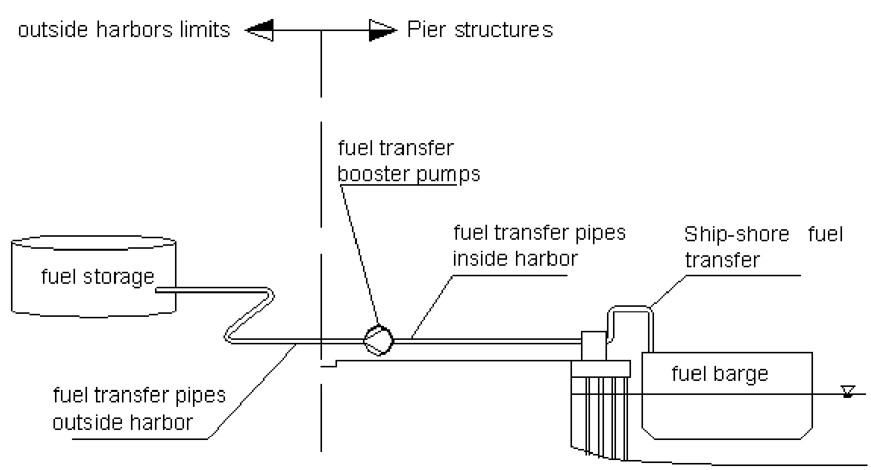


Figure 4-4: Fuel System Components

The entire fuel system is comprised of the above five components plus the fuel barges or tankers that transport liquid-bulk cargos. The fuel vessels are provided by ocean transit companies.

The determination to use larger fuel barges has only logistical and economic benefits if the additional fuel quantities carried can be accommodated in receiving landside storage tanks. Likewise, in order to reduce congestion within the commercial harbors system, larger storage tank capacities would decrease the frequency at which fuel barges or tankers have to make port calls. An optimization of the entire system then would have to consider factors such as the sizes of barges or tankers, the range of products that would be transported, the capacity of pipelines and the size (and to some degree the location) of landside storage tanks.

4.3 Pier Configuration and Other Considerations

At present, all fuel transfer operations (fuel loading and unloading of barges and tankers) are carried out at multi-use piers that also support containerized cargo, dry-bulk cargo and other maritime operations.

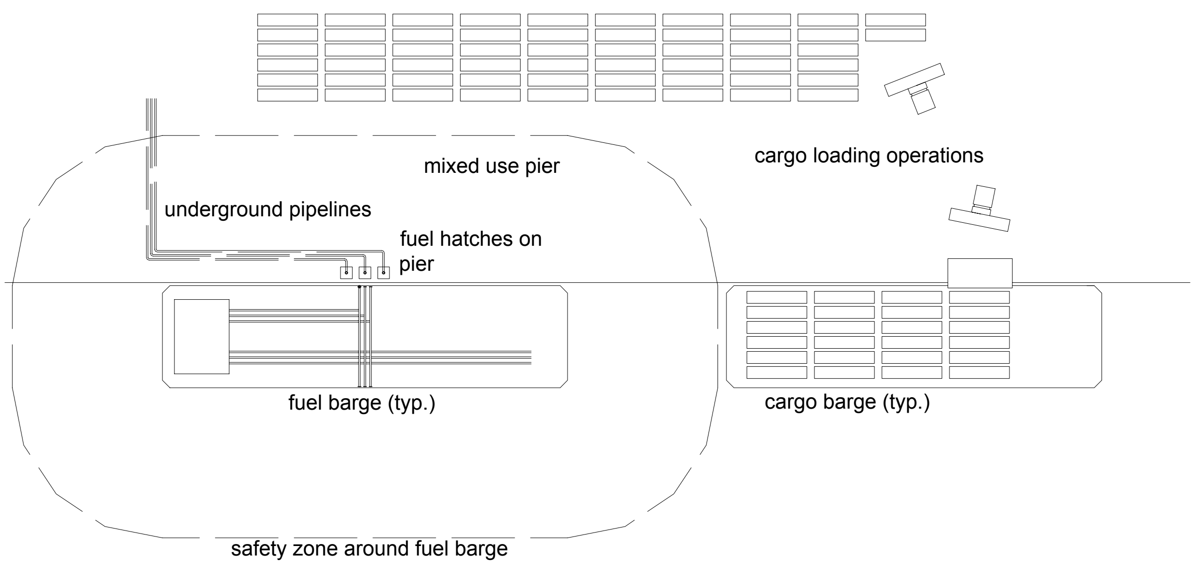


Figure 4-5: Typical Fuel Transfer Infrastructure

Figure 4-5 schematically shows how fuel transfer operations are typically carried out in the commercial harbors system. Figure 4-5 shows a fuel barge berthed at a multi-use pier, along with a cargo barge, which is in the process of being loaded. While fuel barges are in loading or off-loading mode, there is a safety zone that encircles the fuel vessel and extends onto the pier.

No cargo handling or passenger embarkation or disembarkation can be carried out within this safety zone during active fuel loading or off-loading activities. The extent of the safety zone is determined at the discretion of the Captain of the Port (COTP) and a distance of 100 feet is common.

Fuel transmission pipelines for different fuel products run between landside storage facilities and the pier and terminate dockside in the fuel hatches. The transmission pipelines are typically installed below-ground. They often are covered by a thick concrete slab that constitutes the pier traffic area or are encapsulated in a reinforced concrete (RC) pipe jacket. Therefore transmission pipelines cannot be easily repaired if damaged or modified. The fuel hatches are covered with steel plates, when not in use, and thus they do not impede cargo loading operations at times when fuel vessels are not in port. The fuel transmission pipelines have flanges at the take-over-point (TOP) in the fuel hatches that connects the flexible ship-to-shore fuel transfer hose. The fuel barges (as well as tankers) typically have the shipside loading and unloading pipe terminals amidships.

In most instances, fuel vessels provide the required hydraulic pressure to pump the fuel from the barge to the landside storage tanks by onboard pumps when in the unloading mode. In cases of high viscous fuels, such as fuel oil No.6 or certain biofuel feedstock (e.g., vegetable oil), barges and tankers should be able to heat the fuel, so that the fuel can be pumped properly through the pipelines.

4.3.1 Multi-Use Piers

Commercial harbor piers are typically multi-use where a number of cargo users share in its use. There are advantages and disadvantages to this pier configuration. Advantages of multi-use piers for fuel transfer include:

1. Increased flexibility as the piers can be used for containerized, dry- and liquid-bulk cargo operations and other maritime activities. Since the fuel transfer components in the pier are installed below the operating surface, the fuel equipment does not impede the cargo handling activities of the pier. This results in a maximum utilization of the piers space because the cargo vessel (or other ships) can use the entire length of the pier.

2. Its cost-effective nature, because the direct cost of the fuel companies' infrastructure is limited to installing fuel hatches and transmission pipelines. The overall cost of pier improvements are shared by multiple users. The cost-effective nature reduces investment risks for the fuel companies.

Disadvantages of utilizing multi-use piers for fuel transfer:

1. Fuel vessels have to compete with other cargo vessels in scheduling berth times at the pier.

2. While fuel loading or off-loading occurs, certain harbor operations are not allowed within the safety zone because of the flammable and explosive nature of liquid-bulk cargo

transfer. It typically is difficult to implement the full range of fire suppression and other safety measures at multi-use piers, where there are competing uses for pier area.

3. Fuel installations are built into the pier structure and are not easily modified or expanded. It is not easy to add or modify fuel infrastructure in cases when additional capacities are needed (e.g., new fuel companies, new types of fuel).

4.3.2 Dedicated Fuel Piers

When planning for piers, it is important to understand that fuel transfer activities are both easier and more complicated when comparing to regular cargo operations.

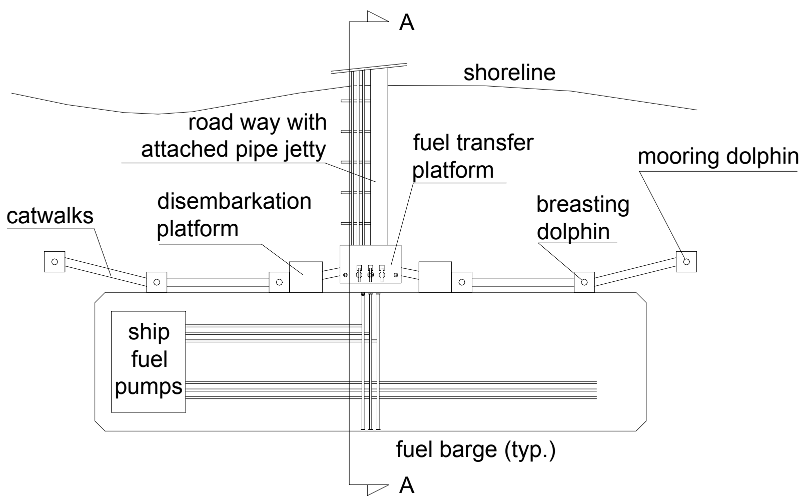
Fuel transfer activities are easier than regular cargo operations because fuel is easily transferred through transmission pipelines. Heavy equipment on the pier is typically not required to unload or load a fuel barge or tanker (though there is one exception where fuel is loaded into small storage tanks and transported on cargo barges to Kauai). Fuel vessels need to connect to transmission pipeline systems at only one point, usually amidships of the barge or tanker. They do not need a continuous pier face, as regular cargo handling requires.

Conversely, fuel transfer activities are more complicated than regular cargo, because fuel can be extremely flammable and harmful to the environment if released. Stringent regulations have to be adhered to and appropriate measures have to be installed in order to safeguard safe operations and the avoidance of environmental threat. In the post 9-11 world, transport of large quantities of explosive and environmentally harmful fuels pose a significant security threat.

For these reasons, we recommend dedicated fuel piers when considering the design of future fuel facilities. Fuel piers could be built differently from conventional cargo piers. As stated above, fuel transfer activities require only a point interface between fuel vessel and the pier to transfer products. In addition, where fuel is pumped from the fuel vessel to landside storage tanks, heavy equipment (e.g., fuel trucks) does not have to access the vessel. Consequently, the fuel pier could be configured such that it is detached from the shoreline or other pier area. This fuel pier configuration would be connected to shore-side only by a relatively small walkway (or roadway to support light maintenance trucks, where required). These walkways or roadways would be supported by piled structures, which also would support the fuel transfer pipelines on a pipeline jetty. A conceptual sketch of the recommended fuel pier, i.e., a detached protruding segmented structure, is depicted in Figure 4-6.

Another alternative includes configuring the fuel transfer pier as a structure that would have no rigid connection to the shore-side at all. Such a fuel transfer structure would be similar to an offshore fuel terminal currently being used offshore at the Kalaeloa Barbers Point Harbor to receive crude oil shipments to Hawaii. Such a fuel transfer structure would be configured either as single-leg or multiple-leg moorings. The fuel pipelines would be laid on the ocean bottom and exit at suitably reinforced shoreline crossings. This study does not consider offshore fuel transfer facilities because it is outside of Harbors Division's jurisdiction.

4.3.3 The Dedicated Fuel Pier System



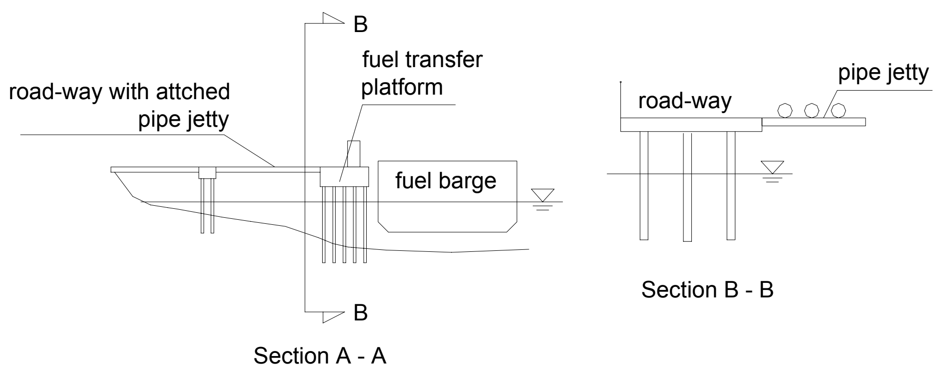


Figure 4-6: Typical Dedicated Protruding Segmented Fuel Pier System

Figure 4-6 depicts the recommended pier system. This system would have the following components:

1. Four breasting dolphins would form the breasting line for the vessel. Each breasting dolphin would contain mooring bollards to secure the vessel. The off-loading fuel transfer platform would be located on the larger pier structure in the center of the dolphin system. The platform would be inside the breasting line so the barge hull won't actually touch it for safety reasons. The fuel transfer platform would support the unloading equipment (e.g., loading arms), controls, pumps (if required) and all safety measures. Disembarkation platforms would be located between the fuel transfer platform and the innermost breasting dolphins on both sides of the fuel transfer platform. It would provide a safe access to the moored vessel. The breasting dolphins would be spaced in such a

way as to accommodate various sizes of ships or barges, according to the design envelope of the fuel pier. A pile-supported walkway or roadway would connect the fuel transfer platform to shore-side. The fuel transfer pipelines would connect the fuel transfer platform with the landside storage facilities. The fuel transmission pipelines would be supported by the walkway or roadway structure.

2. Two mooring dolphins would be located outside the design vessel envelope and inside the breasting line. These mooring dolphins would hold the forward and aft mooring lines that secure the fuel barge or tanker in place at the berth.

3. Catwalks would provide access between the breasting and mooring dolphins from the fuel transfer platform.

4. Section A-A in Figure 4-6 shows how the fuel platform would be connected to the shore. The roadway would extend a certain distance from shore-side to attain the design depth for the fuel pier. Where practical, the design depth would be attained either by using the natural bathymetry (e.g., locating the fuel pier far enough away from the shore to avoid dredging) or by optimizing the distance from shore (e.g., cost of required dredging versus cost of pilled structure, including the roadway). However, this practice would be limited by the location of the federal project line because, as a general policy, structures are prohibited to be located within the federal limits.

5. Section B-B in Figure 4-B shows a typical section of the shore-side connection. Piles would support the roadway, while the transfer pipelines would be supported by the roadway structure.

The protruding segmented fuel pier has the following advantages:

1. This type of pier system could be installed at locations that would otherwise not be suitable for regular cargo piers. In some cases, such locations would not have the required shore-side area or shore-side access.

2. The pier could be configured for optimal fuel transfer operations; this would include an optimal installation of all safety and security measures, without interfering with cargo operations.

3. The fuel equipment could be configured with flexibility in mind. For example, transmission pipelines could be installed above ground on pipeline ways that connect the fuel transfer platform with landside fuel infrastructure. Loading arms could be used without conflicting with cargo operations.

4. The protruding segmented fuel pier system would be inherently cost effective because:

    a. The distance of the fuel transfer platform to shore could be optimized so as to minimize the amount of dredging.

b. No large access roadways would be required that connect the pier with the harbor or other roadways. It might be advantageous to design the shore-side connection as a roadway that supports maintenance vehicles, but this is not necessary in most cases.

c. The structure would be a segmented piled structure, and therefore less expensive than the traditional bulkhead construction or continuous pier structure.

d. The construction would be typically faster than a conventional bulkhead pier structure.

5. The environmental impact would be less since the piled structure results in a significantly smaller ecological footprint than a continuous pier structure.

6. The wave climate along the segmented pier would be less compared to along the face of a regular pier. The amount of wave reflection would be less and more wave energy would be absorbed in the vicinity of the piled pier and adjacent shoreline, therefore making fuel transfer operation more secure.

The primary disadvantage of the protruding segmented pier design would be the fact that it is a dedicated fuel pier, thus normal cargo operations cannot be carried out, therefore limiting berthing capacity to fuel vessels only.

In order to avoid this disadvantage, protruding segmented fuel piers could be used as an initial stage of future pier developments. In such a case the piled fuel pier would be built in such a way to allow for future expansion. Figure 4-7 illustrates such a possibility.

For reasons such as a solution to limited financial resources for new pier construction and having the ability to increase harbor capacity later, it might be advantageous to first build the protruding segmented fuel pier as an initial phase. The breasting line of the protruding fuel pier would then be positioned to fit into the future harbor pier layout. The requirement of orienting the breasting line of the protruding fuel pier in accordance with future pier developments might cause additional dredging that could be avoided if only protruding piers were used.

During the initial phase, the dedicated protruding segmented fuel pier would have a shore-side connection in form of a roadway with a supported pipe-way for the transfer pipelines. In the final construction phase, the area between the dedicated protruding fuel pier and the shoreline would be filled in order to obtain a continuous pier surface. The transmission pipelines, which were installed aboveground on the protruding and dedicated fuel pier structure and the shore side connection would be installed below ground in the final pier configuration. Installing pipelines in a covered pipeline gallery instead of burying them below the concrete pier surface would render the fuel facility more flexible.

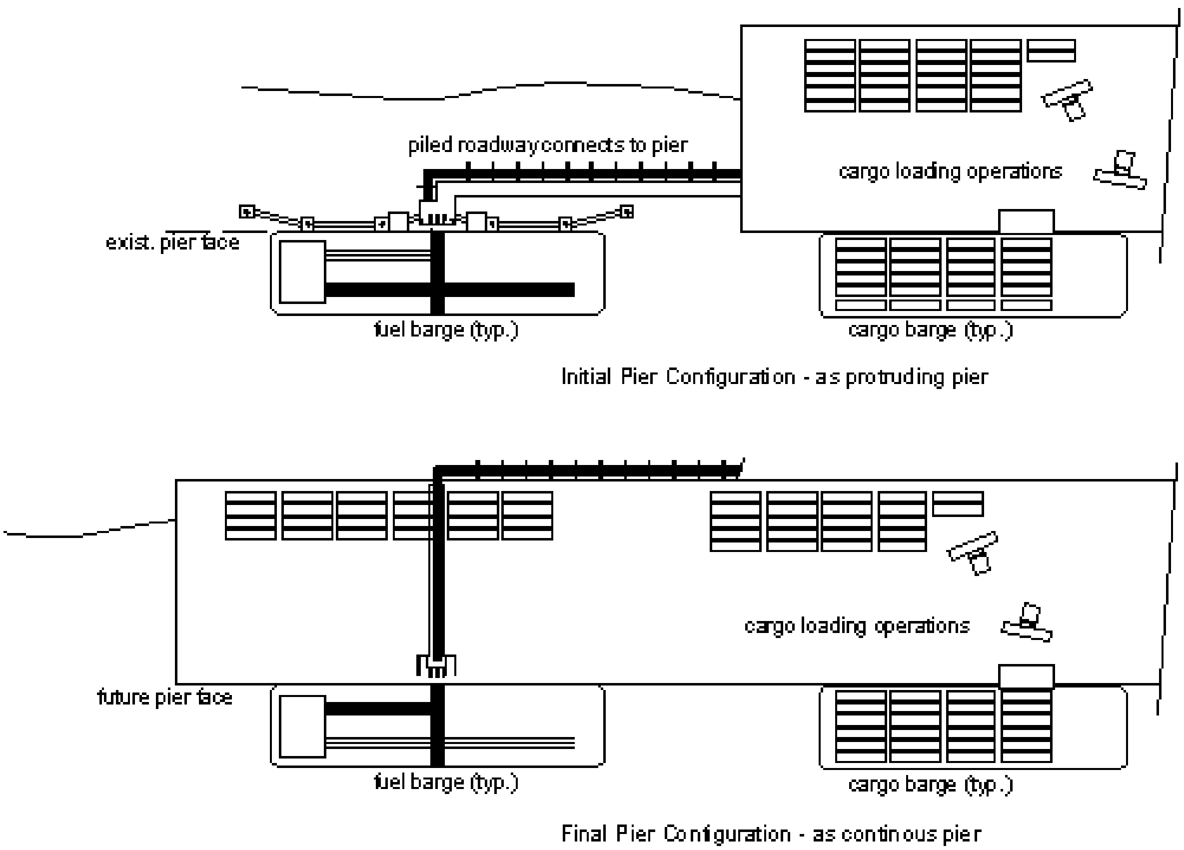


Figure 4-7: Interim and Final Construction Stages

4.4 Design Parameters for Barges and Tankers

Based on the different fuel system scenarios in Hawaii, it is highly likely that future fuel berths in the commercial harbors system will have to accommodate a wide range of fuel vessel types. This section describes the full range of potential fuel vessels that were considered in the design of the fuel facilities in the commercial harbors.

First, fuel barges are primarily used to provide inter-island transport of fuel products. Typically, these barges have varying capacities and are pulled by towboats to the various destinations. All oil carrying vessels that were constructed or have undergone major conversion since 1990 require double-hull structures. Table 4-4, below, lists the fuel barges used in Hawaii.

Table 4-4: Listing of Inter-island Fuel Barges Used in Hawaii

Overview of Interisland Petroleum Barges Used in Hawaii
source: Stillwater, 2003

Name	Products	Capacity
Holokai	Fuel oil	30,000
Hui Mana	Clean Products	40,000
Hukikai	Propane	10,000
Namoku	Clean Products	37,000
Noa	Diesel and fuel oil	70,000
No'eau	Clean Products	30,000
Nuuanu	Diesel and bunker fuel	30,000
Pepeekeo	Clean Products	53,000
Ponokai	Propane	15,600
Tara	Clean Products	4,000

Existing fuel transport facilities in the commercial harbors system determine what barge capacities and dimensions are used. Using larger capacity barges would reduce the frequency of required port calls for fueling operations in commercial harbors and would help to reduce congestion in the harbors. But using larger fuel barges immediately requires more berthing space and deeper drafts at fuel piers. In addition, larger cargo capacities of these barges require a corresponding increase in fuel storage capacities at the receiving port in order to take full advantage of reduced frequency of port calls.

Table 4-5 shows the result of a statistical analysis based on a web-survey of petroleum barge used in the United States (U.S.) (only double-hull barges are considered), which suggests a representative design envelope of overall dimensions. There are no standard dimensions for barges of comparable transport capacities. The individual dimensions of the barges vary with the specific requirements of the particular transport needs and conditions in the commercial harbors served. As an example, the width of a barge might be restricted to fit with dry-dock capacities or the draft of the barge might be limited by conditions in commercial harbors served by the barges. The dimensions in Table 4-5 represent a design dimension envelope for fuel barges considered for future fuel facilities in commercial harbors.

Table 4-5: Correlation of Fuel Barge Dimensions and its Carrying Capacities

Range - approx. capacity of fuel barge in barrels	length feet	width feet	draft feet
30,000	300	62	20
40,000	325	64	20
60,000	350	70	25
80,000	400	74	28
110,000	420	78	34

It should be noted that the fuel barges used in Hawaii represent an old transport technology. The petroleum transport industry, by and large, considers the use of articulated tug barges (ATB) as a more effective replacement of the old tug-towed barges. ATBs, with advanced tug-to-barge swivel connections, permit operation in a wide range of sea conditions and have the following advantages over tug-towed barges:

1. Increases speeds of between 35 and 40 percent over towed units.

2. Fuel savings enhanced by wheel and rudder efficiencies.

3. Eliminates expense and hazards of tow cables.

4. Comfortable ride resulting in reduced crew fatigue.

5. Better maneuverability than tug-towed systems at sea and in port.

6. Safer vessel operation over towed units.

The trend in the maritime industry towards larger barges takes advantage of economies of scale. ATBs generally require a longer pier length than tug-towed barges of the same capacity, due to the fact that the tug of an ATB is situated in a notch at the stern of the barge unit.

Second, other fuel vessels that would use the fuel facilities in the commercial harbor system would typically be smaller than the large tankers that bring crude oil to Hawaii. Crude oil tankers are off-loaded at existing offshore moorings south of Kalaeloa Barbers Point Harbor on Oahu.

The types of tankers that would use facilities in the commercial harbors comprise the following types of vessels:

1. The Handysize Tanker is a small liquid-bulk cargo tanker vessel. These vessels have a capacity between10,000 and 30,000 dead-weight tons (dwt). These vessels are more maneuverable and have shallower drafts than the larger vessels described below and therefore make up the majority of the world's ocean-going liquid-bulk cargo fleet.

2. The Handymax Tanker is a small liquid-bulk cargo vessel with a capacity between 30,001 and 50,000 dwt. This is a larger version of the aforementioned Handysize Tankers.

3. The Panamax Tanker is an ocean-going liquid-bulk cargo vessel of the maximum size possible to pass through the locks of the Panama Canal. Their design envelope is limited by a length of 1000-foot long, a width of 110-foot and a draft of 45-foot deep draft. These vessels typically have a cargo capacity between 45,000 and 80,000 dwt.

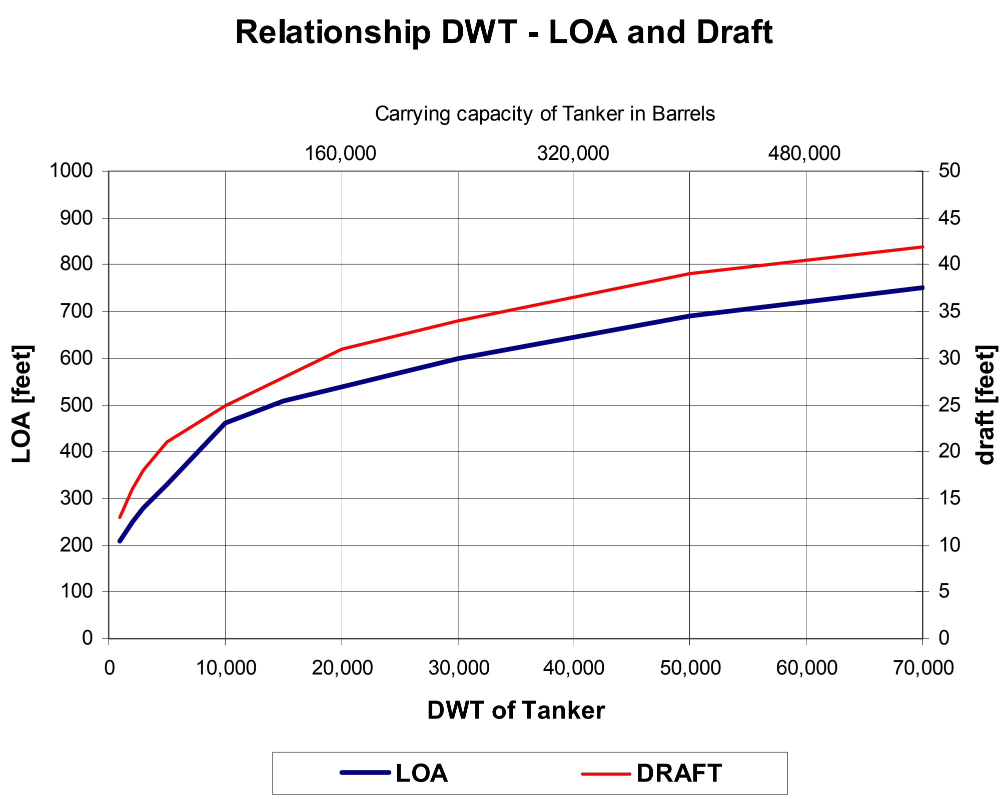


Figure 4-8: Correlation of Tankers and its Carrying Capacities

For the conceptual designs development, the following design vessels will be used:

1. Small fuel barge: capacity between 10,000 and 20,000 barrels, dimensions of 250-foot long by 60-foot wide and 14-foot deep draft.

2. Medium fuel barge: capacity between 30,000 and 40,000 barrels, dimensions of 325-foot long by 64-foot wide and 20-foot deep draft.

3. Large fuel barge: capacity up to 80,000 barrels, dimensions of 400-foot long by 74-foot wide and 28-foot deep draft.

4. Handysize Tanker: capacity up to 240,000 barrels, dimensions of 600-foot longby 90-foot wide and 33-foot deep draft.

5. Handmax Tanker or small Panamax Tanker: capacity of up to 400,000 barrels, dimensions of 700-foot long by 100-foot wide and 38-foot deep draft

6. Articulated tug barge: capacity between 80,000 and 100,000 barrels. The overall length would be longer than a comparable towed tug-barge unit. The design length of about 550 feet would bring it into the range of the Handysize Tanker.

4.5 Pipeline Installation Methodologies

All transmission pipelines within the commercial harbors system are owned and operated by the fuel companies. Installation and operation of transmission pipelines and related infrastructure represents a significant cost component and liability issue. The current policy requires the fuel companies provide their own infrastructure to transfer liquid-bulk cargos from the fuel vessels to their respective landside storage facilities.

Pipelines within the commercial harbors are either buried underground or suspended below the pier structure. The typical installation method of underground pipelines in the pier or harbor area is illustrated in Figures 4-9.

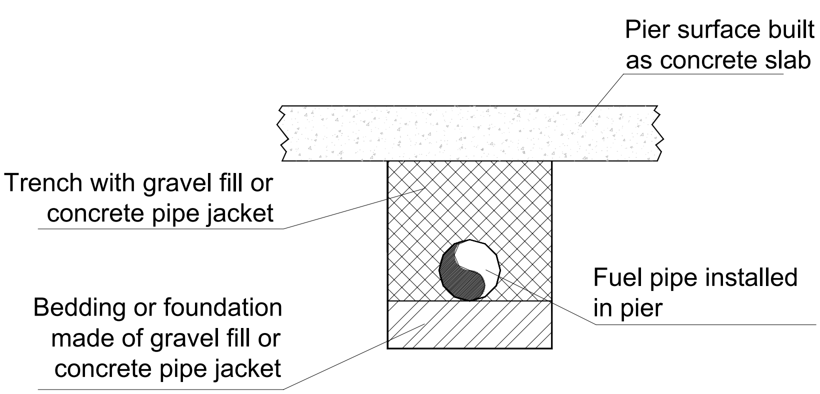


Figure 4-9: Typical Underground Pipeline Installation

Figure 4-9 illustrates the typical pipeline installed in an open trench on a suitable foundation and bedding. The pipeline is then surrounded with suitable gravel backfill. If heavy loads have to be accommodated on the above working surface or at places where there might be differential settling, pipelines are encased in a reinforced concrete pipeline jacket. Trenching pipelines provides a well-protected operational environment. Modification or repair of the pipeline, however, is expensive as the pipeline has to be excavated and the pier section has to be closed during construction. The pipeline has to be equipped with suitable corrosion control measures. Inspection of the pipeline can be carried out with an intelligent pig, if the pipeline is piggable.

In case there are several transmission pipelines running parallel to each other, the pipelines may be combined and installed in one trench or in separate trenches. Several individual parallel trenches require a substantial width for the pipe corridor. The main disadvantage of the buried pipelines is the inability to easily add new pipelines. In short, buried pipeline installations lack flexibility and the means to easily detect and fix leaks.

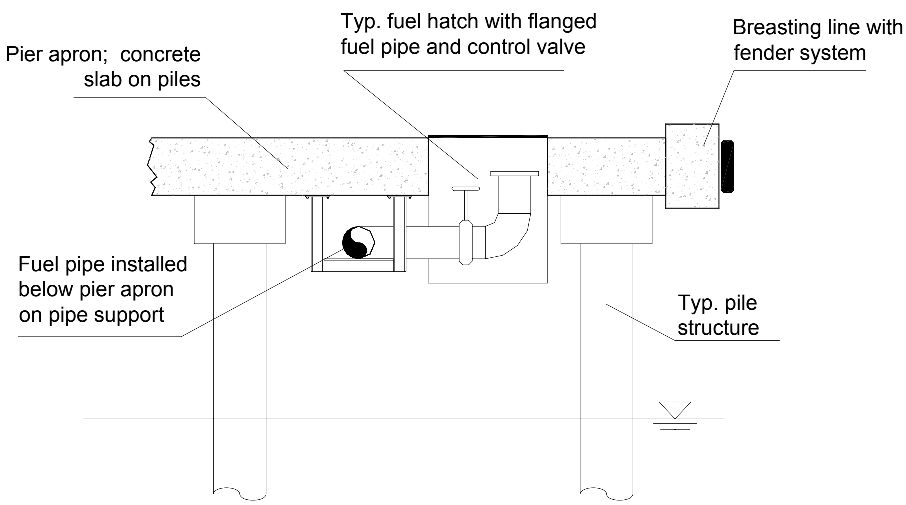


Figure 4-10: Typical Under-Pier Pipeline Installation

Figure 4-10 illustrates a typical fuel pipeline installation under a piled pier structure. The figure shows a section close to the breasting line of the fuel pier. A fuel hatch is installed in the pier structure. It contains the flanged pipeline terminal of the fuel transfer pipeline that connects to the flexible fuel transfer hose and a typical shut-off valve. Downstream of the fuel hatch, the fuel transfer pipes rest on pipe supports that are attached to the underside of the concrete slab of the pier. This methodology allows for periodic external inspection of the pipelines. In case of leaks, there is no containment system to avoid fuel spills into the water below. Pipelines can be modified and new pipelines can be added, subject to available space underneath the piled structure.

Figures 4-9 and 4-10 present the typical pipeline installation methodology that is presently used in commercial harbors. With these conventional methods, the pipelines are laid for a long-term operation, rendering the fuel facilities as a static installation.

A more flexible approach to the installation and operation of fuel pipelines are pipeline racks and pipeline galleries, as illustrated in Figures 4-11 and 4-12, respectively. Pipeline racks and galleries can be frequently found in chemical and petrochemical plants, where the comparatively short operational life of process equipment and the need for frequent inspection make accessibility to the pipelines an important design feature. As proven in the closely regulated chemical and petrochemical industries, pipeline racks and galleries are a safe way to accommodate multiple pipeline runs and retain flexibility in the operation and maintenance of pipeline systems.

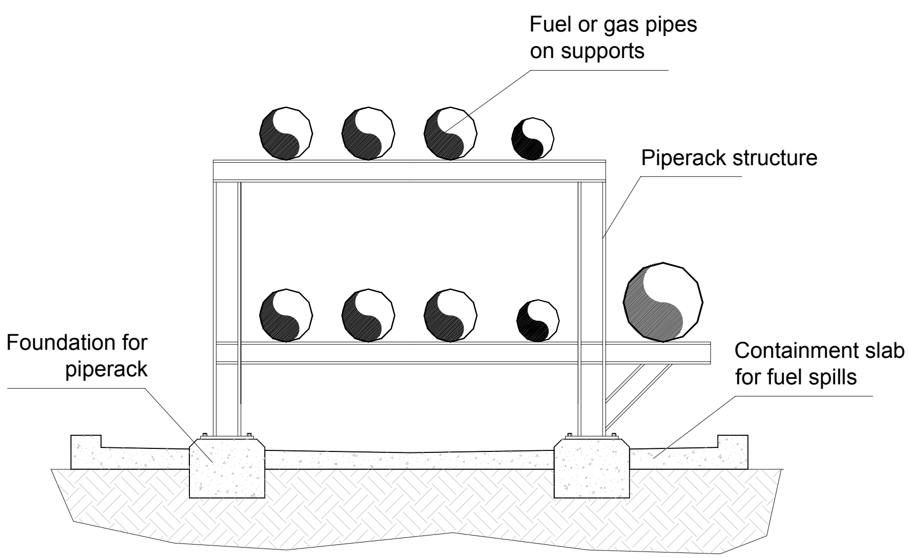


Figure 4-11: Typical Pipeline Rack Installation

Figure 4-11 shows a typical pipeline rack system containing multiple pipelines. The pipeline rack shown in Figure 4-11 is a steel frame with two levels of support for pipelines. Adding support brackets to the side of the vertical structural members can increase the capacity of the pipeline rack. The figure shows a thin concrete slab below the pipes that can contain any minor leaks of the pipelines. Larger pipeline racks might have a walkway in the middle of the structure to facilitate inspection.

Since the pipelines are accessible along the rack, more stringent security measures have to be in place to avoid unauthorized access to this area. Typically, pipeline racks are inside a secure area. In order to protect the pipeline racks from accidental impact of trucks or cargo-handling equipment, safety bollards should be placed between moving traffic and pipeline racks.

There are numerous advantages to the pipeline rack system. They are cost-effective installations, provide good accessibility for inspection and maintenance, and it is relatively easy to increase capacity by adding pipelines.

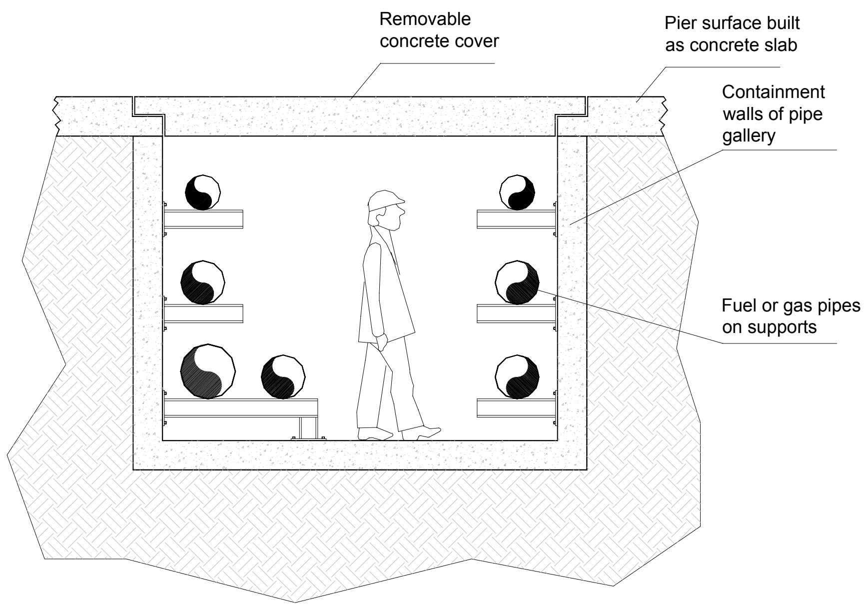


Figure 4-12: Typical Pipeline Gallery Installation

Figure 4-12 shows a typical installation in a pipeline gallery. This design has the advantage of allowing use of the space above the gallery. The pipeline galleries, however, offer flexibility in terms of adding new pipelines and providing ready access for inspections and maintenance services.

The pipeline gallery can provide multiple pipelines in multiple layers. A central walkway ensures access for inspection and maintenance. Removable covers allow easy access for construction purposes. Such covers typically do not span the entire length of the pipeline gallery but are limited to a number of access points. The pipeline gallery has to have sufficient headroom and must have enough access manholes. Since the transmission pipelines contain hazardous products, the space in the pipeline gallery has to be monitored for fuel and vapor leaks. A design challenge of pipeline galleries might include the presence of groundwater.

Summarizing, the current preferred methods of transferring petroleum products in commercial harbors are buried pipelines and pipelines installed under piled pier structures. Pipeline installations in commercial harbors usually have long operating lives and are not frequently accessed for modifications or inspections. Such pipeline installations furthermore offer limited flexibility and are typically costly to install and maintain. An alternative and more flexible approach to install fuel pipelines in commercial harbors can be accomplished with pipeline racks and galleries. Pipeline rack installations represent cost-effective measures to construct and operate pipelines where flexibility is required. Since future fuel facilities in the commercial harbors will have to be more flexible in terms of operation and adding new pipeline capacities (i.e., to handle new fuel types that require specific fuel facilities) by using pipeline racks and galleries offer attractive alternatives that will be used in the conceptual designs of this study, wherever possible.

Thermal expansion of pipelines:

Thermal expansion of certain product pipelines has to be accommodated in the design. Certain fuels are conveyed through fuel transmission pipelines at elevated temperatures, such as fuel oil and biofuel feedstock (e.g., vegetable oil). In these cases, the pipelines must have structural means to expand and contract without causing excessive stress.

Pipelines can be designed to accommodate thermal expansion through an appropriate alignment (e.g., expansion legs or “U-bends”). When the pipeline alignment is restricted and there is not enough space for expansion legs and “U-bends,” mechanical expansion joints are required. The mechanical expansion joints are typically located in manholes or vaults so that they can be accessed for maintenance. Structural supports for the pipelines have to be configured to allow free movement of the pipelines in the principal dimensions of the expansion and contraction; otherwise stresses are introduced into the pipelines.

Product batching and pipeline pigs:

Using dedicated pipelines to transport one specific product represents the best operating procedure, since certain fuel products are not compatible. If fuel products are compatible, however, they can be conveyed through the same pipeline. The operational mode of transporting multiple fuel products transport through one pipeline is called “batching,” which means that a series of products can follow one another through the pipeline in a "batch train".

