Water Resources Technical Report
Honolulu High-Capacity Transit Corridor Project

August 15, 2008

Prepared for:
City and County of Honolulu

Preface

This technical report supports the Draft Environmental Impact Statement (EIS) prepared for the Honolulu High-Capacity Transit Corridor Project. It provides additional detail and information as it relates to:

- Methodology used for the analysis
- Applicable regulations
- Results of the technical analysis
- Proposed mitigation
- Coordination and consultation (as appropriate)
- References
- Model output (as appropriate)
- Other information/data

As described in the Draft EIS, the Locally Preferred Alternative, called the “Full Project,” is an approximate 30-mile corridor from Kapolei to the University of Hawaiʻi at Mānoa with a connection to Waikīkī. However, currently available funding sources are not sufficient to fund the Full Project. Therefore, the focus of the Draft EIS is on the “First Project,” a fundable approximately 20-mile section between East Kapolei and Ala Moana Center. The First Project is identified as “the Project” for the purpose of the Draft EIS.

This technical report documents the detailed analysis completed for the Full Project, which includes the planned extensions, related transit stations, and construction phasing. The planned extensions and related construction planning have not been fully evaluated in the Draft EIS and are qualitatively discussed in the Cumulative Effects section of the Draft EIS as a foreseeable future project(s). Once funding is identified for these extensions, a full environmental evaluation will be completed in a separate environmental study (or studies), as appropriate.

Figure 1-3 through Figure 1-6 (in Chapter 1, Background) show the proposed Build Alternatives and transit stations, including the areas designated as planned extensions.

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Acronyms and Abbreviations

BMP	best management practice
CFR	Code of Federal Regulations
City	City and County of Honolulu
CWA	Clean Water Act
CZM	Coastal Zone Management
DBEDT	Department of Business, Economic Development, and Tourism
EIS	environmental impact statement
EPA	Environmental Protection Agency
‘Ewa (direction)	toward the west (see also Wai‘anae)
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HDOH	Hawai‘i Department of Health
HDOT	Hawai‘i Department of Transportation
Koko Head (direction)	toward the east
makai (direction)	toward the sea
mauka (direction)	toward the mountains
MS4	Municipal Separate Storm Sewer Systems
NEPA	National Environmental Policy Act
NPDES	National Pollution Discharge Elimination System
O‘ahuMPO	O‘ahu Metropolitan Planning Organization
ORTP	O‘ahu Regional Transportation Plan 2030
RTD	Rapid Transit Division
SOBA	Southern O‘ahu Basal Aquifer
TPSS	traction power substation
UH	University of Hawai‘i
UIC	underground injection control
USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
Wai‘anae (direction)	toward the west (see also ‘Ewa)

Summary

The City and County of Honolulu Department of Transportation Services Rapid Transit Division (RTD), in coordination with the United States Department of Transportation (USDOT) Federal Transit Administration (FTA), is preparing a Draft Environmental Impact Statement (EIS) to evaluate alternatives that would provide high-capacity transit service on O‘ahu. The study area is the travel corridor between Kapolei and the University of Hawai‘i at Mānoa (UH Mānoa).

Water resources in the study corridor include the ‘Aiea, Moanalua, Kalihi, Nu‘uanu, Kapālama, and Hālawa Streams and the Ala Wai Canal, which are considered navigable waters and bridges (Figure S-1). Where the Project would cross these water bodies, consultation with the U.S. Coast Guard would be required.

Piers to support the guideway may have to be located in some streams. Permits such as a Department of the Army permit, Water Quality Certification, Coastal Zone Management Consistency Determination, and Stream Channel Alteration Permits would be needed when waterways are affected by the Project.

A floodplain is the lowland adjacent to a river, lake, or ocean likely to be inundated by a 100-year flood. Most known floodplains in the U.S. have been mapped by the Federal Emergency Management Agency (FEMA)'s Flood Insurance Administration. As a linear feature, the guideway would encroach on several floodplains and in order to space the piers close enough to support the guideway, piers would be located in the floodplains. Several transit stations, traction power substations (TPSS), and parking areas would also be located in designated floodplains. However, the Project would not result in a “significant” encroachment on floodplains, as defined by USDOT Order 5650.2, “Floodplain Management and Protection” (Appendix A). This Order distinguishes between an “encroachment” and a “significant encroachment.” A determination of significant floodplain encroachment is made based on the following criteria:

- Whether the alternatives would cause a considerable probability of loss of human life due to flooding;
- Whether likely future damage is associated with the floodplain encroachment that could be substantial in cost or extent, including interruption of service on, or loss of, a vital transportation facility; and
- Whether there would be a notable adverse impact on natural and beneficial floodplain values.

Impervious surfaces increase stormwater runoff volume and pollutant loadings and reduce groundwater recharge. Recent Federal regulations require that stormwater from transportation systems be controlled. Permanent best management practices (BMPs) to minimize stormwater runoff and associated pollutants would be applied to the Project. Stormwater from the guideway should be relatively free from pollutants and would continue to recharge the groundwater.

Parking lots and transit centers would be designed with pollution controls and permanent BMPs. Temporary and permanent stormwater BMPs would also be required by permit agencies and municipal Separate Storm Sewer System (MS4) owners prior to approving project construction and stormwater discharge. The Project would be required to meet the City and County of Honolulu (City) and the Hawai‘i Department of Transportation (HDOT)'s criteria for permanent BMPs.

BMPs to control stormwater during construction would be detailed in a National Pollution Discharge Elimination System (NPDES) permit. If dewatering of the pier foundations is required, an NPDES Dewatering Permit would be obtained and any adjacent structures would be monitored for subsidence. Any discharge into existing waterways must meet State standards. Drilling fluids or slurry would be collected and treated as needed prior to disposal or reuse.

The Southern O‘ahu Basal Aquifer (SOBA) is a freshwater lens that floats on saline groundwater over most of Southern O‘ahu. In accordance with the 1984 Sole Source Aquifer Memorandum of Understanding between the U.S. Environmental Protection Agency (EPA) and the Federal Highway Administration (FHWA), a Groundwater Impact Assessment has been prepared to meet the coordination requirements of Section 1424(e) of the Safe Drinking Water Act. The Project should have no significant impacts on groundwater.

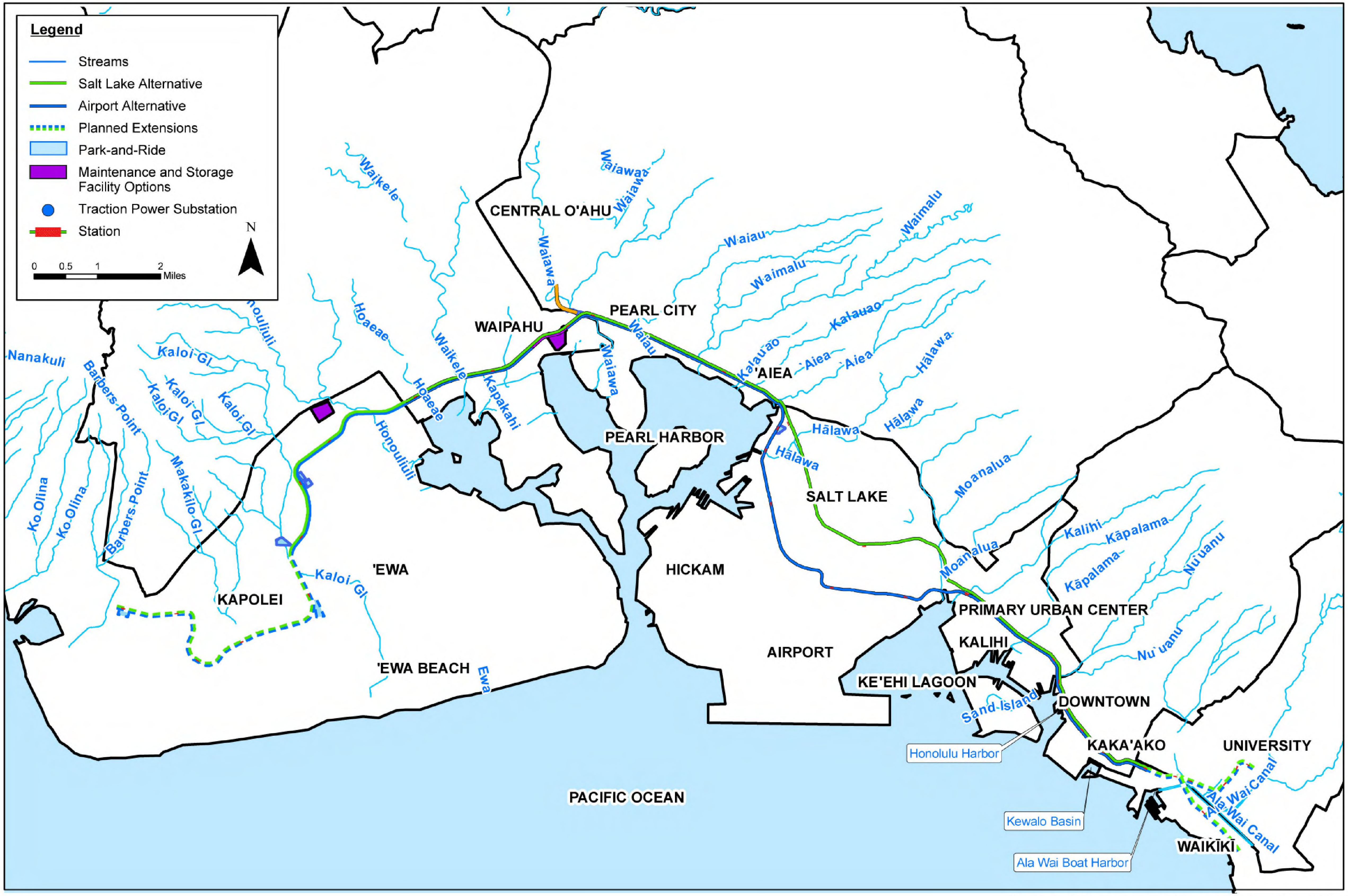

Figure S-1: Streams in the Study Corridor

1 Background

1.1 Introduction

The City and County of Honolulu Department of Transportation Services Rapid Transit Division (RTD), in cooperation with the U.S. Department of Transportation Federal Transit Administration (FTA), is evaluating fixed-guideway alternatives that would provide high-capacity transit service on O‘ahu. The project study area is the travel corridor between Kapolei and the University of Hawai‘i at Mānoa (UH Mānoa) (Figure 1-1). This corridor includes the majority of housing and employment on O‘ahu. The east-west length of the corridor is approximately 23 miles. The north-south width is, at most, 4 miles because the Ko‘olau and Wai‘anae Mountain Ranges bound much of the corridor to the north and the Pacific Ocean to the south.

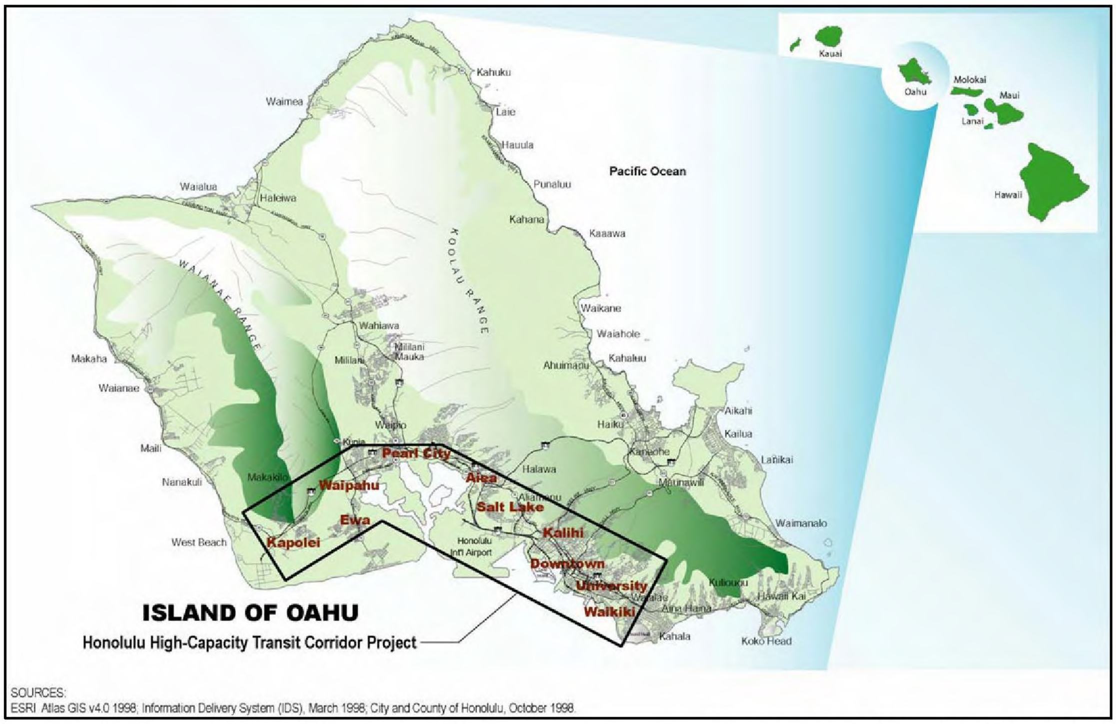

Figure 1-1: Project Vicinity

1.2 Description of the Study Corridor

The Honolulu High-Capacity Transit Corridor extends from Kapolei in the west (Wai‘anae or ‘Ewa direction) to UH Mānoa in the east (Koko Head direction) and is confined by the Wai‘anae and Ko‘olau Mountain Ranges in the mauka direction (towards the mountains, generally to the north within the study corridor) and the Pacific Ocean in the makai direction (towards the sea, generally to the south within the study corridor). Between Pearl City and ‘Aiea, the corridor’s width is less than 1 mile between Pearl Harbor and the base of the Ko‘olau Mountains (Figure 1-2).