The batch train can be separated either through a batching or separation “pig” or the fuel products follow each other without a physical separation. A piggable pipeline system results in minimal product losses. The pipeline system for several products might be composed of a single piggable pipeline thereby replacing numerous dedicated pipelines with little or no impact on production scheduling or product quality. The common practice of flushing pipelines to clean them prior to a subsequent product transfer can be eliminated, along with the resulting accumulation of line flush and/or cross-contaminated product. In metering and loading systems, the use of piggable transfer lines can allow the meter to be remote-mounted from the receiving vessel. In such systems, the product is metered directly into the line and the pig is used to clear the line forward to the receiving vessel. This type of system can significantly reduce overall pipeline costs and enhance operations. Figure 4-13 shows a typical batching pipe.

Pigs are also used to inspect pipelines (called “smart pigs”), for pipe cleaning (pigs with brushes) and for dewatering pipes. A piggable pipeline requires suitable pipe components, such large diameters elbows (e.g., 3D-bends), suitable valves to pass the pig (e.g., fully open ball valves) and pig launching and retrieval stations.

Figure 4-13: Typical Batching Pig

For future fuel facilities in the commercial harbors, piggable pipelines add operational benefits and they avoid costly multiple product lines in cases where the length of the fuel transfer pipelines is considerable. The operation of pigs, however, adds to the complexity of operation. In cases where storage tank farms can only be located at a considerable distance from the harbor, fuel conveyance in piggable pipeline systems might be the preferred method.

4.6 Key Design Guidelines

The objective is to develop and operate fuel facilities in the commercial harbors, which are efficient, secure and environmentally safe. Recommended design features include:

1. Vessel loading systems with mechanically actuated loading arms, sufficiently large diameter pipelines and reliable transfer and control systems, allowing fuel vessels to discharge or load liquid-bulk cargos safely and efficiently, thereby minimizing both vessel emissions and vessel time at berth.

2. Deployment and easily accessible supplies of emergency oil spill equipment (absorbents, protective clothing, etc.).

3. Electric-powered shore-side pumps, designed to reduce tanker energy requirements to offload cargos. This would result in reduced fuel usage by the tankers while docking, thus reducing emissions. Bunker fuel is a significant source of emissions.

4. Alternative Marine Power (AMP) (i.e., cold ironing), allowing properly equipped tankers to use on-shore power and minimize emissions.

5. Control and monitoring systems, designed to graphically display the current status of all equipment to the facility operators, alert the operators to potential problems and take corrective actions should abnormal situations arise.

6. Catholic protection (CP) and pipeline coating systems designed to protect all below grade steel piping against corrosion.

7. Integrity assessment systems designed to allow utilization of all available internal inspection tools (also known as Smart Pigs).

8. Leak detection system, utilizing Computational Pipeline Monitoring (CPM) should be installed for all major pipelines systems. The system would automatically alert the operator when a potential leak is identified, so that appropriate actions can be taken to minimize the spill volume and duration.

9. Fire suppression systems, designed to supply foam and/or water (including cooling water) to critical equipment on the dock structure and off-loading systems.

10. Spill protection equipment, including oil spill booms (deployed during tanker offloading operations or permanently installed pneumatic spill containment) and utility boats for boom deployment.

11. Vapor control system, for fuel facilities that load critical fuel containing Volatile Organic Compounds (VOC) or Hazardous Air Pollutant (HAP), such as gasoline.

12. Security installations for marine berth and ancillary facilities to prevent unauthorized access.

4.7 Fire Suppression System

A primary danger while handling petroleum is the chance of a fire or explosion. An indication of how likely a fuel type is susceptible to fire or explosion is its flash point. Flash point is basically the lowest temperature at which there is enough fuel vapor to ignite. The lower a fuel's flash point, the more prone the fuel is to ignition. The following lists some examples of flash points of various fuels:

Gasoline	-40 °F
Ethanol	55 °F
Jet fuel	>100 °F
Diesel (No.2)	>130 °F
Residual fuel	>150 °F

The low flash points of gasoline and ethanol indicate their susceptibility to form ignitable vapors at normal operating temperatures.

The fire suppression system considered for the fuel facilities contain the following components:

1. Fire alarms and sirens located on the facility.

2. Main fire water system with hydrants.

3. Foam firefighting capability including a central foam tank and remotely operated foam monitors and a reliable source of water (e.g., by means of a diesel driven fire pump).

4. Cooling water systems to reduce the effects of heat.

5. Large, dry chemical wheeled extinguishers.

6. Specialized training like fire drills and exercises.

Because of the nature of oil fires, the foam system is the most important component of the fire suppression system. There are different types of foams for different furl types. Foam agents suppress fire by separating the fuel from the air (oxygen). Depending upon the type of foam agent used, this is accomplished in several ways:

1. Foam blankets the fuel surface, smothering the fire and separating the flames from the surface.

2. The water content in the foam cools the fuel.

3. The foam blanket suppresses the release of flammable vapors that can mix with air.

The basic elements of the foam fire suppression system are the foam proportioning system that mixes the foam agent with water, the high-pressure pumps that pump the foam-water mixture to foam monitors and the monitors that discharge the foam onto the fire. The foam monitors are remotely or manually operated devices that deliver the foam to vital parts of the fuel facility that are the fuel transfer installations on the fuel pier, the parts of the fuel tankers and barges that house fuel transfer pipes and the entire fuel transfer platform. Most foams can use seawater, a fact that alleviates the water supply infrastructure in the commercial harbors. It is recommended that grid-independent diesel-powered pumps be used to provide the required seawater flow to the foam system.

4.8 Vapor Control System

Vapor control systems are required to lower emissions of fuel with low flash points and to safeguard against explosions of fuel vessels while loading certain fuel products. The two main control and safety issues for vapor control systems are:

1. The emission related function of the vapor control system is mandated by the EPA and State regulations (e.g., CFR 40 Parts 61 and 63) to significantly reduce volatile and hazardous vapors that are created during loading of a fuel barge or tanker.

2. The safety regulations ensure that the required emission control devices are designed and operated in a manner that protects operating personnel, the marine vessel, and terminal. The safety related functions are regulated by CFR 33 Part 154.

Vapor control systems are only considered for the Kalaeloa Barbers Point Harbor and Honolulu Harbor, because these are the only harbors where applicable fuel products (e.g., gasoline) are loaded onto fuel barges and tankers. In all other commercial harbors, petroleum products are only off-loaded.

Without performing a detailed analysis of how much weight per year (e.g., in tons per year) of HAP and VOC is released during fueling operations, it is assumed that vapor control system will be required at Kalaeloa Barbers Point Harbor and Honolulu Harbor.

The recommended vapor control system is comprised of the following system components:

1. Regarding the vapor control dock safety equipment, a large portion of the system components of the vapor control system is located at the dock where fuel is loaded onto fuel vessels. Such components include fire and explosion protection, vapor conditioning and vessel over/under pressure protection. Vapor that is displaced from the fuel barge or tanker during loading, is captured and conveyed to the land based vapor control equipment. Typically, a loading arm with the appropriate diameter performs the sensitive ship-to-shore interface for the displaced vapor.

2. Regarding the vapor moving system, the vapors that are displaced from the fuel barges and tankers are conveyed to the vapor blower unit. The vapor blower supplies the required pressure to deliver the vapors from the dock to the vapor emission control system. Typically, the vapor blower unit includes a spark-resistant blower and a detonation arrestor.

3. Regarding the marine vapor emission control system, there are two types of vapor emission control systems:

    a. Vapor combustion systems dispose of the dangerous vapor by burning it under controlled and safe operating conditions.

    b. Vapor recovery systems convert the vapor to liquid form and recycle it, rather than disposal. The preferred process is based on the combination of carbon adsorption and liquid absorption processes. Recovery efficiencies for these systems typically exceed 99 percent. Vapor recovery is the more complicated and costly process but has the advantage that virtually no emissions are released and the liquid can be captured and reused.

    A vapor combustion system is recommended for the fuel facilities in Kalaeloa Barbers Point Harbor and Honolulu Harbor.

4. Integrated Control System: The integrated control system safeguards an effective operation of the overall vapor control system.

5. In addition, there are the following facility and vessel requirements:

   a. Cargo gauging system.
   b. Fuel vessel liquids overfill protection.
   c. Vapor overpressure and vacuum protection.
   d. Lightering and topping-off operations with vapor balancing.
   e. Fire, explosion and detonation protection.
   f. Requirements for inert gas purging, enriching and diluting systems.
   g. All associated personnel training.

4.9 Fuel Transfer between Pier and Barge or Tanker

The fuel transfer between the moving fuel vessels and the rigid fuel pier is a crucial transfer interface. This fuel interface is vulnerable to damages originating from excessive ship movements, operational mistakes and device defects. While not a consideration for the Harbors Division, this section will look at the different technologies available. Fuel transfer devices are regulated in 33 CFR Part 154 and there are two types in use today:

1. Flexible fuel transfer hoses.
2. Marine loading arms.

First, flexible fuel transfer hoses have been used for many years. Fuel transfer in Hawaii's commercial harbors is carried out exclusively with flexible hoses. Hose assemblies are cheaper than the more elaborate loading arms, though maintenance of flexible hoses is more costly then for loading arms. Flexible hoses also carry a more pronounced risk for failure and spilling of oil products. Flexible hoses have the advantage of requiring no permanent above ground fixture on the loading piers. The fuel hoses typically are flanged to the fuel transfer terminals that are housed in fuel hatches within the piers.

Second, marine loading arms have significant advantages in regard to spill prevention and operational safety. Loading arms are mechanical devices, consisting of rigid pipes with swivel joints, which enable the transfer of fluids and gases from ship to shore in a safe manner. Loading arms are typically installed on dedicated fuel piers, since, differently from flexible hoses, they are permanent above-ground installations. If loading arms are installed on mixed cargo piers (e.g., containerized cargo and fuel) the loading arms have to be protected against accidental impact by cargo handling equipment.

Loading arms are counterbalanced pipe assemblies with pipe diameter ranging between 4 and 24 inches. Loading arm systems can handle all types of gaseous and liquid fuels. They are typically equipped with fail-safe breakaway pipeline joints, quick connections and remote controls. Loading arms can follow even significant ship movements at the pier while still providing safe and effective fuel transfer operation. In comparison with flexible hoses loading arms have low maintenance cost and minimal downtime.

Figure 4-14: Marine Loading Arm (photo credit FMC Technologies)

We recommend that advanced and safe fuel transfer installations have the following components:

1. Emergency shutdown: The fuel transfer facility would have an emergency means to stop the flow of oil or hazardous material from the facility to the vessel. For oil products the flow must be stopped within 30 seconds of the detection of the failure of the hose, loading arms or manifold valves.

2. Lighting: For fuel transfer operation between sundown and sunrise the fuel facility would have fixed lighting that adequately illuminates:

    a. Each transfer connection point on the facility.

    b. Each transfer connection point in use on any barge moored at the facility to or from which oil or hazardous material is being transferred.

    c. Each transfer operations work area on the facility.

    d. Each transfer operation work area on any barge moored at the facility.

3. Discharge containment equipment: The facility would have ready access to enough containment material and equipment to contain any oil or hazardous material discharged on the water from operations at that facility.

4. Communication: The fuel facility would have a means that enables continuous two-way voice communication between the person in charge of the vessel transfer operation and the person in charge of the facility transfer operation.

4.10 Oil Spill Protection

An oil spill is an unintentional or accidental release of petroleum products into the water. Petroleum-based hydrocarbons can severely impact marine life at even the lowest level of contamination. Different fractions of petroleum products have different effects and require varying ways to treat and clean an unintentional spill. Lighter fractions of oil such as benzene and toluene, are highly toxic, but are also volatile and evaporate quickly. Crude and other heavy fractions of oil cause the most environmental damage. While they are less toxic than the lighter volatiles, they persist in the environment much longer.

The U.S. Environmental Protection Agency (EPA) has issued several rules that prescribe oil Spill Prevention Control and Countermeasures (SPCC) plans, such as those promulgated in CFR 40 Part 112. Because crude oil or petroleum products spills can cause significant damages, stringent regulations are in place to regulate the avoidance and provide mitigation measures to control it. The best measures against oil spills are preventive measures, such as using double-hull barges and tankers and careful design and operation of fuel transfer facilities. But even with the best designs and technologies, spills cannot be completely avoided.

The biggest risk factors of fuel spills in the commercial harbors are collisions and accidents of fuel vessels and equipment failure during fuel transfer operations. Careful control of vessel movement in the commercial harbors, standby tugs that can assist in cases of primary mover failure and simply good and sound operational procedures are the best methods to avoid collisions of fuel vessels and resulting spills.

Fuel transfers at the piers have to stop whenever considerable wave action at the pier causes large movements of the fuel vessels. Loading arms with breakaway couplings can accommodate larger movement of the fuel barges or tankers than flexible fuel hoses can. Breakaway couplings at the loading arms reduce the risk of significant spills.

When an oil spill has occurred, countermeasures have to be available to contain, clean up, and mitigate the effects of an oil spill.

The containment of the oil spill through a containment boom is the first measure that has to be taken. Since all fuel transfer piers have different configurations, containment booms have to be configured to fit to the geometry of the pier and the prevailing current and wind directions. There are two main types of containment booms. The most popular method of containment is the traditional boom, a floating apparatus consisting of a "skirt" to contain oil. Another method increasing in popularity is the pneumatic barrier, which forces air through a pipe located beneath the surface of the water to cause a surface current entraining the oil. Each is described below.

First, a traditional floating containment boom consists of four primary elements:

1. A method of flotation to keep the boom afloat.
2. The skirt is the part of the boom that lies beneath the surface and contains most of the oil.
3. The freeboard is attached to the top of the boom and prevents waves from carrying oil over the top.
4. A tension member must be incorporated into the entire length of the boom to carry the load caused by wind, waves, and current.

The deployment of the boom around a fuel barge during transshipment is a lengthy, costly, and potentially dangerous endeavor. When the barge is moored, one or two people in a small boat must physically place the boom around the vessel and anchor it properly. These same people must remain on call for the eight to ten hours next to the barge during fuel transfer. When the barge is ready to leave, they must retrieve the boom.

Second, the pneumatic barrier is a containment method that offers significant advantages over the traditional boom during fuel transfer operations. The pneumatic barrier has the advantage that it can be a fixed installation that requires no human deployment. Thus a pneumatic barrier can be operated as a standard procedure when loading or unloading fuel barges and tankers.

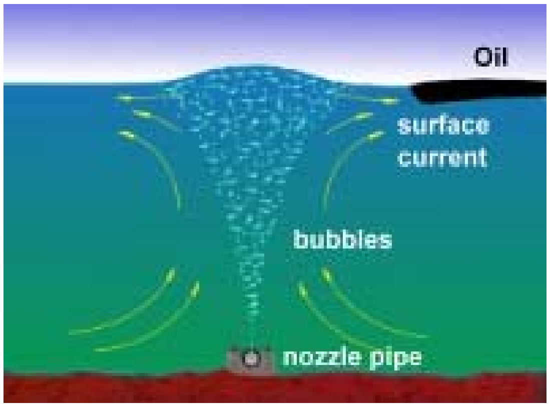


Figure 4-15: Pneumatic Barrier

Figure 4-15 illustrates the basic functional scheme of a pneumatic barrier. Pneumatic barriers prevent spilled oil from spreading on the water surface. The pneumatic barrier produces a current with sufficient velocity to stop the oil from spreading. The current is produced by air flowing through a perforated manifold, which is installed on the ocean bottom. The air is supplied from a compressor that is located ashore. Pneumatic barriers are suitable for waters with minimal currents and waves.

Although the water current and wave climate at the prospective fuel piers in the commercial harbors are not known at this point, a pneumatic barrier is deemed to be an appropriate measure to control fuel spills. The pressurized air pipes would be installed permanently on the harbor bottom.

Conventional oil spill booms are readily available in all commercial harbors to prevent the spread of spilled fuel. The first measure is the containment of the spilled fuel by the barrier. After the spill is contained, fuel recovery measures would remove the spilled fuel by means of mechanical or chemical procedures (e.g., marine clean-up chemical) and deposit it safely.

The layout of the fuel piers have to allow the deployment of oil containment booms. This means that the oil containment booms have to create a continuous screen around the point source of the spill, which is primarily the fuel transfer equipment on the fuel piers or the entire fuel barge.

4.11 Description of Pertinent Fuels

The types of petroleum fuel that are consumed in Hawaii are described in Table 4-6 below (natural gas is also included because Hawaii uses synthetic natural gas produced from petroleum and since natural gas is an important fuel in one of the design schemes considered). Besides petroleum products biofuels are slated to become significant contributors to Hawaii's energy supply in the coming years. In order to emphasize the evolving importance of biofuels, the subsequent sections describe in more detail the main biofuels considered for Hawaii's energy supply.

Table 4-6: Description of Primary Petroleum Fuel Products

Fuel type	Description
Aviation gasoline	Aviation Gasoline is a fuel for a piston-engine powered aircraft (usually a gasoline known as Avgas). It contains an octane number suited to the engine, a freezing point of minus 60 degrees Centigrade (C), and a distillation range usually within the limits of 30 degrees C and 180 degrees C.
Jet fuel	Jet fuel has different quality designations, depending on commercial or military applications. Military jet fuel is typically designated JP-8 (for Jet Propellant). JP-8 has replaced JP-4, in order to use less flammable, less hazardous fuel for better safety (U.S. Navy uses JP-5, which has even higher flash point than JP-8, but it also has a higher cost, limiting its use to aircraft carriers). Commercial jet fuel in the U.S. is typically designated Jet-A (Besides Jet-A, Jet-B is used in areas where its better cold-weather characteristics are absolutely necessary. Jet B's lighter composition makes it more dangerous to handle). Jet-A might have additives to improve lubrication, gumming and corrosion fuel characteristics as well as increase dissipation of static. Jet fuel has similar fuel characteristics to diesel fuel. New aircraft developments use jet fuel for aviation piston engines. A development of jet fuel investigates the use of jet fuel blends containing a substantial percentage of biofuel.
Motor gasoline	Motor gasoline (also known as MoGas) is a light hydrocarbon fuel for use in internal combustion engines, excluding those in aircraft. Motor gasoline is a complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline includes conventional gasoline, all types of oxygenated gasoline, including gasohol, and reformulated gasoline, but excludes aviation gasoline. Volumetric data on blending components, such as oxygenates, are not counted in data on finished motor gasoline until the blending components are blended into the gasoline (e.g., E10, E85).

Fuel type	Description
Diesel fuel (or distillate)	Diesel fuel is a blend of petroleum products that is used in diesel engines. Diesel is designated as fuel oil No. 1 through No. 3. Often fuel oil No.4 is also referred to as diesel. Diesel fuel oil No. 2 is the most widely used diesel fuel and is used on-highway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Since it is used in most diesel engines (e.g., trucks and cars), Diesel No. 2 is referred to as "road diesel". Fuel oil No. 4 is typically used for electricity generation or as a bunker fuel. New emissions standards in the U.S. have introduced ultra-low sulfur diesel (ULSD) in order to curb emmisions from diesel engines. By federal law the transition to low sulfur diesel will have to be accomplished as follows: by 12/01/2010, all highway diesel will be ULSD; Non-road diesel transitioned to 500 parts-per-million (ppm) sulfur in 2007 and to ULSD in 2010; Locomotive and marine diesels must transition to 500 ppm sulfur in 2007 and to ULSD in 2012. There are exemptions for small refiners of nonroad, locomotive and marine diesel that allow for 500 ppm diesel to remain in the system until 2014. After December 1, 2014, all highway, nonroad, locomotive and marine diesel produced and imported will be ULSD.
Fuel oil	Fuel oil is classified into six classes, according to its application and chemical properties, such as boiling temperature and composition. Fuel oil No.1, No.2 and No 3 (rarely used) are referred to as “distillate” or “diesel fuel oil.” No. 5 and No. 6 are referred to as residual fuel oils (RFO) or heavy fuel oils. No.4 is typically a blend of distillate and residual fuel, No. 2 and No.6, respectively. Sometimes No. 4 is also referred to as “diesel”.
Residual oil	Residual oil is typically referred to as Fuel oil No. 5 and No. 6, while often “residual oil” is referreed to as No. 6 since far more No. 6 is produced than No. 5. Residual fuel oil is typically used in power plants and large ships. Residual fuel oil is so viscous that it has to be heated with a special heating system before use and it contains relatively high amounts of pollutants, particularly sulfur, which forms sulfur dioxide upon combustion.
Bunker fuel	Bunker fuel designates the use of fuel oil on ships. There is a range of bunker fuels, which typically are designated as “light” (basically equivalent to Fuel Oil No. 2), “medium” (a mixture of distillate and residual oil, basically equivalent to Fuel Oil No. 4) and “heavy” (pure or nearly pure residual oil, roughly equivalent to No. 6 fuel oil).
Naphtha	Naphtha is a generic term applied to a petroleum fraction with an approximate boiling range between 122º and 400º Fahrenheit (F). Naphtha is used primarily as feedstock in the chemical and petrochemical industry (i.e. for producing a high octane gasoline component via the catalytic reforming process). In Hawaii, Naphtha is also used in power generation.
Liquefied petroleum gas	LPG is a mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles. LPG is a product of crude oil refining or is extracted from natural gas streams as it emerges from the ground. LPG includes gas mixes that are primarily propane, mixes that are primarily butane, and the more common, mixes including both propane (60 percent) and butane (40 percent). At normal temperatures and pressures, LPG evaporates. Because

Fuel type	Description
	of this, LPG has to be stored and transported in either cold or pressurized containers. LPG becomes liquid (equivalent to vapor pressure) at a pressure that relates to its main components; for example, at 68 °F pure butane has a vapor pressure of 32 pound per square inch absolute (psia), pure propane has a vapor pressure of 320 psia. LPG is heavier than air, and thus will flow along floors and tend to settle in low spots, such as basements. In Hawaii LPG is used in residential and commercial heating applications. Recently LPG has become a preferred fuel for distributed power applications.
Natural gas	NG is a gaseous fossil fuel consisting primarily of methane and other heavy hydrocarbons (such as ethane, propane, butane, and pentane) which are later removed as "condensates" (or Natural Gas Liquids [NGL]. Before natural gas can be used as a fuel in heating applications (including electricity generation) and vehicles, materials other than methane have to be removed. If used in Hawaii, natural gas has to be imported as liquefied natural gas (LNG) in a super cooled state or as compressed natural gas (CNG).

4.12 Biofuels

While handling of petroleum products is well established and understood, handling large volumes of biofuels present considerable new challenges to the fuel industry. This section describes the special requirements of ethanol and biodiesel, which are the main biofuels considered for Hawaii.

4.12.1 Ethanol Fuel

The handling of large amounts of ethanol at fuel transfer facilities in the commercial harbors adds a broad range of new technical, environmental and safety challenges. The use of E-95 (the common form of ethanol during shipment and prior to bending with gasoline) has increased significantly recently. Ethanol is a basic process agent for the chemical and petrochemical industry, where the handling of hazardous chemicals is well understood. The use of ethanol as a significant contributor to the nation’s fuel supply places new and significant challenges to the fuel industry that is accustomed to dealing with petroleum products. At present technical standards for handling large volumes of ethanol are evolving. It is anticipated that technical solutions will be developed and fine-tuned in the coming years, which will make ethanol a safe fuel. However, the fuel industry will be confronted with new and previously little known challenges and new fuel technologies.

As is described in the following, major technical, environmental and safety issues of handling large amounts of ethanol are quite different from handling petroleum fuel, especially gasoline.

<u>Ethanol is hygroscopic:</u>

Because ethanol is water soluble, it must be isolated from water, a procedure that makes its handling difficult. Water accumulation is a typical occurrence in petroleum fuel systems, such as in tanks and pipelines. Typical sources of water intrusions in petroleum fuel systems are water vapor, leaks in refinery tank roofs and pipeline connections. Water can also be dissolved in fuels during refinery processes. In petroleum fuel systems, the water collects at lower points in the pipelines and can be normally drained. In gasoline-ethanol mixtures water does not fall out but is absorbed by the ethanol. If the water content of the resulting gasoline ethanol mixture exceeds specifications it can no longer be sold as a transportation fuel, since a too high water concentration in then fuel results in deteriorating engine performance.

The removal of excess water from gasoline-ethanol or pure ethanol mixtures requires advanced procedures and cannot be carried out at a storage facilities or downstream of the fuel transfer point. Transport of ethanol in barges represents a significant challenge because of the omnipresence of water and water vapor.

The consistent presence of water in the fuel system also causes higher risks of corrosion, should water separation occur or if water is allowed to accumulate at low points in tanks or pipes. Since ethanol/petroleum blends are more conductive than just petroleum, there is an increased chance of galvanic and electrolytic corrosion. Ethanol in high concentrations can lead to various forms of corrosion including internal stress corrosion cracking, which is very hard to detect. This damage may be accelerated at weld joints or “hard spots” where the steel metallurgy has been altered.

Ethanol is a strong solvent:

Ethanol has very good solvent properties and its presence in ethanol/petroleum blends tend to loosen rust, scale gum and other deposits in tanks and fuel systems. It is therefore important to ensure the removal of rust and other particles, particularly in steel tanks and associated piping. It is recommended that fuel filters be installed in the fuel system to remove any impurities that was loosed by ethanol. Certain sealants and gasket material that are used in petroleum systems, such as alcohol-based pipeline sealant; Polyurethane, Urethane rubber and Neopren are not recommended for use in ethanol.

Material consideration:

Fittings and Connectors: All fittings, connectors, and adapters that will be in contact with the fuel blend should be made of stainless steel (best choice), black iron, or bronze to avoid degradation. If aluminum or brass fittings are used, they must be nickel plated to avoid any contact between the bare metal and ethanol.

Pipeline: The best choice for underground piping is nonmetallic corrosion free pipeline. Schedule 40 black iron pipeline and galvanized pipeline may be used, but will require corrosion protection to meet requirements. Conventional zinc-plated steel piplines should not be used for fuel ethanol. Pipelines thread sealant, when needed, must be Teflon tape or a Teflon based pipe-thread compound. In new pipeline installations, thermoset reinforced fiberglass or thermoplastic double-wall pipelines should be used.

Environmental and health concerns:

Pure ethanol is toxic to humans. However, in small doses ethanol generally will place the person in a relaxed and euphoric mood, resulting in poor judgment. At higher dosages, ethanol produces impaired sensory and motor functions, slowed cognition, stupefaction and unconsciousness.

Due to its solubility in water and its chemical properties, ethanol will bio-degrade quickly in water and soil. In case of a spill in water, the half-life of ethanol is only a few hours. Residence time of ethanol in water will be primarily controlled by bio-degration. Rapid rates of ethanol bio-degration occur under aerobic and anaerobic conditions. Thus ethanol is a short-lived compound in surface water as well as in ground water.

In case of an ethanol spill, it is much more challenging, if not impossible, to capture and recover ethanol, when compared to gasoline. Deploying a boom to contain the ethanol/petroleum product around a spill might catch gasoline on the surface, but ethanol dilutes in water.

Fire hazards of ethanol:

Ethanol burns with a colorless flame and may generate little or no smoke, making it difficult to determine the existence or the boundaries of the fire. Extra care should be taken in approaching such fires. In contrast, ethanol/petroleum blends burn with the flame color of the base petroleum fuel.

Recent research indicates that firefighting procedures and technologies may differ significantly between ethanol and petroleum products, making it a challenge to fire fighting crews used to combating petroleum fires.

Whether blended with gasoline or not, ethanol is highly flammable. Pure ethanol has a flash point of only 55º F; the flash point of E-85 is 68º F. At 10 percent dilution, ethanol is still combustible, which means if water is sprayed on an ethanol fire ethanol still burns as a 10 percent solution. Therefore diluting ethanol, to achieve a weak and safe solution is not a promising fire fighting solution.

There are few types of foam that are suitable to combat ethanol fires. Most foam typically used for gasoline have shown only limited success. Dealing with ethanol on fire involves using an ATC (Alcohol Type Concentrate) foam specifically designed for such polar solvents. Straight AFFF (Aqueous Film Forming Foams) and protein foam will not work. Therefore, the fuel facility that handles large amounts of ethanol and the fire department that takes care of these fire hazards needs to have available the appropriate foams.

Using ATC foam on an ethanol fire requires double to four times the amount of foam used to extinguish a gasoline fire of the same size. Fixed systems, such as fire monitors that protect fuel transfer facilities have to be configured to handle alcohol resistant foam and larger foam volumes. If ethanol is ignited, the track record of extinguishing large quantities of it is not really promising. Firefighting procedures that work with gasoline fires are not working properly with ethanol/gasoline fires. Fuel transfer facilities in the State commercial harbors will have to implement the right technology, the right foams and the right procedures to safeguard the safe handling of large amounts of ethanol. It will have to be decided if petroleum and ethanol fires should be fought with different foams or if all fires should be fought with a single type of foam.

Considerations for fuel facilities handling ethanol:

Handling of large amounts of ethanol at marine terminal facilities in Hawaii represents a considerable challenge for the terminal operator. Ethanol is a highly flammable fuel, which produces dangerous fires that require fighting procedures, which may significantly differ from gasoline or petroleum fires. Because the hygroscopic characteristics of the ethanol water intrusion or residual water can render ethanol or ethanol/gasoline mixtures out of specifications and therefore resulting in considerable losses and interruption of supply. Ethanol loading of fuel barges requires vapor control to ensure safe loading procedures and lower the risk of explosions and fires. Metals, gaskets and sealing materials of piping and transport or storage tanks require compatibility with ethanol to avoid damages. The solvent characteristics of ethanol require stringent maintenance of the fuel system to avoid clogging and sedimentation in vulnerable sections of the fuel system.

4.12.2 Biodiesel

Biodiesel is a clean burning alternative fuel produced from renewable resources. Specifically, 100 percent biodiesel is a full diesel equivalent (although the energy content of current types of biodiesel is only 90 percent of regular diesel No. 2). Biodiesel is derived from biological sources and can be used in conventional diesel vehicles with little or no modification. The use of biodiesel is much more widespread in Europe than in the U.S., since vehicles (cars and light trucks) with diesel engines have about 55 percent market share in Europe, compared with fewer than 3 percent in the U.S. Compared with the use of ethanol as a biofuel, biodiesel is in the early stages of being a significant contributor to the U.S. transportation fuel supply.

Biodiesel has been identified as a fuel of choice for Hawaii, particularly for electricity generation. Therefore, large amounts of biodiesel might be shipped using fuel transfer and storage facilities in the commercial harbors.

Biodiesel contains no petroleum, but it can be blended with petroleum diesel to create a biodiesel blend (such as B2: 2 percent Biodiesel and 98 percent petroleum diesel, B20: 20 percent Biodiesel and 80 percent petroleum diesel, etc.). Typical biodiesel blends are B10 to B20, which can be handled in much the same way as petroleum diesel. Higher blend levels, such as B50 or B100, require special handling and fuel management and may require equipment modifications such as changing seals and gaskets.

The handling of biodiesel in commercial harbors will very likely also involve handling imported feedstock, such as vegetable oil. The presently announced biodiesel projects that are slated for Hawaii will import feedstock as well as other process products through the commercial harbors. This will add to the complexity of the fuel infrastructure requirements for biodiesel.

Environmental concerns:

In regard to environmental impact in case of spills, biodiesel has less impact to aquatic and marine organisms than petroleum. The EPA, however, considers spills of animal fats and vegetable oils harmful to the environment and considers vegetable oils to be "oil" like petroleum. Even though biodiesel is relatively non-toxic and less viscous than vegetable oil, it can still have a serious impact on marine and aquatic organisms in the event of a spill.

Waterfowl and other birds, mammals and fish that get coated with biodiesel can die from hypothermia or illness, or fall victim to predators. The biodegradation rate of biodiesel in water is about twice as fast as for petroleum diesel. Therefore the half-live time of biodiesel is less than petroleum diesel, which mitigates environmental impact in the occurrence of a spill.

<u>Biodiesel as a strong solvent:</u>

Biodiesel, especially in high concentration such as B100 is a strong solvent. B100 is comprised of methyl esters and has the tendency to dissolve the accumulated sediments in diesel storage and pipeline systems. The level of cleaning depends on the amount of sediment in the system as well as the blend level of biodiesel being used. The cleaning effect is much greater with B100 compared to B20 and lower blends. The cleaning effect of B20 is low so that most problems encountered with B20 are insignificant.

<u>Biodiesel is hygroscopic:</u>

Transportation and storage of biodiesel require special management. For example, biodiesel is hygroscopic so contact with humid air or water sources must be avoided.

<u>Temperature dependency:</u>

B100 freezes at higher temperatures than most types of conventional diesel fuel. Different types of B100 start to cloud at temperatures as high as 60° F, so heated fuel lines and tanks may be needed even in moderate climates. As B100 begins to gel, the viscosity also begins to rise, rising to levels much higher than most diesel fuel, which can cause increased stress on fuel pumps. The higher temperatures in Hawaii mitigate these problems for the fuel transfer in commercial harbors; however, the handling of biodiesel feedstock that is slated for import to Hawaii will most likely require special procedures such as heated pipelines or tanks.

<u>Material considerations:</u>

B100 is not compatible with some metals and plastics found in conventional diesel systems, such as hoses and gaskets. B100 will degrade, soften, or seep through some hoses, gaskets, seals, elastomers, glues, and plastics with prolonged exposure. Nitrile rubber compounds, polypropylene, polyvinyl, and Tygon materials are particularly vulnerable to B100. Contact with B100 may cause affected and vulnerable system components to leak and become degraded to the point where they crumble and become useless. Testing of the compatibility of B100 with certain materials common to regular diesel systems is being conducted at the present time, but more data is needed on the wide variety of grades and variations of compounds that can be found in these systems. Biodiesel will form high sediment levels if in contact with copper or copper containing metals (brass, bronze) or with lead, tin, or zinc (i.e., galvanized surfaces).

<u>Consideration for fuel facilities handling biodiesel:</u>

Handling pure biodiesel (B100) or higher biodiesel / regular diesel blends requires specific knowledge and experience by the fuel facility or transportation personnel. Materials of pipeline systems and storage facilities have to be compatible with biodiesel. Residual water in the transport vessels, pipeline and storage tanks have to be handled to account for the strong hygroscopic character of pure biodiesel. Preparing pipeline systems and storage for biodiesel and biodiesel blends includes proper placement of the water draw-off system and development of a procedure for detecting water accumulation in the fuel.

Most problems in respect to storing and handling pure biodiesel (e.g. B100) can be avoided by blending the biodiesel to lower level biodiesel content (e.g. B20) upstream of the fuel storage and transportation. Blending of biodiesel to B20 would alleviate possible problems, particularly for smaller terminals. Blending of biodiesel, however, lowers the opportunities to use biodiesel as a substitute for conventional petroleum diesel and additionally to replace oil fuel by indigenously produced fuels.

4.12.3 Handling Large Volumes of Biofuel Feedstock

There are plans for large-scale biofuel production in Hawaii within the next several years. While the long-range plans envision biofuel feedstock to be produced in Hawaii for the near-term future, feedstock will be imported using transfer facilities in commercial harbors. In the case of imported biodiesel feedstock, large amounts of vegetable oil, such as palm oil being a preferred feedstock for prospective biodiesel production facilities will be imported to Hawaii. In addition, alcohols such as ethanol or methanol that are required for biodiesel production would also be imported along with the vegetable oil feedstock. The import of such biofuel feedstock will most likely be in specialized Handysize Tankers.

Ethanol production in Hawaii will most likely be able to use locally produced biomass (e.g., sugarcane) as feedstock. If sufficient volumes of feedstock grown in Hawaii were not to be available, then imported feedstock would be use.

In 2000, the EPA and U.S. Coast Guard (USCG) issued regulations affecting facilities that handle or store large amounts of vegetable oil (Facility Response Plan rule for Animal Fat/Vegetable Oil Facilities in 40 Code of Federal Regulations (CFR) 112 and 33 CFR154). In terms of physical properties, petroleum oils, animal fats and vegetable oils share common physical and chemical properties and produce similar harmful environmental effects when they are spilled in the environment. The significant difference between petroleum and vegetable oil is the degree of biodegradability in case of an oil spill. The immediate response to contain the spill is very similar to a petroleum spill and involves the expeditious deployment of containment booms and recovery of the spilled substance.

As a result, facilities for vegetable oils require advanced response plans to combat threats to the environment, which rival that of petroleum facilities.

Biofuel feedstock is more viscous than petroleum products. In order to properly convey biofuel feedstock, the liquid feedstock product has to be pumped or stored at a higher temperature. Product tankers are typically heated and therefore the liquid feedstock has a sufficiently high temperature to flow through the transfer equipment to the storage tanks. The transfer pipes between ship and storage tanks are temperature sensitive pipes and have to be fitted with expansion joints or have an appropriately pipe geometry to accommodate thermally induced pipeline expansions and contractions.

Vegetable oil fires are unlikely to start on their own because the high flash point (320º F for palm oil). The oil, however, is combustible at high temperatures. Fire fighting procedures involve water spray, fog or foam, but no water jets should be used.

Biodiesel production requires an alcohol agent such as ethanol or methanol. If methanol is used for biodiesel production, significant volumes of methanol might be imported through commercial harbors, if not produced locally. In regard to the environmental hazards, methanol is a safer and more environmentally friendly fuel than petroleum products. Therefore spills are far less damaging to the environment. Large methanol spills in commercial harbors would have some immediate impacts to the biota in the direct vicinity of the spill. However, methanol rapidly dissipates into the environment, reaching low concentration levels where biodegradation will occur quickly.

Fire hazards from methanol are significantly lower than from gasoline of ethanol because of its lower volatility, higher flammability requirement, lower vapor density and lower heat release rate. Methanol fires can be extinguished with plain water.

4.13 Proposed Design Guidelines of Future Fuel Facilities

Future fuel facilities in commercial harbors will have to abide by regulations and design approaches that are different and stricter than those that applied when the majority of the current fuel infrastructures in the harbors was constructed. By and large, the fuel infrastructure in Hawaii's commercial harbors is old and should be upgraded in order to accommodate possible rapid changes in the fuel industry.

Historically, fuel has been handled as a liquid form of cargo typically at piers that also serves containerized or other cargos. Fuel facilities, which have been adequate in the past may be not adequate in the future in terms of capacities and design features. As an observation, it seems that containerized cargo has attracted more attention than fuel shipments, though the importance of a safe and uninterrupted supply of petroleum, as well as of alternative fuels and fuel feedstock is crucial for Hawaii's economy.

The following lists design features, which are recommended for new and modified piers:

No.	Proposed design feature	Benefits
1	Dedicated fuel piers: piers that are specialized to berth fuel barges and tankers	Dedicated fuel piers can be configured with the emphasis of optimizing fuel transfer equipment. Piers with fuel transfer installations are more demanding than regular piers in terms of safety, security and space for advanced fuel handling technology. Dedicated fuel piers avoid competition with other cargo handling operations.