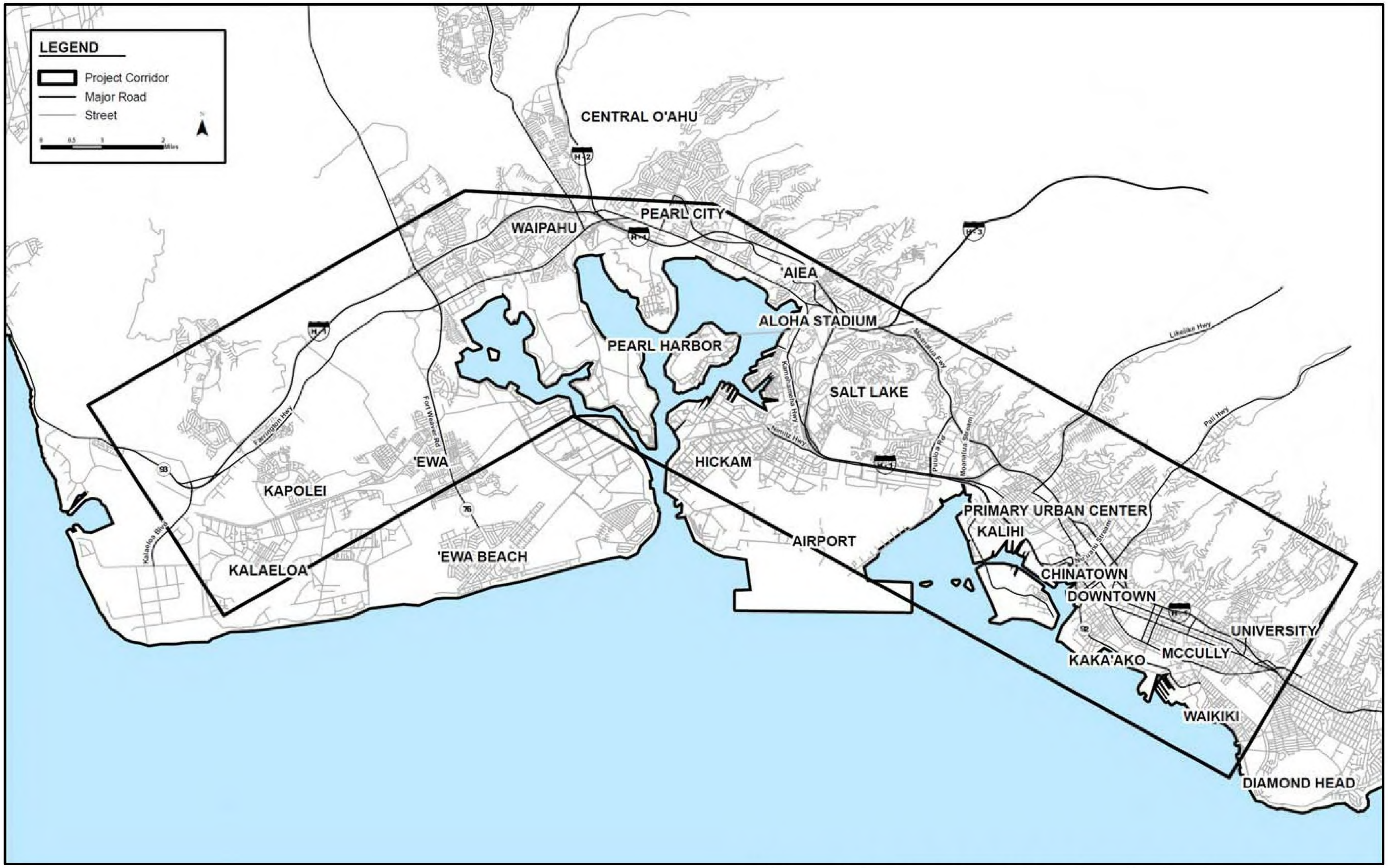

Figure 1-2: Areas and Districts in the Study Corridor

1.3 Alternatives

Four alternatives are being evaluated in the Environmental Impact Statement (EIS). They were developed through a screening process that considered alternatives identified through previous transit studies, a field review of the study corridor, an analysis of current and projected population and employment data for the corridor, a literature review of technology modes, work completed by the O‘ahu Metropolitan Planning Organization (O‘ahuMPO) for its *O‘ahu Regional Transportation Plan 2030* (ORTP) (O‘ahuMPO 2007), a rigorous Alternatives Analysis process, selection of a Locally Preferred Alternative by the City Council, and public and agency comments received during the separate formal project scoping processes held to satisfy National Environmental Policy Act (NEPA) (USC 1969) requirements and the Hawai‘i EIS Law (Chapter 343) (HRS 2008). The alternatives evaluated are as follows:

1. No Build Alternative
2. Salt Lake Alternative
3. Airport Alternative
4. Airport & Salt Lake Alternative

1.3.1 No Build Alternative

The No Build Alternative includes existing transit and highway facilities and committed transportation projects anticipated to be operational by 2030. Committed transportation projects are those identified in the ORTP, as amended (O‘ahuMPO 2007). Highway elements of the No Build Alternative also are included in the Build Alternatives. The No Build Alternative would include an increase in bus fleet size to accommodate growth, allowing service frequencies to remain the same as today.

1.3.2 Build Alternatives

The fixed guideway alternatives would include the construction and operation of a grade-separated fixed guideway transit system between East Kapolei and Ala Moana Center (Figure 1-3 to Figure 1-6). Planned extensions are anticipated to West Kapolei, UH Mānoa, and Waikīkī. The system evaluated a range of fixed-guideway transit technologies that met performance requirements, which could be either automated or employ drivers. All parts of the system would either be elevated or in exclusive right-of-way.

Steel-wheel-on-steel-rail transit technology has been proposed through a comparative process based on the ability of various transit technologies to cost-effectively meet project requirements. As such, this technology is assumed in this analysis.

The guideway would follow the same alignment for all Build Alternatives through most of the study corridor. The Project would begin by following North-South Road and other future roadways to Farrington Highway. Proposed station locations and other project features in this area are shown in Figure 1-3. The guideway would follow Farrington Highway Koko Head on an elevated structure and continue along Kamehameha Highway to the vicinity of Aloha Stadium (Figure 1-4).

Between Aloha Stadium and Kalihi, the alignment differs for each of the Build Alternatives, as detailed later in this section (Figure 1-5). Koko Head of Middle Street, the guideway would follow Dillingham Boulevard to the vicinity of Ka‘aahi Street and then turn Koko Head to connect to Nimitz Highway in the vicinity of Iwilei Road.

The alignment would follow Nimitz Highway Koko Head to Halekauwila Street, then along Halekauwila Street past Ward Avenue, where it would transition to Queen Street and Kona Street. Property on the mauka side of Waimanu Street would be acquired to allow the alignment to cross over to Kona Street. The guideway would run above Kona Street through Ala Moana Center.

Planned extensions would connect at both ends of the corridor. At the Wai‘anae end of the corridor, the alignment would follow Kapolei Parkway to Wākea Street and then turn makai to Saratoga Avenue. The guideway would continue on future extensions of Saratoga Avenue and North-South Road. At the Koko Head end of the corridor, the alignment would veer mauka from Ala Moana Center to follow Kapi‘olani Boulevard to University Avenue, where it would again turn mauka to follow University Avenue over the H-1 Freeway to a proposed terminal facility in UH Mānoa’s Lower Campus. A branch line with a transfer point at Ala Moana Center or the Hawai‘i Convention Center into Waikīkī would follow Kalākaua Avenue to Kūhiō Avenue to end near Kapahulu Avenue (Figure 1-6).

Salt Lake Alternative

The Salt Lake Alternative would leave Kamehameha Highway immediately ‘Ewa of Aloha Stadium, cross the Aloha Stadium parking lot, and continue Koko Head along Salt Lake Boulevard (Figure 1-5). It would follow Pūkōloa Street through Māpunapuna before crossing Moanalua Stream, turning makai, crossing the H-1 Freeway and continuing to the Middle Street Transit Center. Stations would be constructed near Aloha Stadium and Ala Liliko‘i. The total guideway length for this alternative would be approximately 19 miles and it would include 19 stations. The eventual guideway length, including planned extensions, for this alternative would be approximately 28 miles and it would include 31 stations.

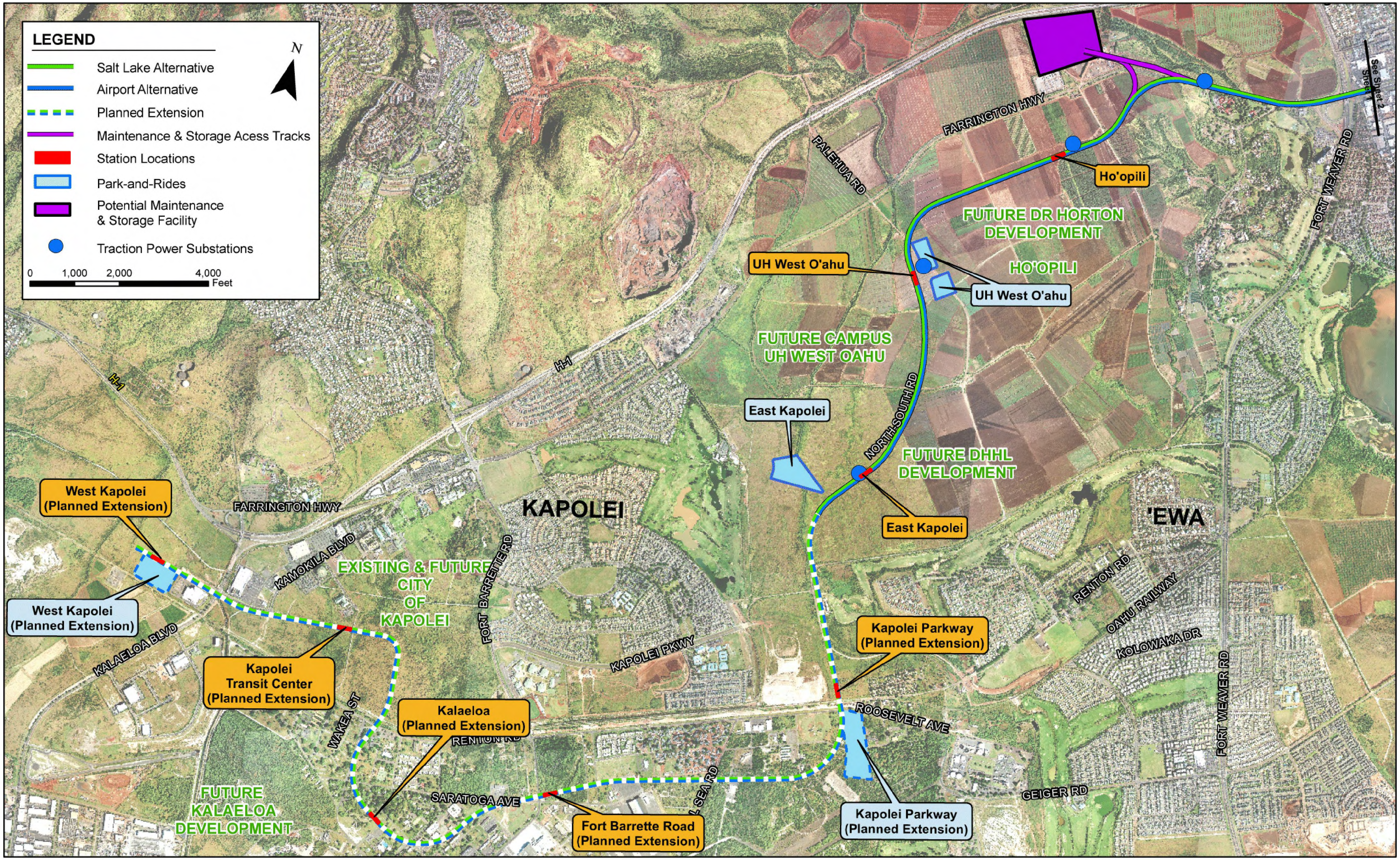

Figure 1-3: Fixed Guideway Transit Alternative Features (Kapolei to Fort Weaver Road)

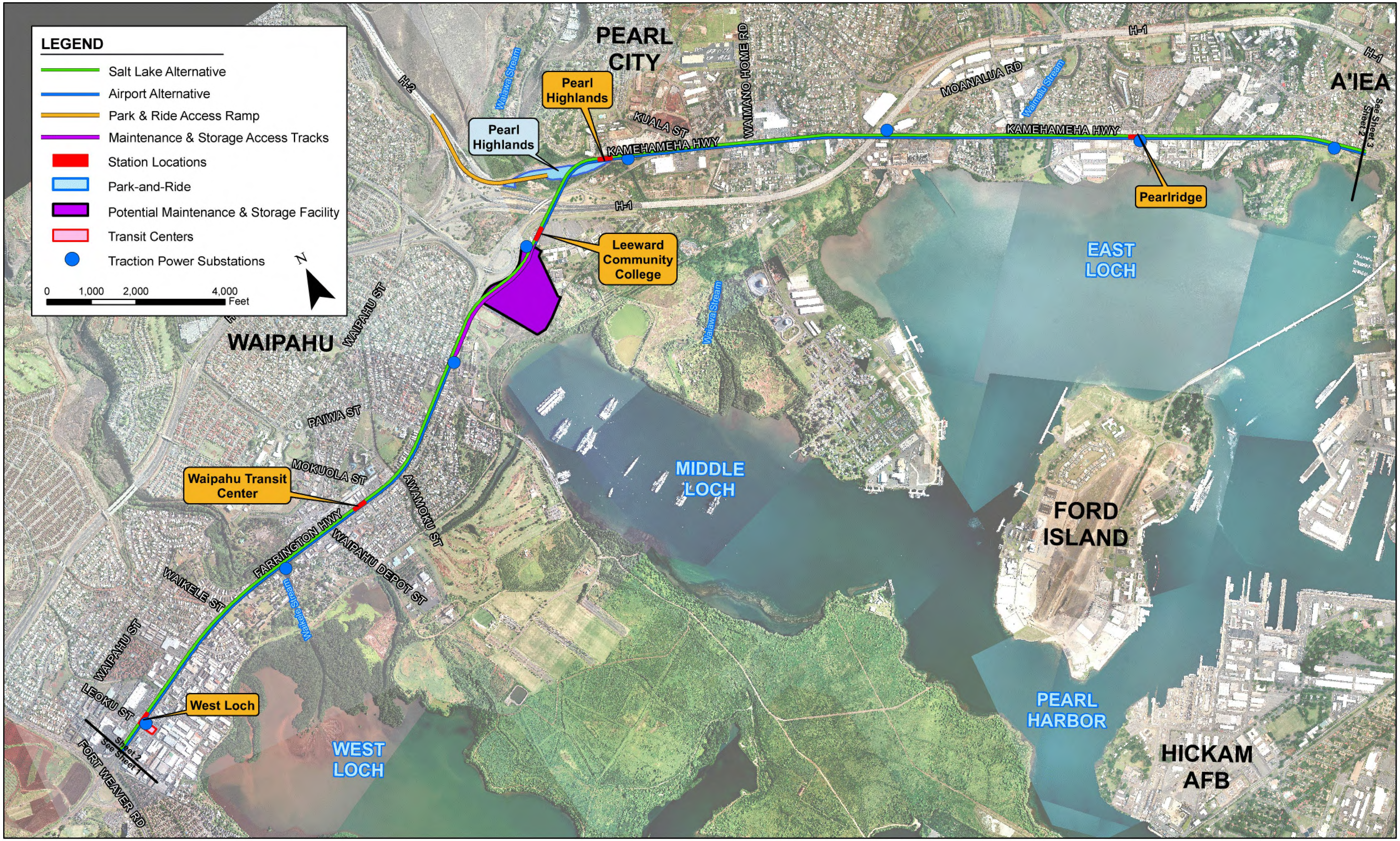

Figure 1-4: Fixed Guideway Transit Alternative Features (Fort Weaver Road to Aloha Stadium)

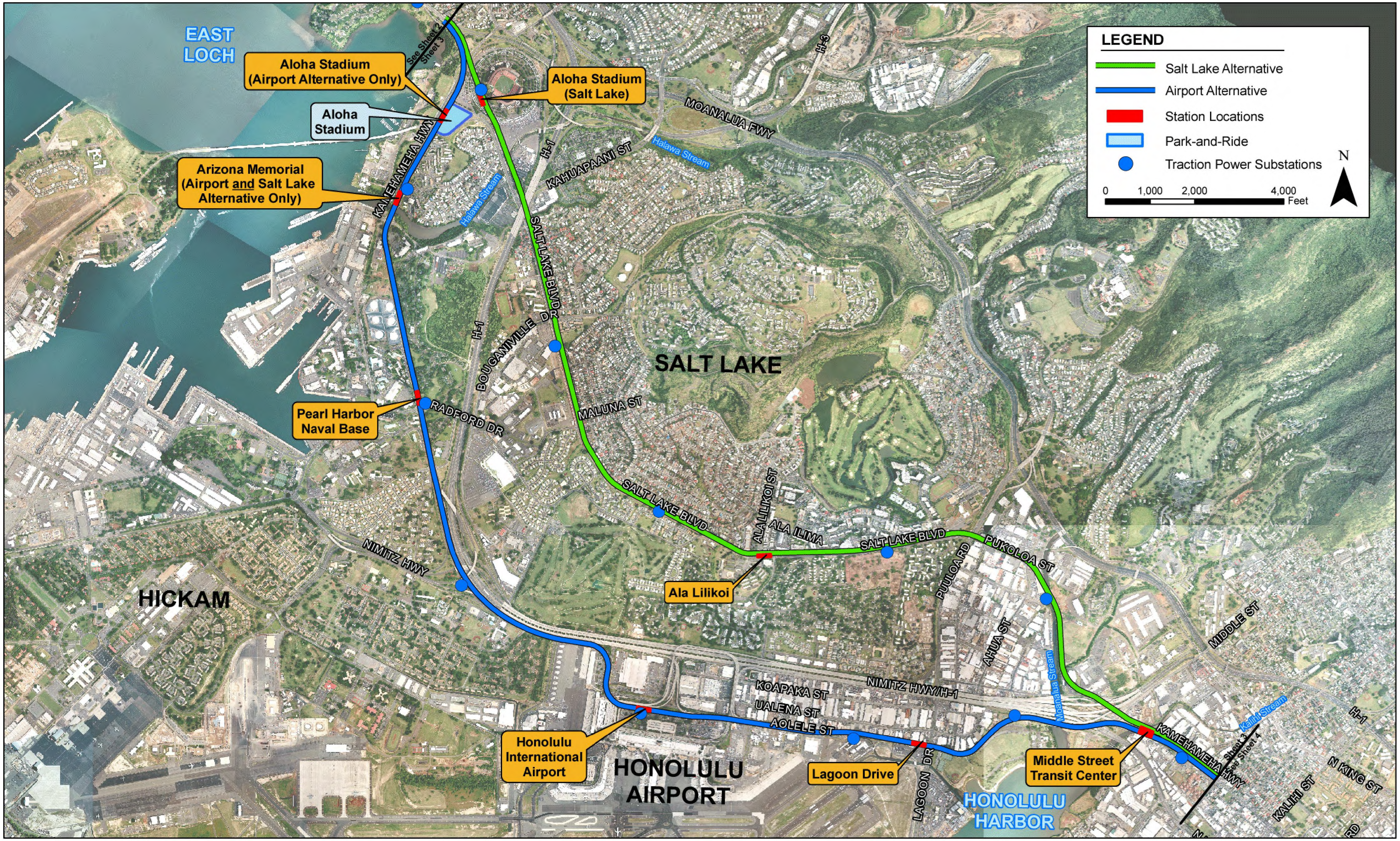

Figure 1-5: Fixed Guideway Transit Alternative Features (Aloha Stadium to Kalihi)

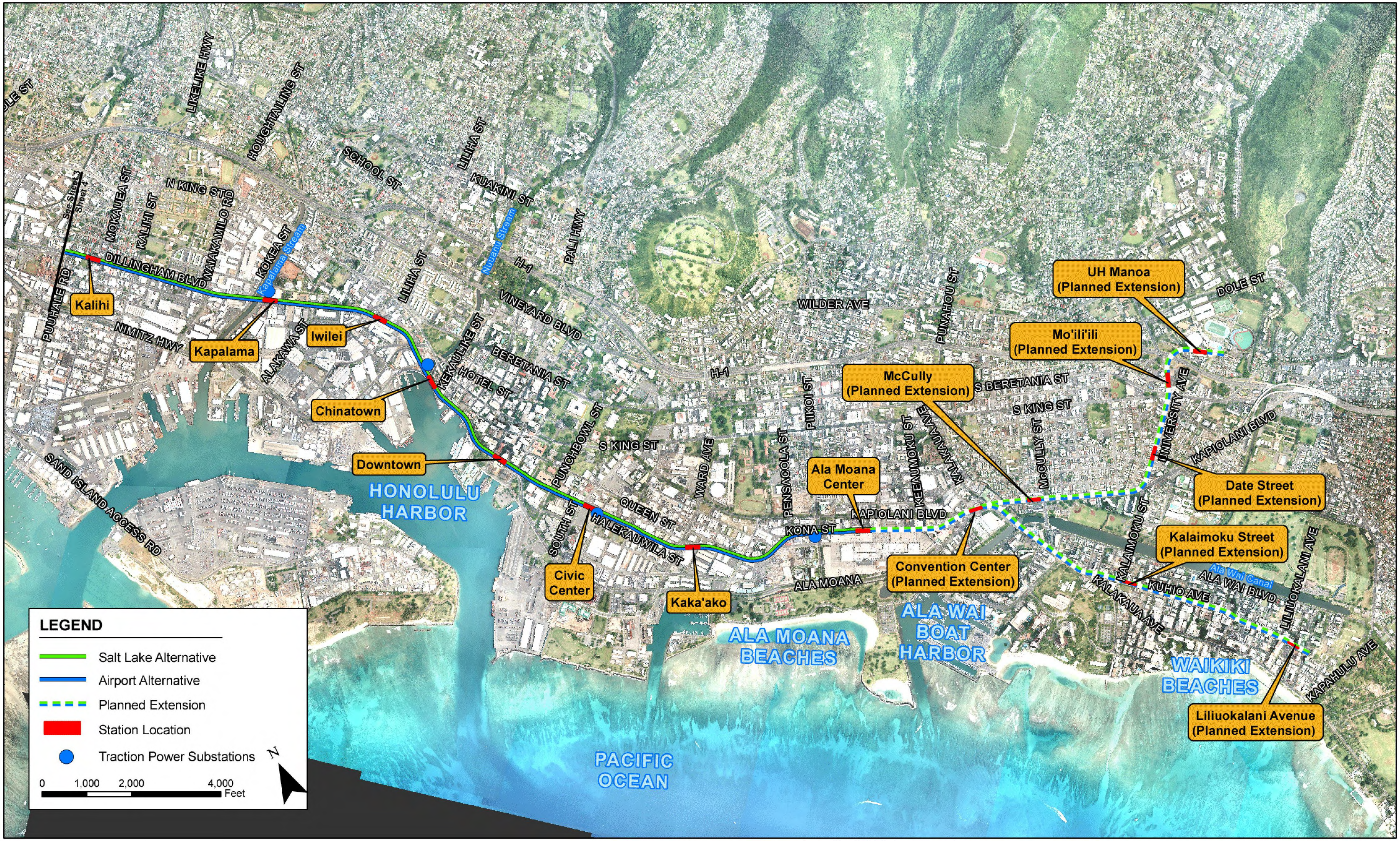

Figure 1-6: Fixed Guideway Transit Alternative Features (Kalihi to UH Mānoa)

Airport Alternative

The Airport Alternative would continue along Kamehameha Highway makai past Aloha Stadium to Nimitz Highway and turn makai onto Aolele Street and then follow Aolele Street Koko Head to reconnect to Nimitz Highway near Moanalua Stream and continuing to the Middle Street Transit Center (Figure 1-5). Stations would be constructed at Aloha Stadium, Pearl Harbor Naval Base, Honolulu International Airport, and Lagoon Drive. The total guideway length for this alternative would be approximately 20 miles and it would include 21 stations. The eventual guideway length, including planned extensions, for this alternative would be approximately 29 miles and it would include 33 stations.

Airport & Salt Lake Alternative

The Airport & Salt Lake Alternative is identical to the Salt Lake Alternative, with the exception of also including a future fork in the alignment following Kamehameha Highway and Aolele Street at Aloha Stadium that rejoins at Middle Street. The station locations discussed for the Salt Lake Alternative would all be provided as part of this alternative. Similarly, all the stations discussed for the Airport Alternative also would be constructed at a later phase of the project; however, the Aloha Stadium Station would be relocated makai to provide an Arizona Memorial Station instead of a second Aloha Stadium Station. At the Middle Street Transit Center Station, each line would have a separate platform with a mezzanine providing a pedestrian connection between them to allow passengers to transfer. The total guideway length for this alternative would be approximately 24 miles and it would include 23 stations. The eventual guideway length, including planned extensions, for this alternative would be approximately 34 miles and it would include 35 stations.

1.3.3 Features Common to All Build Alternatives

In addition to the guideway, the project will require the construction of stations and supporting facilities. Supporting facilities include a maintenance and storage facility, transit centers, park-and-ride lots, and traction power substations (TPSS). The maintenance and storage facility would either be located between North-South Road and Fort Weaver Road or near Leeward Community College (Figure 1-3 and Figure 1-4). Some bus service would be reconfigured to transport riders on local buses to nearby fixed guideway transit stations. To support this system, the bus fleet would be expanded.

2 Studies and Coordination

2.1 Surface Water

2.1.1 Streams and Marine Waters

Numerous water bodies are located in the project area and are regulated by a variety of Federal and State programs under several different laws. Under Section 404 of the Federal Clean Water Act (CWA), the discharge of dredge or fill material into "waters of the United States", as defined by 33 Code of Federal Regulations (CFR) Part 328, automatically triggers the need for a permit from the U.S. Army Corps of Engineers (USACE), which is called a Department of the Army permit. Under Section 401 of the CWA, the need for a Department of the Army permit triggers the need for a Section 401 Water Quality Certification from the Clean Water Branch of the Hawai'i Department of Health (HDOH).

The USACE is also authorized to regulate activities in the nation's waters (e.g., rivers, streams, lakes, navigable waters, and wetlands) pursuant to Section 10 of the Rivers and Harbors Act of 1899 and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972. Section 10 of the Rivers and Harbors Act of 1899 requires authorization for construction of any structure in or over any navigable water of the United States. Structures or work outside the limits defined for navigable waters of the United States require a Section 10 permit if the structure or work affects the course, location, or condition of the water body. The law applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of a navigable water of the United States, and applies to all structures, from the smallest floating dock to the largest commercial undertaking.

The State's general policy is to maintain or improve existing water quality in all State waters. All waters of the State are classified as inland waters or marine waters. Inland waters are fresh waters, brackish waters, or saline waters, including streams, springs, wetlands, estuaries, anchialine pools, and saline lakes. Types of marine waters are embayments, open coastal waters, or oceanic waters. The State has defined water use classifications for inland and marine waters and set water quality criteria for each water use classification.

Marine waters are categorized as Class AA and Class A. Class AA waters are to "remain in the natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions." Class A waters can be used for "recreational use and aesthetic enjoyment," among other allowable uses compatible with protecting natural resources in these waters (Hawai'i Administrative Rules, Chapter 11-54, "Water Quality Standards").

Coastal areas and embayments can be listed by HDOH as "Water Quality-Limited Segments," as required by the CWA Section 305(b) and defined by 40 CFR 130.8. Water Quality-Limited Segments are water bodies with pollutants in excess of the established water quality standards, such that they cannot reasonably be expected to attain or maintain State water quality standards without additional action to control sources of pollution.

According to the HDOH administrative rules, inland waters can be either water use Class 1 or Class 2. The water quality in Class 1 waters is to be maintained in their natural states; no waste discharge is allowed. Class 2 waters are those to be protected for recreational use, propagation of aquatic life, agricultural and industrial water supplies, shipping, and navigation.

The HDOH maintains the 303(d) List of Impaired Waters. This list is composed of streams not expected to meet State water quality standards even after application of technology-based effluent limitations.

Section 402 of the CWA establishes the National Pollutant Discharge Elimination System (NPDES). The NPDES program, administered by the HDOH, establishes a permitting system that regulates the discharge of water-borne pollutants into the nation's waters. Some discharges from construction and operation of roadway facilities are usually unavoidable, triggering the need for NPDES permits for most transportation projects.

The State Commission on Water Resource Management (Water Commission) regulates activities affecting stream channels, which are defined as any natural or artificial watercourse with a definite bed and banks, which periodically or continuously contains flowing water. The Water Commission's regulatory responsibilities include regulating alterations to stream channels through a permit called a Stream Channel Alteration Permit.

Navigable Waters

Waters subject to tidal influence are generally defined as navigable by the U.S. Coast Guard. Navigability is also defined by usage, so non-tidal streams that carry commercial traffic are deemed navigable.

The U.S. Coast Guard is responsible for issuing bridge permits for navigable waters. Bridge permits authorize the location and plans for proposed new bridges or causeways, or reconstruction or modification of existing bridges and causeways to protect the right of navigation. The U.S. Coast Guard's authority comes from Section 9 of the Rivers and Harbors Appropriation Act of 1899, the Act of March 23, 1906, and the General Bridge Act of 1946.

For the purposes of the Department of the Army's permitting requirements, the Division Engineer for the USACE Marine Protection, Research and Sanctuaries Act of 1972 determines navigability under the authority of 33 CFR Part II, Section 329.14(b). The Coast Guard bridge permit determination does not necessarily affect the USACE permitting jurisdiction.

Coastal Zone Management (CZM) Areas

In September 1978, the U.S. Department of Commerce approved the Hawai'i Coastal Zone Management (CZM) Program with the following goals:

- Protect valuable resources
- Preserve management options
- Ensure public access to beaches, recreation areas, and natural reserves
- Provide for solid and liquid waste treatment within the Special Management Area

In Hawai'i, the Department of Business, Economic Development, and Tourism (DBEDT) administers this program. Federally funded activities on O'ahu must receive a consistency determination from the CZM program to ensure that they meet the guidelines in the State policy.

The project limits are within the CZM area. An assessment of the Project's consistency with the State CZM program will be filed with the DBEDT prior to completion of the Final EIS.

The Department of Land and Natural Resources Division of Boating and Ocean Recreation manages the recreational use of shore waters and shore areas in accordance with Chapter 13-250-256, Part III, "Ocean Waters, Navigable Streams, and Beaches". It divides coastal areas into segments and specifies which water-based uses are allowed within specific zones.

2.1.2 Floodplains

A floodplain is any land area that is susceptible to being inundated by water from any source (FEMA 2003). Floodplains are designated by the rarity of the flood that is large enough to inundate them. For example, a 10-year floodplain is likely to be inundated by a 10-year flood and a 100-year floodplain by a 100-year flood. Flood frequencies, such as the 100-year flood, are determined by evaluating stream gauging records, historic flood records, flood data from watersheds that share hydrological similarities, or flood estimates from precipitation records. Statistical analyses are then applied to compute flood flow frequency curves for various recurrence intervals. Another way of expressing flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1-percent chance of occurring in any given year. Most known floodplains in the U.S. have been mapped by FEMA's Flood Insurance Administration.