No.	Proposed design feature	Benefits
2	Using protruding segmented fuel piers rather than conventional bulkhead or piled piers with continuous pier face	Fuel transfer from barges or tankers requires only access to the short section of the barge or tanker that is the fuel transfer-pipeline interface in the center of the fuel vessel. Therefore, only a relatively small fuel transfer platform is required to accommodate the ship-to-shore fuel transfer equipment, while the barge or tanker can be held in position at the fuel dock by breasting dolphins and mooring dolphins. This form of the fuel pier can utilize areas in the harbor that are marginal (or very cost intensive) for construction of conventional piers. Protruding segmented piers also have the advantage of offering an interim stage for future development of continuous pier, thereby facilitating the growth of harbor infrastructure. Locating fuel piers to marginal sites in the harbor frees up space for the growing containerized cargo operations in the commercial harbors. If growing cargo operations still need more piers and berthing space, the protruding segmented fuel piers can be converted to mixed-cargo (continuous) piers at a later point in time.
3	Loading arms to transfer fuel from the vessels to land	Loading arms are safe and effective fuel components to transfer fuel from fuel vessel to landside storage tanks. Loading arms replace flexible hose assemblies that are more prone to mechanical failure than loading arms. Loading arms require significantly less maintenance than flexible hoses. Loading arms are equipped with breakaway couplings to ensure high safety against accidental fuel spills. Loading arms can also be incorporated with pigging installations for multi-fuel transfer. If fuel loading arms are installed on piers where general or containerized cargo is loaded, sufficient protection is required against accidental impact of cargo handling equipment.
4	Piggable pipelines	Piggable fuel pipelines can render a more flexible and effective use of fuel pipelines. Since fuel batch trains are separated by

No.	Proposed design feature	Benefits
		mechanical means, different fuels can be effectively pumped through a single pipeline. This can significantly lower the construction costs of the fuel transfer pipelines if longer transfer pipelines are required to connect the fuel piers with remote storage tanks.
5	Pipeline installations on above-ground pipeline racks or in below-ground pipeline galleries	Pipeline racks and pipeline galleries offer a cost effective way to install fuel pipelines. Since fuel pipelines on pipeline racks are readily accessible, maintenance and repairs are much less costly than in the case of pipelines that are installed rigidly below-ground in trenches or concrete jackets. Pipeline racks and pipeline galleries minimize the impact on harbor operations if additional pipelines or modifications to pipelines are required. Pipelines installed on pipeline racks and in pipeline galleries require adequate security.
6	Fixed fire monitors with foam generator	Fixed manually or remotely operated foam monitors with an adequately high level of foam add significant permanent fire fighting capacities.
7	Fixed lighting and other safety/security installations	Fuel piers have to be adequately lit for operations between sunset and sunrise. Having the required adequate fixed lighting of fuel transfer installations safeguards fueling operations at night, thereby increasing the scheduling flexibility in the harbor. In the post 9/11 world, the vital and vulnerable fuel infrastructures in harbors require elevated security measures. Dedicated security measures around exposed fuel transfer equipment can be better installed and monitored at dedicated fuel piers.
8	Vapor control systems	It is assumed that new fuel facilities in Kalaeloa Barbers Point Harbor and/or Honolulu Harbor require vapor control measures for the loading of gasoline fuel (and possibly ethanol fuel) in order to abide by applicable USCG and/or EPA standards. Installing vapor control measures increases safety of loading operations and avoids environmental impact. If ethanol is loaded

No.	Proposed design feature	Benefits
		on the neighbor islands (a possible future fuel scenario) then vapor control is also required at that point.
9	Protection against fuel spills, fast deployment of containment booms, pre-booming (insurance booming) for certain fuel products.	Fuel spills are enormously destructive to the environment and to harbor operations. Containment booms are the first measure to limit the spread of fuel in the harbor. The second measure is the recovery of the spilled fuel or the limiting of its environmental impact. Geometry of containment booms have to be adjusted to the situations at each fuel pier. Using containment booms and fuel recovery at dedicated piers is less disruptive to harbor operations. Pneumatic spill containment systems might be an effective solution since they can be fixed installations and be activated on short notice.
10	Ethanol compatible fuel infrastructure; making future fuel infrastructure in the harbors compatible with ethanol	Ethanol is a transportation fuel of increasing importance. Hawaii has identified ethanol as a locally produced fuel that can replace volumes of imported oil. The marine transport and handling of large volumes of ethanol in commercial harbors bears significant risks. Materials used in fuel facilities, handling procedures and emergency response are quite different from petroleum products. Material compatibility ensures fuel facilities are suitable for ethanol as well as a wide array of fuels. Advanced detection procedures for contaminants and residual water safeguards that fuel conveyed in fuel system retain specifications. Firefighting procedures and installations (e.g., type of foam and foam application procedures) have to be compatible with the special requirements of ethanol fires. When the future marine facility is designed to accommodate the handling of ethanol, the significant costs and redundant fuel infrastructures can be avoided.

No.	Proposed design feature	Benefits
11	Biodiesel compatible fuel infrastructure; making future fuel infrastructure in the harbors compatible with biodiesel	Although on a national level biodiesel is well outpaced by ethanol in terms of volume produced and used, biodiesel has a special importance for Hawaii. Biodiesel is slated to become an important biofuel for electricity generation and as a transportation fuel in Hawaii. The marine transport and handling of large volumes of biodiesel in commercial harbors bears considerable risks. Materials used in fuel facilities and handling procedures are quite different from petroleum products. Material compatibility ensures fuel facilities are suitable for ethanol as well as a wide array of fuels. Advanced detection procedures for contaminants and residual water safeguards that fuel conveyed in fuel system retain specifications. When the future marine fuel facility is designed to accommodate the handling of biodiesel, the significant costs and redundant fuel infrastructures can be avoided in future.
12	Compressed Natural Gas as a possible future fuel for Hawaii	Compressed Natural Gas (CNG) could become an important fuel for electricity generation and power ground transport. Ocean going tankers and barges for CNG are a mature technology (e.g. ABS certified designs are now available). In the most realistic scenario CNG would be generated at a LNG re-gasification plant on Oahu and then be loaded on CNG barges in the Oahu's commercial harbors for shipment to the neighbor islands. Fuel infrastructure for CNG would be preferably located at dedicated fuel piers.

4.14 Fuel Facility Security in a Post 9/11 World

Over the past decade, the petroleum industry in cooperation with regulatory and advisory agencies (e.g., EPA, USCG, API, and others) have developed and continuously refined security guidelines to safeguard a safe, secure and continuous supply of the petroleum. Oil constitutes the most important form of our energy supply and Hawaii's economy depends on an uninterrupted supply of oil.

Although sound standards and best practices have been in place for years, the terror attacks of 9/11 have changed the way security is perceived and practiced by the energy industry. Many security procedures that were deemed sufficient before 9/11, are no longer deemed adequate today.

Prior to 9/11, the petroleum industry had in place many practices that insured public safety and had detailed plans for emergencies. The pre-9/11 emergency preparedness mainly focused on cases of crime, vandalism, weather and other physical disasters and equipment failure. Post-9/11 measures were intensified since the primary threat origin has shifted to a more strategic nature by deliberately targeting vital assets.

The marine transport of fuel and fuel terminals are subject to a new generation of security threats, since the physical and chemical properties of petroleum that is stored or handled at these facilities may create attractive targets. The explosive and fire prone nature of fuel supply would magnify the initial malicious attack manifold by fires, explosions and release of harmful substances. Therefore fuel facilities have to be designed and operated in a manner that reflects its highest security priority.

Although all fuel facilities in the commercial harbors system are located inside a controlled perimeter, the security of fuel facilities can be further increased if such facilities are located further away from general harbor operations, such as container handling and passenger operations, and given its own unique safety measures and response infrastructures. The focus of security of fuel facilities in the commercial harbors should be: strict access control, capable responses to the high fire and explosion risks, containment and recovery of released agents, and segregation of threat potential from other harbor operations. The potential dangers of a malicious attack on or malfunction of fuel facilities are significantly higher than other forms of cargo.

After 9/11, two relevant alert level systems that have been developed by the government or in government/industry partnerships to warn of the potential for acts of terrorism:

1. Homeland Security Advisory System (HSAS): A 5-level alert system based on the National Threat Advisory System developed by the Department of Homeland Security.

2. Marine Security Levels (MARSEC): A 3 level alert system developed by the U.S. Coast Guard for use by marine vessels and ports.

These alert systems provide information to the industry of the potential for terrorist threats and help facilities implement appropriate response measures, if needed, during a threat crisis. For the marine transport of fuel, the Coast Guard's MARSEC alert system provides the applicable response framework.

Since the implementation of the Oil Pollution Act (OPA) of 1990, the petroleum industry in close cooperation with government regulatory agencies has implemented rules and regulations. These actions have significantly reduced the number of vessel casualties, reduced the number of spills and the quantity of oil spilled, improving overall safety and increased the effectiveness of response efforts. Although these regulations do not fully describe post 9/11 threats, they are very useful to develop designs and response plans for future fuel facilities.

The following is a list of relevant U.S. regulations (i.e., Federal Register [FR]) that apply to fuel facilities in the commercial harbors system:

1. 59 FR 34070 Facility Response Plans.
2. 62 FR 13991 Response Plans for Facilities Located Seaward of the Coast Line.
3. 61 FR 30533 Facility Response Plans for Pipelines (Interim Final Rule).
4. 57 FR 7640 Coastwise Oil Spill Response Cooperatives.
5. 60 FR 45006 Designation of Lightering Zones.
6. 59 FR 42962 Escorts for Certain Tankers.
7. 60 FR 13318 Establishment of Double Hull Requirements for Tank Vessels.
8. 59 FR 40186 Existing Tank Vessel Requirements – Lightering requirements and Advanced Notification.
9. 62 FR 1622 Existing Tank Vessel Requirements – Structural Requirements.
10. 61 FR 39770 Existing Tank Vessel Requirements – Training, Survey and Maneuverability Measures.
11. 61 FR 7890 Facility Response Plans for Marine and Non-Marine Transportation Facilities April 2003 119.
12. 58 FR 48434 Lightering Requirements.
13. 59 FR 47384 National Contingency Plan Revisions.
14. 58 FR 27628 Second Person Required (on bridge).
15. 61 FR 1052 Tank Vessel Response Plans.
16. 57 FR 14483 Vessel Communication Equipment Regulations.

SECTION FIVE

EXISTING FUEL FACILITIES

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SECTION FIVE

EXISTING FUEL FACILITIES

Section Five describes the existing fuel facilities in the seven commercial harbors and summarizes the findings from interviews with stakeholders about the current operating conditions. The recent growth of Hawaii's economy and the corresponding increase in cargo activity has exacerbated congested conditions in the commercial harbors. Because commercial harbor piers are operated in a multi-use mode, all cargo users compete with each other for operating space.

5.1 Description of Existing Fuel Facilities

The Department of Transportation, Harbors Division manages ten commercial harbors in Hawaii. Fuel facilities in the seven main commercial harbors were assessed and recommendations made in subsequent sections. The following commercial harbors were studied:

1. Honolulu Harbor, Oahu.
2. Kalaeloa Barbers Point Harbor, Oahu.
3. Kahului Harbor, Maui.
4. Nawiliwili Harbor, Kauai.
5. Port Allen Harbor, Kauai.
6. Hilo Harbor, Hawaii Island.
7. Kawaiihae Harbor, Hawaii Island.

5.1.1 Honolulu Harbor

Honolulu Harbor is the hub of Hawaii's commercial harbors system through which most of the cargo is received. Cargo is then distributed on Oahu or is shipped further to the neighbor island ports. In regards to fuel facilities, the harbor only handles refined petroleum products. Crude oil is off-loaded at two offshore mooring systems south of Kalaeloa Barbers Point Harbor. Refined products are then transferred from the refineries to Honolulu Harbor by pipelines. The two fuel facilities in Honolulu harbor for interisland fuel shipping are located at Piers and 30 and 51. Pier 30 and its associate storage facilities are privately owned. Bunkering pipelines for fueling vessels are located at Piers 31 and 32.

Figure 5-1 provides an aerial view of Honolulu Harbor and shows the current fuel facilities in the harbor. As alluded to previously, petroleum fuel is pumped from the two refineries that are located at Barbers Point to Honolulu locations by transmission pipelines, also referred to as the "energy corridor". The pipeline system for liquid petroleum products on Oahu energy corridor comprises of two independent pipeline systems: one dedicated to black oil and the other to clean petroleum products. The petroleum products in each pipeline are conveyed in batch trains through the pipelines.

A large jet fuel storage facility, operated by Hawaii Fueling Facilities Corporation (HFFC), is located west of Sand Island near the former-Kapalama Military District. The storage facility receives jet fuel either through the energy corridor from Barbers Point or through jet fuel imports at Pier 51. Pier 51 is a multi-use pier that is primarily used to handle containerized cargo. The fuel tankers that off-load jet fuel at Pier 51 have to compete for berthing with container ships that operate on a regular schedule.

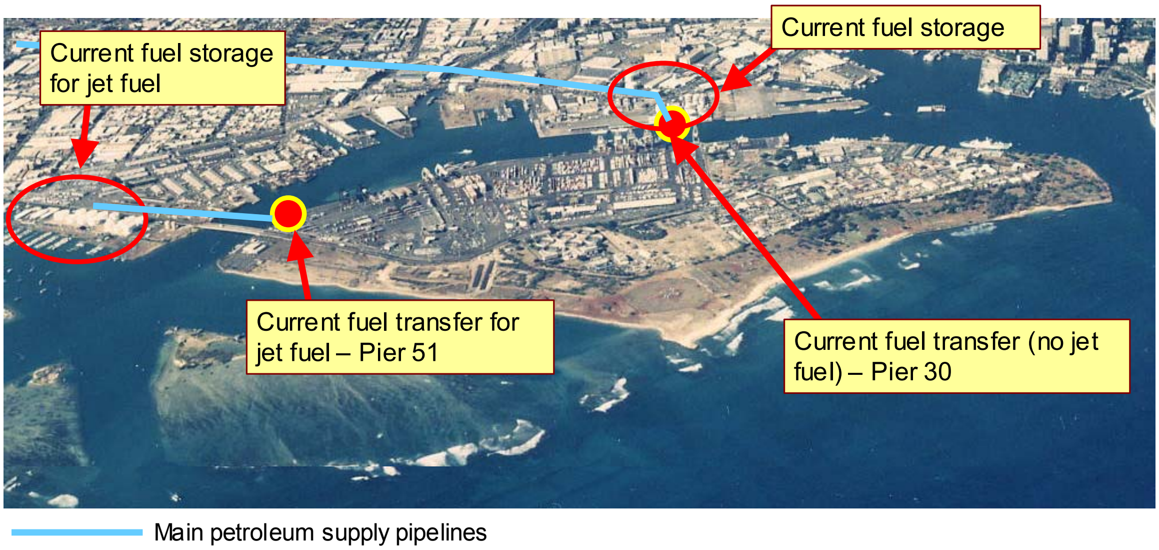


Figure 5.1: Current Fuel Facilities in Honolulu Harbor

The pipelines of the energy corridor also convey petroleum products to several tank farms owned by different fuel companies located around Pier 30. Fuel from the tank farms is then loaded onto barges for shipment to the neighbor islands or is distributed on Oahu.

Current fuel-related harbor operations include:

1. Off-loading HandysizeTankers at Pier 51 that brings in jet fuel.
2. Loading fuel barges for shipments to the neighbor islands at Pier 30.
3. Providing berthing for bunkering barges. Bunker pipelines are along Piers 31 and 32.

As the utilization of Honolulu Harbor keeps growing, berthing conflicts arise from competition of fuel shipments with cargo operations or other harbor uses.

5.1.2 Kalaeloa Barbers Point Harbor

Kalaeloa Barbers Point Harbor serves as the hub of Hawaii’s fuel supply system as well as for the inter-island distribution of finished petroleum products. It handles most of Hawaii’s liquid-bulk cargo volume, even surpassing Honolulu Harbor. Kalaeloa Barbers Point Harbor is located only a short distance away from Hawaii’s two refineries, a gas production plant, a number of large fuel storage tank facilities and is the terminus of the regional pipeline between Barbers Point and Honolulu. An interconnecting pipeline system connects the harbor to the refineries and tank farms located in Campbell Industrial Park. Currently, there are no fuel storage tanks within Harbor Division's boundaries. It can be anticipated that Kalaeloa Barbers Point Harbor will play an increasingly important role for fuel supply and distribution in Hawaii.

Liquid petroleum gas barges (LPG, otherwise known as propane or a mixture of propane and butane) are loaded at Pier P-1. A pipeline system connects the refinery to several storage tanks. LPG is held in these tanks until the fuel is ready to be loaded on barges for distribution to the neighbor islands. Loading at Pier P-1 is affected by occasional high incident waves, especially during winter months.

Other petroleum products are loaded at Piers P-5 and P-6. Pipelines connect the fuel facilities directly with the storage tanks that are located in the Campbell Industrial Park. Piers P-5 and P-6 have several fuel hatches that contain separate product lines. Fuel barges are loaded using the storage facilities' transfer pumps at Barbers Point.

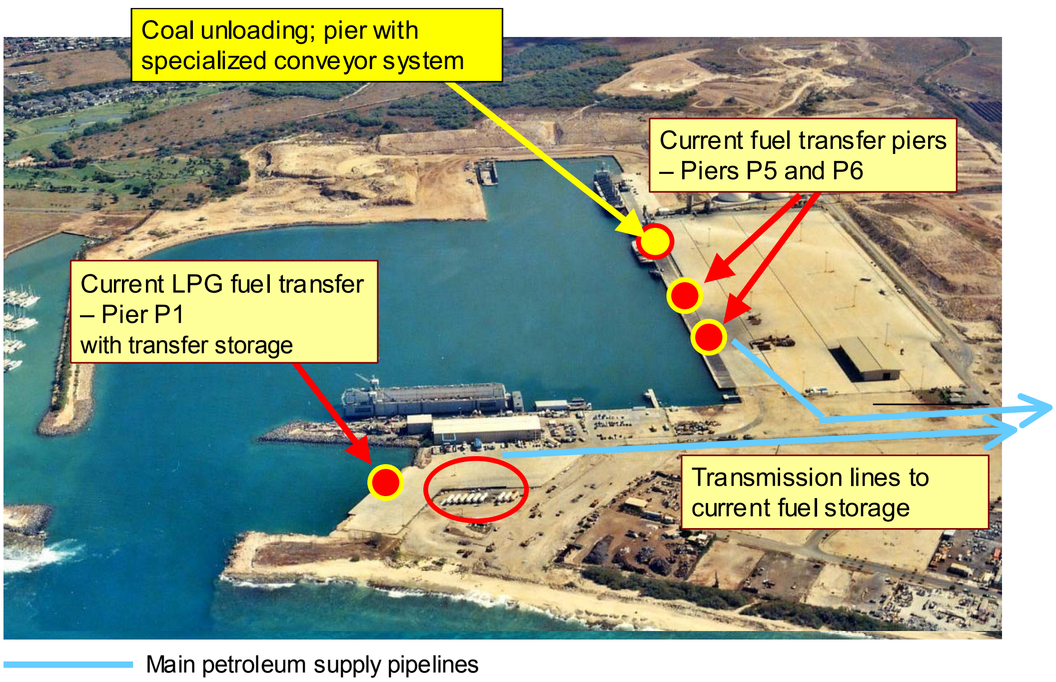


Figure 5-2: Current Fuel Facilities in Kalaeloa Barbers Point Harbor

Figure 5-2 provides an aerial view of Kalaeloa Barbers Point Harbor and shows the current fuel facilities in the harbor. The harbor receives regular shipments of ethanol by Handysize tankers. Fuel is pumped from the tanker to storage tanks using the shipboard transfer pumps. The harbor also receives occasional shipments of refined products (e.g,. gasoline) for independent fuel retailers.

Fuel transfer operations at Piers P-5 and P-6 are primarily affected by the busy berthing schedule. Cargo volumes have significantly increased recently, resulting in berthing conflicts.

Compounding this situation is the fact that coal shipments are received at Pier P-6. Coal ships are large and occupy portions of Pier P-6.

Current fuel-related harbor operations:

1. Loading fuel barges for the shipment of petroleum products (including LPG; typically propane) and non-petroleum products (i.e., ethanol) to the neighbor islands.

2. Off-loading Handysize tankers, which bring refined petroleum products and ethanol to Oahu.

5.1.3 Kahului Harbor

The fuel infrastructure in Kahului Harbor is crucially important to the economy of Maui. Unlike Kauai, Hawaii and Oahu, which all have two harbors with fuel transfer capabilities and therefore, some form of redundancy, Maui must receive all of its fuel supply through Kahului Harbor. Efficient and safe operation of the fuel facilities is therefore of utmost importance, not only for continuing the current level of fuel operations, but also to accommodate future growth in fuel quantities and increasing environmental, operational safety and security requirements. In addition, the fuel infrastructure in Kahului Harbor will have to serve an increasing market for alternative fuels.

Figure 5-3 provides an aerial view of Kahului Harbor and shows the current fuel facilities in the harbor. Fuel is currently transferred at three locations in the harbor. LPG shipments are received at Pier 2. A pipeline (plus balancing pipeline) connects the LPG barge with storage tanks that are located outside of the harbor. Petroleum products (other than LPG) are unloaded at Piers 1 and 3, where Pier 3 is the most widely used fuel pier in the harbor.

Fuel transfer operations are affected by a tight berthing schedule at this only harbor on Maui. Cargo operations have been steadily increasing over the past years. Large cruise ships are calling port on several days per week, occupying a significant part of Pier 1. The inter-island ferry has started operations in 2007 and occupies a significant portion of Pier 2 during her daily port calls. The ferry’s barge and ramp system is located at Pier 2B.

Apart from the increasing harbor operations and the increasing competition for berthing space among barges and ships, there are other factors affecting fuel transfer. Pier 3 has limited water depth and therefore fully loaded fuel barges cannot berth there. In addition, it directly faces the harbor entrance and is exposed to high wave situations, which hamper the fuel transfer operations to a point where unloading has to be suspended to avoid unsafe operational conditions.

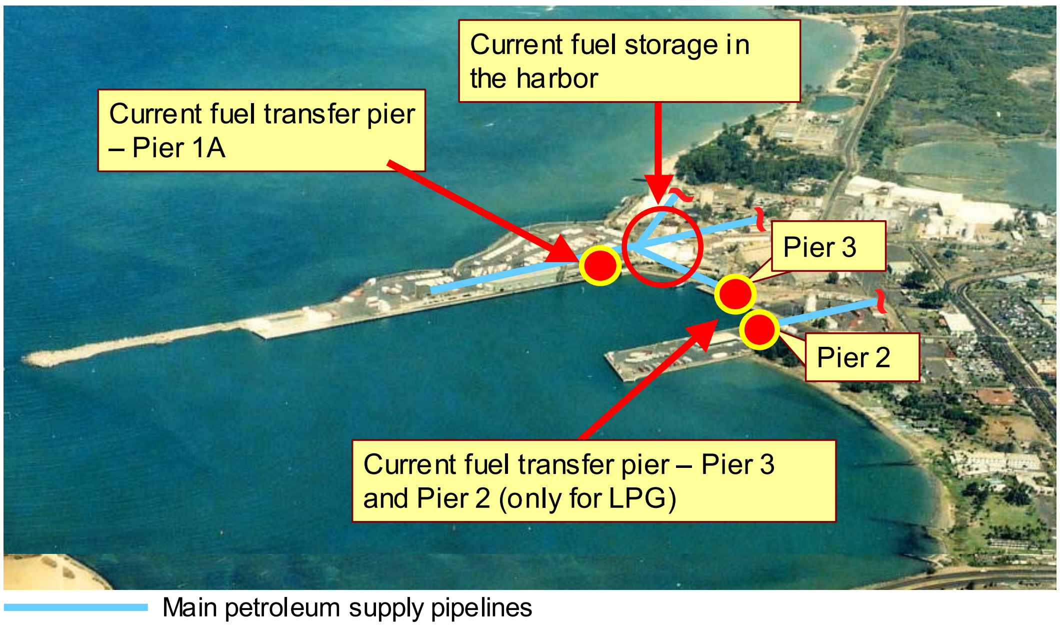


Figure 5-3: Current Fuel Facilities in Kahului Harbor

Current fuel-related harbor operations:

1. Off-loading fuel barges that arrive from Honolulu Harbor or Kalaeloa Harbor and carry petroleum, non-petroleum (i.e., ethanol) fuel products and LPG.

2. Fuel is transferred using fuel hatches located at Piers 1, 2 (only LPG) and 3.

5.1.4 Nawiliwili Harbor

Nawiliwili Harbor is the principal commercial harbor on Kauai. All of the cargo for the island is handled there. It also accommodates large cruise ships several days out of the week. The harbor handles a significant portion of fuel products, mainly transportation fuel such as gasoline, diesel and jet fuel. As a remnant of the sugar industry, there still exist pipelines and storage tanks to handle molasses. In addition, the harbor accommodates the terminal of the inter-island ferry.

The fuel operations in Nawiliwili Harbor are presently carried out on Piers 2 and 3. The fuel operations at Pier 2 have to compete for berthing time with passenger operations. Pier 2 has two fuel hatches for gasoline, diesel and jet fuel, which belong to two fuel companies. Pier 3 accommodates the loading hatch for liquid petroleum gas (LPG). Fuel storage facilities are to the north of Pier 2 (i.e., gasoline, diesel and jet fuel) and to the west of Pier 3 (i.e., LPG).

Figure 5-4 provides an aerial view of Nawiliwili Harbor and shows the current fuel facilities in the harbor.

Current fuel-related harbor operations:

1. Off-loading fuel barges that carry petroleum and non-petroleum (i.e., ethanol) fuel products. Barges carrying transportation fuel products (i.e., gasoline, diesel and jet fuel) are unloaded at two separate fuel hatches at Pier 2 and transferred to the two fuel storage facilities located to the north of the harbor.

2. Off-loading LPG (presently only propane) barges or tankers (not regularly) that arrive from Kalaeloa Barbers Point Harbor or from international origins. LPG barges and small LPG tankers are unloaded at Pier 3.

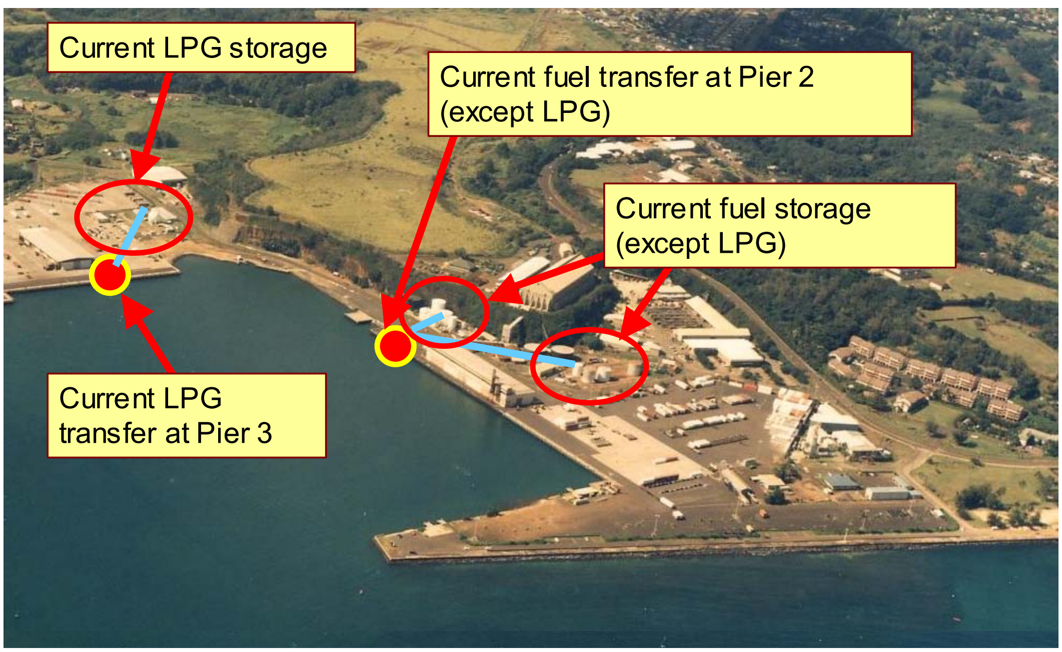


Figure 5-4 : Current Fuel Facilities in Nawiliwili Harbor

Nawiliwili Harbor is unique in that it is one of two commercial harbors that have landside storage tanks located within Harbors Division's boundaries. The storage system is located landside from Pier 2.

5.1.5 Port Allen Harbor

Port Allen Harbor is the only fuel transfer facility on Kauai that receives fuel for the electrical generating plant. Besides receiving diesel fuel and Naphtha (for electricity production), the harbor also handles gasoline and ethanol. In its present configuration, Port Allen Harbor can only accommodate fuel barges and not tankers. It is one of two marine fuel transfer facilities on

Kauai. Therefore, it serves in a contingency function, in case fuel shipments through Nawiliwili harbor are interrupted.

Current fuel transfer operations are carried out at Port Allen Harbor's main pier, which is a piled pier structure that supports a concrete deck. The piled pier structure has been showing structural problems, because of the specific construction method used for the pier. Specifically, the use of wooden timbers buried below the mud line to support the concrete pilings above. In addition, the pier lacks lateral stability because of the absence of lateral supports due to the use of the aforementioned construction method. The *Kauai Commercial Harbors 2025 Master Plan* recommends the demolition of the existing pier structure and the construction of new pier infrastructure.

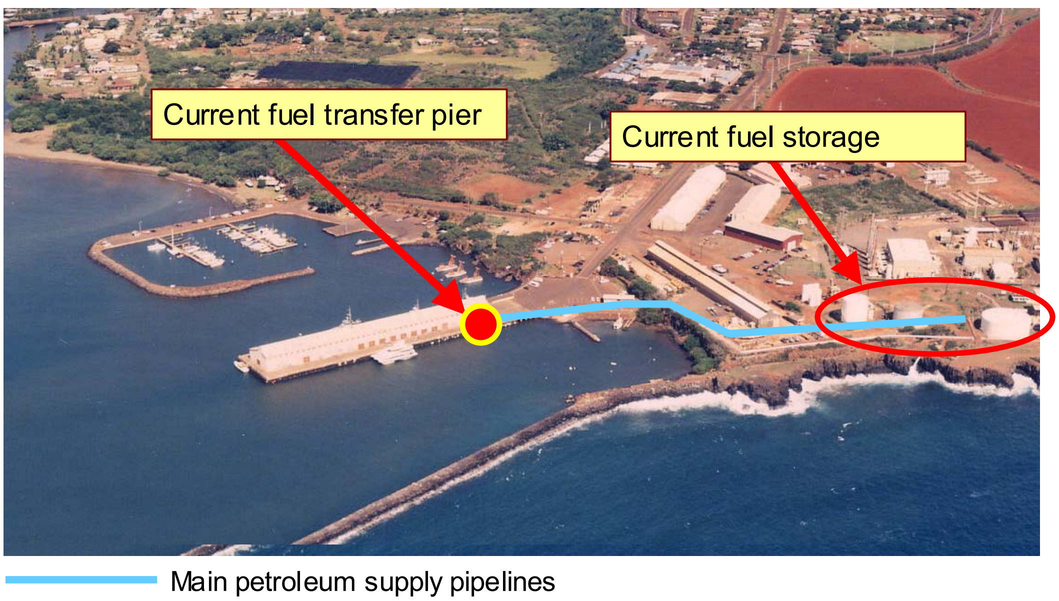


Figure 5-5: Current Fuel Facilities in Port Allen Harbor

The current fuel pier is connected via pipelines to a storage tank farm located outside of harbor boundaries. The transmission pipelines convey diesel fuel, gasoline, jet fuel and ethanol in separate pipelines. The transmission pipelines are laid below ground inside the harbor boundaries and above-ground on pipeline racks outside of the harbor.

Current fuel-related harbor operations:

1. Unloading fuel barges that arrive from Honolulu Harbor or Kalaeloa Barbers Point Harbor that transport petroleum and non-petroleum (i.e., ethanol) fuel products.

5.1.6 Hilo Harbor

Hilo Harbor is the principal harbor for fuel shipments to Hawaii Island. While some quantity of gasoline and diesel are currently transferred in Kawaihae Harbor; all supplies of fuel oil, jet fuel, ethanol and LPG are shipped through Hilo Harbor.

Jet fuel, ethanol and LPG, as well as quantities of diesel and gasoline, are then transported to West Hawaii by fuel trucks. The transfer by truck is a proven and well-established means of supplying the entire island with fuel. But safety and environmental concerns associated with heavy trucking over long distances and through a narrow and curvy road system would render transfer supply for West Hawaii through Kawaiihae Harbor more advantageous. Consequently, the fuel transfer infrastructure in Kawaihae Harbor should be upgraded to accommodate more fuel quantities and a wider variety of fuels. Considering the recommendation of expanding fuel shipments through Kawaihae Harbor, this would likely result in lower fuel volumes through Hilo Harbor.

Current fuel-related harbor operations:

1. Off-loading fuel barges that arrive from Honolulu Harbor or Kalaeloa Barbers Point Harbor that carry petroleum, non-petroleum (ethanol) fuel products.

2. Off-loading LPG barges that arrive from Kalaeloa Barbers Point Harbor.

3. Fuel barges are off-loaded at Pier 3, where there are a number of fuel hatches operated by different fuel companies and a consortium.

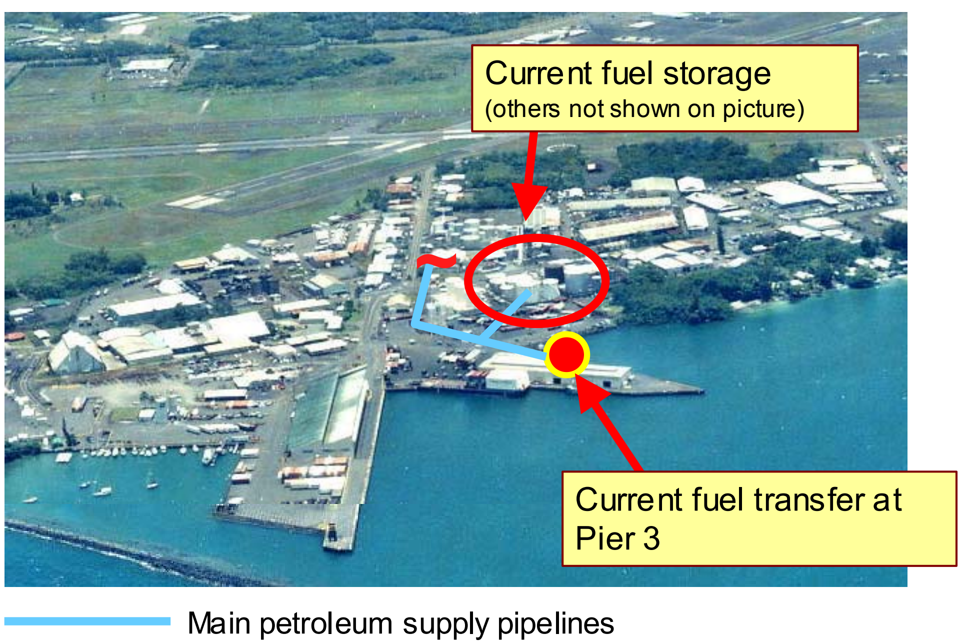


Figure 5-6: Current Fuel Facilities in Hilo Harbor

Figure 5-6 provides an aerial view of Hilo Harbor and shows the current fuel facilities in the harbor. The current fuel transfer is carried out at Pier 3. Several fuel hatches as well as interconnecting pipes are installed in Pier 3, which are owned and operated by individual fuel companies. The fuel transfer from the fuel barges or tankers to the dockside fuel hatches are carried out by flexible fuel hoses.

5.1.7 Kawaihae Harbor

Kawaihae Harbor is the second busiest commercial harbor on the island and serves West Hawaii. Because Hilo historically has been the economic center of the island, its harbor has developed rapidly over time. Hilo Harbor has the larger fuel capacity of the two harbors to handle shipments to the island. Conversely, Kawaihae Harbor has limited capacity to unload diesel and gasoline. As a result, all jet fuel, ethanol, LPG gas and a major portion of diesel and gasoline have to be trucked from Hilo to West Hawaii. Trucking large amounts of different fuels over long distances raises safety and environmental concerns because the fuel trucks travel over narrow and curvy roads and through congested residential areas.

More recently, West Hawaii has experienced dynamic economic expansion and is reflected in an increased level of harbor activities at Kawaihae Harbor. While cargo capacities for containerized cargo volumes have expanded significantly, fuel shipments have not increased at the same rate. Due to the increased cargo operations, fuel transfer operations are increasingly competing with cargo operations for berthing space. The congestion problem is compounded because of its location in the central portion of Pier 2. This creates a conflict because Pier 2 can accommodate only two barges at one time.

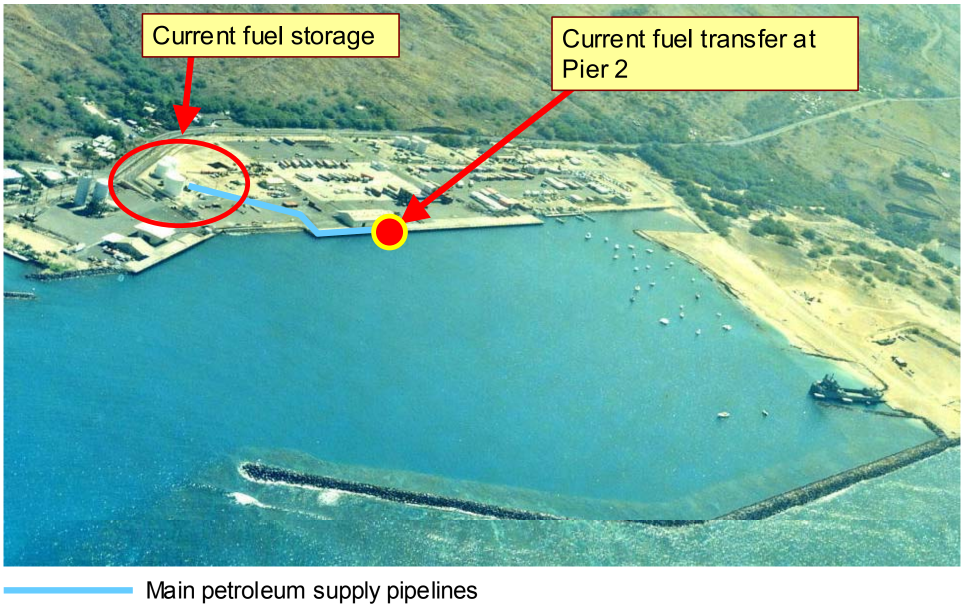
Figure 5-7 provides an aerial view of Kawaihae Harbor and shows the current fuel facilities in the harbor. Currently, two fuel companies operate fuel storage tanks on harbor property or in close proximity therefore. Only one tank farm, however, receives fuel through the fuel pier at Pier 2.

Current fuel-related harbor operations:

1. Off-loading fuel barges that arrive from Honolulu Harbor or Kalaeloa Barbers Point Harbor that carry petroleum fuel products.

2. Fuel barges are off-loaded at Pier 2.

Kawaihae Harbor is the other harbor that contains landside storage facilities within its boundaries. *Hawaii Island Commercial Harbors 2020 Master Plan* recommends an additional fuel storage site in the coral stockpile area, but this proposal will be re-evaluated during the update of the master plan.



5-7: Current Fuel Facilities in Kawaihae Harbor

5.2 Future Fuel Facilities Needs Identification

In the process of identifying optimization measures for the fuel facilities in the commercial harbors system, numerous discussions were conducted with various stakeholders. This included representatives from: Hawaii's petroleum industry, fuel shipping companies, the District Managers from each harbor and the evolving alternative fuel energy industry. (see Appendix A for a list of people interviewed for this study).

It was identified that future fuel facilities in the commercial harbors would have to address several types of challenges in order to safeguard a secure, safe and expeditious supply of fuel to the islands. Such challenges might determine a changing Hawaii fuel system and such challenges include increasingly strict environmental protection measures, post 9/11 security concerns, a fundamentally changing global oil market and the emergence of alternative fuels and renewable energy for Hawaii.

Hawaii's petroleum industry has been very effective in providing a secure supply of petroleum products for transportation and electricity generation over the past decades, while Hawaii's economy has been going through changes. The key to improvement of fuel facilities in the commercial harbors hinges on the ability to dovetail experiences of the fuel industry stakeholders and to accommodate evolving technologies and policies as well as manage implementation of alternative fuels.

Though the original scope of the project did not include alternative fuels such as biofuels and NG, several meetings were held to gain information about future needs and developments from pertinent industry stakeholders.

All commercial harbors that were assessed in this study have their own unique challenges and possible remedies, but a number of comments refer to general challenges. These general challenges are categorized and listed in the following:

1. <u>Increasing scheduling conflicts resulting from competition for berthing space and time.</u> Most of the stakeholders identify increased utilization of the commercial harbors as a prime obstacle to effective fuel related operations. Since fuel transfer can only occur at designated locations at the piers, increased port calls of ships and barges of varying lengths create competition for pier space and berthing time. Delays and adverse weather conditions during transit can result in substantial delays, which than cause scheduling conflicts with other vessels.

2. <u>Increasing competition with passenger ships.</u> The passenger industry has created a high demand on berthing space in a number of commercial harbors. In particular, the large size of the cruise ships coupled with demanding security and safety measures for passenger movement is causing significant logistical bottlenecks for cargo and fuel vessels.

3. <u>Landside constraints to expanded operations.</u> As in the case of general or containerized cargo operations, fuel facilities require adequate ancillary facilities to be effective. Fuel transfer requirements might be less demanding in terms of pier space and staging area, yet an effective fuel transfer in the commercial harbors requires adequate fuel transmission pipelines and landside storage tanks. Transmission pipelines and landside storage tanks require space in or near the harbor. The present Harbors Division's policy prefer fuel storage tanks be located outside the harbor boundaries, in order to minimize liabilities in the event of spills and fires. The advantage of liquid-bulk cargo transfer is that fuel can be easily and efficiently transported from the fuel piers to remote storage facilities through transmission pipelines, therefore the tanks can be located away from the commercial harbors, thereby reducing the demand for space within the harbors.