Executive Order 11988, "Floodplain Management," places special importance on floodplains and directs Federal agencies to avoid conducting, allowing, or supporting actions on a floodplain. Flood Insurance Rate Maps have been consulted to determine if the project site is located within the 100-year floodplain.

If the Project is located within a floodplain, a sufficient analysis must be included in the environmental document, as specified in USDOT Order 5650.2, "Floodplain Management and Protection," April 23, 1979 (included as Appendix A to this report). This analysis should discuss any risk to or risk resulting from the Project. The document must also discuss effects on natural and beneficial floodplain values; the degree to which the Project would provide direct or indirect support for development in the floodplain; and measures to minimize harm, and where practicable, to restore and preserve the natural and beneficial floodplain values affected by the Project. This USDOT Order distinguishes between an "encroachment" and a "significant encroachment." A determination of significant floodplain encroachment is made based on the following criteria:

- Whether the alternatives would cause a considerable probability of loss of human life due to flooding;
- Whether there would be likely future damage associated with the floodplain encroachment that could be substantial in cost or extent, including interruption of service on, or loss of, a vital transportation facility; and
- Whether there would be a notable adverse impact on natural and beneficial floodplain values.

If a preferred alternative would involve significant encroachment of the floodplain, the final environmental document must include the following:

- The FTA's finding that the proposed action is the only practicable alternative
- Supporting documentation reflecting consideration of alternatives that would avoid or reduce adverse impacts on the floodplain

Locally, the State National Flood Insurance Program staff has been consulted. Land use in flood zones is described in the City's Flood Ordinance (Article 9, Special District Regulations) and off-street parking lots are potentially permitted uses in floodways.

2.1.3 Stormwater

The objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Section 402 of the CWA establishes the NPDES. The NPDES program, administered by the HDOH, establishes a permitting system that regulates the discharge of water-borne pollutants into the nation's waters. Stormwater discharges from construction of the guideway will require an NPDES Stormwater Discharge Permit during construction.

Stormwater runoff from developed areas is a source of pollutants that has degraded the nation's waters. In an effort to control pollutants from stormwater and other non-point sources during operation of transportation systems, the CWA regulates discharges to the separate storm sewer system on O'ahu. Since 1990, Municipal Separate Storm Sewer Systems (MS4s) serving populations over 100,000 (considered to be large MS4s) have been required to obtain NPDES permits, reduce discharges of pollutants to the maximum extent practicable, and prohibit illicit discharges into their MS4. This requirement was expanded to small MS4s in 1999. Techniques and types of permanent BMPs to minimize surface-water contamination from increased stormwater runoff are being developed by the Statewide Stormwater Management Program. During the design phase for each section of the project area, a Permanent BMP Design Report will be produced. The Project's stormwater runoff contribution from additional impervious surfaces will be compared to pre-construction runoff values to determine hydrologic impacts. Hydraulic analysis will be performed to determine flow and drainage system capacity, and potential drainage system upgrades will be formulated. Techniques and types of permanent BMPs to minimize surface-water contamination from increased stormwater runoff will be addressed, and any necessary permits will be identified. Permanent BMPs will be evaluated based on criteria such as the ability to meet the City and State DOT's water quality requirements, the volume of stormwater runoff, maintenance requirements, and their potential footprint. Inspection schedules and maintenance details will also be formulated.

Total Maximum Daily Loads

Total maximum daily loads are a CWA tool used to manage water quality-limited segments of waters of the United States. A segment of a stream or water body where water quality standards are not being met is considered water quality-limited and is listed on the Section 303(d) list (*http://www.Hawai'i.gov/health/environmental/env-planning/wqm/303dpcfinal.pdf*).

When a water body is water quality-limited, its ability to accept a load of pollutants from a stormwater or other discharge is lessened. The total maximum daily loads process establishes load allocations for the universe of discharges to the limited segment. These allocations are derived from a water quality assessment and waste assimilative analysis process. The load allocations are translated into discharge goals for each discharger, so the water body can recover and eventually be removed from the list.

2.2 Groundwater

The Southern O'ahu Basal Aquifer (SOBA) is the principal aquifer underlying all of southern O'ahu. The portions of the SOBA within the study corridor are the Pearl Harbor Aquifer Sector and the 'Ewa Aquifer System. The EPA has designated the SOBA as the sole or principal source of drinking water for O'ahu. Based on Hawai'i status codes related to the protection of drinking water, much of the SOBA is designated as a currently used source of fresh drinking water that is both irreplaceable and highly vulnerable to contamination (Mink and Lau 1990). In accordance with the 1984 Sole Source Aquifer Memorandum of Understanding between the EPA and the FHWA, a Groundwater Impact Assessment is being prepared to meet the coordination requirements of Section 1424(e) of the Safe Drinking Water Act.

The boundary between non-drinking-water aquifers and underground sources of drinking water is generally referred to as the *Underground Injection Control (UIC) line*. Restrictions on injection wells differ, depending on whether the area is mauka or makai of the UIC line. They are allowed both mauka and makai of the UIC line, but injection wells mauka of the UIC line are required to meet higher water quality standards and public notification is required during the permit application process. The UIC program is administered by HDOH's Safe Drinking Water Branch.

3 Methodology

3.1 Surface Waters

3.1.1 Streams and Marine Waters

This report identifies surface-water resources in the study corridor from existing maps. Their use and water quality are described in relationship to State standards. Areas of potential conflict with the project alternatives have been delineated and evaluated, and mitigation measures to reduce operational impacts have been identified. The report also assesses construction impacts on surface-water quality, proposes mitigation measures, and identifies necessary permits.

Potential permits required to cross surface-water bodies are discussed. For areas where the elevated structure would cross navigable waterways, consultation with the U.S. Coast Guard is occurring. Any impacts to waterway navigation are also addressed.

The project alternatives have also been assessed to determine any impacts on shoreline and coastal resources. Special aquatic sites are identified, and steps will be taken to avoid or minimize impacts to these areas. Any permits involving coastal areas have been identified.

3.1.2 Floodplains

Protection of floodplains is required by Executive Order 11988, "Floodplain Management"*;* USDOT Order 5650.2, "Flood Management and Protection"*;* FHPM-6-7-3-2; and 23 CFR 650. Existing floodways and floodplain limits within the study area have been identified using FEMA Flood Insurance Rate Maps and other existing data.

All floodplain encroachments have been noted. The USDOT Order distinguishes between an "encroachment" and a "significant encroachment." A determination of significant floodplain encroachment is made based on the following criteria:

- Whether the alternatives would cause a considerable probability of loss of human life due to flooding;
- Whether there would be likely future damage associated with the floodplain encroachment that could be substantial in cost or extent, including interruption of service on, or loss of, a vital transportation facility; and
- Whether there would be a notable adverse impact on natural and beneficial floodplain values.

Current floodplain use and development have been noted. Natural floodplain uses such as open space, groundwater recharge, or wildlife habitat are described and evaluated.

The FHWA requires the following findings pursuant to 23 CFR 650, Subpart A. These findings are summarized in Section 650.111, Subpart C:

1. Risks associated with implementation of the action
2. Impacts on natural and beneficial floodplain values
3. The support of probable incompatible floodplain development
4. Measures to minimize floodplain impacts associated with the action
5. Measures to restore and preserve the natural and beneficial floodplain values impacted by the action

Where structures are in the floodplain, potential impacts (e.g., changes to floodplain elevations and floodplain boundaries) must be identified for each alternative. As the piers are located and designed, potential impacts to the floodplain from the proposed structures will be evaluated using location hydraulic studies. Water surface elevations and flow velocities will be computed using methodologies and recurrence intervals acceptable to FEMA and City and State governmental agencies having jurisdiction.

3.1.3 Stormwater

Impervious surfaces increase stormwater runoff volume and pollutant loadings, and reduce groundwater recharge. Any runoff from an impervious area should be considered potentially pollutant-laden, and can pollute downstream water bodies or infiltrate into the groundwater. Each of the Project's three primary components − (1) the guideway and stations, (2) park-and-ride facilities, and (3) the maintenance and storage facility − would increase the impervious surface area. Their potential stormwater contributions and controls are discussed in this report.

Along the study corridor, stormwater is either collected in one of several MS4s, injected into drainage injection wells, or runs naturally overland to water bodies. The 303(d) status of streams in the study corridor is summarized in this report, and major MS4s within the study corridor are identified.

Construction impacts on water quality are assessed and mitigation measures are proposed. The number of acres disturbed during construction is tabulated for each alternative. A number of permits and permissions will have to be obtained for the management and discharge of stormwater during construction and for the completed fixed guideway system. Types of permanent and temporary BMPs are discussed for all phases of the Project.

3.2 Groundwater

This report describes the Project's geohydrologic setting. Because most of the study corridor overlies the Southern O'ahu Basal Aquifer, a sole-source aquifer, a Groundwater Impact Assessment has been conducted to meet the requirements of Section 1424 (e) under the Safe Drinking Water Act. This assessment is provided in Appendix B and is intended to provide EPA with the necessary information to determine the Project's impact on groundwater quality. Project impacts to the quantity of groundwater recharge will also be assessed, and mitigation measures to protect groundwater resources from construction and operation of the alternatives will be developed. Conclusion of the assessment process, including EPA coordination will be documented in the Final EIS.

4 Affected Environment

4.1 Surface Waters

4.1.1 Streams, Marine Waters, and the Coastal Zone

Streams

Many streams are located within the study corridor (Table 4-1 and Figure 4-1). Most of these stream channels have been altered in their lower reaches and are not of high ecological quality. The overall water quality in these urban streams is poor, and many are included on HDOH's 303(d) List of Impaired Waters. Many streams in the State are not listed in the table because data collection is ongoing.

Complete navigability determinations for each impacted waterway are pending with the U.S. Coast Guard. Tentatively, the U.S. Coast Guard may classify them as Advanced Approval Waterways because they are only navigated by rowboats, canoes, and small motorboats.

Recreational use of navigable streams in the corridor along the guideway is minimal, with the exception of the Ala Wai Canal. As noted in Table 4-1, many of the other streams are urban drainages lined with concrete that are unsuitable for regular kayaking, fishing, or other recreational opportunities.

The Ala Wai Canal, however, is a major recreational facility. Its location in urban Honolulu and near the tourist center of Waikīkī makes the recreational demand on the Ala Wai Canal high. Although it is so polluted that swimming is extremely rare and ill advised, this canal is used extensively for fishing, crabbing, kayaking, and canoeing.

Fishermen catch papio, oʻio, tilapia, and other species in the Ala Wai Canal. Consumption of organisms caught in the canal is discouraged by the HDOH due to high levels of pesticides and heavy metals present in the water that accumulate in the tissues of organisms living in the canal.

At least seven canoe clubs with six-person outrigger canoes, such as the Lōkahi Canoe Club, the Waikīkī Surf Club, and the Outrigger Canoe Club, use the canal to practice (HADV 2006). Approximately 1,000 paddlers use the Ala Wai Canal during the summer regatta season. Although paddlers are encouraged to wash with soap and water due to the contaminated water (Honolulu 1998), they continue to use the canal.

Table 4-1: Streams in the Study Corridor

Alternative and Section	Navigable Water[1]	Associated Floodplain[2]	Stream Channel	303(d) Impaired[3]
Common to All Build Alternatives				
Kalo'i Gulch	No	Yes	natural	No
Honouliuli Stream	No	Yes	natural	No
Hō'ae'ae Stream	No	No	concrete	No
Waikele Stream	No	Yes	concrete	Yes
Kapakahi Stream	No	Yes	natural	Yes
Makaleha Stream	No	Yes	concrete	No
Waiawa Stream	No	Yes	natural	No
Pearl City Stream	No	No	Concrete	No
Waiau Stream	No	No	natural	No
Waimalu Stream	No	No	natural	Yes
Kalauao Stream	No	Yes	natural	No
'Aiea Stream	Yes	No	natural	Yes
Kalihi Stream	Yes	Yes	natural	Yes
Kapālama Canal	Yes	No	concrete	Yes
Nu'uanu Stream	Yes	No	natural	Yes
Salt Lake Alternative				
Hālawa Stream	Yes	No	concrete	Yes
Moanalua Stream	Yes	Yes	natural	Yes
Airport Alternative				
Hālawa Stream	Yes	No	concrete	Yes
Moanalua Stream	Yes	Yes	concrete	Yes
Airport & Salt Lake Alternative				
Hālawa Stream	Yes	No	concrete	Yes
Moanalua Stream	Yes	Yes	concrete	Yes
UH Extension				
Ala Wai Canal and Tributaries	Canal: Yes Tributaries: No	Yes	Canal: channelized Tributaries: concrete	Yes
Waikīkī Extension				
Ala Wai Canal and Tributaries	Canal: Yes Tributaries: No	Yes	Canal: channelized Tributaries: concrete	Yes

Notes: [1]Navigability as defined by the U.S. Coast Guard
[2] Floodplains as defined by FEMA
[3] 303(d) Impaired Waterway as defined by HDOH

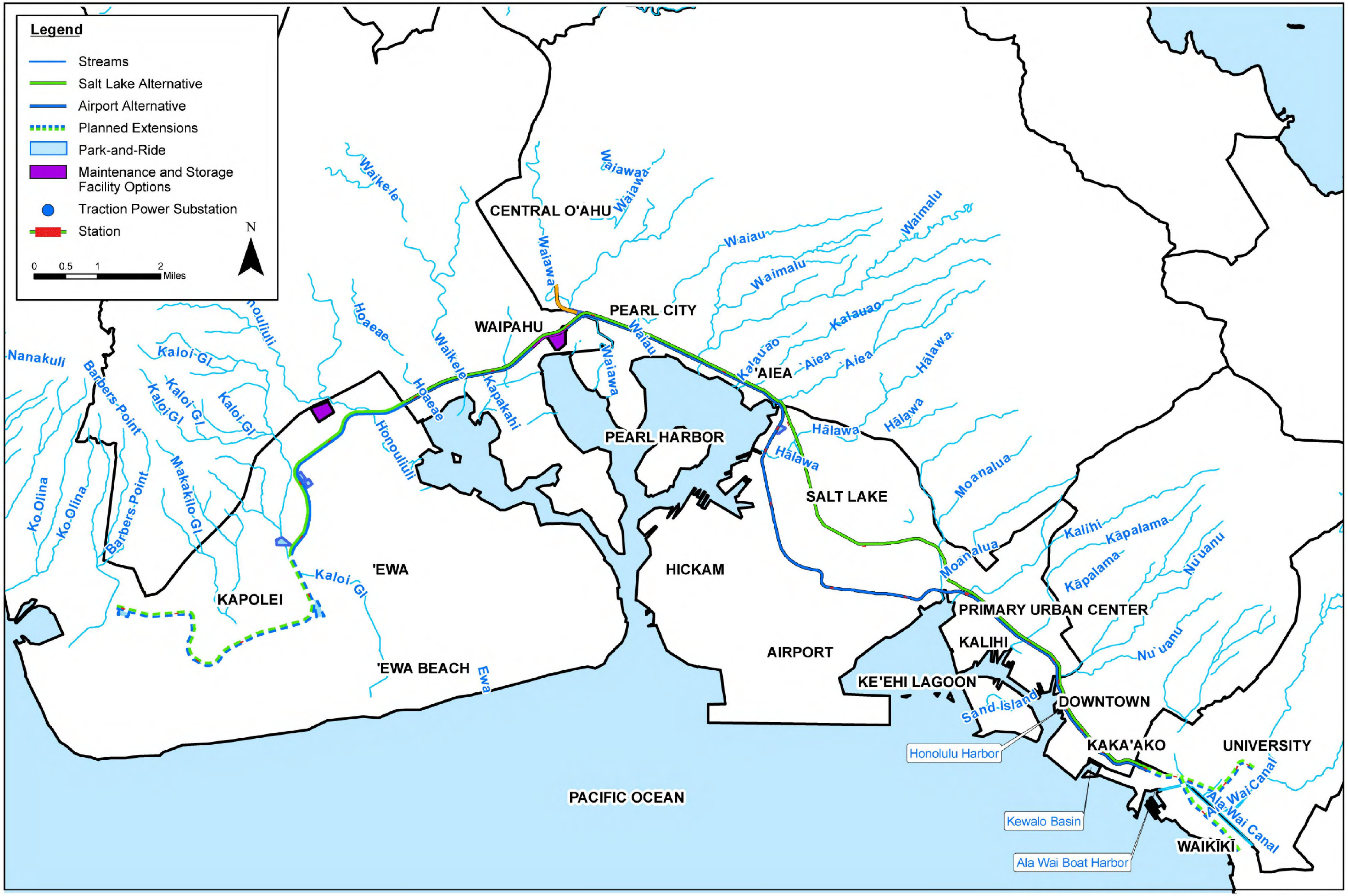

Figure 4-1: Streams in the Study Corridor

Marine Waters

The following large coastal surface-water bodies are located within or adjacent to the study corridor and are shown on Figure 4-1:

- Pearl Harbor
- Ke'ehi Lagoon
- Honolulu Harbor
- Kewalo Basin
- Ala Wai Canal and Boat Harbor

These five water bodies are all highly urbanized and/or altered from their natural state. They are all listed by HDOH as "Water Quality-Limited Segments."

Pearl Harbor

Pearl Harbor is an estuary designated as a Class 2 inland water, with a special set of water quality criteria because of its polluted condition. Pearl Harbor receives flows from a drainage basin of approximately 100 square miles. Freshwater inflows create a stratified estuary, where a surface layer of brackish water flows out of the main channel with little tidal influence. The abundant rainfall at the heads of the streams that drain into Pearl Harbor results in runoff that transports pollutants from upland forest, agricultural, commercial, industrial, military, and residential lands. Water quality parameters for nitrogen, phosphorus, turbidity, fecal coliform, temperature, and chlorophyll are frequently violated. The narrow entrance channel and the configuration of the lochs retard flushing of the harbor. Siltation is also a major problem that is addressed by frequent maintenance dredging, and sediments are continuously re-suspended by ship traffic.

Ke'ehi Lagoon

Ke'ehi Lagoon is a highly modified water body, designated Class A by HDOH. After World War II seaplane runways were dredged, greatly increasing the volume and retarding flushing of the lagoon. When Honolulu International Airport was built, an additional circulation channel was constructed that improved water quality, but a gradient of increasing turbidity and plant nutrients exists toward the discharges of Kalihi and Moanalua Streams. Other point-source discharges to the lagoon include a drainage canal from the airport and adjacent industrial areas, and several additional drainage outlets along Lagoon Drive on the lagoon's more southwesterly shoreline.

The currents in O'ahu's southern coastal waters move from Honolulu Harbor into Ke'ehi Lagoon. These currents may transport pollutants into Ke'ehi Lagoon and recirculate suspended matter. Various causes, effects, and symptoms of water pollution in the lagoon have been documented, including petrochemical contamination of sediments and water, fish kills, and the presence of human enteric viruses. Although circulation in Ke'ehi Lagoon is good, the lagoon regularly violates water quality parameters for phosphorus and turbidity. Nearly the entire lagoon includes fill material deposited from nearby dredging and other sources.

In 1943, Kalihi Channel was dredged to a depth of 35 to 40 feet, as part of a military project to connect Kapālama Basin in Honolulu Harbor with the open ocean. Two bridges currently cross the Kalihi Channel, which effectively blocks ship access to Honolulu Harbor from Ke‘ehi Lagoon.

More than 300 vessels (e.g., boats and floating structures) are anchored throughout Ke‘ehi Lagoon and are often used as residences. Many vessels are not seaworthy and cannot propel themselves under their own power.

Honolulu Harbor

Honolulu Harbor is a Class A marine embayment. It has had recognized water pollution problems since the 1920s. Two streams (Kapālama and Nu‘uanu) and numerous ditches and storm drains contribute runoff to the harbor, along with associated pollutants. Water quality in the Kapālama Basin portion of the harbor is particularly poor because of discharges from Kapālama Stream. The parameters of greatest concern are nutrients, metals, suspended solids, pathogens, and turbidity. Bacteria, nitrogen, phosphorus, and turbidity levels in the water regularly exceed State water quality standards.

Kewalo Basin

Two major storm drains discharge into Kewalo Basin, which is a Class A marine embayment. One drain serves Ala Moana Park and Center and the mauka residential and commercial areas. The other drain serves the Ward Avenue-Kaka‘ako District, which consists of mostly light industrial and commercial businesses. All areas support heavy vehicular traffic.

Kewalo Basin’s design hinders circulation of water in the basin. As a result, urban pollutants that collect in the basin remain concentrated for extended periods. Street debris, oil, chemicals, nutrients, and heavy metals are transported by urban runoff into Kewalo Basin. Water quality standards have been exceeded for nitrogen, phosphorus, and turbidity.

Ala Wai Canal and Boat Harbor

The Ala Wai Canal is a Class 2 inland water or estuary, and the Ala Wai Boat Harbor at the mouth of the Ala Wai Canal is a Class A marine water body (Honolulu 1998). As the connecting point for the Makiki, Mānoa, Pālolo, and Kapahulu Watersheds, the Ala Wai Canal accumulates sediments, nutrients, heavy metal contaminants, solid waste, and trash (EPA/HDOH 2002). Phytoplankton growth, suspended sediments, and visually objectionable trash discolor water in the canal. Some incidences of bacterial infection have also been reported. Water circulation from the point where Mānoa Stream meets the canal to near Kapahulu Avenue is poor, and floating debris collects under the makai side of the McCully Street Bridge.

Coastal Zone Management Areas

The project limits are within the CZM area. An assessment of the Project's consistency with the State CZM program will be filed with the DBEDT prior to issuing the Final EIS.

Recreational uses of surface waters within or adjacent to the corridor are primarily limited to the ocean and Ala Wai Canal. The ‘Ewa portion of the corridor falls within a non-designated ocean recreation area from Pearl Harbor to Kalaeloa (formerly Barbers Point). The remainder of the corridor falls within the South Shore O‘ahu Ocean Recreation Management area, which includes all ocean waters and navigable streams from Makapu‘u Point to the western boundary of the Reef Runway of Honolulu International Airport. Activities in this area include swimming, sunbathing, surfing, snorkeling, paddling, canoeing, sailing, cruising, riding jet skis, whale watching, water skiing, and fishing.

Offshore of Ala Moana Regional Park is the Ala Moana Commercial Thrill Craft Zone, which is restricted to commercial operators. ‘Ewa of this zone and Koko Head of the airport is the Ke‘ehi Lagoon/Kahaka‘aulana Islet Commercial Zone, which is the site of commercial thrill craft and other commercial ocean activities. Recreational thrill craft are accommodated in the Reef Runway Zone that parallels the airport's Reef Runway.

4.1.2 Floodplains

Flood Insurance Rate Maps indicate that several areas crossed by the alignment fall within floodplains associated with streams, estuaries, and canals (Figure 4-2 through Figure 4-5). The zones on the Flood Insurance Rate Maps are defined as follows:

- Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.
- Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains determined in the Flood Insurance Study by detailed methods. In most instances, base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.
- Zone AEF is the area within Zone AE reserved to pass the base flood.
- Zone AH is the flood insurance rate zone that corresponds to areas of 100-year shallow flooding that have a constant water-surface elevation (usually areas of ponding) where average depths are between 1 and 3 feet. The base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.
- Zone AO is the flood insurance rate zone that corresponds to areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. The depth should be averaged along the cross-section and then along the direction of flow to determine the

extent of the zone. Average flood depths derived from the detailed hydraulic analyses are shown within this zone. In addition, alluvial fan flood hazards are shown as Zone AO on the Flood Insurance Rate Map.

- Zone V is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.
- Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

The flood that has a 1-percent chance of being equaled or exceeded in any given year is called the *base flood*. The base flood elevation shown on the Flood Insurance Rate Maps indicates the water surface elevation resulting from a flood that has a 1-percent chance of equaling or exceeding that level in any given year. Of particular concern are the zones designated “A”. For example, Zone AE is where base flood elevations have been determined by detailed methods. Zone AEF, the most restrictive, is the area within Zone AE reserved to pass the base flood. Flooding can occur in other areas that have not been studied and delineated by FEMA.

Kalo‘i Gulch

Floodplains are associated with Kalo‘i Gulch, near Kapolei Parkway and North-South Road. The ‘Ewa region is in the rain shadow of O‘ahu’s mountain ranges and is therefore generally dry. Annual rainfall in the region averages about 20 inches. Most rainfall occurs during southerly (Kona) storms, which can be short, high-intensity events that cause extremely rapid flooding. As this area is developed (see the *Honolulu High-Capacity Transit Corridor Project Land Use Technical Report*), there will be numerous changes to the paths taken by stormwater.

The floodplain in this area is currently open space, which serves to recharge groundwater and convey stormwater toward the ocean. The area was previously farmed for sugarcane and now supports urban wildlife and plants. The area is being developed and lies along the North-South Road corridor. With the drainage system being built for North-South Road, the floodplain will have to be redelineated. The floodplain shown on current maps does not reflect the condition that will be present at the start of construction of the Project.

Honouliuli Stream

The Honouliuli floodplain is currently open space that serves to recharge groundwater and convey stormwater toward the ocean. The adjacent area was previously farmed for sugarcane and is now used for diversified agriculture.

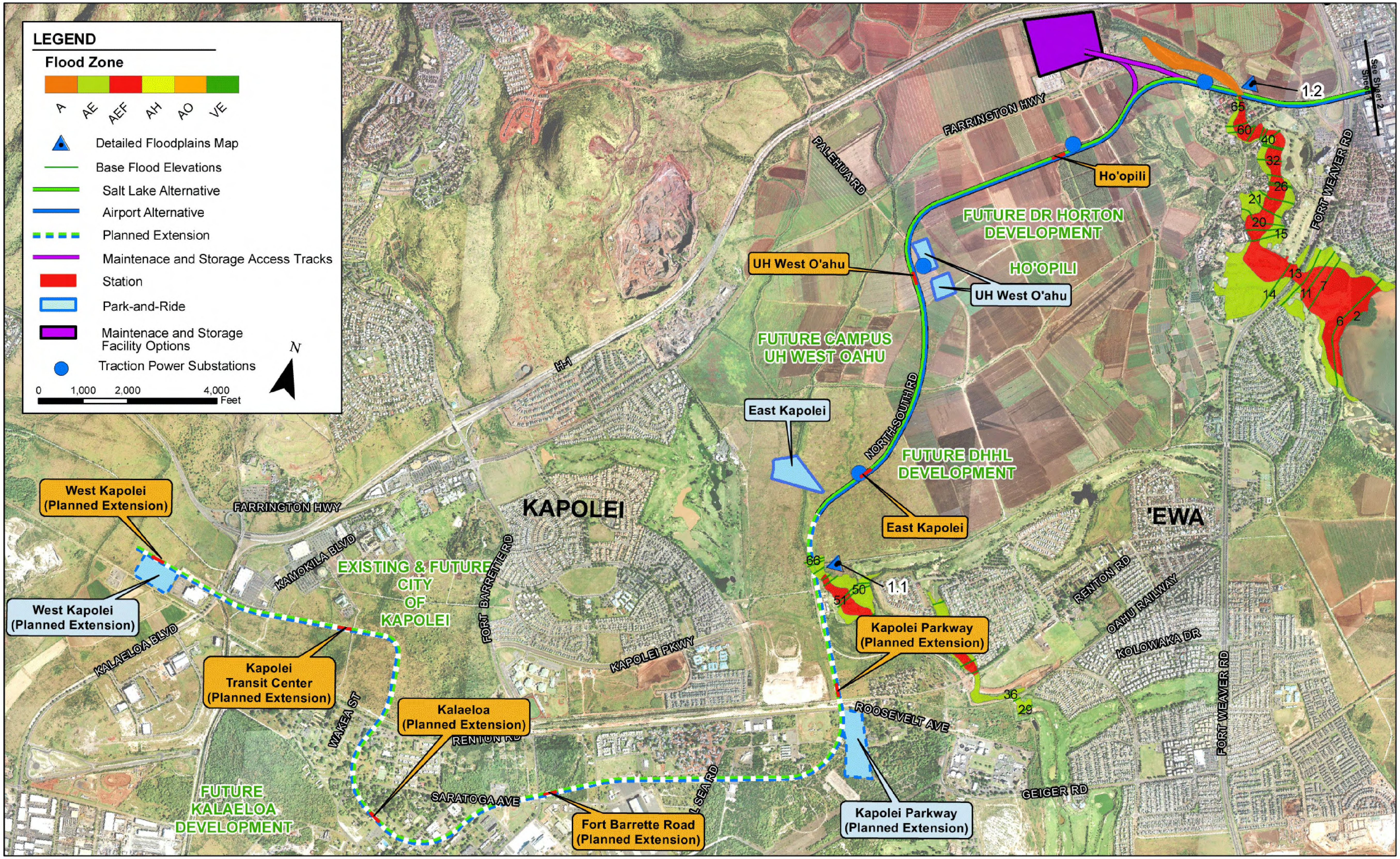

Figure 4-2: Floodplains from Kapolei to Fort Weaver Road

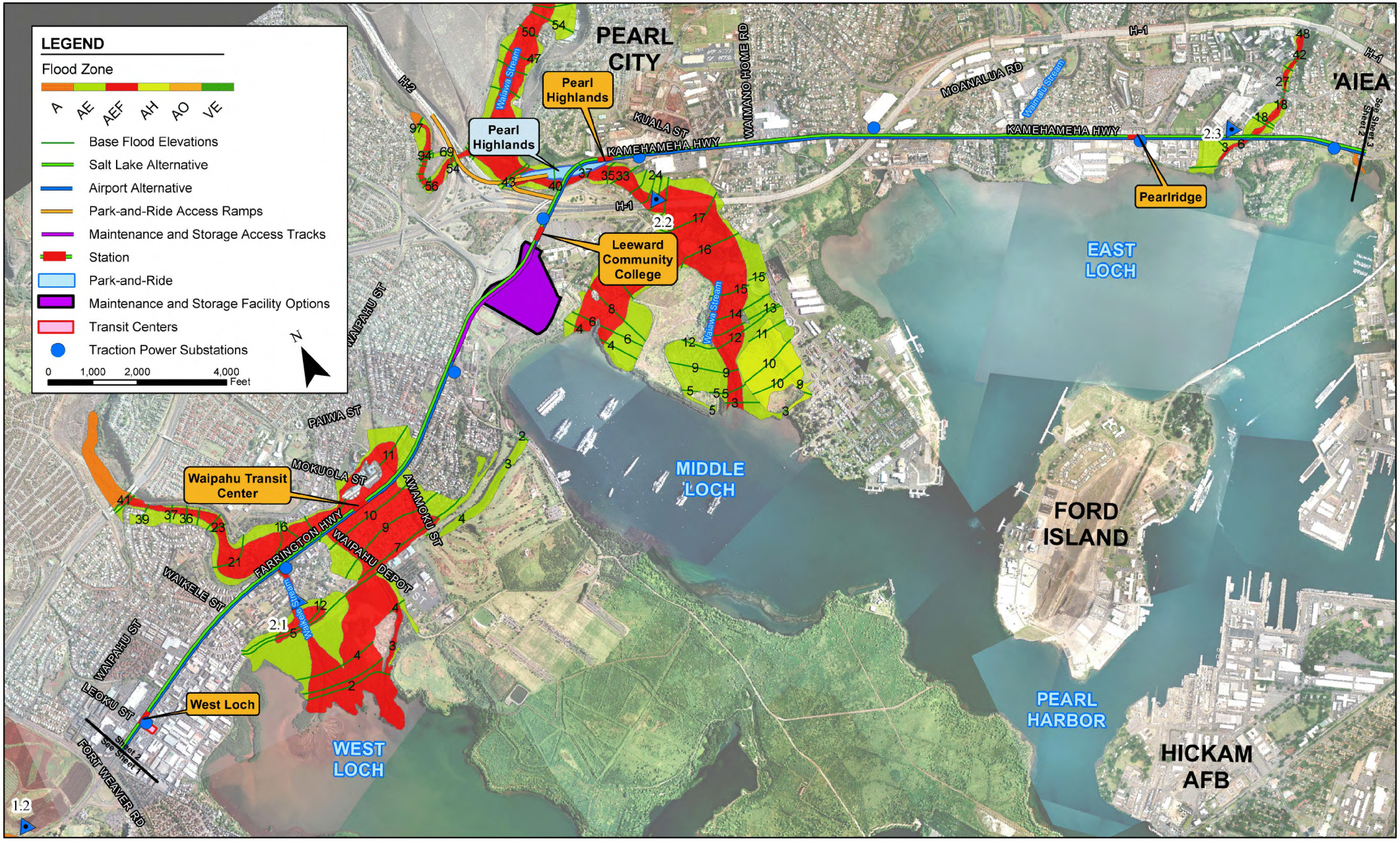

Figure 4-3: Floodplains from Fort Weaver Road to Aloha Stadium

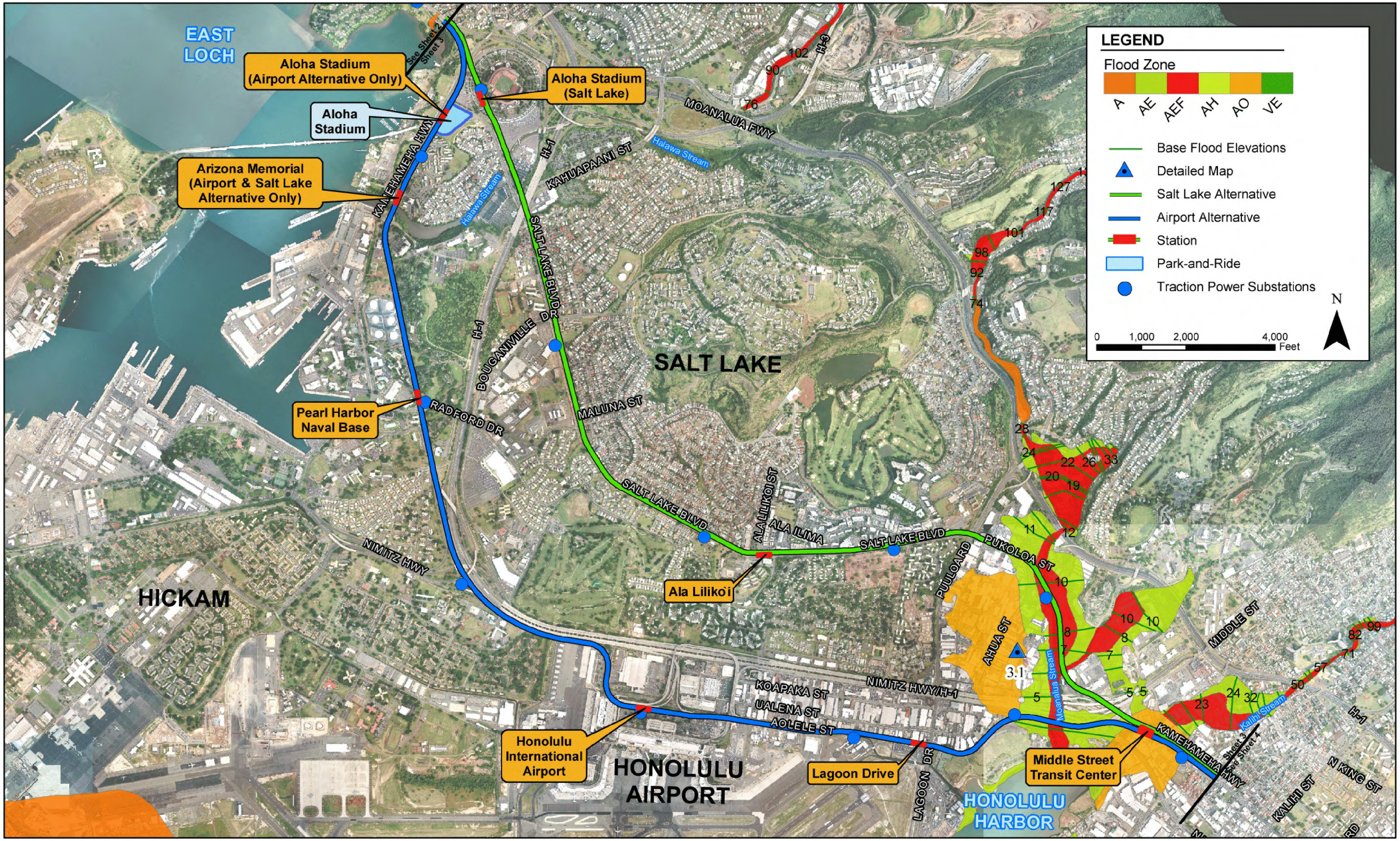

Figure 4-4: Floodplains from Aloha Stadium to Kalihi

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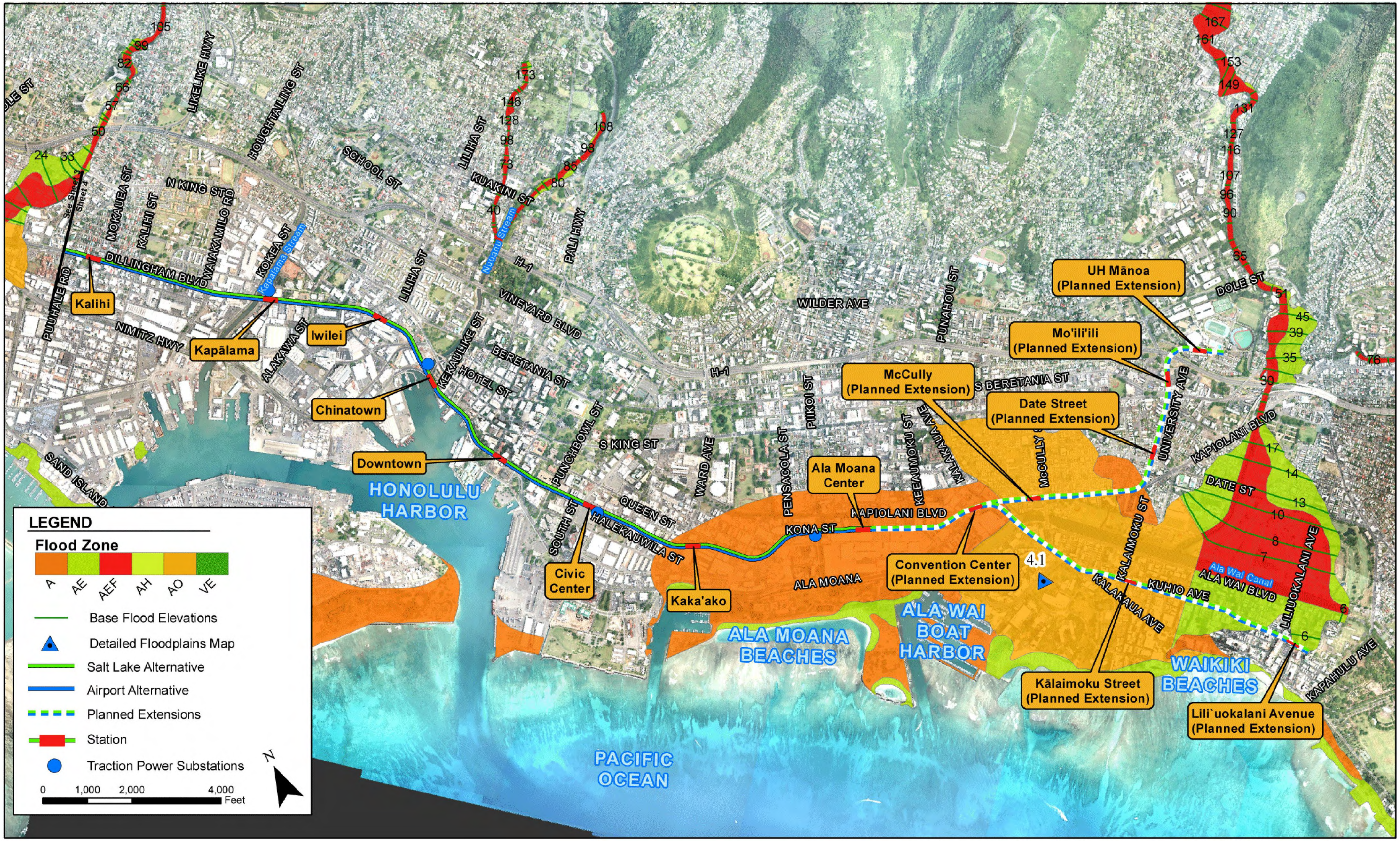

Figure 4-5: Floodplains from Kalihi to UH Mānoa and Waikīkī

Waikele, Makaleha, and Kapakahi Streams

Waikele, Makaleha, and Kapakahi Streams are in Zone AEF as they approach West Loch. Waikele Stream is in a concrete-lined channel, and Kapakahi is a natural drainage where the guideway would cross these floodplains. The guideway would not cross Makaleha Stream. This floodplain along Farrington Highway is highly urban and developed with many commercial uses. The floodplain's only value is to convey stormwater.

Waiawa Stream

Another floodway is associated with Waiawa Stream, which is a natural, unlined drainageway at the point where the guideway would cross it along Kamehameha Highway. The floodway is designated as Zones AEF and AE. This area is very urbanized with shopping malls and other commercial uses.

Kalauao Stream

The guideway would cross Kalauao Stream along Kamehameha Highway. The floodway crossed by the guideway at this point is designated as AEF.

Moanalua and Kalihi Streams

The alignment would follow the AEF and AE zones along Moanalua Stream and Kalihi Streams. This area is very developed with a mixture of military, commercial, and industrial uses. The Moanalua Stream channel in this area is a natural drainage.

Ala Wai Tributaries

One of the largest of the floodplain areas occurs Koko Head of Ward Avenue, makai of South King Street, and ʻEwa of Kapahulu Avenue in the Primary Urban Center Development Plan area. This area includes Ala Moana Beach Park, the Ala Moana Center, and Waikīkī. The area includes the floodplains associated with Mānoa-Pālolo Stream and the Ala Wai Canal. It includes areas that would be inundated by worst-case hurricane conditions. The Flood Insurance Rate Maps in this area are currently undergoing major revisions in the flood zone designations (Tyau-Beam 2007). This is a highly developed area with housing, businesses, and schools and includes Waikīkī, Oʻahu's major tourist area.

4.1.3 Stormwater

Along the study corridor, stormwater is either collected in one of several MS4s or runs naturally overland. Either way, stormwater quickly enters a water of the United States (a stream, the Pacific Ocean, or an embayment). MS4 holders have obtained an NPDES permit from the HDOH to discharge stormwater to waters of the United States. The MS4 holders then work with dischargers to their system, to ensure that discharges from their MS4 comply with requirements imposed by their NPDES permit. Some of the major MS4s within the study corridor follow:

- City and County of Honolulu Environmental Services Department, NPDES Permit HI S000002 for a large MS4 (*http://www.cleanwaterhonolulu.com/storm/*). This MS4 covers stormwater collection systems along City streets and is therefore the biggest MS4 on O'ahu. The City storm drains are generally curb inlets with underground pipes that follow the myriad of City streets and discharge to nearby waters of the United States, often at a bridge.
- HDOT Highways Division, NPDES Permit HI S000001 for a large MS4. The HDOT MS4 includes all storm drain inlets along State highways, including North-South Road, Farrington Highway, Kamehameha Highway, Nimitz Highway, and Ala Moana Boulevard. In urban areas, the HDOT storm drain systems are typically curb inlets with underground pipes parallel with the roadway, which discharge to nearby waters of the United States, often at a bridge. HDOT storm drains sometimes flow into the City's MS4.
- HDOT Airports Division, Honolulu International Airport, NPDES Permit HI S000005 for a small MS4. This permit covers all storm drains on airport property.
- UH Mānoa, NPDES Permit HI 03KB495 for a small MS4.
- U.S. Department of the Navy, Pearl Harbor Navy Base, NPDES Permit HI S000006.

Because of the stormwater system's age, the bulk of the MS4 infrastructure in the vicinity of the Project was developed with limited consideration of stormwater quality or quantity control. The density of development along the study corridor also makes upgrading the systems difficult.

MS4 permits only apply to the publicly owned system constructed to convey stormwater runoff (e.g., catch basins, storm sewers, drainage ditches, and curbs and gutters). These permits targets pollutants of concern and establish benchmarks for pollutants for which a total maximum daily load has been established. MS4 holders are now the primary long-term stormwater quality and quantity managers on O'ahu. They implement permanent BMPs in their drainage areas or within their MS4 systems, and perform preventative maintenance to manage the quality and quantity of stormwater discharging from their systems. MS4 holders require those discharging to their MS4 system to implement appropriate BMPs to manage stormwater quality and quantity prior to allowing new or modified discharges to their MS4.