4. <u>Inability to accommodate the new generation of larger barges.</u> Many of the fuel transfer facilities in the commercial harbors system were designed and built long ago to support smaller fuel vessels. The new generation of barges is longer, wider and has greater draft requirements. Large capacity barges theoretically decrease the frequency of delivery and therefore decrease the operating costs and congestion within the commercial harbors system. However, because of their larger sizes, they may not fit into present harbor configuration. For example, while the dimensions of existing harbor piers might be suitable to accommodate two regular size barges (fuel barge and cargo barge), using a larger fuel barge, only the fuel barge might take up all the space thereby nullifying the advantages of larger barges altogether. In addition, large capacity barges require correspondingly large fuel storage capacity to off-load its greater cargo loads; otherwise the capacity advantage cannot be realized. Finally, larger barges also have

greater drafts in order to meet the double-hull safety requirements, which, at some piers in the commercial harbors, exceed the allowable draft.

5. Insufficient safety envelope around barges. Safe fuel transfer operations of large quantities of flammable and dangerous fuels in the commercial harbors require an adequate safety envelope (both in terms of physical distance and operational measures) around fuel vessels. In some instances a safe safety envelope is marginal or unsatisfactory, thereby creating unnecessary risks. It is desirable to establish sufficient space between fuel operations and other harbor uses.

6. Increasing numbers of fuel types. The number of types of petroleum and alternative fuels handled in commercial harbors system keeps increasing. This creates operation difficulties since some of the newer fuels require more sophisticated equipment and handling procedures. Some of the present and future fuels might require facilities and equipment that are not mutually compatible (e.g., materials for fuel conveyance and storage, fire suppression, spill prevention, water problems, etc.).

7. Stricter environmental standards and requirements. Some of the older fuel facilities were built under less demanding environmental standards and regulations. Newer environmental requirements call for more protection against harmful emissions emitted during fueling operations and accidental spills, such as spill containment and recovery as well as vapor control for fuels with higher vapor pressure.

8. Limited capability to directly import refined products to Hawaii. Most of the fuel imports to Hawaii occur as crude oil through the two Barbers Point offshore terminals. The crude oil is then refined in the two refineries at Barbers Point. A direct import of refined petroleum products is limited in quantity and frequency. Some quantity of jet fuel and LPG is imported to Hawaii rather than produced in the local refineries. Some stakeholders in Hawaii's fuel industry would prefer adequate fuel facilities in the commercial harbors to directly import various refined fuel products to Oahu and the neighbor islands.

9. No dedicated fuel piers to optimize fuel transfer operations. Dedicated fuel piers can provide unique opportunities to alleviate increasingly sophisticated fueling operations and scheduling conflicts with other harbor operations. Dedicated fuel piers can be more easily optimized for effective fuel transfer operations than piers that are shared with other cargo operations.

10. Barriers to finance new fuel transfer equipment. While it is advantageous to invest into more effective and state-of-the-art fueling systems, stakeholders expressed the concern that much of the fuel infrastructure in the harbors were installed by individual companies and that changes in the configuration of the fuel piers might bring about renewed need for costly investments. While many of the general cargo loading operations can be shifted from one location to the next, without excessive investment into new cargo handling infrastructure, fuel transfer equipment cannot be modified or moved easily, since the piping infrastructure is fixed in location. Replacing fuel infrastructure before their expected lifetime is over is perceived as an unreasonable financial burden.

11. Challenges to determine where individual ownership of fuel facilities ends and where common fuel facilities begin. Difficulty in implementing new fuel facilities with fuel components that are commonly shared by different fuel companies. Several stakeholders recognize the fact that future fuel facilities will be more sophisticated than the existing facilities (some are several decades old) and will require measures that are only cost effective when shared by multiple users (e.g., vapor control system, advanced fire suppression systems, fuel booster pumps, advanced ship-to-shore fuel transfer like loading arms, etc.). It is, however, perceived that it will be important to clearly define the point in the system (e.g., downstream from the ship-shore fuel transfer) from where the individual fuel companies operate own equipment. A solution might be to operate fuel facilities that are commonly shared by consortia or other appropriate entities. The current policy of the Harbors Division is to have the entire fuel infrastructure installed and operated by the fuel companies. It should be analyzed if it is be more effective to have the State install such facilities and recover the costs through appropriate harbor fees.

12. The need for more flexible scheduling to accommodate delays due to weather and other factors. A considerable challenge to the scheduling of fuel barges is the effects of delays. For example, when due to a schedule conflict on Oahu a fuel barge cannot leave in time to make the scheduled port call in the neighbor island harbor destination, long delays are sometimes unavoidable. Since the on-time fuel loading in Kalaeloa Barbers Point Harbor or Honolulu Harbor represent an important prerequisite for being on schedule in the ports on Kauai, Maui and Hawaii, measures (such a dedicated fuel pier in Kalaeloa) are important to ensure on-time loading at harbors at Kalaeloa and Honolulu.

13. The need to promote greater awareness about importance of fuels for Hawaii's economic heath. Stakeholders in Hawaii's fuel system regard it as unfortunate that the real importance of Hawaii fuel shipping remains somewhat clouded. Though containerized cargo is frequently perceived as the driver for harbor expansion and improvement, fuel shipments are crucially important for the wellbeing of Hawaii's economy. While an interruption of cargo operations in the commercial harbors has short-term negative economic consequences, an interruption of the fuel supply to the islands would quickly and severely interrupt power supply and transportation, since stocks are often not sufficient to sustain normal operations during a prolonged interruption of fuel shipments. Although fuel transfer is often regarded as "simple" due to the ease of pumping fuel from the vessels rather than unloading containers, fuel transfer requires a significant safety envelope and sophisticated technology and operational methodology.

14. Required are sweeping and expeditious solutions in order to safeguard security of fuel supply to Hawaii. Several stakeholders pointed to the need for short-term improvements in the fuel facilities in the commercial harbors system, in order to avoid operating beyond facility capacities. The concern was voiced that even to remain at the current level of fuel shipments requires immediate attention and improvements in the fuel handling capacities. In order to safely manage anticipated future increases in fuel quantity and fuel diversity, the fuel facilities in commercial harbors system will have to be improved significantly and expeditiously.

15. Provide opportunities to install fuel facilities for biofuels and biofuel feedstocks as well as adequate storage facilities. Since the State of Hawaii strongly supports the development of the biofuels industry, it is of great importance to have adequate biofuels transfer and storage facilities in place before shipment commences. It was stated that the fuel industry should not carry the entire burden and risks of infrastructure investment to safeguard that appropriate biofuels facilities are in place.

SECTION SIX

FUEL FACILITIES ALTERNATIVES

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SECTION SIX

FUEL FACILITES ALTERNATIVES

Section Six presents the range of alternatives that have been identified in the Fuel Development Plan for each of the seven commercial harbors. These alternatives were developed based on the identified needs of the fuel shipping industry and the competing uses within the commercial harbors system. In addition, environmental safety, post-9/11 security concerns, developments in the global oil markets and evolving needs for alternative fuels were also considered.

6.1 Fuel Facility Alternatives in Honolulu Harbor

Before Kalaeloa Barbers Point Harbor and Hawaii's refineries were built, Honolulu Harbor provided the only facilities for refined fuel imports and inter-island fuel distribution. Honolulu Harbor was the fuel hub of the islands. After Hawaii's refineries were built, the state's fuel system changed, where significantly less refined products were imported and most of the petroleum supply for Hawaii was imported as crude oil and then refined. Today, the two refineries are located at Barbers Point on Oahu. A system of interconnecting transmission pipelines, known as the "Energy Corridor", was built to connect Barbers Point with Honolulu Harbor and other users to efficiently transport petroleum products for electrical generation and transportation. Fuel shipments between the islands still were carried out solely from Honolulu Harbor until Kalaeloa Barbers Point Harbor was constructed and went into operation.

Based on its proximity to the main source and storage of refined petroleum products and the growth potential, Kalaeloa Barbers Point Harbor is well situated to become the new hub for fuel shipments on Oahu and the rest of the state. If this was to occur, Honolulu Harbor's role would become relegated as the secondary harbor for fuel transport, but would still be crucially important the fuel system's back-up.

6.1.1 Identification of Fuel Facility Alternatives

In Honolulu Harbor, the present fuel transfer operations are carried out at Pier 30 and at Pier 51 (only for jet fuel; Pier 30 is privately owned). Piers 31 and 32 contain bunkering lines that provide fuel for commercial vessels.

Since Honolulu Harbor is the state's containerized cargo hub and is dealing with increasingly congested conditions, no new fuel facility locations were identified at this time. Current plans call for the development of a container terminal at the former-Kapalama Military Reservation area, across the channel from the present container terminal at Piers 51 to 53. This new development should increase the berthing availability at the existing fuel hatches at Pier 51.

While the fuel loading at Piers 30 to 32 emits certain Volatile Organic Compounds (VOC) and Hazardous Air Pollutant (HAP) emissions during vessel loading operations, it is not certain that these existing fuel piers would require a vapor control system. Any modifications, however, to the existing fuel pier would certainly warrant a closer look whether or not vapor control is required.

Summarizing, no new or updated fuel transfer capacities have been identified for Honolulu Harbor since it is anticipated that the capacity and variety of fuel shipments in and out of the

Harbor will not significantly increase in future. Expanding fuel transfer capacities in Honolulu Harbor is therefore considered not necessary. In the event that most of the fuel shipments will be shipped out from Kalaeloa Barbers Point Harbor in the future, Honolulu Harbor would still retain an important the back-up function. Therefore, fuel facilities in Honolulu Harbor should be maintained in the current capacities, even if Kalaeloa Barbers Point Harbor becomes the primary fuel transfer harbor on Oahu.

6.2 Kalaeloa Barbers Point Harbor

Kalaeloa Barbers Point Harbor was originally developed as the reliever harbor to augment Honolulu Harbor's capacity. Over the past decade, the volume of fuel shipments, both fuel product imports and inter-island shipments has significantly grown. Today, it is the top harbor in terms of increases in liquid-bulk cargo.

In the new fuel system, Kalaeloa Barbers Point Harbor continues to serve as the primary fuel handling harbor for importing refined fuels and biofuel feedstock, as well as for exporting various fuel products and biofuels. Its proximity to the two refineries with their comprehensive fuel infrastructure, the availability of undeveloped area to add harbor capacity and available lands for alternative fuel production suggests that Kalaeloa Barbers Point Harbor is ideally suited to serve as the hub for Hawaii's fuel system.

6.2.1 Design Framework for the Future Fuel Facilities

Considering the three energy design schemes described in Section 4, Kalaeloa Barbers Point Harbor could provide the following future fuel-related functions:

1. Loading fuel barges for the shipment of petroleum products (including liquefied petroleum gas [LPG]) to the neighbor islands.
2. Unloading Handysize to Panamax tankers, that bring petroleum products and LPG (mostly propane) to the islands.
3. Loading Handysize to Panamax tankers, that export refined petroleum products produced locally to remote markets outside of Hawaii.
4. Unloading Handysize to Panamax tankers, that bring biofuel feedstock to Oahu (e.g., palm oil, molasses).
5. Loading and unloading barges that transport biofuel feedstock between the islands.
6. Loading and unloading barges that transport biofuels between the islands.
7. Loading compressed natural gas (CNG) barges to distribute it to the neighbor islands, as a future option.

It is anticipated that the range of types of fuels to be handle in the future will include the following:

1. Clean petroleum products (including conventional and evolving), possibly some “dirty” fuels such as residual fuels for power plants.

2. Non-petroleum products (e.g., ethanol, biodiesel, biofuel feedstock such as vegetable oil, molasses, etc.).

3. LPG (i.e., propane, butane).

4. Possibly CNG in the future.

For the seven fuel-related functions above, the future fuel pier would have to be able to accommodate the following vessel types (please note that the vessel type 4 described below represents a new fuel technology, which would be applicable only in the event that NG is introduced in Hawaii):

1. Double-hull fuel barge: 400-foot long by 80-foot wide by 28-foot deep draft, capacity of approximately 80,000 barrels.

2. Gas barge: 246-foot long by 46-foot wide by 12-foot deep draft; capacity of approximately 16,000 barrels.

3. Handysize Tankers: 600-foot long by 95-foot wide by 34-foot deep draft, capacity of approximately 225,000 barrels and small Panamax Tanker: 720-foot long by 106-foot wide by 38-foot deep draft, capacity of approximately 420,000 barrels.

4. CNG barge (evolving shipping technology): unknown dimensions and capacity.

Figure 6-1 illustrates the recommended location of the new fuel facilities in the Kalaeloa Barbers Point Harbor at Piers P-3 and P-4. Currently, a ship repair company uses the area and this operation would have to be relocated to another site.

The advantages of choosing this location are as follows:

1. The harbor stakeholders recommended this location in the *Oahu Commercial Harbors 2020 Master Plan*.

2. This location is undeveloped in terms of pier infrastructure and therefore an available area for new pier developments.

3. This location is in close proximity to the existing transmission pipelines and construction costs would be minimized to extend these pipelines.

4. The recommended location is close to the harbor entrance and separated from cargo handling operations at Piers P-5 to P-7, which increases operational safety during fuel transfer operations.

5. Since the prevailing winds are coming from the northeast, possible fuel spills would be confined to and intercepted at the fuel berths at Piers P-3 and P-4 and would not drift into the inner harbor, thereby mitigating the environmental and operational risk potential.

6. This location would be further away fro residential units located to the north of Kalaeloa Harbor

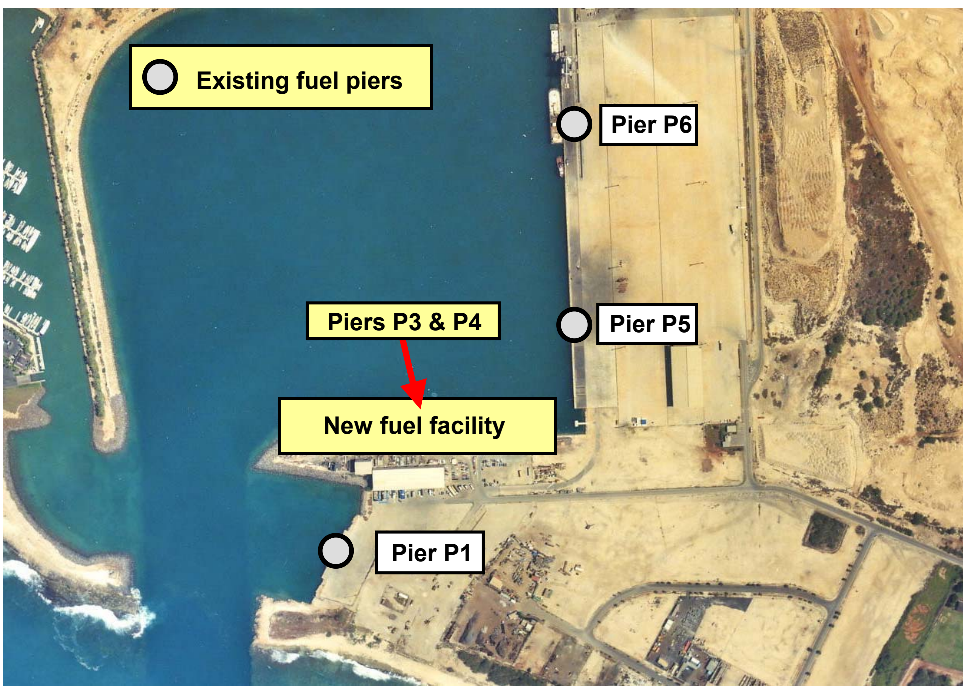


Figure 6-1: Recommended Location of New Fuel Piers - Kalaeloa Barbers Point Harbor

6.2.2. Proposed Fuel Pier

The total length of Piers P-3 and P-4 is about 1,350 feet, which would allow for the construction of two fuel berths. In this design, one small tanker and one large fuel barge (or two large fuel barges) could be accommodated simultaneously. In addition, there would be ample room for ancillary facilities around the pier area. Three ancillary fuel facilities alternatives are presented.

Figures 6-2 and 6-3 show the site plan and the detail layout for the proposed configuration, respectively. The fuel piers at Pier P-3 and P-4 would be dedicated to fuel handling only. Therefore, fuel transfer at Piers P-5 and P-6 would serve as backup facilities depending on the availability of the dedicated facility. Since the pier system would be dedicated to fuel transfer, it is recommended that a protruding segmented pier configuration be used, using a series of breasting and mooring dolphins.

Near the corner between Piers P-4 and P-5 is a small finger pier for a utility boat, which is used, among other activities, to contain and recover spilled fuel.

The recommended location for Fuel Berth 1 is at Pier P-4. Berth 1 would be developed first because it could accommodate fuel vessels from a large barge to a small Panamax tanker with a length of 720 feet. The pier face would be established by the straight alignment of four breasting dolphins against which the fuel vessels could rest against while fuel transfer is carried out. The fuel transfer platform supports the loading arms, which provide a safe ship-to-shore connection. The forward side of the fuel transfer platform is placed back from the breasting line so that fuel barges or the tanker actually do not touch the fuel transfer platform. For fuel transfer operations the fuel barges or tanker are positioned in such a way that their onboard fuel pipelines, located amidships, would be within reach of the loading arms. Secured berthing would be accomplished by several bollards located on land and on the breasting dolphins. Shore-side access and gangway landing would be available on a walkway that is suspended between two breasting dolphins. Two of the breasting dolphins would be accessed from landside via these shore-side access platforms. The other breasting dolphins would be accessed from landside via a catwalk and they would also be inter-connected by a catwalk.

Fuel Berth 1 would have two remotely controlled fire suppression monitors, which could distribute different types of foams to combat different product fires on the loading platform and on the fuel vessel. In addition, several fire hydrants would be placed directly at the fuel berths to provide fire-suppression water or to cool equipment.

The recommended location for Fuel Berth 2 is at Pier P-3. If construction is done in phases, Berth 2 would be built last. It is designed to accommodate a large fuel barge up to 400 feet long. The design details are the same as above.

Figure 6-4 shows several typical cross-sections of the layout shown in Figure 6-2. Sections A-A and B-B show the configuration of Fuel Berth 2. In Section A-A, the barge would rest against a breasting dolphin, which would be connected to shore by a catwalk. The breasting dolphins would have the necessary vertical and battering piles to take the impact and breasting loads of the design fuel barge.

Section B-B shows the fuel transfer platform with the loading arm. These pipelines would connect to the fuel pier transmission pipeline system on shore. Because the fuel transfer platform does not touch the fuel barge, the piling system would have to accommodate lower loads than the breasting dolphins.

Section C-C shows a typical cross-section of Fuel Berth 1 with a small Panamax tanker resting against one of the breasting dolphin.

Configuration and outfitting of the Fuel Berths 1 and 2 are given in the following pages as follows:

Fuel Berth 1 would have the following components:

1. There would be four breasting dolphins in series with mooring bollards and fendering systems. Two breasting dolphins would have disembarkation platforms attached to them to allow safe access to the fuel barge.

2. Catwalks between each breasting dolphin and shore-side would provide access.

3. Four mooring bollards would be built on land using sheeted bulkhead structures and with shore-side access.

4. A fuel transfer platform (recessed from the breasting line) with a roadway from shore-side that would provide access for a maintenance truck to the fuel loading arms.

5. Fuel loading arms, which can serve Panamax tankers and fuel barges, would establish safe and efficient shore-to-ship fuel transfer connections. This would be either single- or dual-product loading arms. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

6. A fire suppression system with two fixed foam monitors (using seawater) would be installed on Piers 3 and 4. Different types of foam would be required for different fuels to be handled. The fixed foam monitors would be installed on shore-side at suitable locations to allow good working coverage of foam spray on the fuel berth.

7. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

8. A central fuel monitoring system (fuel flow, pressures, temperatures, etc.) would inform the operator about fuel transfer progress. The fuel monitoring system would be equipped with alarms for certain high or low controls functions.

9. Two-stage alarm system would alert the operator to stop pumping fuel when the unloading arms near its limits of reach or when the mooring line loads are near its limits of loading capacity.

10. Real-time environmental monitoring system would observe wind, current, waves, and seismic conditions.

11. An emergency shutdown system could be activated from the central point or at the pier.

12. A vapor control system with piping would collect fuel vapor from the fuel vessels and convey it to the vapor treatment system.

13. Dredging to a continuous depth of 42 feet along the fuel pier (assuming that the harbor basin is dredged to such).

Like Fuel Berth 1, Berth 2 is similar except in the following ways:

1. A disembarkation platform would be suspended between two breasting dolphins.

2. Fuel loading arms with smaller pipe diameters than Fuel Berth 1 to serve fuel barges would establish safe and efficient shore-to-ship fuel transfer connections. This would be either single- or dual-product loading arms. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

In addition, there are a number of common pier components and ancillary facilities that serve both fuel berths. The common facilities include:

1. A vapor control system would collect fuel vapor, which could be subject to federal guidelines. This system would process the collected vapor in a vapor incinerator.

2. Electrical powered shore-side pumps, designed to reduce tanker energy requirements to offload cargos. This would result in reduced fuel usage and emissions from the tankers.

3. A central fire control system would control the fire pumps, which would supply seawater to the water-foam generators and which also would control the foam monitors.

4. Marine fuel loading arms would provide safe and efficient shore connections. Either single-product or dual-product loading arms would feature the following benefits:

    a. Increased safety against accidental spills.

    b. Fast connection of shore-to-ship fuel transfer pipes – manual/hydraulic quick connect.

    c. Remote connect and disconnect for more personal safety.

    d. Faster loading operation, higher pressure/flow velocity and higher flow rates.

        i. Less maintenance than flexible transfer hoses, elimination of wear and tear, more efficient than transfer hoses.

5. Emergency release coupling with spill preventer.

6. Spill protection equipment; including oil spill booms (deployed during tanker offloading operations), utility boats for containment boom deployment, and easily accessible supplies of emergency oil spill equipment (absorbents, protective clothing, etc.).

6.2.3 Ancillary Facilities Conceptual Design Alternatives

Vital support functions for the fuel transfer operation at the new fuel pier would be supported by several ancillary facilities, located adjacent to the fuel pier. Three alternative layouts for ancillary facilities presented would provide various pipelines, storage facilities and other fuel infrastructure in support of the new fuel pier system.

Under Alternative A, the space in the immediate vicinity to the fuel pier would be used to either store or process biofuels or marginal fuels (the term marginal fuels refers to innovative fuels other than biofuels, which are introduced to Hawaii's energy market by companies other than the established fuel companies). Alternative A proposes a tank farm for biofuels or marginal fuel. The tank farm would provide essential fuel storage capacities that is otherwise not available at the moment.

For Alternatives B and C, the space adjacent to the fuel pier would not be used for fuel related operations, but instead would be available to support other cargo operations. The pipeline system that connects the new fuel piers with the existing fuel system in the harbor crosses the space in below-ground transmission pipelines. Alternatives B and C differ in the manner the product pipelines are installed, either as above- or below-ground systems.

6.2.4 Ancillary Facility Alternative A

Figure 6-5 depicts Alternative A. If this scenario is used, the land adjacent to the new fuel piers would accommodate a new tank farm system that could provide storage capacities for biofuels, its feedstock or other high-quality fuels. The tank farm would comprise of several above-ground tanks with a total storage capacity of about 130,000 barrels. The tank farm would have containment walls to limit potential fuel spills. The entire tank facility would be equipped with a suitable fire suppression system comprised of fixed and manually operated foam monitors. Centralized controls would provide real time data access of relevant process parameters of the tank storage facilities.

A fuel pumping station would provide hydraulic head for more efficient fuel discharge operations. Electrical-powered shore-side pumps would reduce tanker energy requirements to offload cargos resulting in reduced fuel usage and emissions from the fuel vessels during offloading operations.

An administration building would contain controls, as well as security and product quality assurance facilities. A parking lot would be situated outside the perimeter fence. The fuel facility would be a secure facility and equipped with perimeter security fencing and video monitoring system. Access to the facility would be controlled and visitors would have to pass through a security gate.

The fuel facility would provide a holding tank for waste oil and oily water that is collected from tankers and barges during loading and maintenance activities. These waste products would be held until appropriate treatment could occur or until the waste oil and oily water could be safely disposed of. A vapor recovery unit or a vapor incinerator would be provided to safely discharge fuel vapors that are collected by the vapor control pipeline system.

The product transmission pipelines within the boundaries of the fuel facility could be installed above-ground on pipeline racks. This would reduce the installation and maintenance costs and adds flexibility to the pipeline arrangements inside the facility limits. Outside the facility boundary, the transmission pipelines would connect the new fuel pier with the existing fuel system in the harbor and would be installed in below-ground pipeline gallery.

The installation of the transmission pipelines on pipeline racks and pipeline galleries would result in flexible and cost-effective construction and maintenance. Figure 6-8 and 6-9 show details of the typical configurations of pipeline racks and pipeline galleries, respectively, which are considered for the new fuel pier facilities. Some of the transmission pipelines would have to be insulated and/or heated to convey viscous fuel or liquid agents for fuel processing.

6.2.5 Ancillary Facility Alternative B

Figure 6–6 shows Alternative B. In Alternative B, the ancillary facilities would be limited to the essential support functions of the fuel pier only. The space that was used for fuel storage or fuel processing in Alternative A is now used for other harbor operations.

A fuel pumping station would provide hydraulic head for more efficient fuel discharge operations. Electrical-powered shore-side pumps would reduce tanker energy requirements to offload cargos resulting in reduced fuel usage and emissions from the fuel vessels during offloading operations.

An administration building would contain controls, as well as security and product quality assurance facilities. A parking lot would be situated outside the perimeter fence. The fuel facility would be a secure facility and equipped with perimeter security fencing and video monitoring system. Access to the facility would be controlled and visitors would have to pass through a security gate.

The fuel facility would provide a holding tank for waste oil and oily water that is collected from tankers and barges during loading and maintenance activities. These waste products would be held until appropriate treatment could occur or until the waste oil and oily water could be safely disposed of. A vapor recovery unit or a vapor incinerator would be provided to safely discharge fuel vapors that are collected by the vapor control pipeline system.

The product transmission pipelines within the boundaries of the fuel facility could be installed below-ground in pipeline galleries. This would reduce the installation and maintenance costs and adds flexibility to the pipeline arrangements inside the battery limits.

The installation of the transmission pipelines on pipeline racks and pipeline galleries would result in flexible and cost-effective construction and maintenance of it. Figure 6-8 and 6-9 show details of the typical configurations of pipeline racks and pipeline galleries, respectively, which are considered for the new fuel pier facilities. Some of the transmission pipelines would have to be insulated and/or heated to convey viscous fuel or liquid agents for fuel processing.

6.2.6 Ancillary Facility Alternative C

Figure 6–7 shows Alternative C. Alternative C differs from Alternative B only to the extent that the process and interconnecting piping inside the fuel facility are installed aboveground on pipeline racks

6.2.7 Proposed Configuration of Pipeline Racks and Pipeline Galleries

Figure 6-8 shows the configuration a typical pipeline rack system that could be used for the ancillary facilities. The pipeline rack system would accommodate up to 15 product pipelines. The pipelines would be supported approximately every 20 feet by steel frames, which would be anchored in the ground. Thermal (axial) stress compensation of pipelines (due to varying process temperatures in some fuels) would be accommodated by directional changes of pipeline alignment or mechanical expansion joints. The pipeline racks would feature inspection catwalks for maintenance and regular inspections. Access ladders would be provided every 90 to 100 feet to allow ready access to the interior catwalk. The space below the pipeline racks could be sealed to avoid ground contamination from leaking transmission pipelines. The capacity of pipeline racks could be increased by adding pipeline support brackets on the outside of the support frames opposite the access ladders.

Pipeline installation on pipeline racks is a common and safe design feature used in the chemical and petrochemical industries. Pipeline installation on pipeline racks add significant flexibility and cost effectiveness for construction and maintenance. It is anticipated that the new fuel facilities at Piers P-3 and P-4 will go though significant changes after completion in the coming years as new types of fuels are introduced to the market or volume of specific fuels change.

Figure 6-9 shows a typical configuration of a pipeline gallery, which would accommodate fuel pipelines within the new fuel facility at Piers P-3 and P-4 (in Ancillary Alternative B) and the interconnecting pipelines that connect the fuel facility at Piers P-3 and P-4 with the existing fuel piping system in the harbor.

The pipeline gallery is basically a concrete trough with pipeline supports on which the pipelines are installed. The covers of the pipeline gallery would be made of concrete slabs with removable sections in appropriate distances to allow access for construction. The pipeline gallery would be accessed by secured manholes (access hatches) located at appropriate distances. The pipeline gallery features room for a central inspection pathway with adequate head and side clearance. The space above the pipeline gallery could be used for regular harbor operations, provided that the cover of the pipeline gallery provide enough structural strength.

Typically, the pipeline gallery would feature sensors that provide alarm and control capabilities to detect dangerous vapors or leaking product lines.

Pipeline installations in pipeline galleries are common and safe design features in the chemical and petrochemical industries. Pipeline installations in pipeline galleries add significant flexibility and cost effectiveness for construction and maintenance. It is anticipated that the new fuel facilities at Piers P-3 and P-4 will go though significant changes after completion in the coming years, as new types are added and volume of fuels are increasing.

Figure 6-2 : CONCEPTUAL DESIGN - FUEL FACILITIES - SITE PLAN
Kalaeloa Barbers Point Commercial Harbor, Oahu

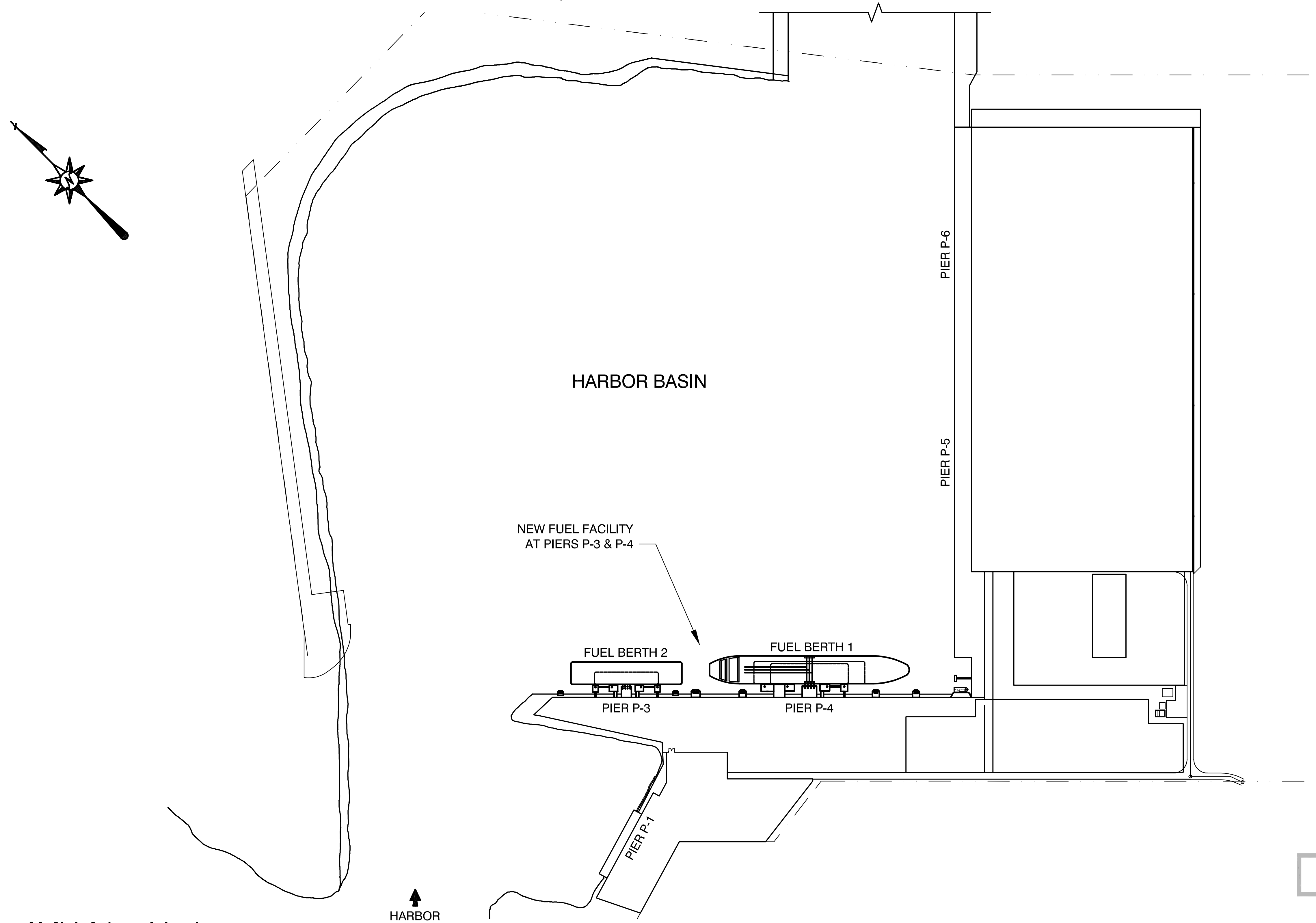


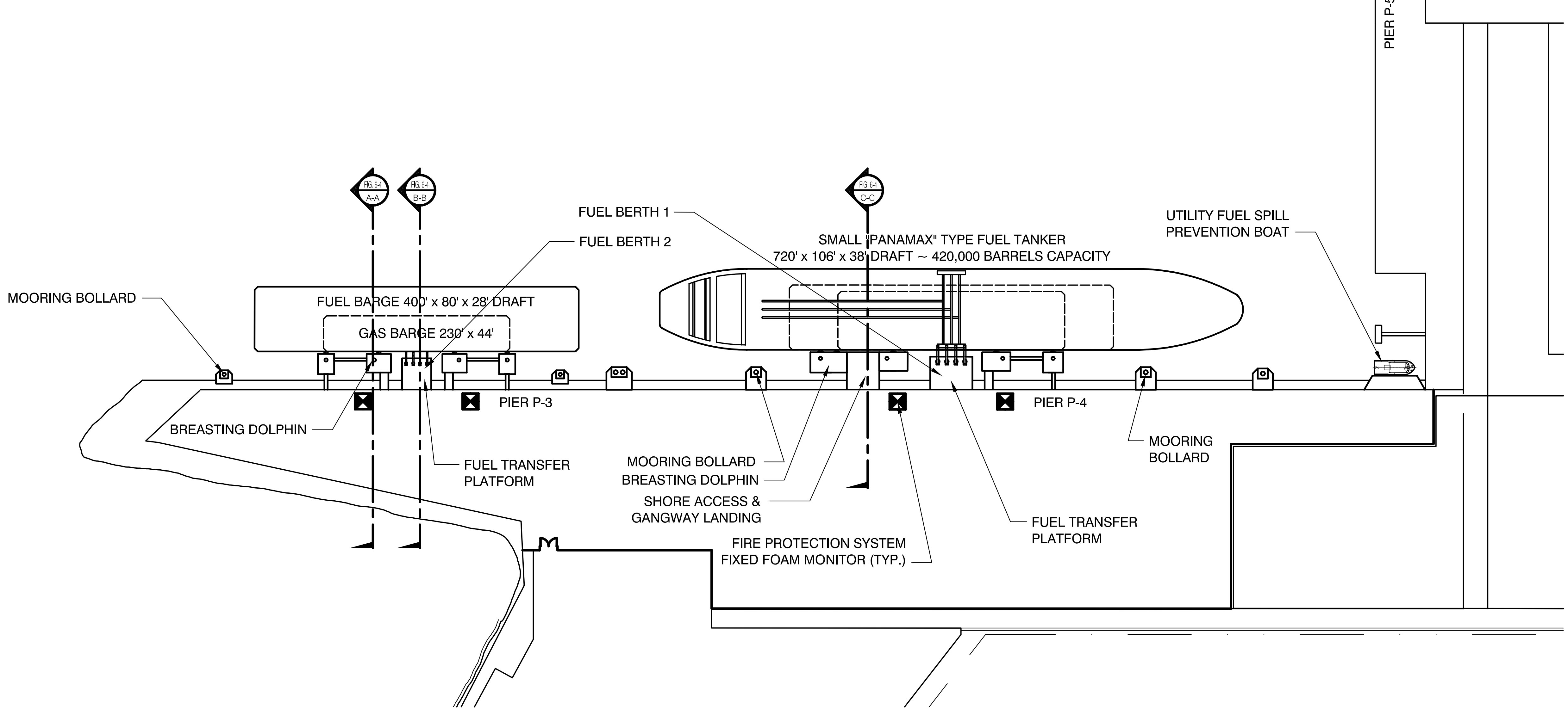
FIGURE 6-2

Marc M. Siah & Associates, Inc.
Consulting Civil . Structural . Environmental & Ocean Engineers
820 South Beretania Street, Suite 201, Honolulu, Hawaii 96813 TEL. 538-7180 FAX: 528-4352

GRAPHIC SCALE:
400' 0 400' 800'
SCALE: 1" = 400'-0"

DWG: J:\1244\dwg\Presentation-4_Revised\KALAELOA (12-10-07)\Figure 6-2.dwg USER: nsantos
DATE: May 22, 2008 2:09pm XREFS: 1244-x-TBK Kalaeloa 11x17 1244-x- Kalaeloa2 IMAGES:

Figure 6-3 : CONCEPTUAL DESIGN - FUEL FACILITIES - DETAIL PLAN
Kalaeloa Barbers Point Commercial Harbor, Oahu



DWG: J:\1244\dwg\Presentation-4_Revised\KALAELOA (12-10-07)\Figure 6-3.dwg USER: nsantos
DATE: May 22, 2008 2:10pm XREFS: 1244-x-TBK Kalaeloa 11x17 1244-x- Kalaeloa2 IMAGES:

FIGURE 6-3

GRAPHIC SCALE:

150' 0 150' 300'

SCALE: 1" = 150'-0"

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Figure 6-4 : CONCEPTUAL DESIGN - FUEL FACILITIES - DETAIL SECTION
Kalaeloa Barbers Point Commercial Harbor, Oahu

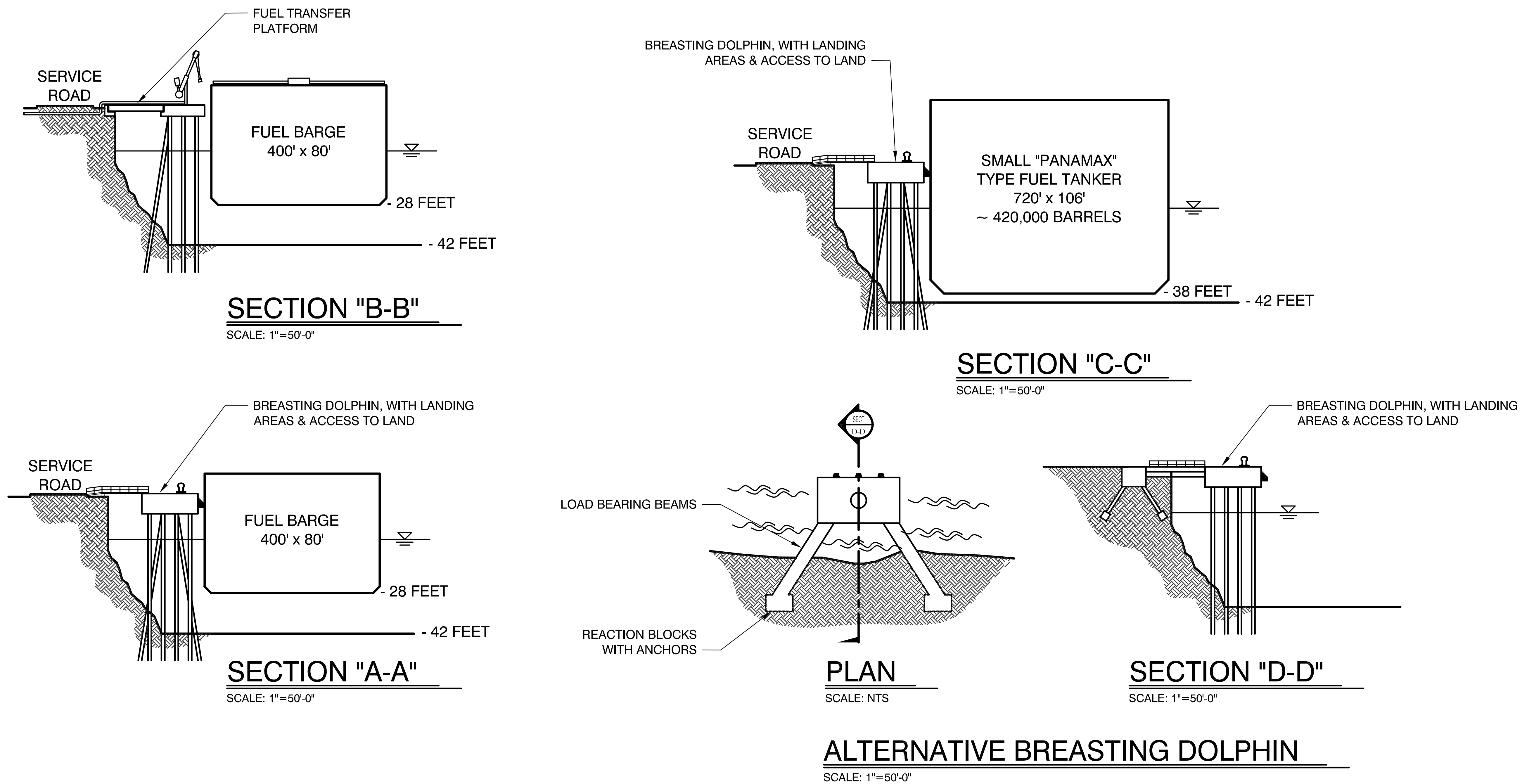

FIGURE 6-4

Marc M. Siah & Associates, Inc.
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820 South Beretania Street, Suite 201, Honolulu, Hawaii 96813 TEL. 538-7180 FAX: 528-4352