Dischargers of stormwater to a MS4 or to other receiving waters are also required to obtain their own NPDES permits from the HDOH if they fall into certain categories. Some of the most common types of NPDES permits include:

- Industrial activities
- Construction sites where more than 1 acre of land will be disturbed
- Once-through cooling water
- Treated-process wastewater

- Discharges from recycled water systems (e.g., car washes)
- Circulation water from decorative ponds or tanks

Total Maximum Daily Loads

The status of the streams in the project area is summarized in Table 4-1. Most of the streams the Project would cross are considered water quality-limited, and the ocean harbors, bays, and lagoons along the coast from Pearl Harbor to Waikīkī are on the 303(d) list.

Establishment and implementation of the total maximum daily load process has not been completed for most 303(d)-listed waters in the project area. The only completed study is for the Ala Wai Canal Watershed (Makiki, Mānoa, and Pālolo Streams) for total nitrogen and phosphorus (*http://www.Hawai'i.gov/health environmental/env-planning/wqm/awtmdlfinal.pdf*). This report allocated a load to (1) non-urban lands, (2) the City and County of Honolulu and HDOT combined, (3) groundwater, and (4) cesspools. This allocation required at least a 50-percent reduction in the discharge load for all parties. A new project in the Ala Wai watershed will have stringent limits on discharge loads.

According to the HDOH Environmental Planning Office's Water Quality Management Program website, a total maximum daily loads study is in progress for the Pearl Harbor watershed (including seven streams). Pearl Harbor is listed as having nutrient, turbidity, suspended solids, and polychlorinated biphenyl pollutants. None of these pollutants are associated with operation of an electrically powered fixed guideway transit system.

Injection Wells

Injection wells are sometimes used to manage stormwater and are referred to as *drainage injection wells*. Injection wells are regulated by the HDOH Safe Drinking Water Branch. The Underground Injection Control (UIC) line (Figure 4-6) is the boundary between non-drinking water aquifers and underground sources of drinking water. Restrictions on injection wells differ depending on whether the area is mauka or makai of the UIC line. They are allowed both mauka and makai of the UIC line; however, injection wells mauka of the UIC line are required to meet higher water quality standards and public notification is required during the permit application process. Drainage injection wells are generally used where subsurface conditions are conducive to relatively rapid stormwater injection and there are no down-gradient drinking water wells. Injection wells are currently used in the Kalaeloa area, which is makai of the UIC line.

4.2 Groundwater

As described by Mink and Lau (Mink 1990) and the Honolulu Board of Water Supply (BWS 2007), groundwater aquifers within the study corridor are the Pearl Harbor Aquifer Sector, which contains the 'Ewa, Waipahu, Waiawa, and Waimalu Aquifer Systems, and the Honolulu Aquifer Sector, which contains the Moanalua, Kalihi, and

Nu‘uanu Aquifer Systems. Based on the Hawai‘i status codes related to protecting drinking water, the aquifers are generally designated as currently used sources of fresh drinking water that are both irreplaceable and highly vulnerable to contamination.

The SOBA (Figure 4-6) is another method of classifying this group of aquifers. The SOBA is the basal freshwater lens floating on saline groundwater over most of southern O‘ahu. The EPA has designated the SOBA as the sole or principal source of drinking water for O‘ahu. It is recharged by rainfall that falls on the mauka areas of the island. The entire study area is underlain by the SOBA.

Caprock overlies the SOBA on the Leeward coast and impedes the escape of groundwater from this basaltic aquifer. Water in the caprock is brackish and not potable. The caprock is less permeable than water-bearing lava flows and constitutes a barrier that retards the seaward flow of groundwater. The caprock layer thins with distance from the shoreline and ends at varying distances inland, and the basalt layer is exposed or underlies superficial materials.

Beneath the caprock and underlying all of southern O‘ahu, the SOBA is heavily used because it contains large supplies of fresh water. Although the caprock’s capacity to store and transmit water is small compared to the basalt aquifer’s, the caprock contains large quantities of water accumulating from rainfall, irrigation return, and leakage upward from the artesian portion of the basalt aquifer. Caprock water is generally of poor quality because of its relatively high chloride content, but it has been developed for agricultural and industrial purposes. Groundwater levels in the caprock along the study corridor vary with ocean tides and may also be influenced locally by streams.

As a consequence of the caprock, inland areas in southern O‘ahu have high water tables and some artesian wells. Where the basal groundwater is under artesian pressure, water levels can range up to 30 feet above sea level.

There are numerous injection wells for waste discharge into the caprock in central Honolulu, including those for thermal effluent, car wash return, and rainwater. However, pollutants from these discharges do not reach the SOBA because of upward artesian pressure. Most of the Project is mauka of the UIC line, reinforcing the need to protect the underlying groundwater resources.

For the far ‘Ewa portion of the alignment, the groundwater encountered by the drilled shafts would be in the caprock several tens of feet below the ground surface. As the alignment follows North-South Road, the caprock thins and the drilled shafts would be directly in the basalt.

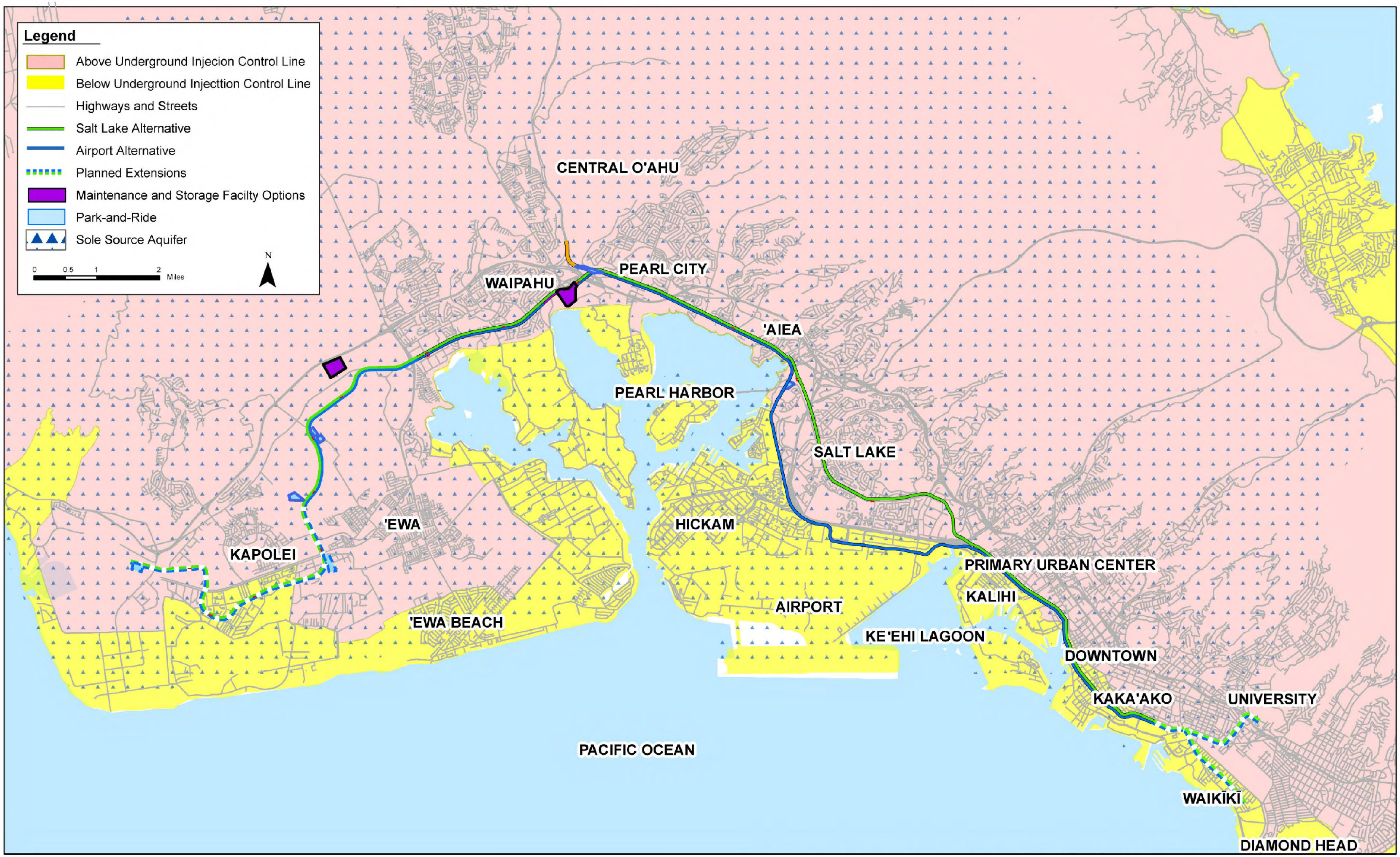

Figure 4-6: Southern O‘ahu Basal Aquifer and Underground Injection Control Line

From Leeward Community College to Aloha Stadium along Kamehameha Highway, shallow groundwater levels or artesian groundwater conditions may be encountered. This is a consequence of the caprock confining the groundwater in the SOBA. Of particular importance are groundwater seeps that provide water to the Sumida Watercress Farm on Kamehameha Highway.

Groundwater would probably not be encountered at the shaft depths along the Salt Lake Boulevard alignment. The shafts would be in volcanic tuff overlying alluvial deposits. For the Airport alignment, depths to groundwater would be approximately 10 feet below the surface.

For the remainder of the First Project alignment, groundwater may be encountered at about 10 feet below the surface. The subsurface is a complicated interbedded sequence of alluvial deposits, harbor muds, coral, and volcanic tuffs. A tidal influence on groundwater depth will be observed in some of the drilled shafts.

Depths may be as little as 5 feet below the ground surface in the Waikīkī Branch portion of the corridor. Tides in this location would influence groundwater levels.

Depth to groundwater would vary greatly for the UH Mānoa extension. Near Ala Moana, groundwater would be encountered at approximately 10 feet below the surface. At UH Mānoa, the drilled shafts may not encounter groundwater.

5 Consequences

5.1 No Build Alternative

5.1.1 Streams, Marine Waters, and the Coastal Zone

The No Build Alternative would not affect streams and marine waters.

5.1.2 Floodplains

No impacts to floodplains would be attributed to the No Build Alternative.

5.1.3 Stormwater

The volume of stormwater runoff would not be affected by the No Build Alternative. Islandwide, runoff from roadway surfaces would contain more pollutants than any of the Build Alternatives, because the daily vehicle miles traveled would be greater with the No Build Alternative than with any of the Build Alternatives. The quantity of stormwater pollutants from roadway runoff is proportional to average daily traffic volumes for roadways, because vehicles drip oil and release other pollutants. The more vehicles that travel on a road, the more pollutants accumulate on the road surface to be washed away by stormwater.

5.1.4 Groundwater

Groundwater would not be affected by the No Build Alternative.

5.2 Build Alternatives

5.2.1 Streams, Marine Waters, and the Coastal Zone

Where the guideway would cross the ‘Aiea, Moanalua, Kalihi, Nu‘uanu, Kapālama, and Hālawa Streams and the Ala Wai Canal, these water bodies are considered navigable waters. Bridges over navigable waters require approval from the U.S. Coast Guard prior to construction. Piers may have to be placed in some streams, such as Moanalua Stream or the Ala Wai Canal. The Build Alternatives would not affect navigation. Navigation on these streams, when present, is limited to small pleasure craft such as outrigger canoes, which would be unimpeded by the expanded or new bridges. No impacts to recreational opportunities are expected.

5.2.2 Floodplains

The Build Alternatives would not cause significant floodplain encroachment as defined by USDOT Order 5650.2. The fixed guideway would not cause a considerable probability of loss of human life due to flooding. The guideway and stations would be elevated above the floodplain by piers that would withstand flooding from 100-year floods. Figure 5-1 and Figure 5-2 show detailed floodplains in the study area, and Table 5-1 shows how many feet of the alignment would be located in the various flood zones.

Facilities in floodplains at ground level, such as stairs and elevators, would be designed to function and remain safe during the 100-year flood. The TPSS would have to be built above the flood level. The impact of having facilities in the floodplain is that they displace water, so the flood level would rise (usually by a very small amount). The more piers or other facilities are added to the flood zone, the greater the associated rise in the flood zone level. However, this rise is usually very small because the flood zone is generally very large compared to the number of project components added (e.g., piers). Location hydraulic studies will be performed, and any rise in base flood elevations will be mitigated during the Project's design phase.

No known property risks are associated with the fixed guideway. The fixed guideway would provide a safe alternative to surface transportation during storms.

No likely future damage is associated with floodplain encroachment that could be substantial in cost or extent, including interruption of service on or loss of a vital transportation facility. The guideway would be elevated and could continue to run even if flooding occurred on the ground underneath the guideway.

No notable adverse effects on natural and beneficial floodplain values would occur with the Project. In general, the benefits of the floodplains analyzed are the recharge of groundwater, stormwater conveyance, and flood moderation. These areas also support plants and wildlife within urbanized areas, and maintain areas for outdoor recreation and enjoyment while preserving the land's natural beauty. It is not expected that any of these functions would be adversely affected by any of the Build Alternatives.

As noted in the *Honolulu High-Capacity Transit Corridor Project Land Use Technical Report,* the land surrounding the fixed guideway is either developed or planned for development. The fixed guideway would not encourage or support incompatible floodplain development. Development will occur even if the fixed guideway is not constructed. Future development will need to comply with Federal, State, and local floodplain protection regulations.

Land use in floodplains is described in the City's Flood Ordinance (Article 9, Special District Regulations). Transit systems are not specifically addressed, although roads are an allowed use. Parking lots are also allowable uses in the floodplain.

Table 5-1: Guideway Crossings of Floodplains

		Length of Crossing (feet) by Zone for Each Watershed										Total Length of Crossing (feet)
		Kalo'i Gulch	Honouliuli Stream	Waikele, Kapakahi, Makaleha	Waiawa	Kalauao	Moanalua, Kalihi	Moanalua, Kalihi	Ala Wai	Ala Wai	Ala Wai	
Alternative	**Zone**	**5-1 (1.1)***	**5-1 (1.2)**	**5-1 (2.1)**	**5-1 (2.2)**	**5-1 (2.3)**	**5-2 (3.1)**	**5-2 (3.1)**	**5-2 (4.1)**	**5-2 (4.1)**	**5-2 (4.1)**	
Salt Lake	A		377						7,615	1,059	598	9,649
	AE	132		1,473	536		1,175				2,082	5,398
	AEF			2,511	249	139	2,497					5,639
	AO						1,387			2,544	4,421	8,352
	Total	**132**	**377**	**3,984**	**785**	**139**	**5,059**		**7,615**	**3,603**	**7,101**	**28,795**
Airport	A		377						7,615	1,059	598	9,649
	AE	132		1,473	536			2,217			2,082	6,440
	AEF			2,511	249	139		337				3,236
	AO							1,517		2,544	4,421	8,482
	Total	**132**	**377**	**3,984**	**785**	**139**		**4,071**	**7,615**	**3,603**	**7,101**	**27,807**
Airport & Salt Lake	A		377						7,615	1,059	598	9,649
	AE	132		1,473	536		1,175	2,217			2,082	7,615
	AEF			2,511	249	139	2,497	337				5,733
	AO						1,387	1,517		2,544	4,421	9,869
	Total	**132**	**377**	**3,984**	**785**	**139**	**5,059**	**4,071**	**7,615**	**3,603**	**7,101**	**32,866**

*Figure Number (Detailed Map): see Figures 5-1 and 5-2, following

Kalo'i Gulch

Based on current mapping of the undeveloped area, a small span of the guideway would cross the AE floodplain for Kalo'i Gulch (Figure 5-1, Detailed Map 1.1). It may be possible to design the guideway with the piers straddling Zone AE.