GRAPHIC SCALE:
50' 0 50' 100'
SCALE: 1" = 50'-0"

DWG: J:\1244\dwg\Presentation-4_Revised\KALAELOA (12-10-07)\Figure 6-4.dwg USER: nsantos
DATE: May 22, 2008 2:13pm XREFS: 1244-x-TBK Kalaeloa 11x17 IMAGES:

Figure 6-5 : CONCEPTUAL DESIGN - FUEL FACILITIES - ANCILLARY FACILITY ALTERNATIVE A - DETAIL PLAN
Kalaeloa Barbers Point Commercial Harbor, Oahu

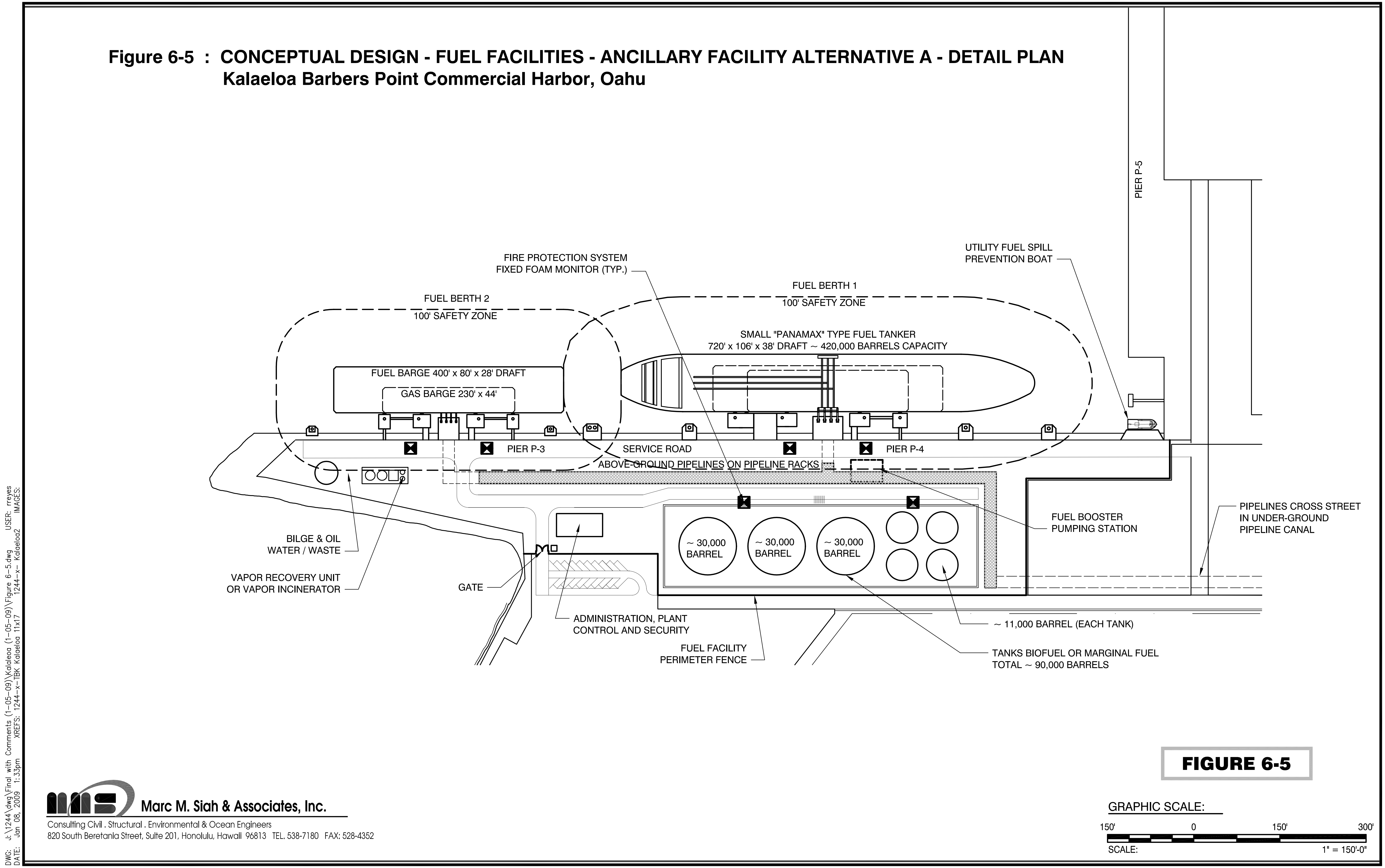

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Figure 6-6 : CONCEPTUAL DESIGN - FUEL FACILITIES - ANCILLARY FACILITY ALTERNATIVE B - DETAIL PLAN
Kalaeloa Barbers Point Commercial Harbor, Oahu

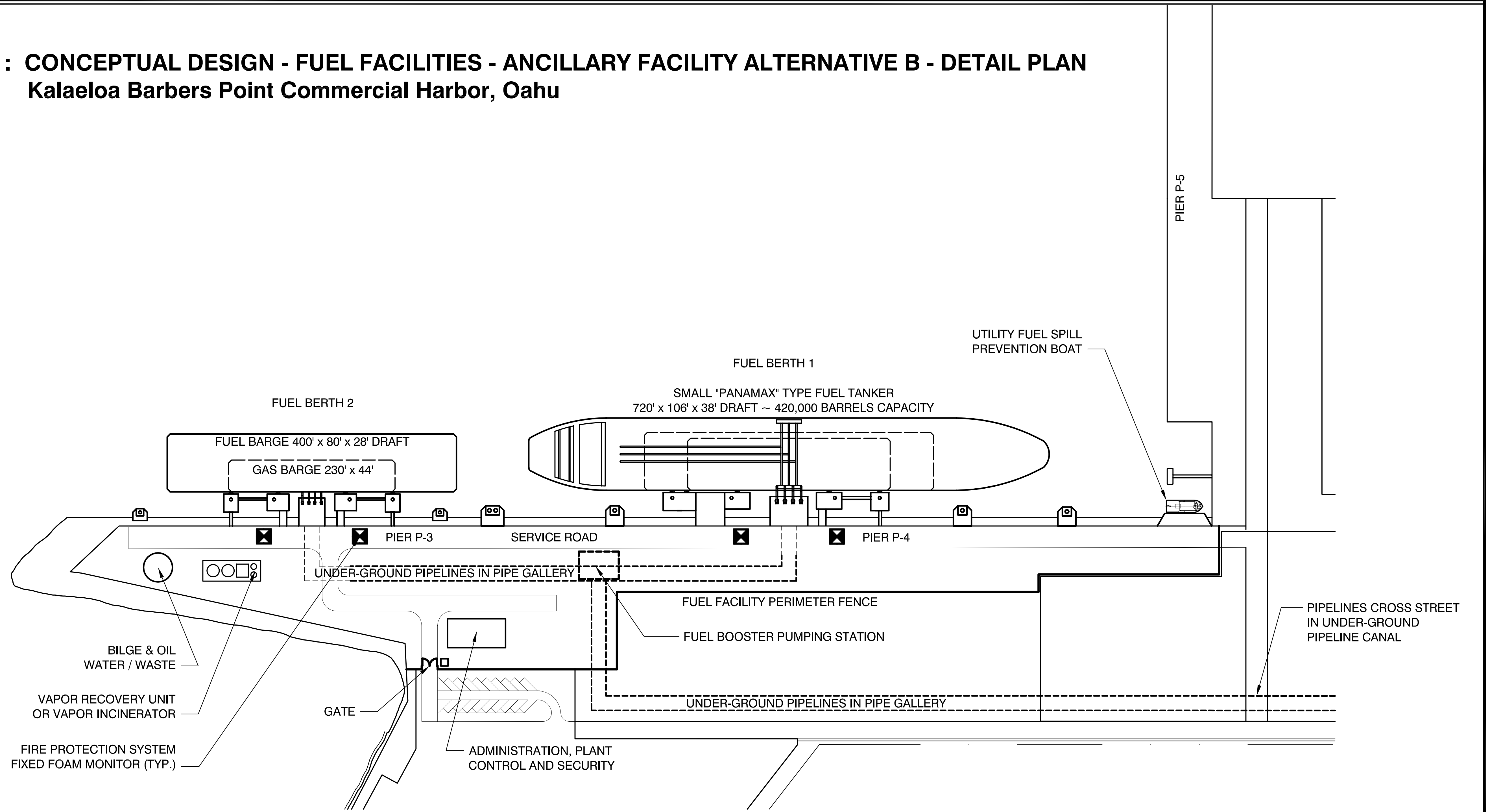

FIGURE 6-6

GRAPHIC SCALE:
150' 0 150' 300'
SCALE: 1" = 150'-0"

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DWG: J:\1244\dwg\Final with Comments (1-05-09)\Kalaeloa (1-05-09)\Figure 6-6.dwg USER: rreyes
DATE: Jan 08, 2009 1:35pm XREFS: 1244-x-TBK Kalaeloa 11x17 1244-x- Kalaeloa2 IMAGES:

Figure 6-7 : CONCEPTUAL DESIGN - FUEL FACILITIES - ANCILLARY FACILITY ALTERNATIVE C - DETAIL PLAN
Kalaeloa Barbers Point Commercial Harbor, Oahu

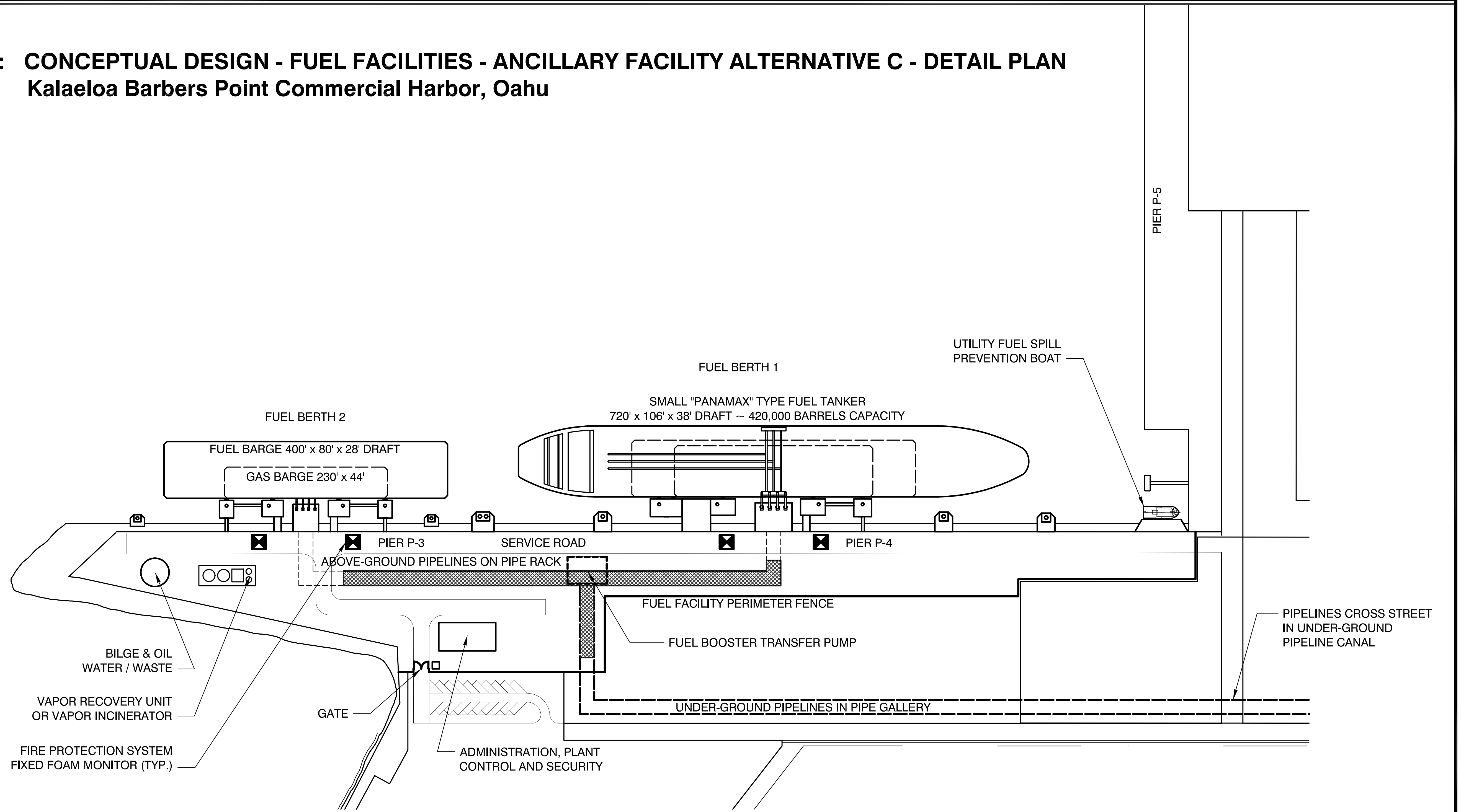

FIGURE 6-7

GRAPHIC SCALE:
150' 0 150' 300'
SCALE: 1" = 150'-0"

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DWG: J:\1244\dwg\Final with Comments (1-05-09)\Kalaeloa (1-05-09)\Figure 6-7.dwg USER: rreyes
DATE: Jan 08, 2009 1:38pm XREFS: 1244-x-TBK Kalaeloa 11x17 1244-x- Kalaeloa2 IMAGES:

Figure 6-8 : CONCEPTUAL DESIGN - FUEL FACILITIES - PIPELINE RACK DETAILS
Kalaeloa Barbers Point Commercial Harbor, Oahu

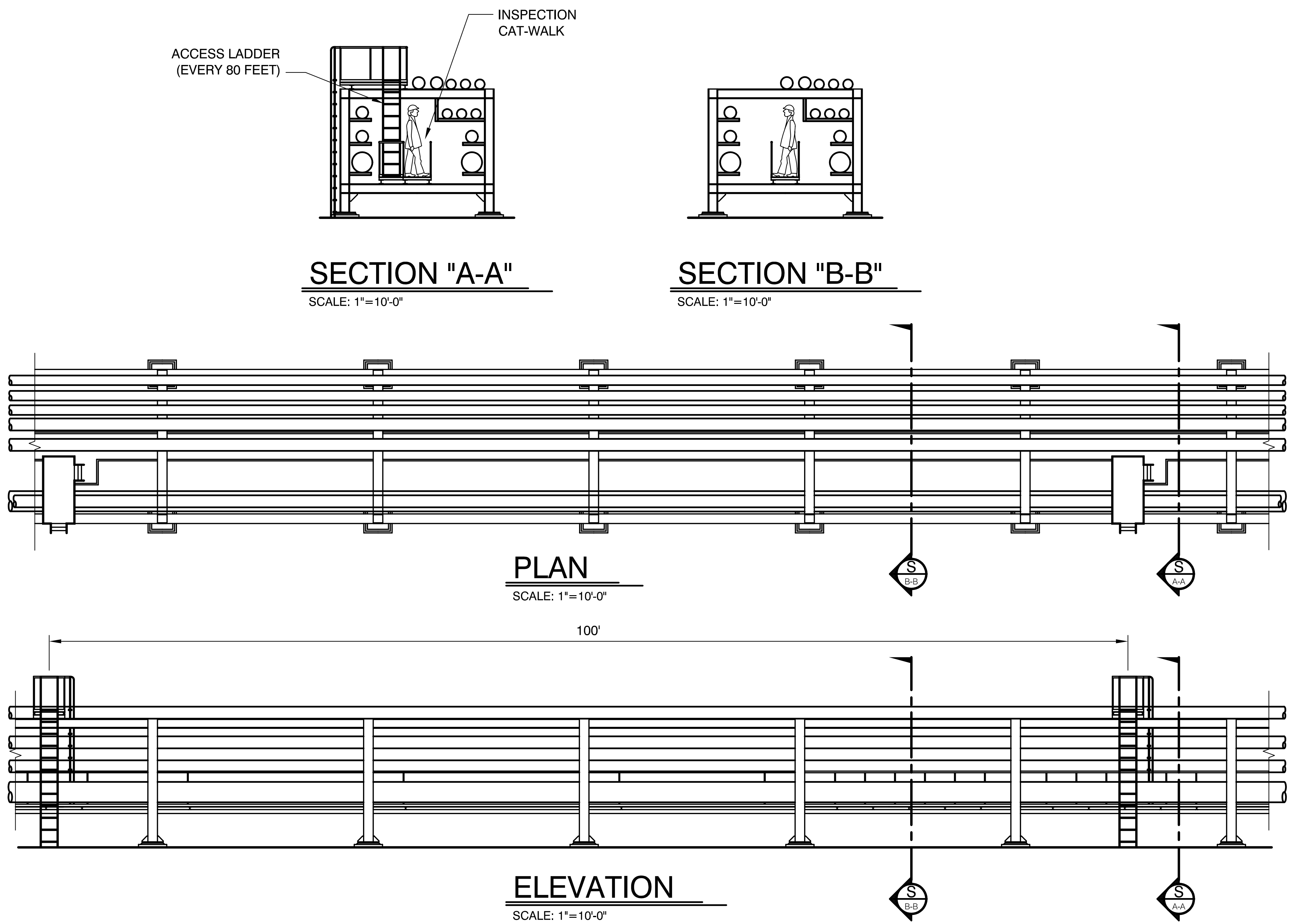

FIGURE 6-8

GRAPHIC SCALE:

10' 0 10' 20'

SCALE: 1" = 10'-0"

Marc M. Siah & Associates, Inc.
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DWG: J:\1244\dwg\Presentation-4_Revised\KALAELOA (12-10-07)\Figure 6-8.dwg USER: nsantos
DATE: May 22, 2008 2:29pm XREFS: 1244-x-TBK Kalaeloa 11x17 IMAGES:

Figure 6-9 : CONCEPTUAL DESIGN - FUEL FACILITIES - PIPELINE GALLERIES DETAILS
Kalaeloa Barbers Point Commercial Harbor, Oahu

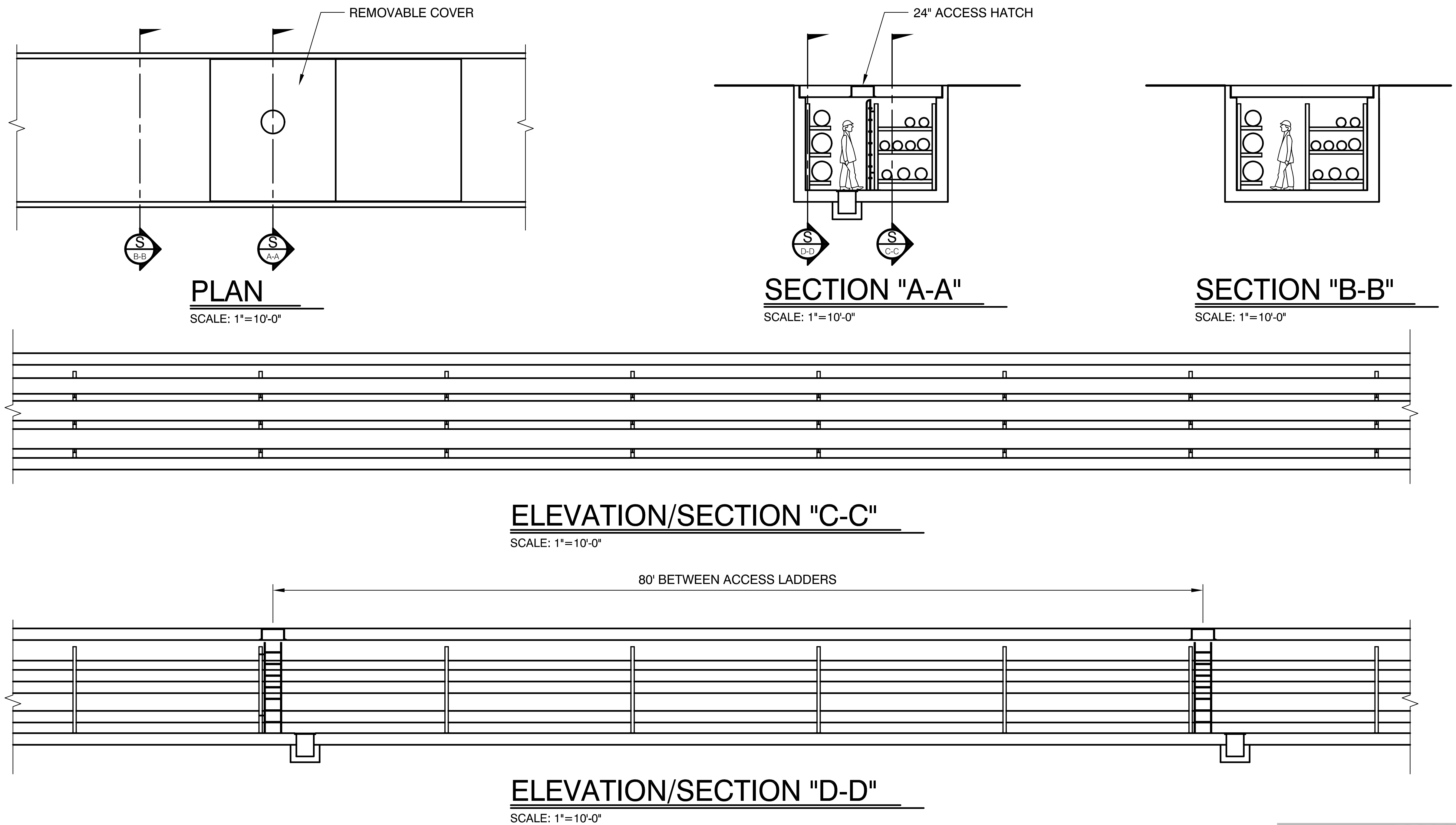

FIGURE 6-9

Marc M. Siah & Associates, Inc.
Consulting Civil . Structural . Environmental & Ocean Engineers
820 South Beretania Street, Suite 201, Honolulu, Hawaii 96813 TEL. 538-7180 FAX: 528-4352

GRAPHIC SCALE:
10' 0 10' 20'
SCALE: 1" = 10'-0"

DWG: J:\1244\dwg\Presentation-4_Revised\KALAELOA (12-10-07)\Figure 6-9.dwg USER: nsantos
DATE: May 22, 2008 2:32pm XREFS: 1244-x-TBK Kalaeloa 11x17 IMAGES:

6.3 Fuel Facility Alternatives in Kahului Harbor

Kahului Harbor serves a critical role for Maui because it is the only harbor on the island that provides fuel transfer facilities. Maui is unlike the other major islands, which all have two harbors with fuel transfer capabilities and therefore some form of redundancy. Efficient and safe operations of the fuel facilities in Kahului Harbor are therefore of utmost importance, not only for continuing the current level of fuel operations but also to accommodate future growth in fuel quantities and the growing market of alternative fuels.

During the course of completing the Fuel Development Plan, numerous design alternatives for improving fuel facilities in the harbor have been identified and developed. Possible alternatives were introduced during the course of the *Kahului Commercial Harbor 2030 Master Plan* efforts. As a result of the initial elaboration, several alternatives were recommended for more detailed analysis while other alternatives were ruled out.

Section 6.3.1 introduces and briefly discusses seven alternatives that were prepared for the Kahului Master Plan efforts. The subsequent sections further elaborate on each of the alternatives that were selected after initial consultations with stakeholders during the master planning process.

6.3.1 Alternatives Presented in the Kahului Master Plan Efforts

Design Alternative A is presented in Figure 6-10. Alternative A, and all other alternatives introduced during the Kahului Master Plan efforts, would provide berthing for two fuel vessels. There would be a newly constructed and dedicated fuel pier beyond the far end of existing Pier 1C near the channel entrance. The new pier would replace the existing piled mooring dolphin that is currently there. The second berth would use the existing Pier 1C. Pier 1C would remain as a multi-use facility and could accommodate a Handysize tanker. New interconnecting pipelines would have to be installed along the perimeter of the harbor along the breakwater to connect the new fuel berths with existing fuel storage tanks.

The advantage of Design Alternative A is that it would separate the fuel facilities away from cargo and passenger operations and move it toward the outer areas of the harbor. This would create valuable pier space in the inner harbor. The disadvantage of this alternative is the need to install one or several 2,400-foot long transfer pipelines that connect the new fuel pier to the existing storage facilities located outside the harbor.

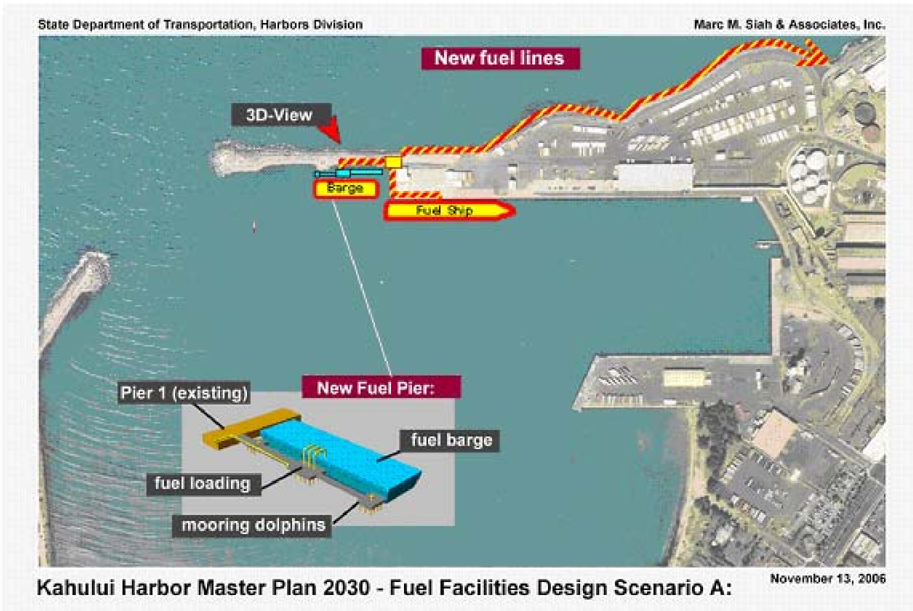

Figure 6-10: Design Alternative A

Design Alternative B is presented in Figure 6-11. It would create a piled fuel pier perpendicular to Pier 3. The fuel barge would then be moored at one side of the new fuel pier. On the other side, a roll on and roll off (RO/RO) cargo barge could be accommodated. The Handysize Tanker would use Pier 1A. The advantage of this scenario is that the perpendicular pier provides one additional berthing space to the harbor. The existing Pier 3 accommodates only one barge.

The advantage of this alternative is that the new fuel berth would be close to the existing fuel pipeline system. Therefore, the cost to connect to existing pipelines would be minimal. The main disadvantage is that the perpendicular pier would protrude into the harbor basin and could negatively affect navigation in the inner harbor basin.

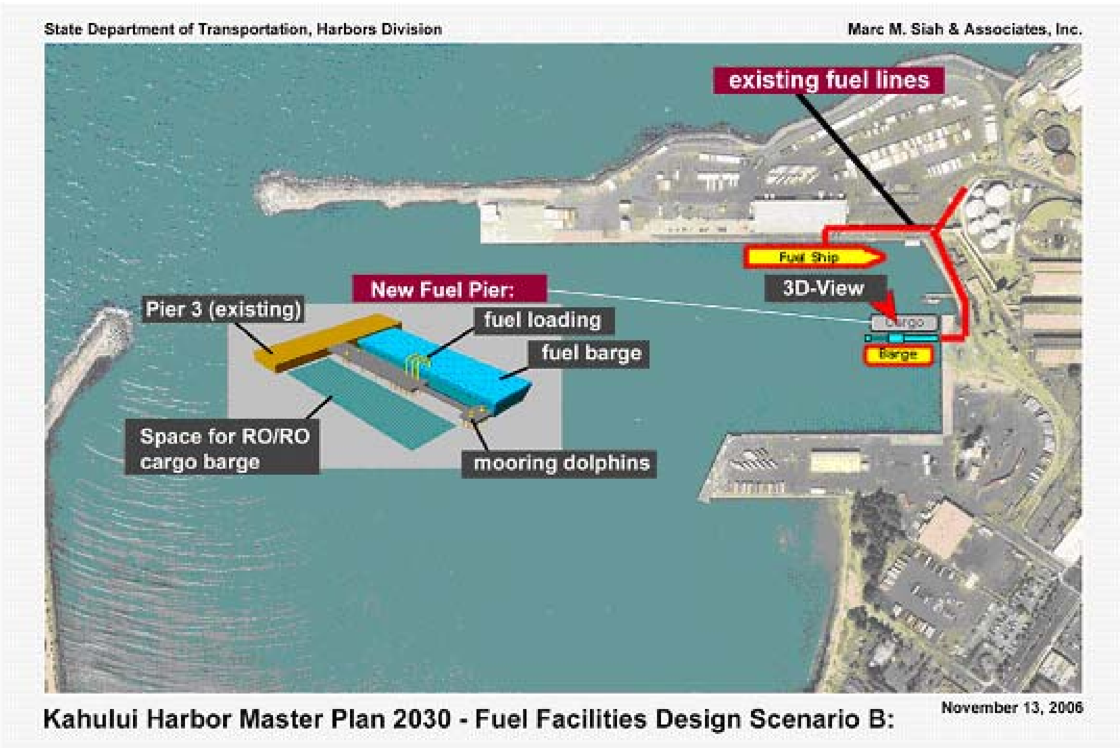

Figure 6-11: Design Alternative B

Design Alternative C is presented in Figure 6-12. It would provide berthing space for a fuel barge at a modified existing Pier 3. The structure would extend the face of Pier 3 outward away from shore-side by using a floating or fixed pier extension to add to existing Pier 3. This alternative would to mitigate the limited water depth in the immediate vicinity of Pier 3. A Handysize Tanker could use existing Pier 1A.

The advantage of this alternative is the limited scope of the pier modification and keeping the installation of new fuel transfer equipment to a minimum.

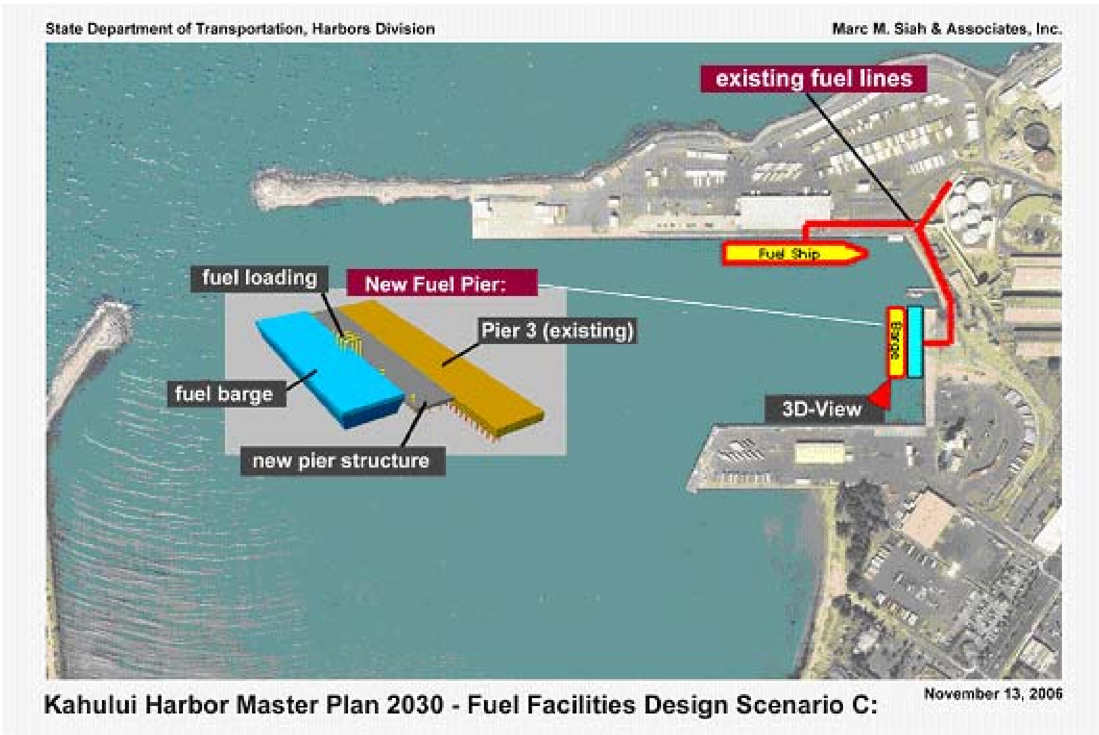

Figure 6-12: Design Alternative C

<u>Design Alternative D</u> is presented in Figure 6-13. It would feature a new protruding fuel pier structure for a dedicated fuel pier south of existing Pier 2 in a previously undeveloped part of Kahului Harbor. This dedicated fuel pier could accommodate fuel barges. A Handysize Tanker could berth at the existing Pier 1.

The advantage of this scenario is that most of the fuel transfer operations would be transferred to a part of the harbor that is undeveloped. Since the pier structure would be a protruding pier, there would be minimal construction costs. The disadvantage would be the proximity to existing recreational uses of the harbor (e.g., canoe clubs). New transfer pipelines would cross a part of the harbor in order to connect to the existing fuel pipeline system at Pier 3.

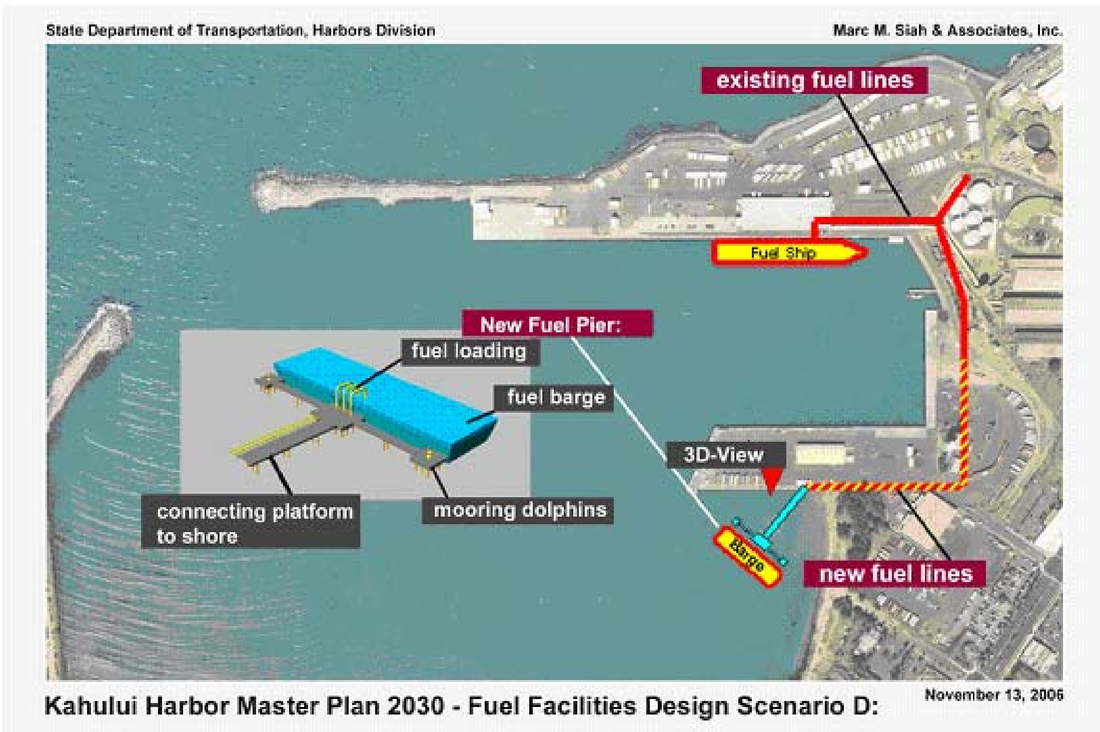

Figure 6-13: Design Alternative D

Design Scenario E is presented in Figure 6-14. Two new protruding fuel piers would be constructed to accommodate tankers and fuel barges at a new Pier 1D and at the shoreward side of a newly constructed breakwater in the western part of the harbor.

The advantage of this scenario is that fuel operation would use a part of the harbor, which is not developed at the present time. The disadvantage is one or more long fuel interconnecting pipelines, which would have to be installed to connect the new fuel piers to the existing fuel transmission pipeline system. The transfer pipelines would connect the new protruding fuel pier in the western part of the harbor. It would require that the pipeline cross the harbor entrance, which could result in costly and elaborate piping construction, with the prospect of significantly affecting ship movement during construction. In addition, the transfer pipelines that would cross the harbor entrance need to be buried deep enough to be sufficiently protected.

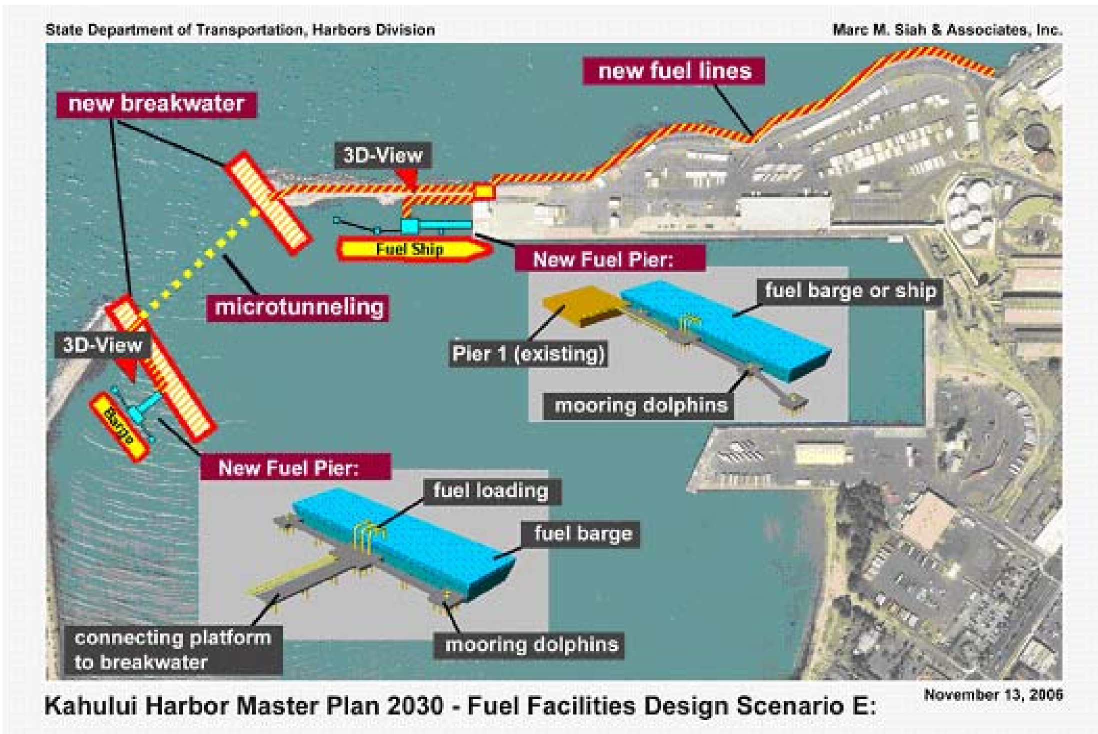

Figure 6-14: Design Scenario E

Design Scenario F would use offshore fuel transfer systems. Offshore fuel transfer systems would have the advantage of freeing Kahului Harbor of fuel transfer operations and of requiring berthing space. Offshore terminals could be located at suitable offshore locations that feature protected waters and suitable shore access for the transfer pipeslines. In the case of Maui, offshore fuel terminals could also be located at a location away from Kahului Harbor, for example, in the southern area of the island. Figure 6-15 shows three variances of offshore fuel loading terminals.

1. A fuel barge is shown moored at a CALM (catenary anchor leg mooring) buoy. CALM fuel buoys are used at many fuel terminals arounf the world and these type of fuel terminals have a good track record. Figure 6-16 shows an example of a CALM buoy. The mooring bridle would hold the fuel barge in position at the single-point mooring system, while the barge could sway according to wind and currents. Fuel would be pumped through flexible and buoyant fuel hoses from the fuel barge to the CALM buoy and from there through a fuel transfer pipeline to the shore side storage facilities.

2. A fuel vessel is shown berthed at a floating fuel terminal to a eight-point mooring system. Fuel barges and even tankers would dock at the fuel terminal and discharge into the terminal pipeline system, thus avoiding floating hoses, as in the case of the CALM buoy.

Since the eight-point mooring system does remain in a fixed orientation, this configuration might be affected by rough sea conditions during fueling operation.

3. A floating fuel terminal could also be configured as a single-point mooring system. This configuration has the advantage that the floating fuel terminal orients itself to a downwind or down current direction, thereby avoiding adverse sea conditions during loading.

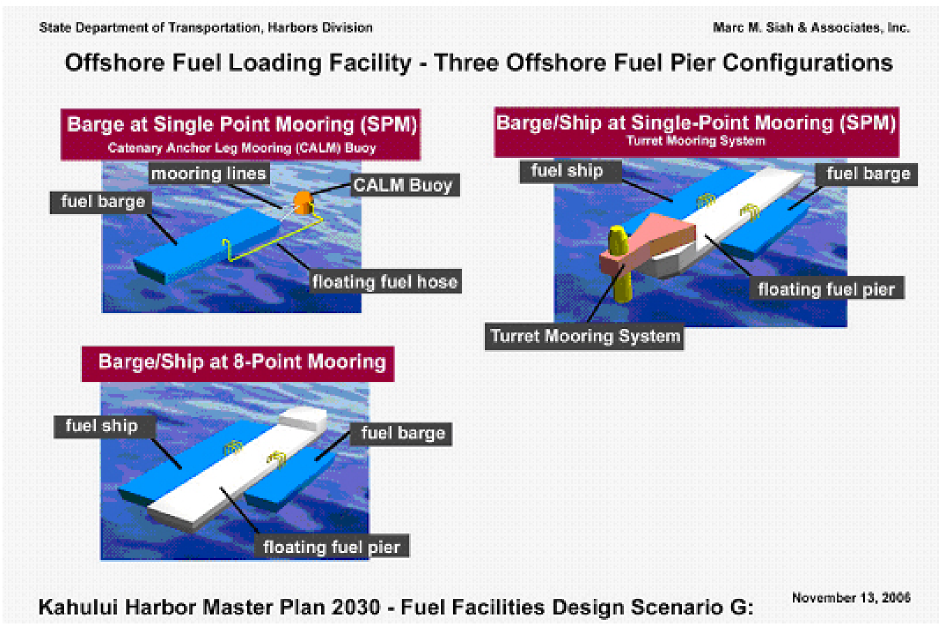

Figure 6-15: Design Alternative F

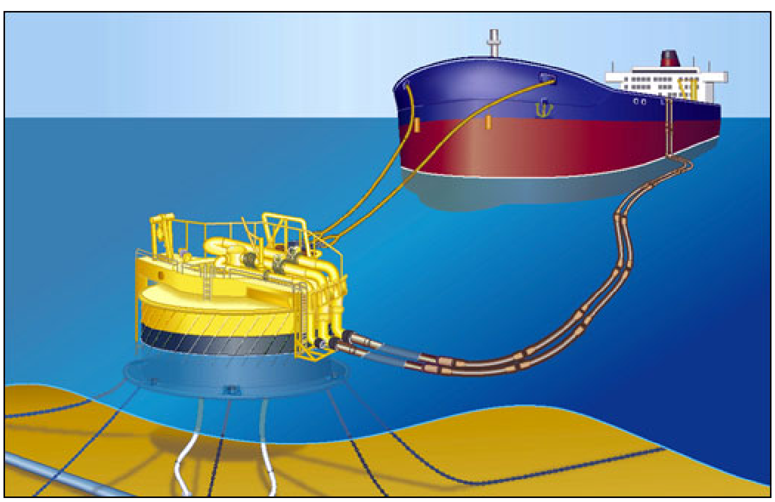

Figure 6-16: Fuel Tanker moored at CALM Buoy During Offshore Fuel Transfer
(Photo Credit IPS Innovative Pipeline Services)

6.3.2 Preferred Master Plan Design Scenarios

Initial deliberations of stakeholders during the *Kahului Commercial Harbor 2030 Master Plan* recommended the following selections from the Kahului Master Plan fuel facilities alternatives

1. Fuel facilities following Design Scenarios A, B and C are favored over other scenarios. It is preferred that the fuel facilities remain in the eastern part and established areas of Kahului Harbor, namely in the area of Piers 1 and 3.

2. Fuel facilities represented by Design Scenarios D and E were not favored and will no longer be considered. These facilities are using preferably undeveloped areas of Kahului Harbor, which might be used for future development of cargo facilities or passenger terminal or which are close to recreational areas.

3. Offshore fuel terminals were not found appropriate and will not be considered. It was, however, recognized that offshore terminals might be viable redundant fuel transfer facilities.

6.3.3 Design Alternatives for Kahului Harbor

Based on the above, five alternatives were developed. A brief overview of each alternative is described below:

1. Conceptual Design Alternative A. This incorporates two locations of fuel transfer: (1) the new Pier 4, constructed perpendicular to Pier 3 would be dedicated for fuel barges. and (2) an upgraded fuel berth at the existing Pier 1A, that could accommodate Handysize Tankers.

2. Conceptual Design Alternative B. This incorporates two locations of fuel transfer: (1) the new Pier 1D, constructed as a segmented protruding pier next to existing Pier 1C, would be dedicated for fuel barges and (2) an upgraded fuel berth at the existing Pier 1C, that could accommodate Handysize Tankers.

3. Conceptual Design Alternative C. This incorporates two locations of fuel transfer: (1) the new Pier 1D, constructed as a conventional continuous pier next to existing Pier 1C would be mixed-cargo pier for fuel barges and general cargo and (2) an upgraded fuel berth at the existing Pier 1C that could accommodate Handysize Tankers.

4. Conceptual Design Alternative D. This incorporates two locations of fuel transfer: (1) the expanded Pier 3, constructed as a piled pier structure next to existing Pier 1C would be mixed-cargo pier for fuel barges and general cargo and (2) an upgraded fuel berth at the existing Pier 1A, that could accommodate Handysize Tankers.

5. Conceptual Design Alternative E. This incorporates two locations of fuel transfer: (1) the modified Pier 3, where Pier 3 would be equipped with a sheetpile apron to allow

dredging and would be a mixed-cargo pier for fuel barges and general cargo and (2) an upgraded fuel berth at the existing Pier 1A that could accommodate Handysize Tankers.

Figure 6-17 shows the locations of these five alternatives. The alternatives A, D and E are modifications or expansions of fuel facilities at Pier 3. Alternatives B and C incorporate the construction of new fuel piers as additions to Pier 1.

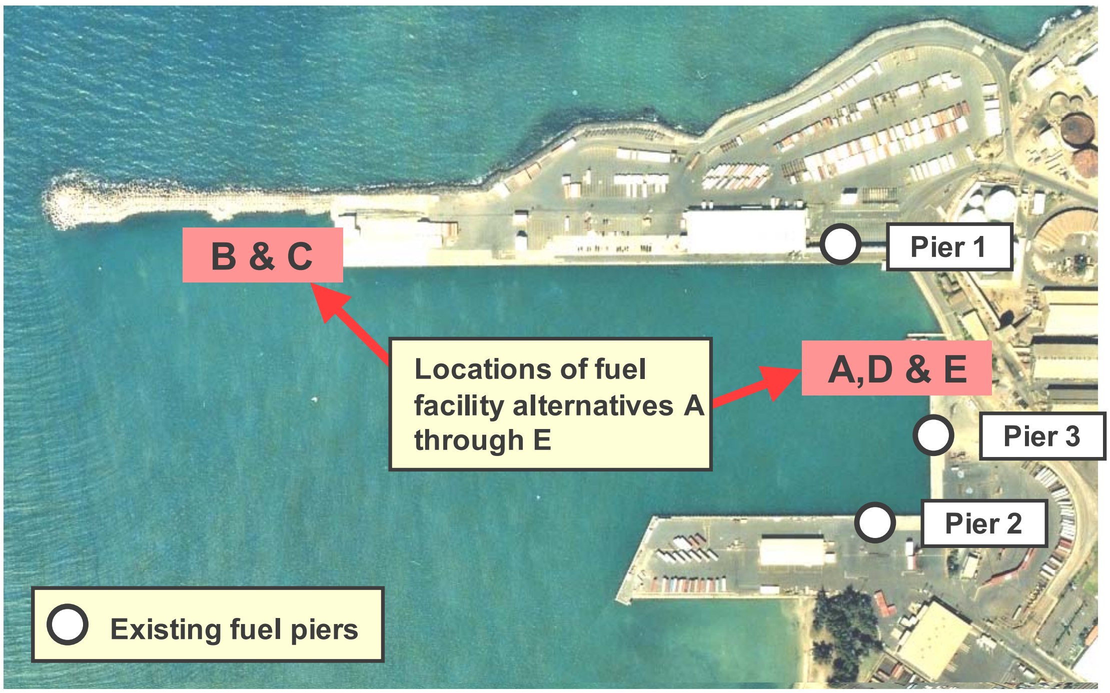

Figure 6-17: Locations of Fuel Facility Alternatives

6.3.4 Design Framework for Future Fuel Facilities

Considering the three energy design schemes as described in Section 4, Kahului Harbor could support the following future fuel related functions:

1. Off-loading fuel barges, which bring petroleum products (including liquid petroleum gas (LPG) to Maui.

2. Off-loading Handysize tankers that would bring LPG to Maui.

3. Off-loading Handysize tankers or barges that transport biofuel feedstock to Maui.

4. Loading barges that transport biofuels or biofuel feedstock between the Hawaiian Islands.

5. Off-loading of compressed natural gas (CNG) barges to supply natural gas (NG) to the island gas utility (emerging technology).

It is anticipated that the range of fuel types to be handles in the future would include the following:

1. Clean petroleum products (conventional and evolving), possibly also some dirty fuels, such as residual fuels for power plants.

2. Non-petroleum products (i.e., ethanol, biodiesel, biofuel feedstock such as vegetable oil, molasses, etc.).

3. LPG (i.e., propane, butane).

4. Possibly CNG in the future.

For the five fuel shipping functions listed above, the following vessel types would have to be accommodated at the future fuel pier (please note that the vessel type 4, below, the CNG barge represents a new fuel technology that would be applicable in Hawaii if liquefied natural gas (LNG) would be introduced as a major energy component):

1. Double-hull fuel barge: 400-foot long by 80-foot wide by 28-foot deep draft, capacity of approximately 80,000 barrels.

2. Gas barge: 246-foot long by 46-foot wide by 12-foot deep draft, capacity of approximately 16,000 barrels.

3. Handysize Tanker: 600-foot long by 95-foot wide by 34-foot deep draft, capacity of approximately 225,000 barrels.

4. CNG barge (evolving shipping technology) with unknown overall dimensions.

6.3.5 Conceptual Design Alternative A

Figure 6-18 (and Figures 6-19 and 6-20 for detailed descriptions) shows the plan view of Design Alternative A. Alternative A incorporates two locations of fuel transfer: (1) the new Pier 4, which would be constructed perpendicular to Pier 3 and designed to accommodate fuel barges and (2) an upgraded fuel berth at the existing Pier 1A that would accommodate Handysize Tankers. Pier 4 would be a dedicated fuel pier, whereas Pier 1A would remain as a multi-use facility. Therefore, Alternative A would provide a fuel transfer infrastructure to unload and load both fuel barges and Handysize Tankers. The new Pier 4 is a piled structure, which would accommodate a fuel barge on one side and a roll-on/roll-off (RO/RO) cargo barge on the other. The most important advantage of Pier 4 would be the short distance to existing fuel pipelines and storage facilities. However, the foremost disadvantage of Pier 4 is that it would protrude far into the existing harbor basin and might affect the navigation of larger ships moored at Piers 1A and 1B.

6.3.5.1 Pier 1A Modifications for Fuel Barges and Tankers

Fuel barges and Handysize Tankers would be moored and unloaded/loaded at upgraded fuel transfer facilities at existing Pier 1A. The types of fuels handled at Pier 1A would include: gasoline, diesel, residual oil, biofuels and biofuel feedstock. There are existing fuel lines in Pier 1A that could be incorporated into the final design.

The new pier would have the following components:

1. The upgraded fuel pier at Pier 1A would be preferably fitted with loading arms. Permanently installed loading arms, however, could impede mixed-cargo operations at Pier 1A. It has to be determined if loading arms at Pier 1A are too obstructive for the mixed cargo use of Pier 1A.

2. In order to improve the fuel transfer operation and to shorten the time for loading/off-loading, installation of new interconnecting pipelines on or below Pier 1A is recommended where existing pipelines are too small to discharge the quantities of fuel anticipated.

3. Fire suppression system. Two fixed foam monitors, using seawater for foam generation, would be installed on Pier 1A. Different types of foam would be required for different fuel that is handled. The fixed foam monitors are installed on shore-side at suitable locations to allow good working coverage of foam spray on the fuel berth.

4. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

6.3.5.2 New Pier 4 for Fuel Barges

The new Pier 4 would only accommodate fuel barges, but no tankers. It would be constructed as a piled pier extending perpendicular from Pier 3 towards Kahului Bay. Though one side of the new pier would be a dedicated fuel pier, the other side would accommodate a roll-on/roll-off (RO/RO cargo) barge. The RO/RO cargo barge would load over the stern from Pier 3. This configuration would accommodate two barges simultaneously, thereby providing one additional berthing space than would otherwise be available at Pier 3.

The existing structure of Pier 3 would be incorporated into the design of the dedicated fuel pier. RO/RO cargo barges would load or unload over a stern ramp. Interconnecting pipelines would extend onto the fuel pier. Additional or new pipelines would have to be installed in order to make the fuel transfer between Pier 4 and the fuel storage tanks more effective and to allow for new types of fuels.

Pier 4 would have the following components:

1. Three breasting dolphins would be installed with mooring bollards and fendering systems. The breasting dolphins would be connected to the roadway of the fuel pier. The roadway would connect the fuel transfer platform with Pier 3.

2. One mooring dolphin would be installed that is not connected to the roadway. This stern mooring dolphin would be accessible by a catwalk via the fuel pier structure.

3. Infrastructure that incorporates land-based loading ramps or supports ship borne loading ramp would be installed on Pier 3. This would allow the RO/RO cargo barge to be loaded/off-loaded over the stern.

4. Four adjacent breasting dolphins would be constructed as piled structures, each with a mooring bollard and fendering systems; two breasting dolphins would each have a disembarkation platform attached to the breasting dolphin platform to allow safe access to the fuel barge.

5. Two mooring dolphins would be constructed as piled structures, each with a mooring bollard.

6. Fuel loading arms (either single-product or dual-product loading arms) would establish safe and efficient shore-to-ship fuel transfer connections. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

7. A piled roadway would connect the fuel transfer platform structures with Pier 3. The roadway could accommodate a medium-size service truck to maintain the pier components (e.g., loading arms, fire protection system, fendering system, etc.). The roadway would incorporate precast concrete structural parts in order shorten the construction time of the new pier. The roadway would support cantilevered truss structure, on which the interconnecting pipelines would be installed that convey the fuel from the fuel transfer platform and connect to interconnecting pipelines in Pier 3.

8. Fire suppression system. Two fixed foam monitors using seawater for foam generation would be installed on the pier next to the loading platform. Different types of foam would be required for different fuel that is handled. The fixed foam monitors are installed shore-side at suitable locations to allow a good coverage of foam spray on the fuel berth.

9. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

10. A central fuel monitoring system (fuel flow, pressures, temperatures, etc.) would inform the operator about fuel transfer progress. The fuel monitoring system would be equipped with alarms for certain high or low controls functions.

11. An alarm system would alert the operator to stop pumping when the unloading arms near the limits of their reach.

12. An emergency shutdown system could be activated from a central point or at the pier.

13. Adequate draft at the dedicated fuel pier is established by dredging to a continuous depth of 35 feet.

14. Depending on operational requirements (compatibility of fuel), new fuel pipelines for a range of fuel products (e.g., gasoline, diesel, jet fuel, ethanol, biodiesel, LPG) would be installed on the fuel transfer platform.

15. The interconnecting pipelines would be installed on pipeline supports that would be attached to the roadway that spans between the fuel transfer platform and Pier 3.

16. The new fuel pipelines would connect to existing pipelines that are presently installed in Pier 3.

17. Pipelines for LPG and a fuel transfer hatch are presently installed in Pier 2. Since the normal LPG transfer from the fuel barges would be carried out at the new fuel pier, the new transfer pipelines that serve the new fuel pier would be connected to the existing LPG piping system at Pier 2.

18. As required, new interconnecting pipeline would be installed for future fuel types. The installation of new pipelines on above-ground pipeline racks would offer flexibility of construction and maintenance. New interconnecting pipelines from Pier 3 to the fuel storage tanks outside the harbor would be installed as below-ground pipeline.

All fuel storage tanks are presently located outside of Harbors Division's property and therefore are operated and/or owned by individual fuel companies. The current fuel storage capacity is very limited if the number of days of fuel supply is considered. For example, there is approximately a minimum of 7 days worth of gasoline on Maui at any given time. By law, the number of days of fuel for electrical generation is approximately 30 days. The installation of additional storage capacity is deemed necessary to expand the storage capacities to meet the needs of current petroleum products, but also for biofuels and its feedstock and other emerging petroleum-based fuels. Because of the finite space in Kahului Harbor, storage facilities within Harbors Division's property will not be considered at this time unless additional lands are acquired.

6.3.6 Conceptual Design Alternative B

Figure 6-21 shows the plan view of the Design Alternative B. Alternative B incorporates two fuel transfer locations: (1) the new Pier 1D would accommodate fuel barges and (2) a new fuel berth at existing Pier 1C would accommodate Handysize tankers. The new Pier 1D would be a piled pier structure. The main advantage of Pier 1D is that it could be cost-effectively constructed at a location in the harbor that is not in use at the present time. However, the main disadvantage is one or multiple long fuel pipelines that would be required to connect the fuel transfer facilities at Piers 1D and 1C with existing fuel storage facilities in the eastern part of Kahului Harbor.

Alternative B (refer to Figures 6-22 and 6-23 for detailed descriptions) includes two improvements: (1) new Pier 1D and (2) Pier 1C modifications.

6.3.6.1 New Pier 1 D for Fuel Barges

Fuel barges would off-load at a new dedicated fuel pier, designated as Pier 1D. The fuel pier structure would be recessed from the pier face of Pier 1. This could have the advantage that the wave climate at the proposed location of the new pier would be less than if the pier was aligned with the face of Pier 1. A roadway, which would provide access to the pier, would be constructed and would connect the fuel transfer platform with the existing Pier 1C. A new fuel transfer pumping station would be installed on Pier 1C. The existing piled mooring dolphin with a concrete catwalk that connects it to Pier 1C would be demolished.

Pier 1D would have the following components:

1. A dedicated fuel pier would be constructed at the northern end of existing Pier 1C. The fuel pier would be constructed as a piled pier structure.

2. Four adjacent breasting dolphins would be constructed as piled structure, each with mooring bollard and fendering systems; two breasting dolphins would each have a disembarkation platform attached to the breasting dolphin platform in order to allow safe access to the fuel barge.

3. Two mooring dolphins would be constructed as piled structures.

4. Catwalks would connect the breasting and mooring dolphins among each other and to the roadway.

5. Fuel loading arms (either single-product or dual-product loading arms) would establish safe and efficient shore-to-ship fuel transfer connections. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

6. A piled roadway would connect the fuel transfer platform with Pier 1C. The roadway could accommodate a medium service truck to maintain the pier components (loading arms, fire protection system, fendering system, etc.). The roadway would use precast concrete structural parts in order to shorten the construction time. The roadway would support a pipe way for the interconnecting pipelines that would connect the fuel transfer platform with pipelines on Pier 1C.

7. Fire suppression system. Two fixed foam monitors using seawater for foam generation would be installed on the pier next to the loading platform. Different types of foam would be required for different fuel that is handled. The fixed foam monitors would be installed shore-side at suitable locations to allow good coverage of foam spray on the fuel berth.

8. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

9. A central fuel monitoring system (fuel flow, pressures, temperatures, etc.) would inform the operator about fuel transfer progress.

10. An alarm system would alert the operator to stop pumping when the unloading arms near the limits of their reach.

11. An emergency shutdown system that could be activated from a central point or at the pier.

12. Adequate draft at the dedicated fuel pier would be established by dredging to a continuous depth of 35 feet.

13. Interconnecting pipelines would be installed in Pier 1D to connect the fuel transfer station with the fuel transfer pumping station. The pipelines would be installed in a below-ground pipeline gallery. The pipeline gallery would have removable cover to allow for cost-effective installation and efficient maintenance.

14. A fuel transfer pumping station would be constructed at Pier 1C. The fuel pumping station would be equipped with a number of fuel pumps that act as booster pumps for the long transfer pipelines that connect the new fuel facilities with the existing fuel tank farms. Booster pumps would increase the liquid fuel pressure in the pipelines, since the capacities of the pumps on the barges might not be adequate to transfer the fuel over the significant distance to the existing fuel storage tanks. Since the shore-side fuel pumps operate with electric power, emissions by tankers and barges during unloading could be significantly diminished.

15. Interconnecting pipelines would be installed above-ground from the fuel transfer pumping station on Pier 1C to the existing storage facilities, which are located in the

eastern part of Kahului Harbor, outside the harbor boundary. The total length of each interconnecting pipeline would be approximately 2,400 feet. The pipelines would be installed above-ground on pipeline racks. The pipeline racks would be located inside the harbor peripheral fence. The pipeline and pipeline racks would be protected by bollards against accidental impact from trucks.

16. The number of required interconnecting pipelines would be determined by the type of fuel to be conveyed. Installation of pipelines on pipeline racks would offer a cost-effective and flexible installation and efficient maintenance of the pipelines. As an alternative to transferring the fuel through multiple product pipelines over the long distance between the new fuel pier and the existing tank farms, piggable pipelines could be used in order to pump batch trains of different products through one or two pipelines. This would reduce the number and therefore the costs of the interconnecting pipelines.

6.3.6.2 Pier 1C Modifications for Fuel Tankers

A Handysize tanker would moor and off-load/load at the existing Pier 1C. New fuel transfer components would be installed at Pier 1C in order to allow a safe and efficient unloading/loading of fuel and fuel feedstock.

Pier 1C would have the following components:

1. Fuel loading arms (either single-product or dual-product loading arms) would establish safe and efficient shore-to-ship fuel transfer connections. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

2. Bollards would be installed around the fuel transfer station in order to secure the loading arms and above ground transfer pipelines from accidental impact by trucks, which operate on the multi-use pier.

3. Fire suppression system. Two fixed foam monitors, using seawater for foam generation would be installed on the pier next to the loading platform. Different types of foam would be required for different fuel that is handled. The fixed foam monitors are installed at suitable locations to allow good working coverage of foam spray on the fuel berth.

4. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

5. Transfer pipelines would be installed to connect the fuel transfer station at Pier 1C with the fuel transfer pumping station. Transmission pipelines would be installed underground in a concrete pipe gallery with a removable cover for easy installation and maintenance.

All fuel storage tanks are presently located outside of Harbors Division’s property and therefore are operated and/or owned by individual fuel companies. The current fuel storage capacity is limited if the number of days of fuel supply is considered. For example, there is approximately 7 days worth of gasoline on Maui at any given time. By law, the number of days of fuel for electrical generation is approximately 30 days. The installation of additional storage capacity is deemed necessary to expand the storage capacities to meet the needs of current petroleum products, but also for biofuels and its feedstock and other emerging petroleum-based fuels. Because of the finite space in Kahului Harbor, storage facilities within Harbors Division's property will not be considered at this time unless additional lands are acquired.

6.3.7 Conceptual Design Alternative C

Figure 6-24 shows the plan view of Design Alternative C. Alternative C incorporates two fuel transfer locations: (1) the new Pier 1D that could accommodate fuel barges and (2) a new fuel facility on the existing Pier 1C, which could accommodate Handysize tankers. The new Pier 1D would be a multi-use pier using a combination of pilings and bulkhead designs. The main advantage of Pier 1D would be the multi-use mode of cargo operations. Pier 1D would not be dedicated to fuel transfer and therefore increases the cargo handling capacity of Kahului Harbor. The main disadvantages of Alternative C would be the high cost of constructing a conventional bulkhead pier and the fact that the new fuel transfer pier would not be a dedicated fuel pier. In addition, a major drawback of Alternative C would be the required long fuel pipelines to connect the new fuel transfer facilities with the existing fuel storage facilities in the eastern part of Kahului Harbor.

Alternative C (refer to Figures 6-25 and 6-26) includes two improvements: (1) new multi-use Pier 1D and (2) Pier 1C modifications.

6.3.7.1 New Pier 1D

Fuel barges would unload at a new fuel pier, designated as Pier 1 D. Pier 1D would be located north of the existing Pier 1C. Pier 1D would be a multi-use pier using a combination of pilings and bulkhead designs. The pier face of Pier 1D would be in line with the face of existing Piers 1A through 1C. It is anticipated that the wave action at Pier 1D would be more severe than at the recessed fuel pier proposed in Alternative B described above. The fuel transfer pumping station and the above ground long interconnecting pipelines would be identical with Alternative B.

Pier 1D would have the following components:

1. A fuel transfer station would be installed on the new, multi-use Pier 1D. The new pier would be a conventional bulkhead pier with an outward piled section.

2. Fuel loading arms (either single-product or dual-product loading arms) would establish safe and efficient shore-to-ship fuel transfer connections. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

3. Bollards would be installed to secure the loading arms and transfer pipelines from accidental impact by trucks, which operate on the multi-use pier.

4. Fire suppression system. Two fixed foam monitors using seawater for foam generation would be installed on the pier next to the loading platform. Different types of foam would be required for different fuel that is handled. The fixed foam monitors are installed on shore-side at suitable locations to allow good working coverage of foam spray on the fuel berth.

5. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

6. A central fuel monitoring system (fuel flow, pressures, temperatures, etc.) would inform the operator about fuel transfer progress.

7. An alarm system would alert the operator to stop pumping when the unloading arms near the limits of their reach.

8. An emergency shutdown system that could be activated from a central point or at the pier.

9. Adequate draft at the dedicated fuel pier would be established by dredging to a continuous depth of 35 feet. Some of the dredged material could be used as fill for the bulkhead pier structure.

10. Interconnecting pipelines would be installed in Pier 1D to connect the fuel transfer station with the fuel transfer pumping station. The pipelines would be installed in a below-ground concrete pipeline gallery. The pipeline gallery would have removable cover to allow for cost-effective installation and efficient maintenance.

11. A fuel transfer pumping station would be constructed at Pier 1C. The fuel pumping station would be equipped with a number of fuel pumps that act as booster pumps for the long transfer pipelines that connect the new fuel facilities with the existing fuel tank farms. Booster pumps would increase the liquid fuel pressure in the pipelines, since the capacities of the pumps on the barges might not be adequate to transfer the fuel over the significant distance to the existing fuel storage tanks. Since the shore-side fuel pumps operate with electric power, emissions by tankers and barges during unloading could significantly diminish.

12. Interconnecting pipelines would be installed above-ground from the fuel transfer pumping station on Pier 1C to the existing storage facilities, which are located in the eastern part of Kahului Harbor. The total length of individual interconnecting pipelines would be approximately 2,400 feet. The pipelines would be installed above-ground, on pipeline racks. The pipeline racks would be located inside the harbor peripheral fence. The pipeline and pipeline racks would be protected by bollards against accidental impact from trucks.

13. The number of required interconnecting pipelines would be determined by the type of fuel to be conveyed. Installation of pipelines on pipeline racks would offer a cost-effective and flexible installation and efficient maintenance of the pipelines. As an alternative to transferring the fuel through multiple product pipelines over the long distance between the new fuel pier and the existing tank farms, piggable pipelines could be used in order to pump batch trains of different products through one or two pipelines. This would reduce the number and therefore the costs of the interconnecting pipelines.

All fuel storage tanks are presently located outside of Harbors Division's property and therefore are operated and/or owned by individual fuel companies. The current fuel storage capacity is limited if the number of days of fuel supply is considered. For example, there is approximately 7 days worth of gasoline on Maui at any given time. By law, the number of days of fuel for electrical generation is approximately 30 days. The installation of additional storage capacity is deemed necessary to expand the storage capacities to meet the needs of current petroleum products, but also for biofuels and its feedstock and other emerging petroleum-based fuels. Because of the finite space in Kahului Harbor, storage facilities within Harbors Division's property will not be considered at this time unless additional lands are acquired.

6.3.7.2 Pier 1C Modifications for Fuel Tankers

A Handysize tanker would moor and off-load/load at the existing Pier 1C. New fuel transfer components would be installed at Pier 1C in order to allow a safe and efficient unloading/loading of fuel and fuel feedstock.

Pier 1C would have the following components:

1. Fuel loading arms (either single-product or dual-product loading arms) would establish safe and efficient shore-to-ship fuel transfer connections. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

2. Bollards would be installed around the fuel transfer station in order to secure the loading arms and above ground transfer piping from accidental impact by trucks, which operate on the multi-use pier.

3. Fire suppression system. Two fixed foam monitors using seawater for foam generation would be installed on the pier next to the loading platform. Different types of foam would be required for different fuel that is handled. The fixed foam monitors are installed at suitable locations to allow good working coverage of foam spray on the fuel berth.

4. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

5. Transfer pipelines would be installed to connect the fuel transfer station at Pier 1C with the fuel transfer pumping station. Transmission pipelines would be installed underground in a concrete pipe gallery with a removable cover for easy installation and maintenance.

6.3.8 Conceptual Design Alternative D

Figure 6-27 shows a plan view of Design Alternative D. Alternative D would incorporate two fuel transfer locations: (1) the modified Pier 3 that would accommodate fuel barges and (2) a new upgraded fuel berth at the existing Pier 1A that would accommodate Handysize tankers. The modified Pier 3 would be a multi-use pier using a combination of pilings and bulkhead designs. Since Pier 3 would not be dedicated to fuel transfer, Kahului Harbor's cargo handling capacity could be increased. The proposed Pier 3 structure would provide a significant additional area for cargo operations. The main disadvantage of Alternative D would be the fact that the fuel transfer would not be carried out at dedicated fuel piers. The main advantage of Alternative D would be the additional pier space that would be provided by the extension of Pier 3 as well as the close proximity of the new fuel transfer station on Pier 3 to the existing interconnecting fuel pipeline, thus causing no major new pipeline construction.

Kahului Alternative D (refer to Figures 6-28, 6-29 and 6-30 for detailed descriptions) includes two improvements: (1) Pier 1A modifications and (2) Pier 3 modifications:

6.3.8.1 Pier 1A Modifications for the Fuel Tankers or Fuel Barges

Fuel barges and Handysize tankers would moor and be off-loaded/loaded at upgraded fuel transfer facilities at the multi purpose Pier 1A. The tankers and barges would use the breasting line and mooring infrastructure at Pier 1A. The types of fuels handled at Pier 1A are: gasoline, diesel, residual oil, biofuels and its feedstock. There are existing fuel lines in Pier 1A that could be incorporated into the final design.

Pier 1A would have the following components:

1. The upgraded fuel pier at Pier 1A is preferably fitted with loading arms. Permanently installed loading arms, however, could impede mixed-cargo operations at Pier 1A. It has to be determined if loading arms at Pier 1A are too obstructive for the mixed cargo use of Pier 1A.

2. In order to improve the fuel transfer operation and to shorten the time for loading/off-loading the installation of new interconnecting pipelines on or below Pier 1 is recommended where existing pipelines are too small to discharge the quantity of fuel that is anticipated in the future.

3. Fire suppression system. Two fixed foam monitors are installed on the pier that would use seawater for the foam generation. Different types of foam would be required for different fuel that is handled. The fixed foam monitors would be installed at suitable locations to allow good working coverage of foam spray on the fuel berth.

4. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

6.3.8.2 Pier 3 Extension for Fuel Barges

The new fuel pier at the multi-use pier Pier 3 would accommodate fuel barges, but no tankers. The new breasting line of the pier would be dredged to a depth of 35 feet. This would expand Pier 3 by means of a piled pier platform, thus creating an additional 57,000 square feet of operating area for cargo operations. Since the expanded Pier 3 would be a multi-use pier, it would accommodate both fuel and cargo operations. The fuel barges would use fuel loading arms, which would be installed at a fuel transfer station in the center of the pier, close to the pier face. The fuel transfer station with fuel loading arms and bollards would protect fixed foam monitors in order to avoid accidental impacts of cargo handling equipment.

Pier 3 would have the following components:

1. The multi-purpose pier would be the extension of the existing Pier 3. The entire pier would be built as a piled structure.

2. The fuel and cargo barges would moor against the pier face. A fendering system would accommodate vessel movement that is at times affected by significant wave action at Pier 3.

3. The northern portion of the extended pier structure would be a piled pier structure from the pier face to the existing rock revetment at the shoreline of the harbor basin. The piling and rock revetment would contribute to energy dissipation of the incident waves, therefore lowering wave actions in this part of the harbor basin.

4. Fuel loading arms (either single-product or dual-product loading arms) would establish safe and efficient shore-to-ship fuel transfer connections. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

5. Fire suppression system. Two fixed foam monitors would be installed at Pier 3 that would use seawater for foam generation. Different types of foam would be required for different fuel that is handled. The fixed foam monitors would be installed at suitable locations to allow good working coverage of foam spray on the fuel berth.

6. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

7. A central fuel monitoring system (fuel flow, pressures, temperatures, etc.) would inform the operator about fuel transfer progress. The fuel monitoring system would be equipped with alarms for certain high or low controls functions.

8. An alarm system that would alert the operator to stop pumping when the unloading arms near the limits of their reach.

9. An emergency shutdown system that could be activated from the central point or at the pier.

10. Adequate draft at the pier would be established by dredging to a continuous depth of 35 feet.

11. Depending on operational requirements (compatibility of fuel, batching or dedicated pipelines), new fuel pipelines for a range of fuel products (e.g., gasoline, diesel, jet fuel, ethanol, biodiesel, LPG) would be installed that connect the fuel transfer station with existing interconnecting pipelines.

12. Fuel pipelines serving the new fuel transfer facilities in Pier 3 would connect to the existing interconnecting pipelines, which convey the fuel from Pier 3 to the storage tank farms. Pipelines for petroleum and non-petroleum fuel would connect to pipelines that are installed in the harbor. Fuel pipelines for LPG (e.g., propane) would connect to existing interconnecting piers that are installed in Pier 2.

13. As required, new interconnecting pipelines would be installed for future fuel types. Wherever possible, pipelines would be installed below-ground in pipe galleries, in order to facilitate construction and maintenance of the fuel pipes.

All fuel storage tanks are presently located outside of Harbors Division's property and therefore are operated and/or owned by individual fuel companies. The current fuel storage capacity is very limited if the number of days of fuel supply is considered. For example, there is approximately 7 days worth of gasoline on Maui at any given time. By law, the number of days of fuel for electrical generation is approximately 30 days. The installation of additional storage capacity is deemed necessary to expand the storage capacities to meet the needs of current petroleum products, but also for biofuels and its feedstock and other emerging petroleum-based fuels. Because of the finite space in Kahului Harbor, storage facilities within Harbors Division's property will not be considered at this time unless additional leads are acquired.

6.3.9 Conceptual Design Alternative E

Figure 6-31 shows the plan view of Design Alternative E. Alternative E would incorporate two fuel transfer locations: (1) the modified multi-use Pier 3 would accommodate a fuel barge and (2) a new fuel facility on the existing Pier 1A would accommodate Handysize Tankers. It would provide fuel transfer infrastructure to off-load and load both types of fuel vessels. The modified Pier 3 would have the same overall dimension as the existing Pier 3. A sheetpile apron would be installed around the existing Pier 3 in order to allow dredging to a depth of 35 feet, thereby making this fuel berth capable of accommodating the design fuel barge at full draft. The main advantage of the new fuel pier configuration would be the limited amount of construction that is required to improve fuel transfer operations at Pier 3. Another advantage of Alternative E would be the close proximity of the new fuel transfer station on Pier 3 to the existing fuel pipelines in this part of the harbor, thus requiring no major new pipeline construction.

Kahului Alternative E (refer to Figures 6-32 and 6-33 for detailed descriptions; see 11x17 inch drawing at the end of this section) includes two improvements: (1) Pier 1A modifications and (2) Pier 3 modifications.

6.3.9.1 Pier 1A Modifications for the Fuel Vessels

Handysize tankers and barges would be moored at upgraded fuel transfer facilities at the existing Pier 1A. Pier 1A would be a multi-use pier that would accommodate both fuel and cargo uses. There are existing fuel pipelines in Pier 1A, which might be incorporated into the final design.

Pier 1A would have the following components:

1. The upgraded Pier 1A would be preferably fitted with loading arms. Permanently installed loading arms, however, could impede mixed-cargo operations at Pier 1A. It has to be determined if loading arms at Pier 1A would be too obstructive for the mixed cargo use of Pier 1A.

2. In order to improve the fuel transfer operation and to shorten the time for loading/unloading the installation of new interconnecting pipelines on or below Pier 1 is recommended where existing pipelines are too small to discharge the quantity of fuel that is anticipated in the future.

3. Fire suppression system. Two fixed foam monitors would be installed at Pier 1A that would use seawater for foam generation. Different types of foam would be required for different fuel that is handled. The fixed foam monitors would be installed at suitable locations to allow good working coverage of foam spray on the fuel berth.

4. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

6.3.9.2 Pier 3 Modifications for Fuel Barges

The modified Pier 3 would accommodate fuel barges, but no tankers. The new breasting line of the pier is dredged to a depth of 35 feet. The pier would be a multi-purpose pier that could accommodate both fuel and cargo operations. The fuel barges would use fuel loading arms, which would be installed at a fuel transfer station in the center of the pier, close to the pier face. The fuel transfer station and fixed foam monitors would be protected by bollards in order to avoid accidental impact of cargo handling equipment.

Pier 3 would have the following components:

1. The multi-use pier would be a modification of the existing Pier 3. A sheetpile apron would be installed in front of the Pier 3 to allow dredging to a design depth of 35 feet, which would enable fully loaded fuel barges to dock.

2. In order to extend the breasting line of the pier, a breasting dolphin would be installed between Piers 1 and 3. The breasting dolphin would have a mooring bollard. The breasting dolphin would be accessible from landside by means of a catwalk.

3. Larger barges would moor against the pier face and the breasting dolphin. A fendering system would accommodate vessel movement that is at times affected by significant wave action at Pier 3.

4. Fuel loading arms (either single-product or dual-product loading arms) would establish safe and efficient shore-to-ship fuel transfer connections. The number of loading arms would be determined by the type of fuel to be loaded and unloaded at the fuel berth.

5. Fire suppression system. Two fixed foam monitors would be installed at Pier 2 That would use seawater for foam generation. Different types of foam would be required for different fuel that is handled. The fixed foam monitors would be installed at suitable locations next to the new fuel transfer station to allow good working coverage of foam spray on the fuel berth.

6. Adequate fixed lighting would be installed to illuminate all parts of the fuel pier that are critical for operating the fuel pier.

7. A central fuel monitoring system (fuel flow, pressures, temperatures, etc.) would inform the operator about fuel transfer progress.

8. Two-stage alarm system would alert the operator to stop pumping fuel when the unloading arms near its limits of reach or when the mooring line loads are near its limits of loading capacity.

9. An emergency shutdown system could be activated from the central point or at the pier.

10. Adequate draft at the pier would be established by dredging to a continuous depth of 35 feet.

11. Depending on operational needs, new fuel transmission pipelines would be installed for a range of fuel products that connect the new fuel transfer station on Pier 3 with existing interconnecting pipelines.

12. Fuel pipelines in Pier 3 would connect the fuel transfer station to the existing interconnecting pipelines. Fuel pipeline for LPG (e.g., propane) connect to existing interconnecting piers that are installed in Pier 2.

All fuel storage tanks are presently located outside of Harbors Division's property and therefore are operated and/or owned by individual fuel companies. The current fuel storage capacity is limited if the number of days of fuel supply is considered. For example, there is approximately 7 days worth of gasoline on Maui at any given time. By law, the number of days of fuel for electrical generation is approximately 30 days. The installation of additional storage capacity is deemed necessary to expand the storage capacities to meet the needs of current petroleum products, but also for biofuels and its feedstock and other emerging petroleum-based fuels. Because of the finite space in Kahului Harbor, storage facilities within Harbors Division's property will not be considered at this time unless additional lands are acquired.

6.3.10 Advantages and Disadvantages of Conceptual Design Alternatives

Table 6-1 lists advantages and disadvantages of the five conceptual design alternatives for Kahului Harbor.

Figure 6-18 : CONCEPTUAL DESIGN - ALTERNATIVE A - SITE PLAN
Kahului Commercial Harbor, Maui

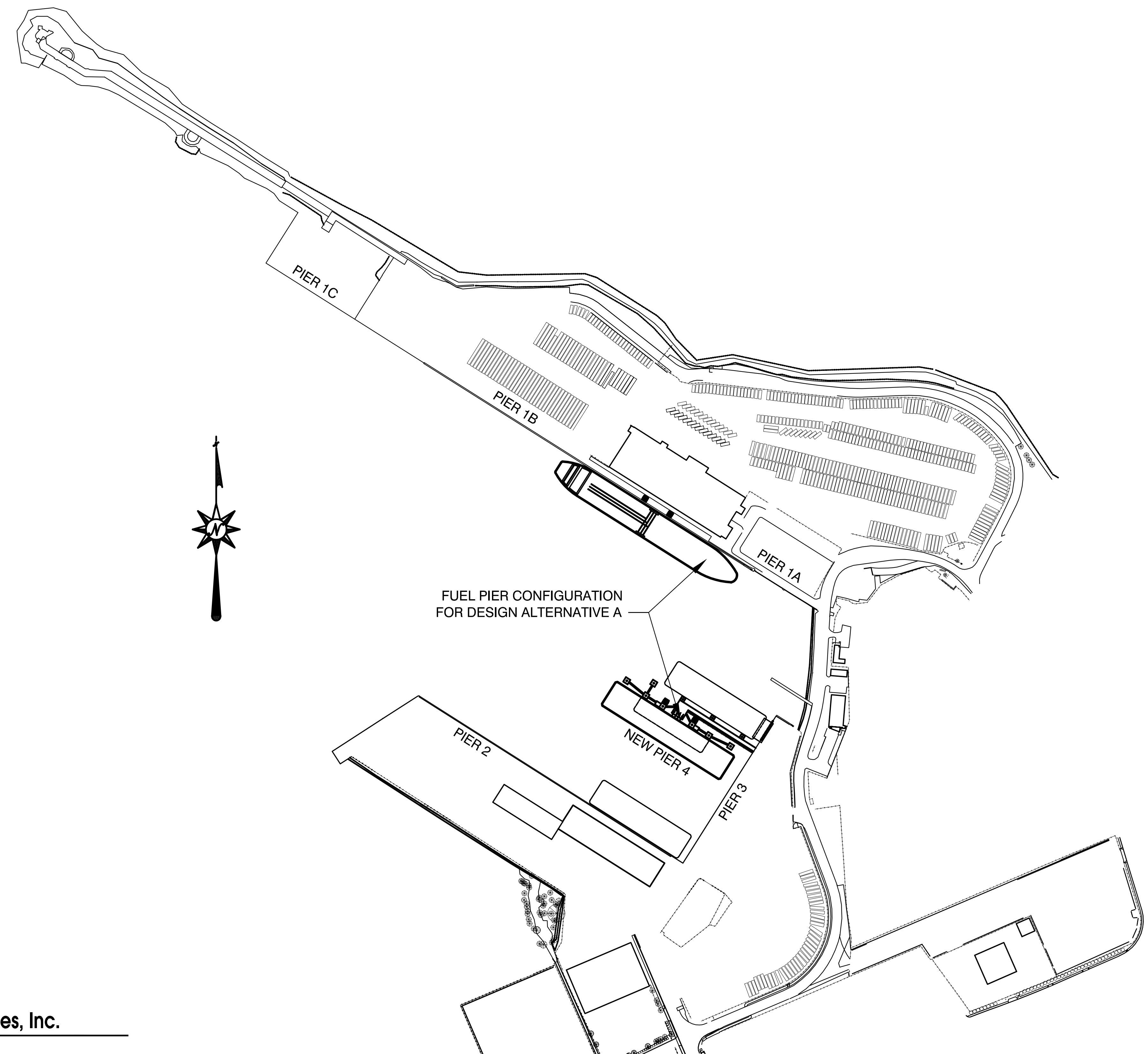

FIGURE 6-18

GRAPHIC SCALE:

350' 0 350' 700'

SCALE: 1" =350'-0"

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DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-18.dwg USER: nsantos
DATE: May 22, 2008 2:40pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-1 IMAGES:

Figure 6-19 : CONCEPTUAL DESIGN - ALTERNATIVE A - DETAIL PLAN
Kahului Commercial Harbor, Maui

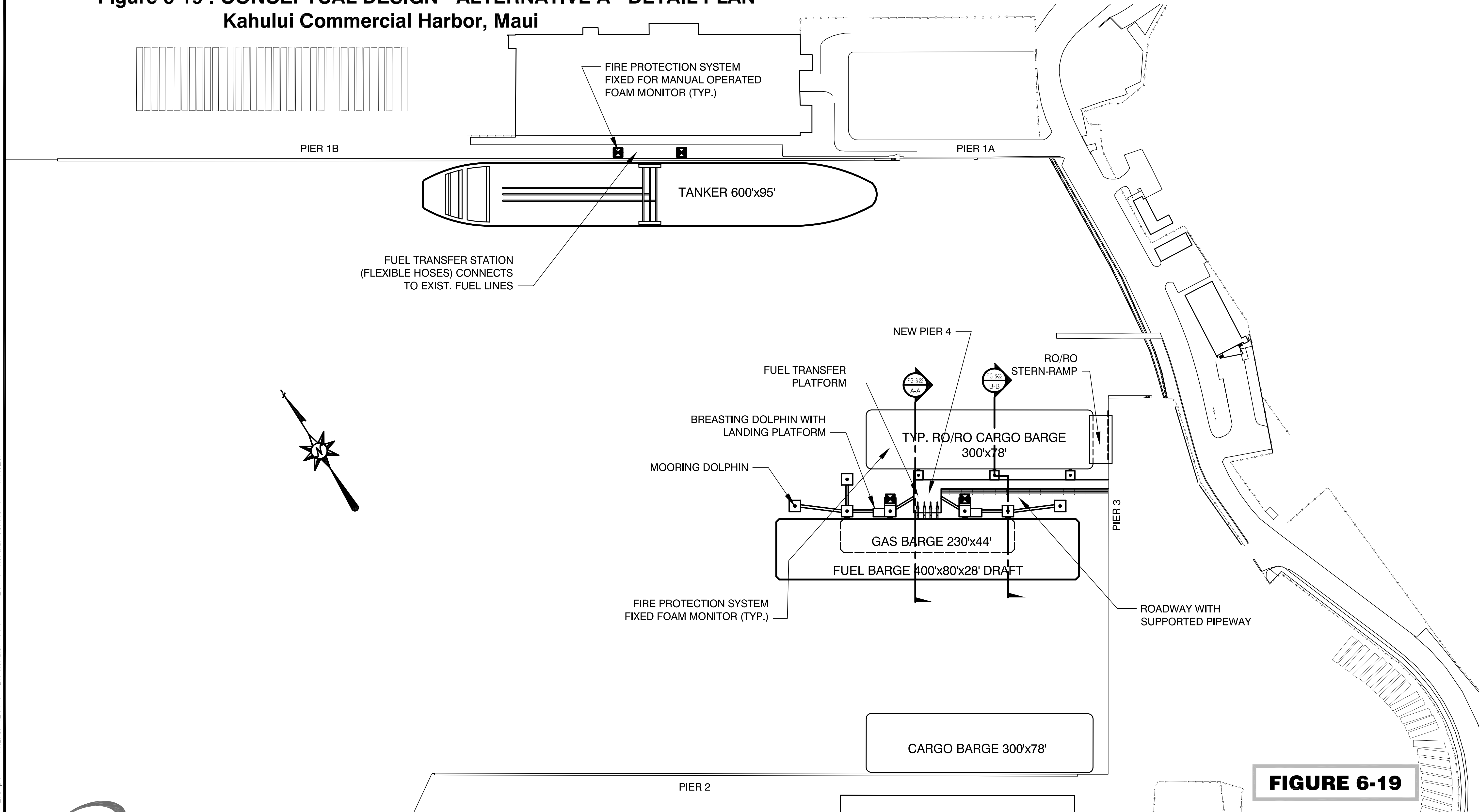

FIGURE 6-19

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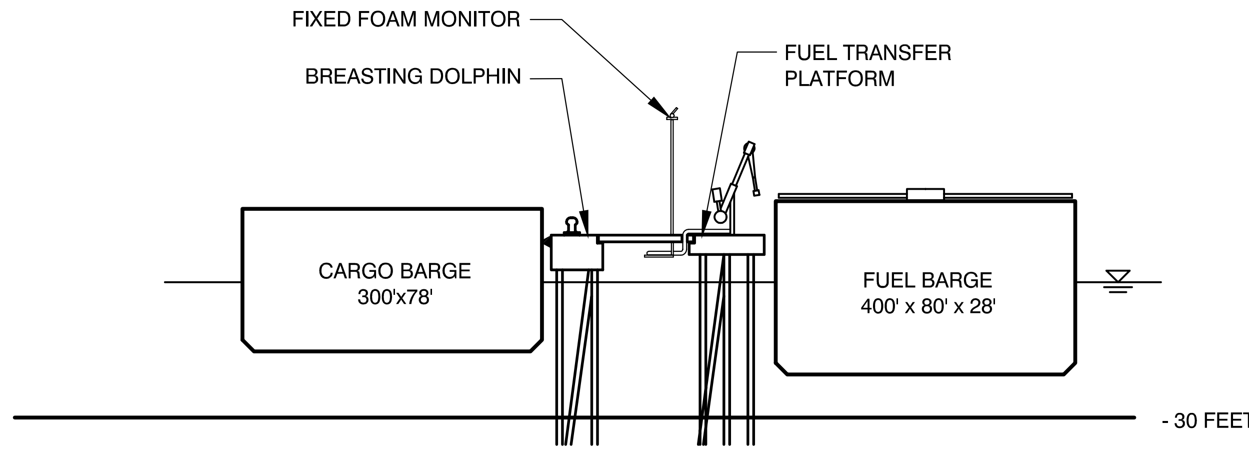
GRAPHIC SCALE:

125' 0 125' 250'

SCALE: 1" = 125'-0"

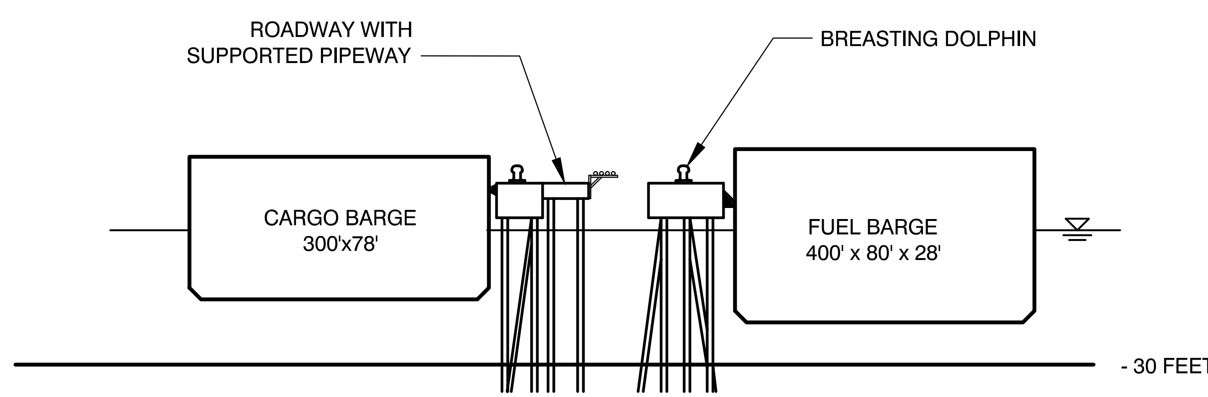
DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-19.dwg USER: nsantos IMAGES:
DATE: May 22, 2008 2:57pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-1

Figure 6-20 : CONCEPTUAL DESIGN - ALTERNATIVE A - DETAIL SECTIONS
Kahului Commercial Harbor, Maui



SECTION "A-A"

SCALE: NTS



SECTION "B-B"

SCALE: NTS

FIGURE 6-20

GRAPHIC SCALE:

50' 0 50' 100'

SCALE: 1" =50'-0"

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DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-20.dwg USER: nsantos
DATE: May 22, 2008 3:07pm XREFS: 1244-x-TBK Kahului 11x17 IMAGES:

Figure 6-21 : CONCEPTUAL DESIGN - ALTERNATIVE B - SITE PLAN
Kahului Commercial Harbor, Maui

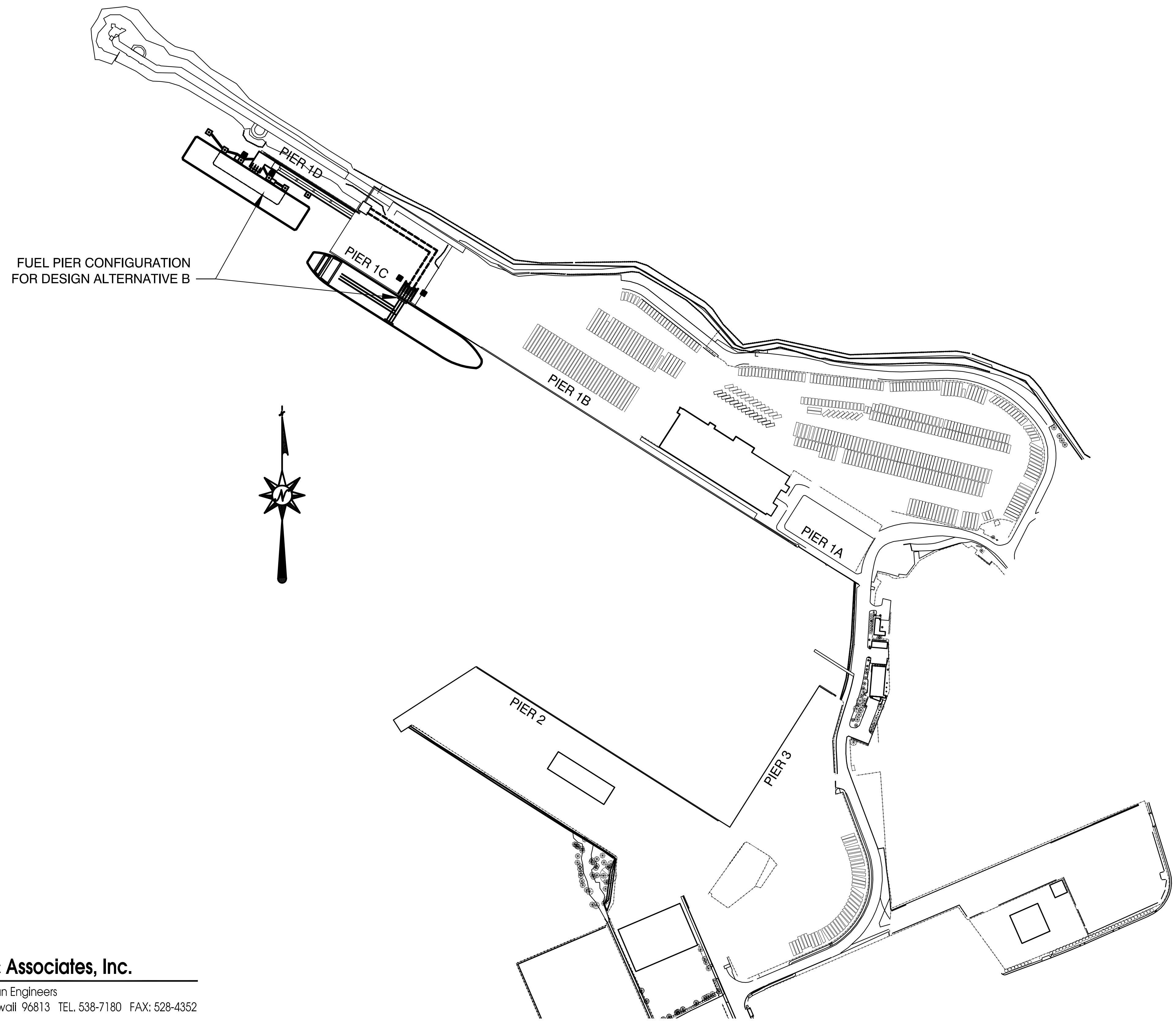

FIGURE 6-21

GRAPHIC SCALE:

350' 0 350' 700'

SCALE: 1" =350'-0"

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DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-21.dwg USER: nsantos IMAGES:
DATE: May 22, 2008 3:09pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-2

Figure 6-22 : CONCEPTUAL DESIGN - ALTERNATIVE B - DETAIL PLAN
Kahului Commercial Harbor, Maui

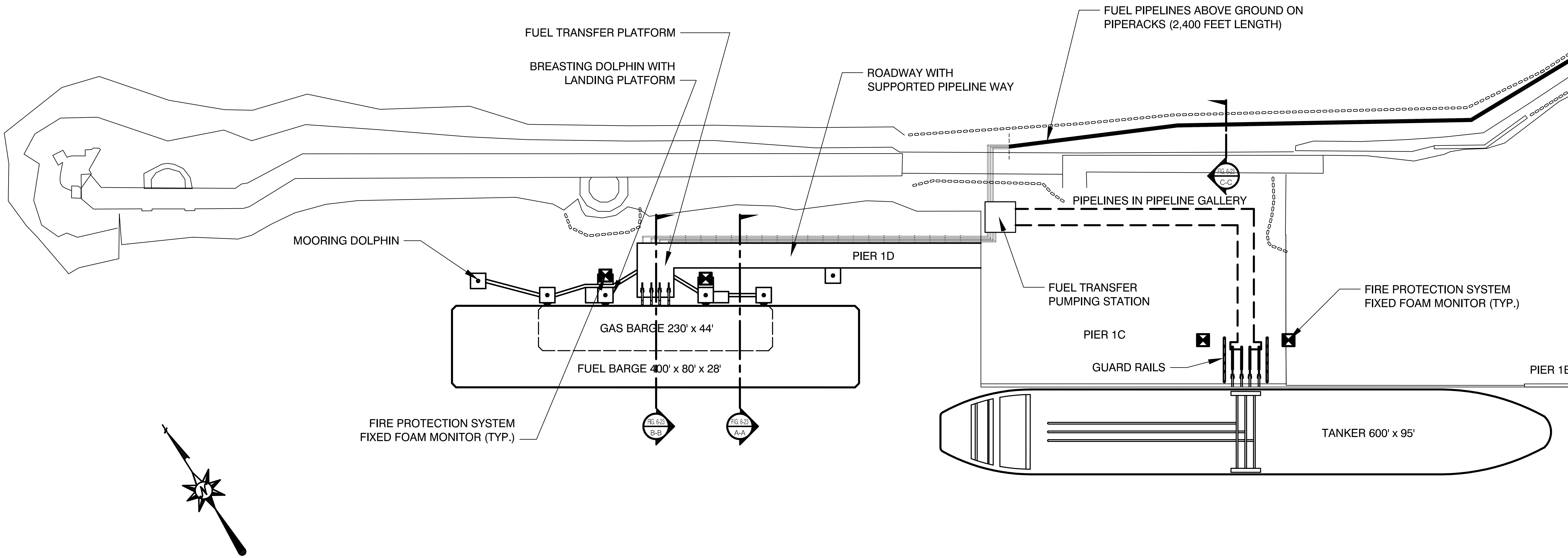

FIGURE 6-22

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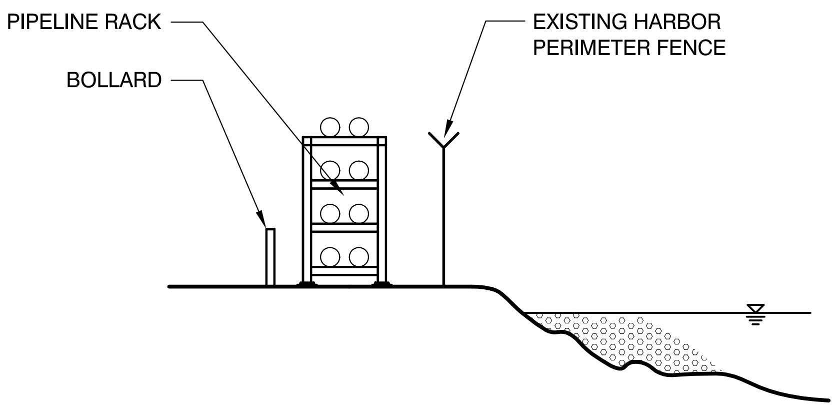
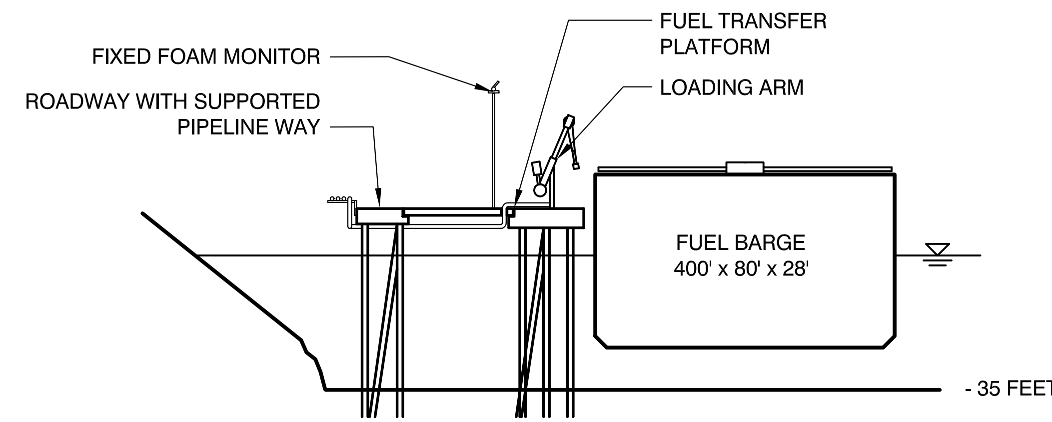
DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-22.dwg USER: nsantos IMAGES:
DATE: May 22, 2008 3:13pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-2_NEW

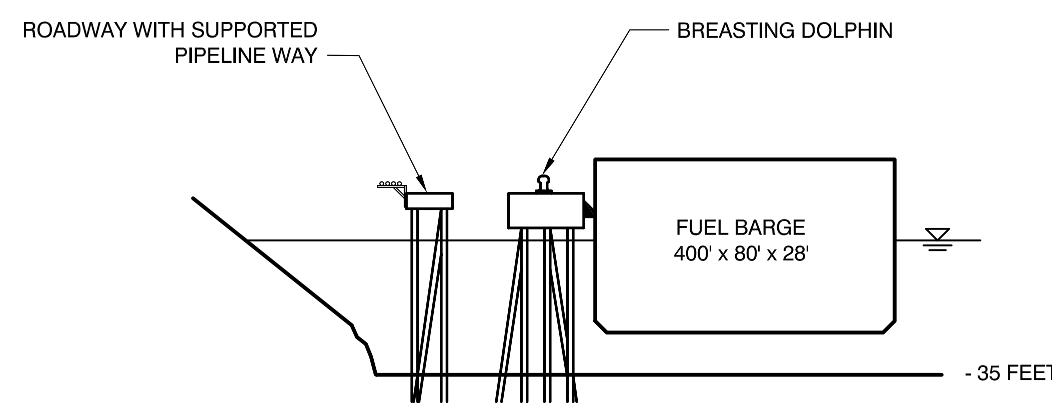
Figure 6-23 : CONCEPTUAL DESIGN - ALTERNATIVE B - DETAIL SECTIONS
Kahului Commercial Harbor, Maui



SECTION "C-C"
SCALE: NTS



SECTION "B-B"
SCALE: NTS



SECTION "A-A"
SCALE: NTS

FIGURE 6-23

GRAPHIC SCALE:
50' 0 50' 100'
SCALE: 1" =50'-0"

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DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-23.dwg USER: nsantos
DATE: May 22, 2008 3:14pm XREFS: 1244-x-TBK Kahului 11x17 IMAGES:

Figure 6-24 : CONCEPTUAL DESIGN - ALTERNATIVE C - SITE PLAN
Kahului Commercial Harbor, Maui

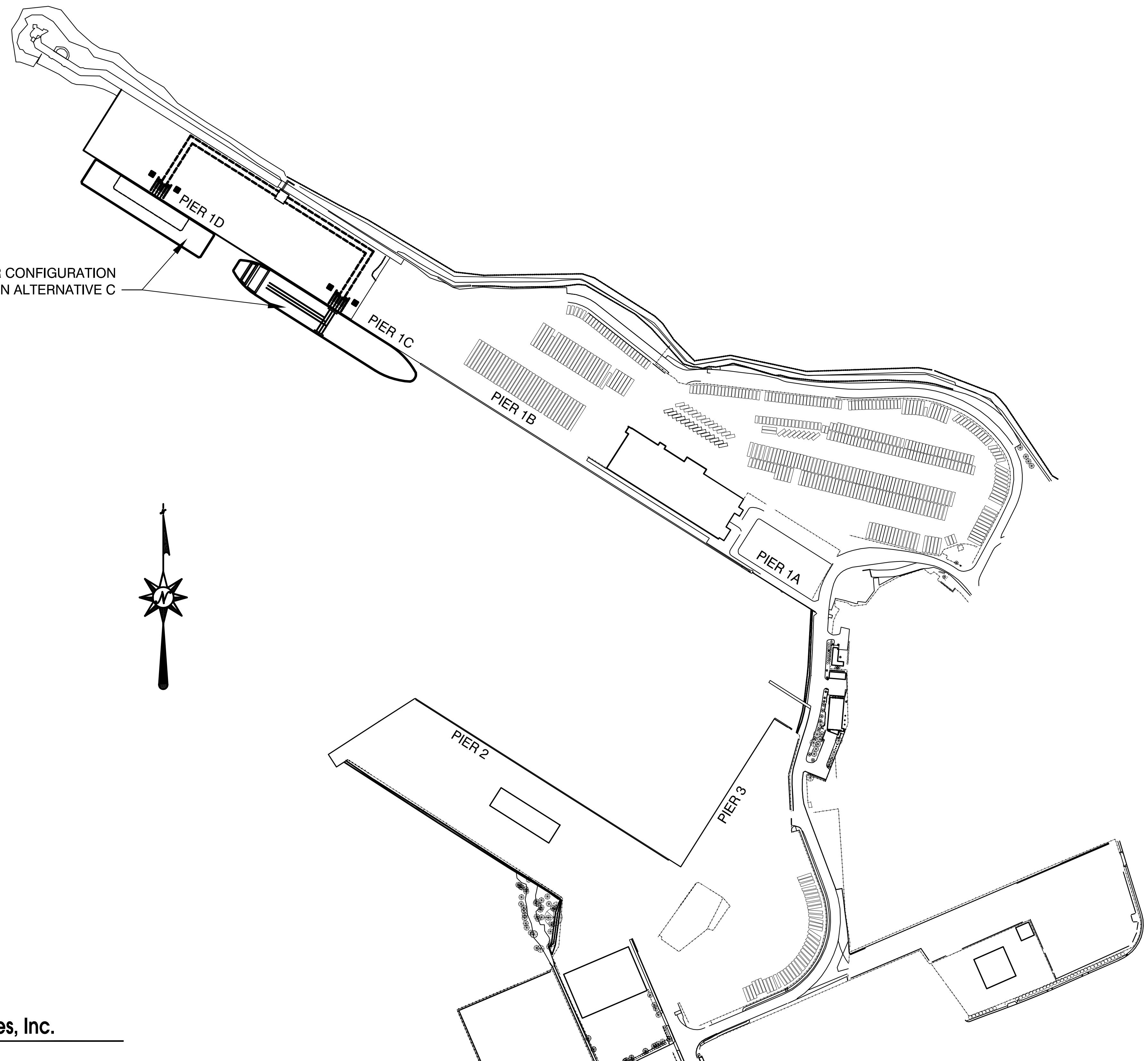

FIGURE 6-24

GRAPHIC SCALE:
350' 0 350' 700'
SCALE: 1" =350'-0"

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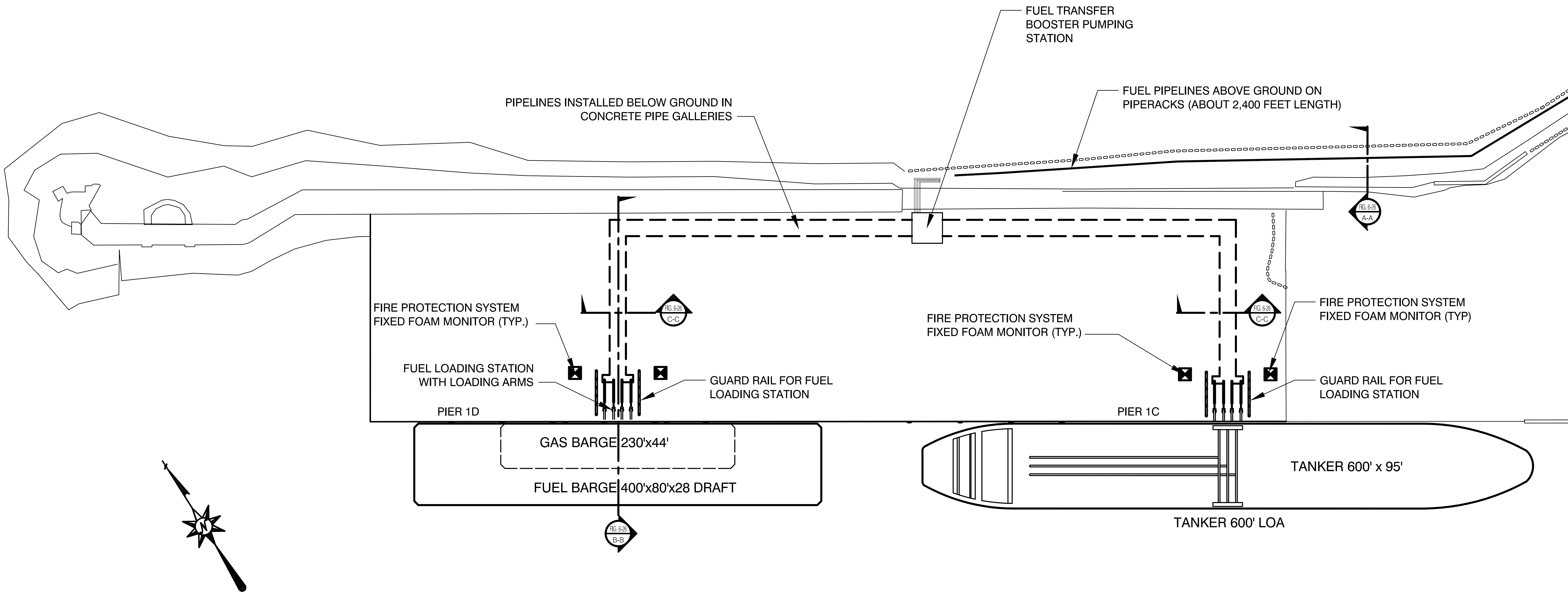
DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-24.dwg USER: nsantos
DATE: May 22, 2008 3:15pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-3_NEW IMAGES:

Figure 6-25 : CONCEPTUAL DESIGN - ALTERNATIVE C - DETAIL PLAN
Kahului Commercial Harbor, Maui



DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-25.dwg USER: nsantos IMAGES:
DATE: May 22, 2008 3:16pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-3_NEW

FIGURE 6-25

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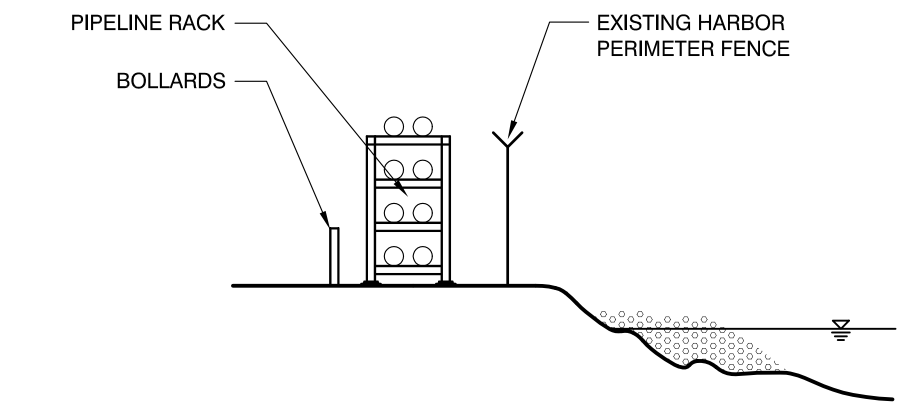
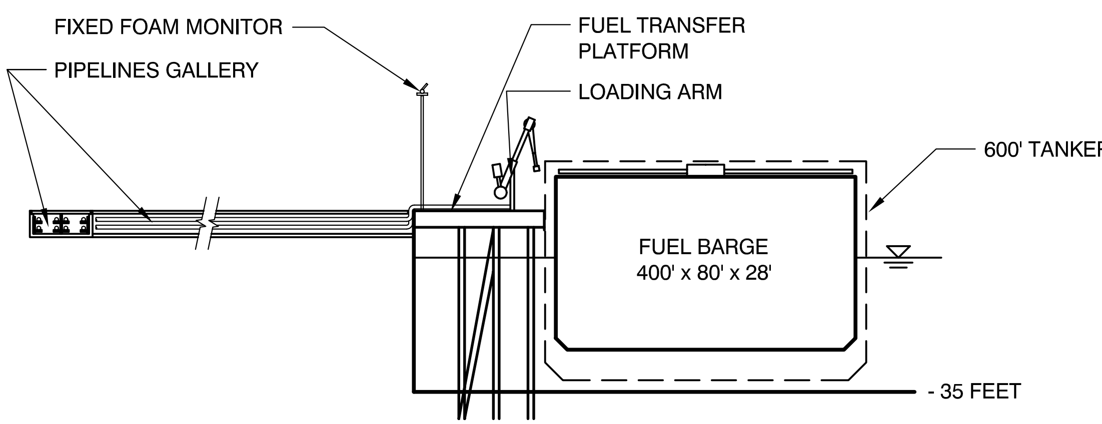
GRAPHIC SCALE:
100' 0 100' 200'
SCALE: 1" =100'-0"

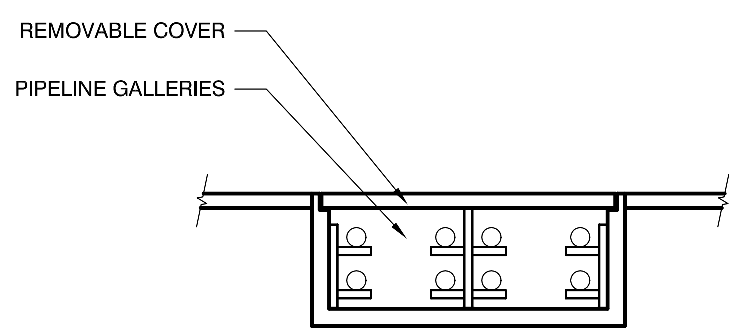
Figure 6-26 : CONCEPTUAL DESIGN - ALTERNATIVE C - DETAIL SECTIONS
Kahului Commercial Harbor, Maui



SECTION "A-A"
SCALE: NTS



SECTION "B-B"
SCALE: NTS



SECTION "C-C"
SCALE: NTS

FIGURE 6-26

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GRAPHIC SCALE:
50' 0 50' 100'
SCALE: 1" =50'-0"

DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-26.dwg USER: nsantos
DATE: May 22, 2008 3:17pm XREFS: 1244-x-TBK Kahului 11x17 IMAGES:

Figure 6-27 : CONCEPTUAL DESIGN - ALTERNATIVE D - SITE PLAN
Kahului Commercial Harbor, Maui

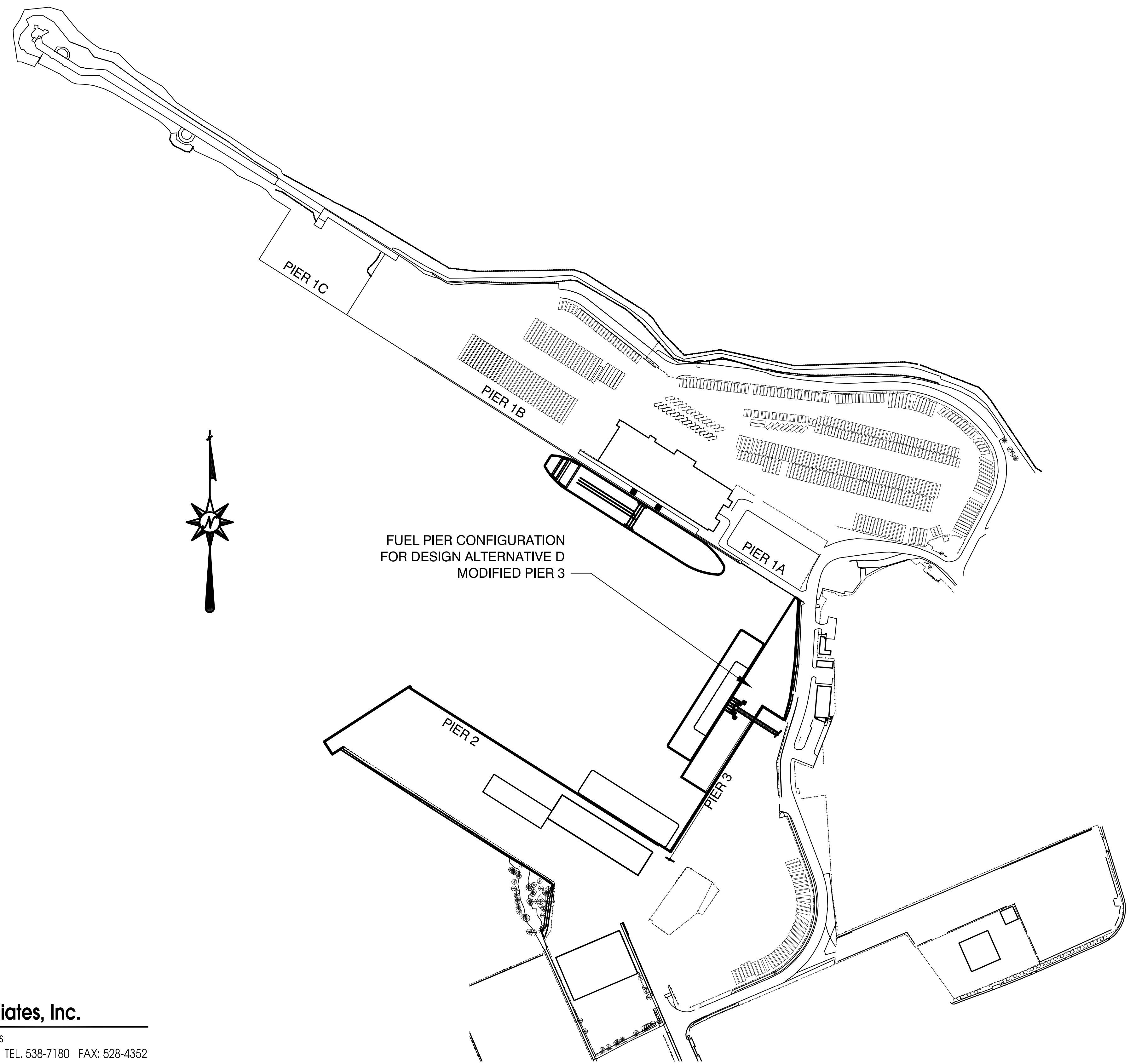

FIGURE 6-27

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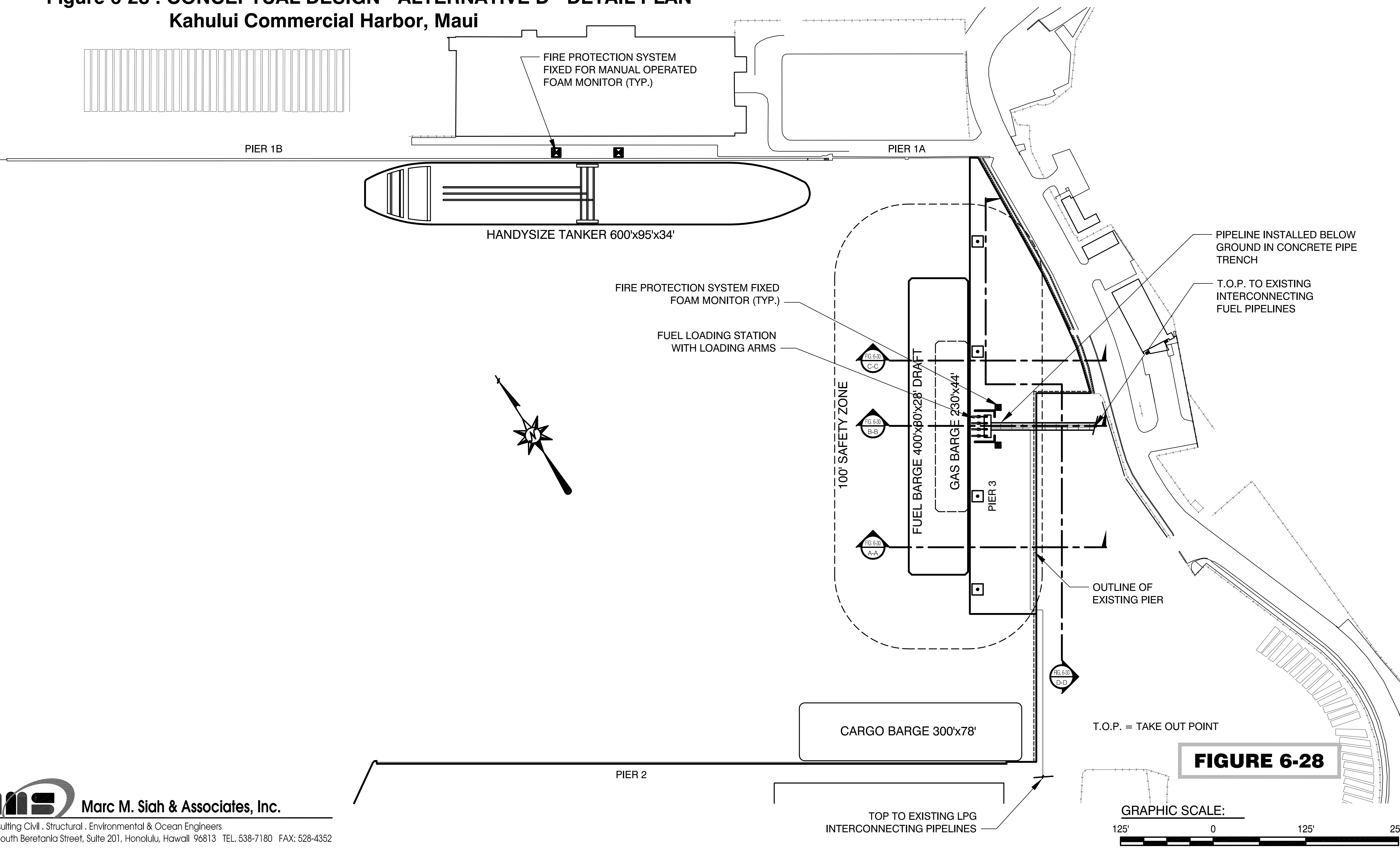
GRAPHIC SCALE:
350' 0 350' 700'
SCALE: 1" =350'-0"

DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-27.dwg USER: nsantos
DATE: May 22, 2008 3:18pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-4 IMAGES:

Figure 6-28 : CONCEPTUAL DESIGN - ALTERNATIVE D - DETAIL PLAN
Kahului Commercial Harbor, Maui



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DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-28.dwg USER: nsantos
DATE: May 22, 2008 3:20pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-4 IMAGES:

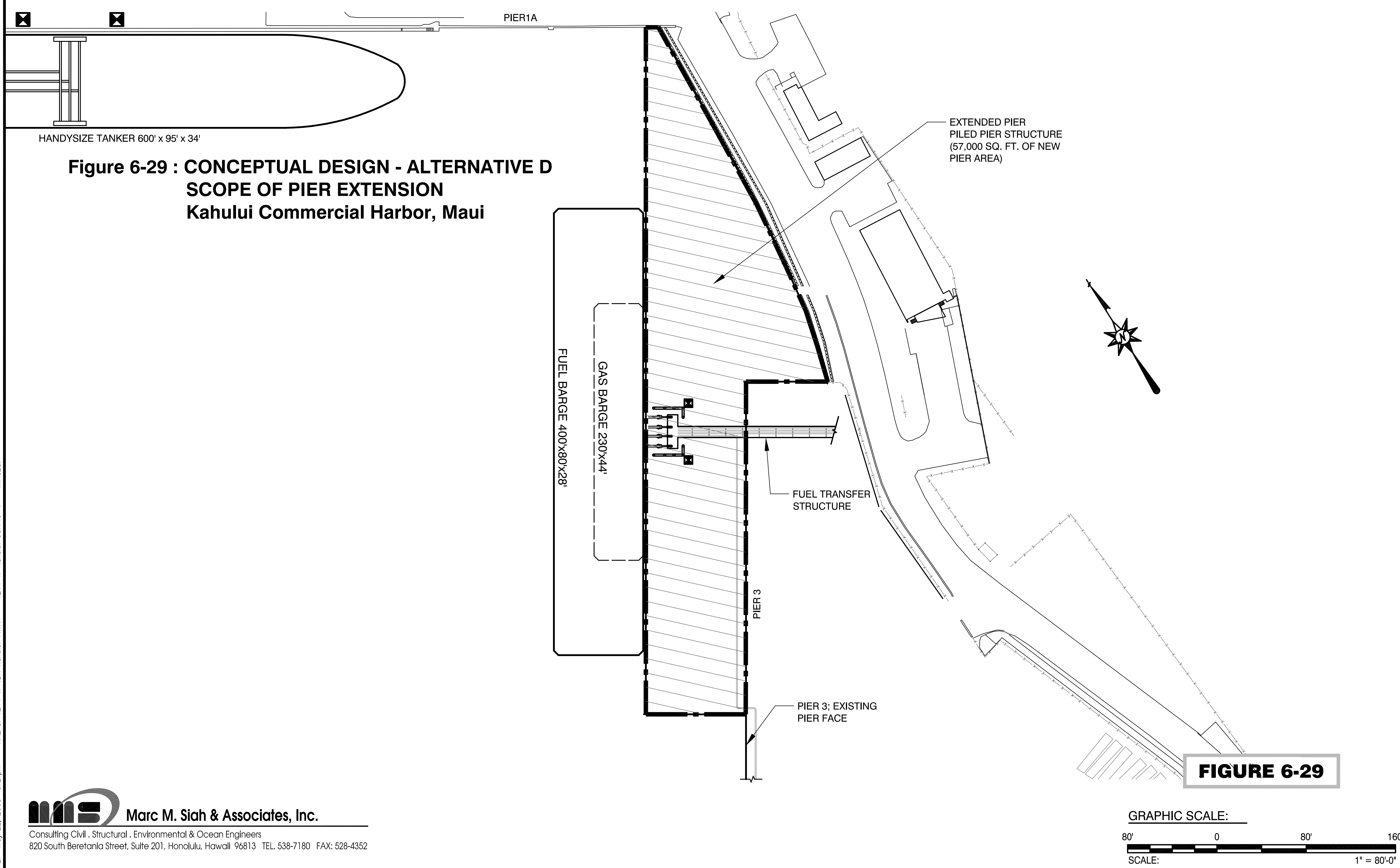

Figure 6-29 : CONCEPTUAL DESIGN - ALTERNATIVE D
SCOPE OF PIER EXTENSION
Kahului Commercial Harbor, Maui

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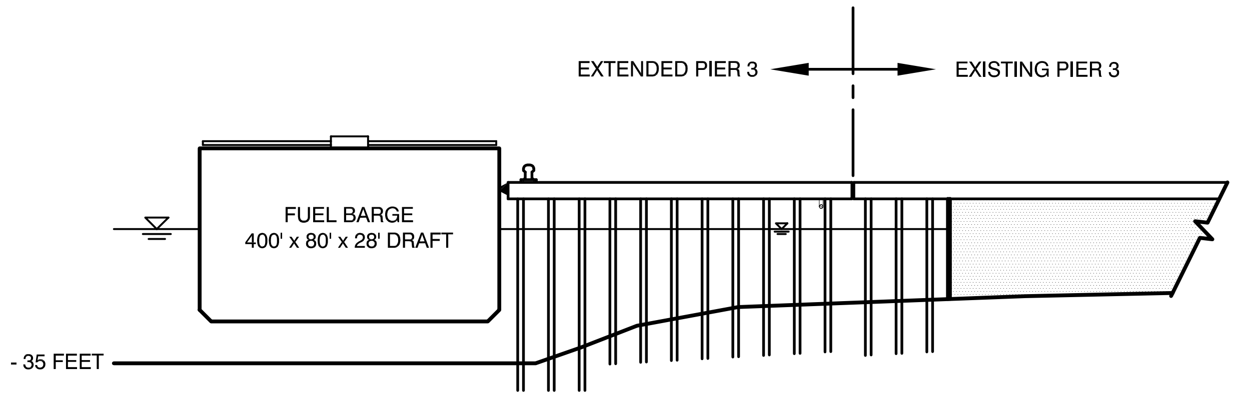
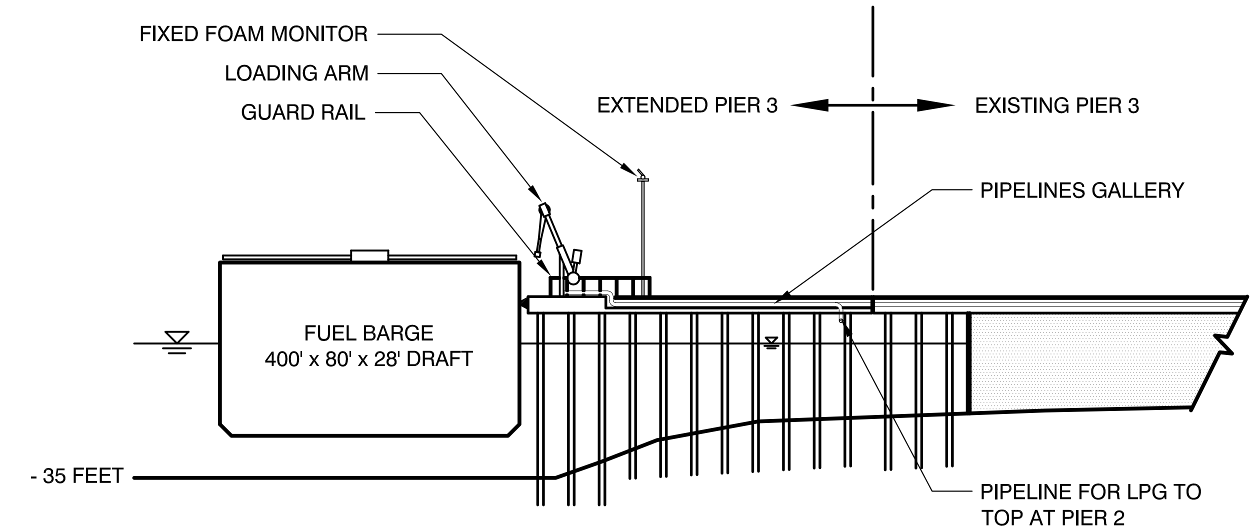
DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-29.dwg USER: nsantos IMAGES:
DATE: May 22, 2008 3:21pm XREFS: 1244-x-TBK Kahului 11x17 1244-x-Kahului CONFIG-4

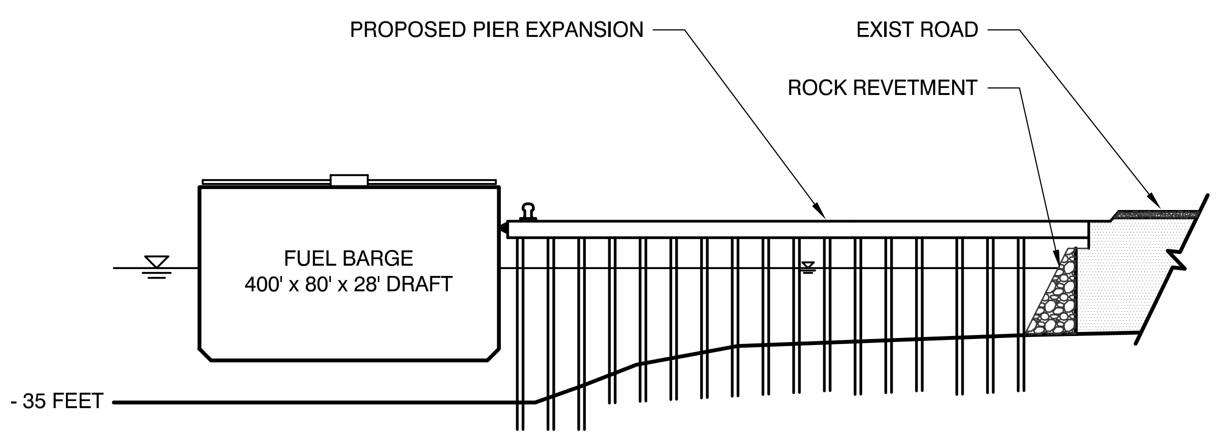
Figure 6-30 : CONCEPTUAL DESIGN - ALTERNATIVE D - DETAIL SECTIONS
Kahului Commercial Harbor, Maui



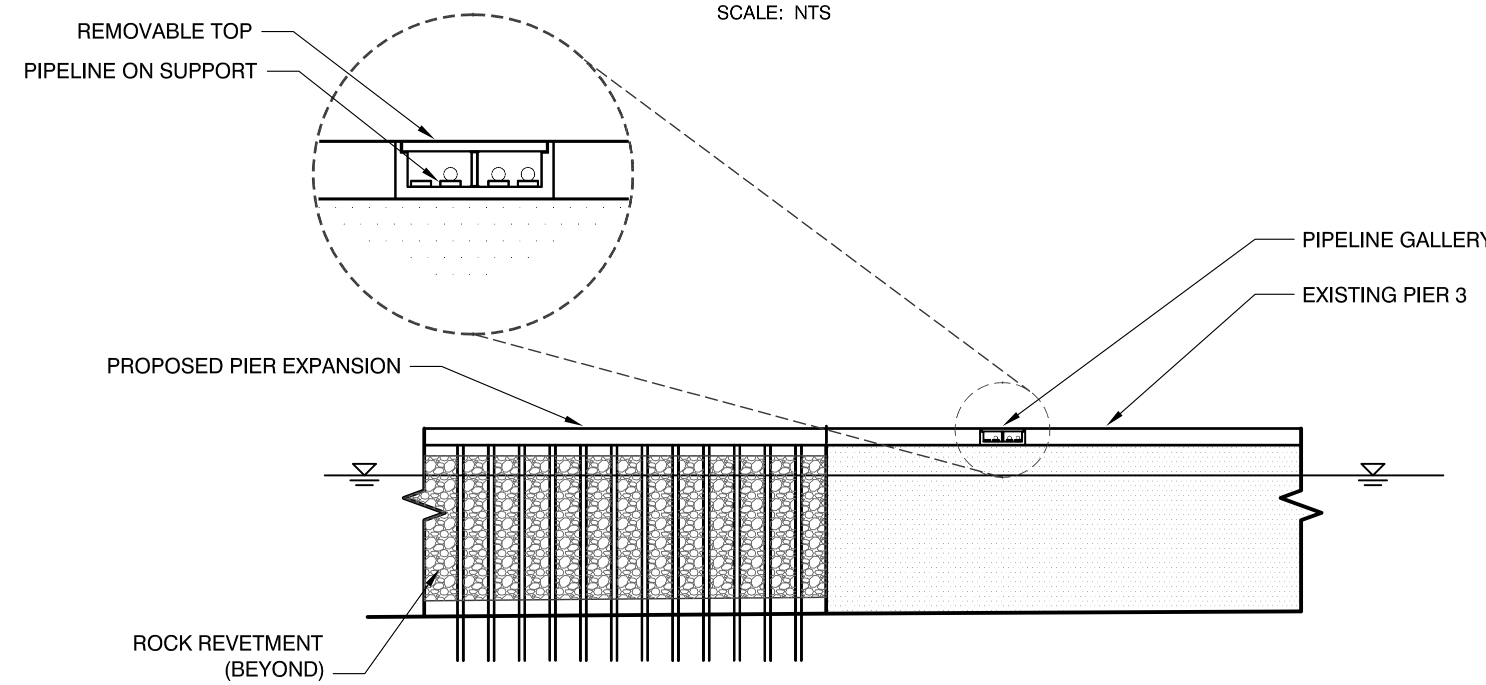
SECTION "A-A"
SCALE: NTS



SECTION "B-B"
SCALE: NTS



SECTION "C-C"
SCALE: NTS



SECTION "D-D"
SCALE: NTS

FIGURE 6-30

GRAPHIC SCALE:
50' 0 50' 100'
SCALE: 1" =50'-0"

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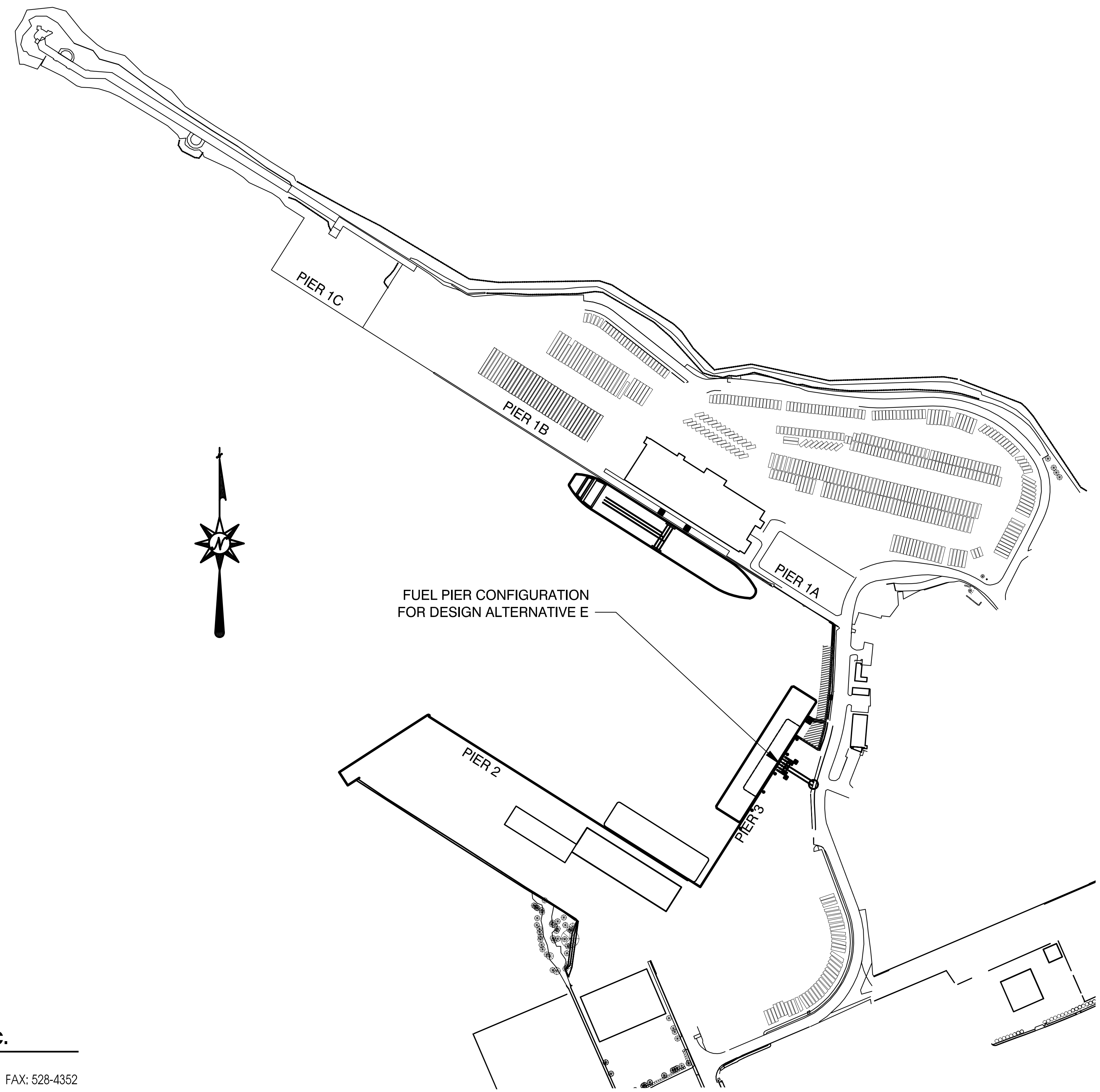
DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-30.dwg USER: nsantos
DATE: May 22, 2008 3:21pm XREFS: 1244-x-TBK Kahului 11x17 IMAGES:

Figure 6-31 : CONCEPTUAL DESIGN - ALTERNATIVE E - SITE PLAN
Kahului Commercial Harbor, Maui



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DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-31.dwg USER: nsantos
DATE: May 22, 2008 3:22pm XREFS: 1244-x-TBK Kahului 11x17 Alternaive E Kahului IMAGES:

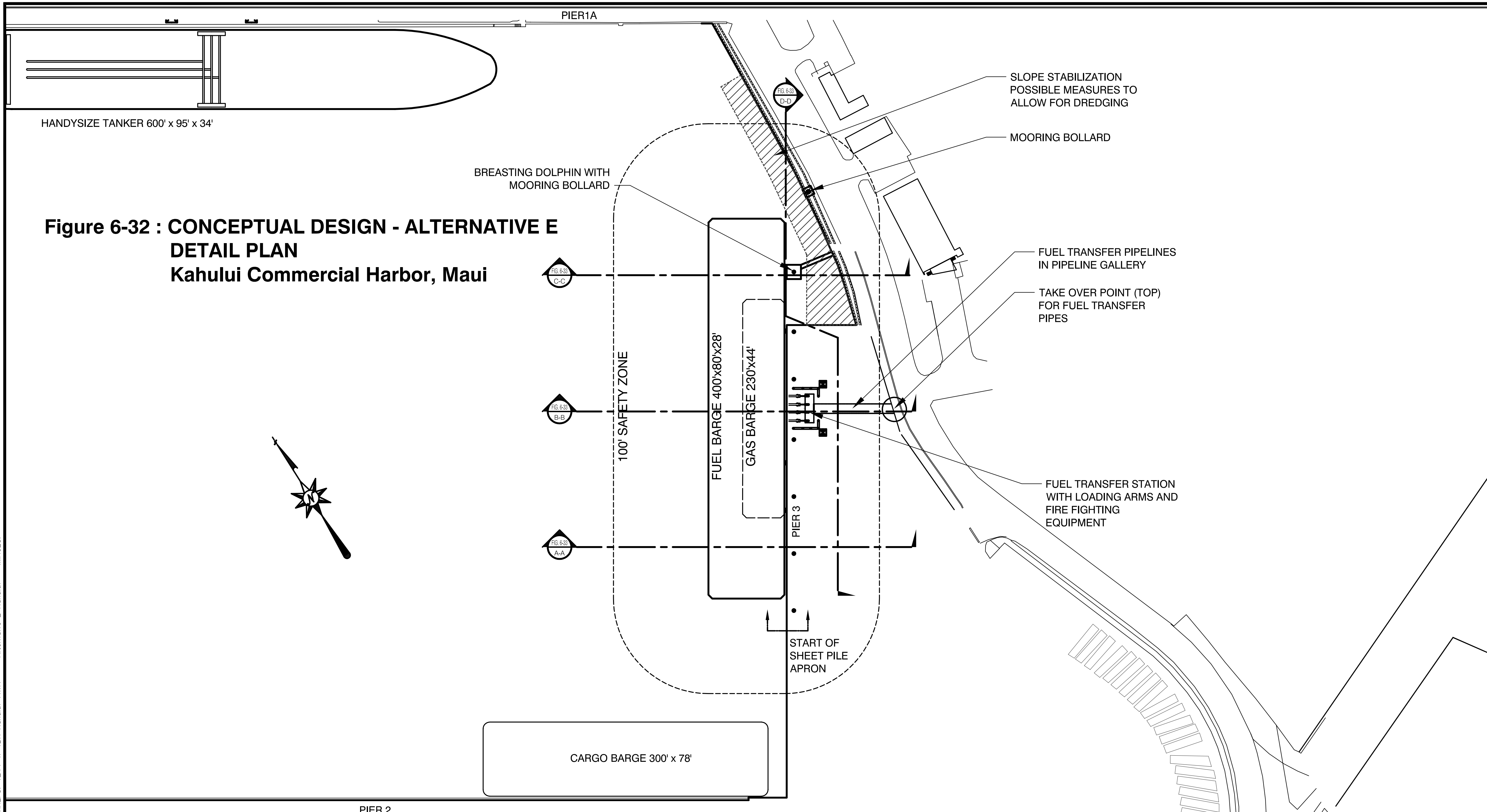

Figure 6-32 : CONCEPTUAL DESIGN - ALTERNATIVE E DETAIL PLAN Kahului Commercial Harbor, Maui

FIGURE 6-32

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GRAPHIC SCALE:
100' 0 100' 200'
SCALE: 1" = 100'-0"

DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-32.dwg USER: nsantos
DATE: May 22, 2008 3:23pm XREFS: 1244-x-TBK Kahului 11x17 Alternaive E Kahului IMAGES:

Figure 6-33 : CONCEPTUAL DESIGN - ALTERNATIVE E - DETAIL SECTIONS
Kahului Commercial Harbor, Maui

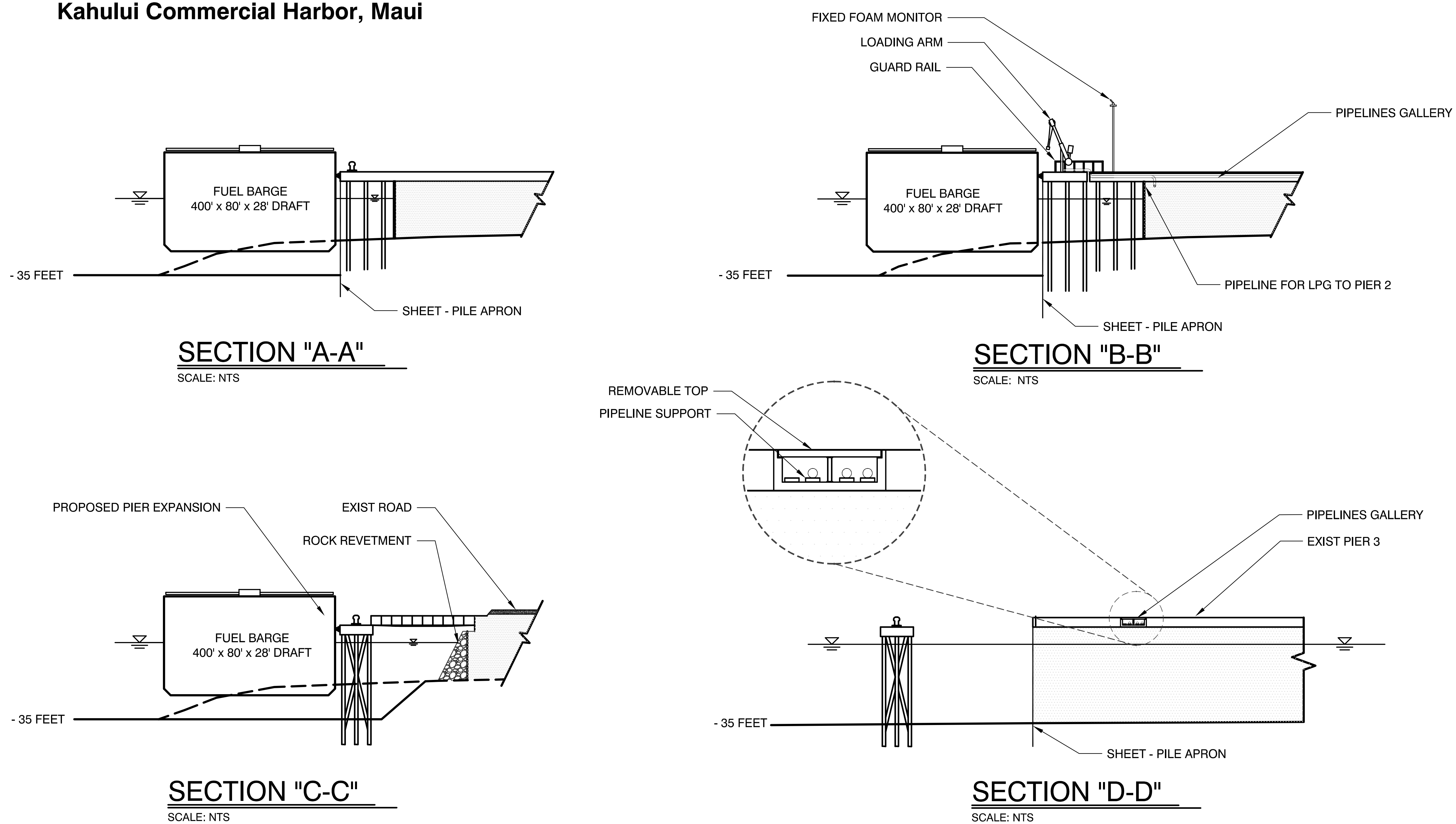

FIGURE 6-33

GRAPHIC SCALE:

50' 0 50' 100'

SCALE: 1" =50'-0"

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DWG: J:\1244\dwg\Presentation-4_Revised\KAHULUI (12-10-07)\Figure 6-33.dwg USER: nsantos
DATE: May 22, 2008 3:24pm XREFS: 1244-x-TBK Kahului 11x17 IMAGES:

Table 6-1 Kahului Harbor: Advantages and Disadvantages of Conceptual Design Alternatives (Page 1 of 5)

Kahului Alternative A: New Pier 4 and improved fuel transfer facility at Pier 1A.

Advantages	Disadvantages
• Two fuel berths would be available providing operational flexibility and redundancy. • One side of the new Pier 4 would be dedicated to fuel barges and this would guarantee availability and flexibility of mooring for fuel barges. • On the other side of the new Pier 4, a RO/RO cargo pier could be integrated into the pier improvement and this would provide an additional mooring space in the harbor. • The close proximity of the new Pier 4 to existing transmission pipelines would minimize the costs for new fuel pipelines. • The piled pier structure (consisting of a fuel transfer platform, roadway, breasting and mooring dolphins) is a cost-effective improvement. • The construction period of the piled structure would be shorter than a conventional bulkhead pier. Structural components could be pre-fabricated and expeditiously installed. This would minimize the impacts to harbor operations. • The new Pier 4 (and integrated RO/RO cargo pier) would provide additional berthing where it is logistically most beneficial (i.e., in the inner harbor). • Using fuel loading arms would reduce the vulnerability of fuel barges to large movements due to short- and long-period waves in the inner harbor.	• The new Pier 4 would protrude more than 450 feet into the inner harbor basin. The pier configuration in Alternative A may create navigational conflicts in the inner harbor. • During pier construction, there would be considerable disruptions of harbor operations. With Pier 3 temporarily not available, the fuel barges would have to use Pier 1A exclusively to unload fuel. This may create an untenable situation because fuel barges would have to compete with other harbor users for berthing and time at Pier 1A. • In the event of a fuel spill at the new Pier 4, the inner harbor could not be used. Fuel would aggregate in the innermost harbor basin. • Wave actions caused by wave reflection and long-period waves in the harbor would be significant at the site of the new Pier 4.

Table 6-1 Kahului Harbor: Advantages and Disadvantages of Conceptual Design Alternatives (Page 2 of 5)

Kahului Alternative B: New Pier 1D (using piled, protruding pier structure) and improved fuel transfer facility at Pier 1C.

Advantages	Disadvantages
• Two fuel berths would be available providing operational flexibility and redundancy. • The new Pier 1D would be dedicated to fuel barges and this would guarantee availability and flexibility of mooring for fuel barges. • The piled pier structure, consisting of a fuel transfer platform, roadway, breasting dolphins and mooring dolphins, would be a cost-effective structure. • The construction period of the piled structure would be shorter than a conventional bulkhead pier. Structural components could be pre-fabricated and expeditiously installed. • Wave action at the new Pier 1D would be limited since the new pier would be recessed inwards towards the breakwater, away from the face of Pier 1. • Using the loading arms would reduce the vulnerability of fuel barges/tankers to large movements due to short and long period waves at the pier. Fuel transfer would be safer with loading arms than with flexible hoses. • Amount of dredging at the new Pier 1D would be limited. • Aboveground transmission pipelines would allow for flexibility. Interconnecting pipelines on pipeline racks result in cost-effective construction and maintenance. Pipelines could be easily added on the pipeline racks. • Minimal impact on harbor operations during construction of the new Pier 1D.	• The long distance between Pier 1D to existing fuel tanks and existing transmission pipelines system located in the inner harbor necessitates the installation of a new and costly 2,400-foot long pipeline system. • Since fuel vessels might have insufficient pumping capacity to discharge fuel through the new pipeline system, a fuel pumping station would be added to increase pressure for the efficient discharge of product to the existing tank farms (The electric shore-site pumping station limits the burning of residual oil to drive the fuel pumps for unloading). • The placement of the aboveground transmission pipelines inside the harbor area would take space away from harbor operation (i.e., traffic area, cargo storage, parking area). • The pipeline racks with the pipelines would be protected against impact from cargo handling equipment and traffic adjacent to the northern fence of the harbor. (It is assumed that security for the pipelines is provided for inside harbor boundaries). • Fuel spills are likely to travel downwind of prevailing wind direction (trade winds from the northeast) into Kahului Bay.

Table 6-1 Kahului Harbor: Advantages and Disadvantages of Conceptual Design Alternatives (Page 3 of 5)

Kahului Alternative C: New Pier 1D (using bulkhead and piled pier structure) and improved fuel transfer facility at Pier 1C.

Advantages	Disadvantages
• The new Pier 1D would be a multi-use pier that would provide additional berthing space in the harbor; the new pier could accommodate all types of ships. • Using the loading arms would reduce the vulnerability of fuel vessels to large movements due to short- and long-period waves in the inner harbor. • Amount of dredging at the new Pier 1D would be minimized because the pier is located close to deep water. • Dredged material could be used to fill in behind the bulkhead piers. • Flexible configuration of the belowground installation of pipelines at existing Pier 1C and new Pier 1D in concrete pipe galleries would allow for flexibility in construction and operation. • Flexible configuration of the aboveground installation of pipelines would allow for flexibility; transmission piping on pipeline racks result in cost effective construction and maintenance, as well as addition of pipelines on the pipeline racks. • Moderate impact on harbor operations during construction of the new fuel pier since the new pier would be at a previously undeveloped site of the harbor.	• Since Pier 1D would be a multi-use facility and not dedicated to fuel operations, there may be limited ability to install flexible fuel transfer technology. • Because the Pier 1D pier face coincides with the existing pier face, the fuel vessels would be closer to wave excitation. • The construction of the conventional bulkhead pier would be more costly and time consuming than a piled protruding segmented pier dedicated to fuel transfer only. The construction of Pier 1D would cause moderate disruptions of harbor operations. • The distance of Pier 1D from the tank farms and existing inter-connecting pipelines necessitates the installation of new and costly 2,400-foot of transmission pipelines. • Since fuel vessels might have insufficient pumping capacity to discharge fuel through the new pipelines system, a fuel pumping station would be added to increase pressure for the efficient discharge of product to the existing tank farms (The electric shore-site pumping station limits the burning of residual oil to drive the fuel pumps for unloading). • The placement of the transmission pipelines inside the harbor area would take space away from harbor operation (traffic area, cargo storage, parking area). The pipeline rack and the pipelines on it would have to be protected against impact by cargo handling equipment and traffic adjacent to the northern fence. • Fuel spills are likely to travel downwind of prevailing wind direction (trade winds from the northeast) into Kahului Bay.

Table 6-1 Kahului Harbor: Advantages and Disadvantages of Conceptual Design Alternatives (Page 4 of 5)

Kahului Alternative D: Extended Pier 3 and improved fuel transfer facility at Pier 1A.

Advantages	Disadvantages
• Two fuel berths would be available providing operational flexibility and redundancy. • The close proximity of the extended Pier 3 to existing transmission pipelines would minimize construction and maintenance costs for new fuel pipeline infrastructure. • Both fuel berths would be multi-purpose berths, which would increase cargo-handling capacity in the harbor. • The extended Pier 3 would significantly increase the area that is available for cargo handling and temporary storage. • The construction period of the piled structure would be shorter than a conventional bulkhead pier. Structural components could be pre-fabricated and expeditiously installed. This would minimize impacts to harbor operations. • The piled pier structure and the rock revetment at the shoreline of the harbor basin would contribute to wave attenuation due to energy dissipation through flow around piles and partial reflection from the rock revetment. The resulting wave action at the extended, piled Pier 3 would therefore be less than with a solid bulkhead pier close to the pier face. • Using fuel loading arms would reduce the vulnerability of fuel barges/tankers to significant movements due to short and long period waves in the inner harbor and increases safety of the fuel transfer. • Dredging could be carried out without impact on the existing structure of Pier 3, therefore it could be fully integrated into the extended Pier 3.	• During pier construction, there could be considerable disruptions to harbor operations. With Pier 3 temporarily not available, fuel barges would have to use Pier 1A exclusively to off-load fuel. This creates a situation where fuel barges would have to compete with other harbor users for berthing space and time at Pier 1A. • In the event of a fuel spill at Pier 3 or 1A, the inner harbor could not be used. Spilled fuel would aggregate in the innermost harbor basin. Accumulation of fuel under the piled pier (Pier 3) sections could cause significant environmental. • The area that is covered with the new pier structure would be comparatively large and therefore construction time and costs would be considerable. However, the piling and construction of the pier structure between existing Pier 3 and Pier I could be carried out without significant interference of harbor operations since this part of the harbor is presently not used. • The area between existing Pier 3 and Pier 1 is presently used for mooring/berthing of smaller utility and service boats (i.e., boats to combat fuel spills). New berthing spaces would have to be provided for these smaller workboats.

Table 6-1 Kahului Harbor: Advantages and Disadvantages of Conceptual Design Alternatives (Page 5 of 5)

Kahului Alternative E: Pier 3 with new sheet pile apron and improved fuel transfer facility at Pier 1A.

Advantages	Disadvantages
• Two fuel berths would be available providing operational flexibility and redundancy. • The close proximity of fuel transfer equipment to existing interconnecting pipelines at Pier 3 would minimize construction and maintenance costs for new fuel pipeline infrastructure. • Both fuel berths would be multi-purpose berths, which increase cargo handling capacity in the harbor. • The construction period of the sheet pile apron around Pier 3 would be shorter than for a conventional bulkhead pier or plied pier. This would minimize impacts to harbor operations. • Using fuel-loading arms would reduce the vulnerability of fuel barges/tankers to significant movements due to short and long period waves in the inner harbor and increases safety of the fuel transfer. • By installing a breasting dolphin, the pier face at Pier 3 could be extended to accommodate a 400-foot long design barge with enough space left for cargo barges at Pier 2. • The pier modifications at Pier 3 would be very cost effective.	• During pier construction, there could be considerable disruptions to harbor operations. With Pier 3 temporarily not available, fuel barges would have to use Pier 1A exclusively to unload fuel. This could create situations where fuel barges would have to compete with other harbor users for berthing space and time at Pier 1A. • In the event of a fuel spill at Piers 3 or 1A, the inner harbor could not be used. Spilled fuel will aggregate in the innermost harbor basin. • Stagnant water, possibly contaminated with fuel, below Pier 3 (and inside the sheet pile apron) could be an environmental concern. • Dredging close to the shoreline in the area between Piers 1 and 3 might impact shore stability and might require slope stabilization measures.

End of Part 1 of the report:

Part 2 of the report starts with Section 6.4