Honouliuli Stream

Other floodplains within the corridor are associated with streams entering Pearl Harbor. The alignment would cross Honouliuli Stream in a floodplain labeled "A" (Figure 5-1, Detailed Map 1.2). At least one pier would likely be located in Zone A.

Waikele, Makaleha, and Kapakahi Streams

Waikele, Makaleha, and Kapakahi Streams are in Zone AEF as they approach West Loch (Figure 5-1, Detailed Map 2.1). Assuming the piers are spaced between 80 and 180 feet apart, up to 32 piers, the Waipahu Transit Station, and a TPSS would be located in Zone AEF. Between 8 and 17 piers would be located in Zone AE.

Waiawa Stream

A proposed 9-acre park-and-ride structure at Pearl Highlands would be located in the Waiawa floodway in an AEF Zone (Figure 5-1, Detailed Map 2.2). The parking structure would have to be designed to allow floodwaters to pass unimpeded.

Kalauao Stream

The guideway would cross Kalauao Stream, but because it would only cross the floodplain for a short distance, the piers may be able to span across the floodplain (Figure 5-1, Detailed Map 2.3).

Moanalua and Kalihi Streams

As many as 31 piers may be located in Zone AEF (Figure 5-2, Detailed Map 3.1).

The guideway and the Middle Street Transit Center and Park-and-Ride are in Zone AO. Zone AO is the flood insurance rate zone that corresponds to the areas of shallow flooding – usually sheet flow on sloping terrain. Parking lots are an allowable land use in floodplains, according to the City's Flood Ordinance.

Ala Wai Tributaries

Several transit stations in the First Project would be located in Zone A – Kaka'ako, Ala Moana, and the Convention Center, as would two TPSS (Figure 5-2, Detailed Map 4.1).

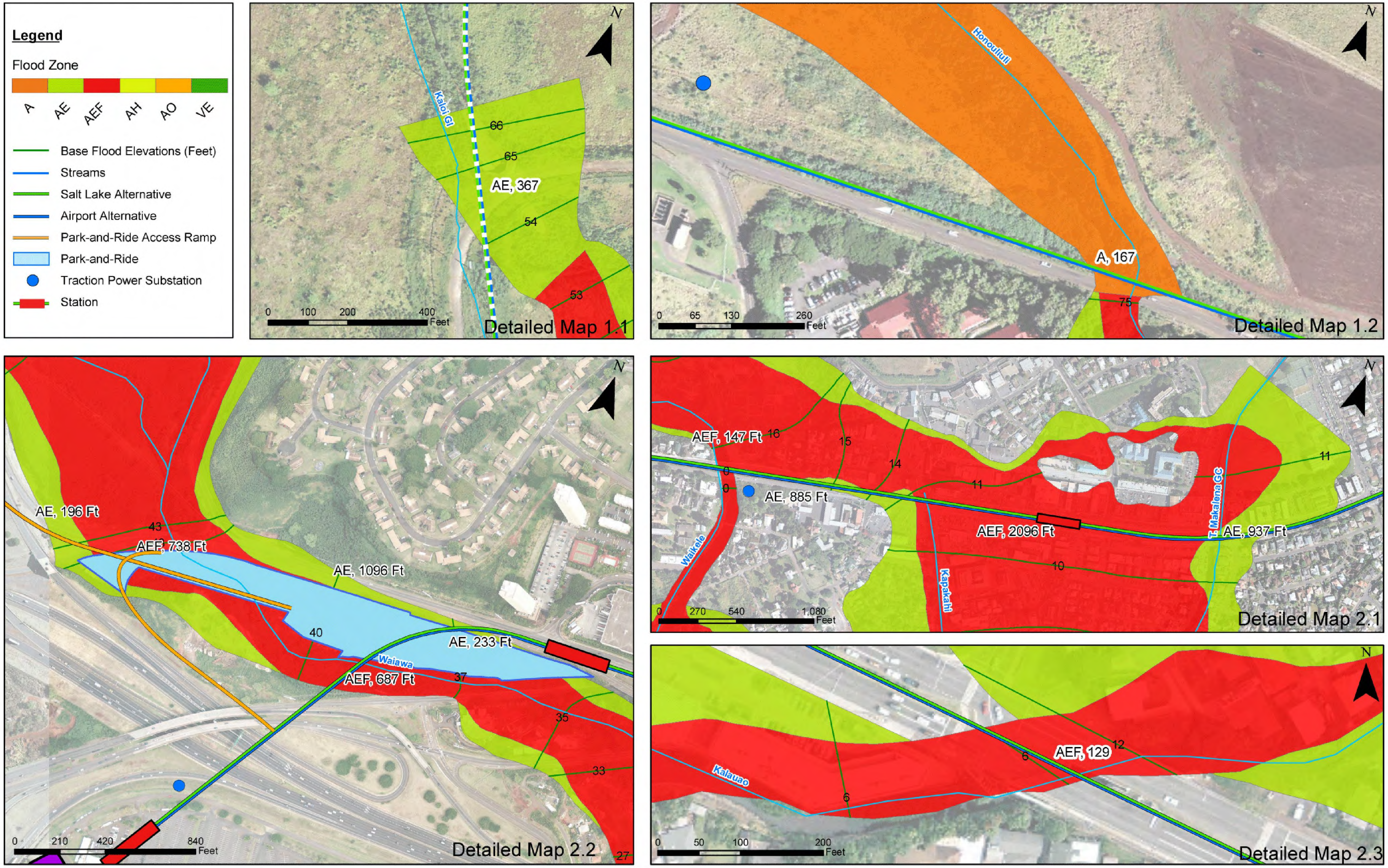

Figure 5-1: Streams and Floodplains Detailed Maps Kapolei to Aloha Stadium

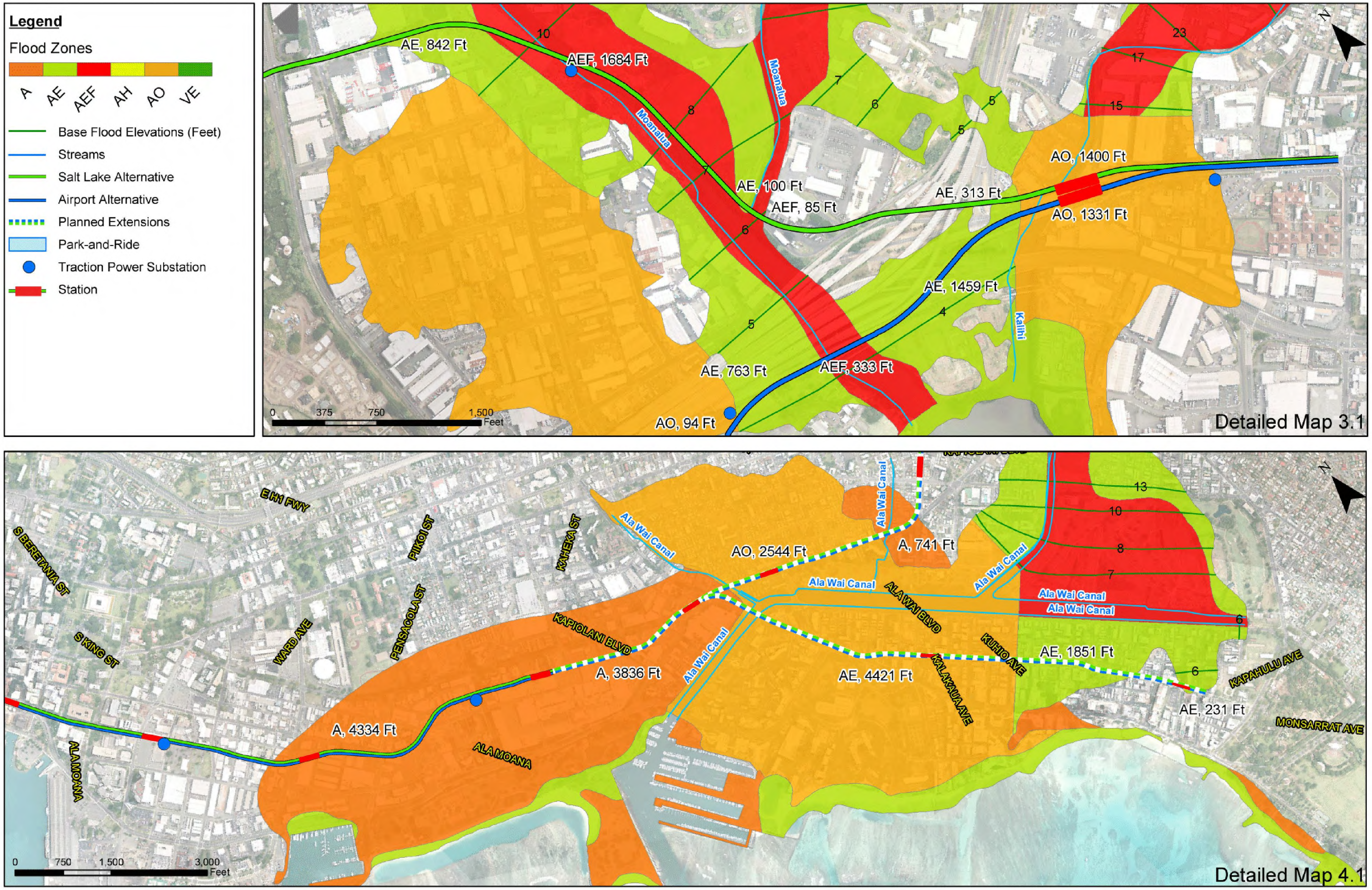

Figure 5-2: Streams and Floodplains Detailed Maps Aloha Stadium to UH Mānoa and Waikīkī

Airport Alignment

The guideway would cross approximately 4,000 feet of designated Flood Zones AO, AE, and AEF associated with Moanalua Stream (Figure 5-2, Detailed Map 3.1). A TPSS would be located in the AE Zone and would need to be set above the flood level.

The guideway and the Middle Street Transit Center and Park-and-Ride are in Zone AO of Kalihi Stream.

UH Extension

Portions of the alignment to UH Mānoa would be located in Zone AO (Figure 5-2, Detailed Map 4.1). Other parts of the alignment are in Zone A.

Waikīkī Extension

Portions of the alignment to Waikīkī would be located in Zone A (Figure 5-2, Detailed Map 4.1). Other parts of the alignment would be located in Zone AO. The Liliʻuokalani Avenue Station would be located partially in Zone AE, along with a TPSS.

5.2.3 Stormwater

Impervious surfaces increase stormwater runoff volume and pollutant loadings, and reduce groundwater recharge. Any runoff from an impervious area should be considered potentially pollutant laden, and can pollute downstream water bodies or infiltrate into the groundwater. Three primary components of the fixed guideway transit system would increase the impervious surface area: (1) the guideway, TPSS and stations, (2) park-and-ride facilities, and (3) the maintenance and storage facility. Each is discussed in the following sections.

Guideway, Stations, and Traction Power Substations

Because rail relies on electric propulsion, the quantity of pollution generated on the guideway would be minimal compared to roadway traffic. The remainder of this section discusses the quantity and quality of stormwater (quantity is discussed first).

Most of the fixed guideway system would be installed along highways and roads in urban areas, where most land is already covered with pavement and buildings and impervious surfaces already dominate the landscape. Therefore, the fixed guideway, transit stations and TPSS would not dramatically increase the impervious area, increase runoff, or decrease groundwater recharge. In many cases, the guideway would run above areas that are already impervious, so no net change in runoff would result. In general, the closer the guideway is to the urban center of Honolulu, the less new impervious surface it will create.

For example, along Farrington Highway where a 2.4-mile length of the fixed guideway would be over the highway median, the 26-foot-wide fixed guideway structure would have an approximately 7.4-acre impervious surface, but only 4.4 of those acres are over a currently pervious surface. Similarly, where a 2.5 mile length of the fixed guideway would be over Kamehameha Highway's median from Farrington Highway to Honomanu Street, only 2.6 acres of the 8.0 acres would be new impervious surface.

In the undeveloped area Wai'anae of Fort Weaver Road, the fixed guideway would primarily be built over currently undeveloped, pervious land. Approximately 8.5 miles of the fixed guideway would be located in this relatively undeveloped area, 3.4 miles of which would be within the limits of the First Project. In this section the fixed guideway, transit stations, and TPSS would generate more new impervious surface and, therefore, more stormwater runoff. The ground beneath the fixed guideway (but not beneath the stations or TPSS) would remain pervious but would no longer be exposed to direct rainfall.

Regardless of whether the fixed guideway generates new impervious surface, it would collect stormwater and concentrate it differently than the current ground surface does. The fixed guideway would be sloped between 0 and 6 percent, and stormwater would flow down along it. The slope of the guideway would sometimes be in the opposite direction of the current underlying ground slope, depending on the location of stations and other features. The fixed guideway would include pipes at support columns to route collected stormwater to the ground surface or to a subsurface drain periodically. Stormwater would be released at intervals of between one and four support columns. With columns placed every 150 to 180 feet apart, this would result in stormwater being removed from the fixed guideway approximately every 150 to 720 linear feet. The flow at each one of the drop locations would range from approximately 0.5 to 2.5 cubic feet per second ($Q = CIFA = 0.98 * 2.5$ in/hr $* 2.3 * A$). This is a small flow relative to the runoff from a similar length of a four-lane roadway.

In some instances, it may not be possible to discharge stormwater from the project area to an existing MS4. This is especially true in the undeveloped areas of Kapolei and 'Ewa or where the Project is in low-lying areas. If new outfalls are required, additional permits beyond an NPDES would also be required. Additional permits could include a Department of the Army Section 404 permit with accompanying Section 401 Water Quality Certification and CZM, as well as a Stream Channel Alteration Permit.

Stormwater from the fixed guideway, transit stations, and TPSS should be relatively free of pollutants. Rail is electric powered and therefore would have little to no fuel, oil, and grease associated with it. Modern transit vehicles are built to high standards that limit exposure of chemicals to stormwater or the chance of fluid leakage. With steel-wheeled transit technologies, the slow wear of the rail and wheels would result in exposing minute amounts of metal dust to stormwater along the guideway. The volume and variety of pollutants exposed to stormwater on the fixed guideway would be much smaller than those on the roadway below.

The type and load of pollutants that might be present in stormwater will be studied by collecting stormwater monitoring results from similar technology installations around the U.S.

Park-and-Ride Lots

Impervious surfaces would also be created by park-and-ride lots (Table 5-2). Stormwater runoff from these large, paved surfaces would increase the overall stormwater runoff in these areas and reduce groundwater recharge, because most of these areas are currently undeveloped and unpaved. Storm drains would need to be placed within the parking lot to collect stormwater, and permanent BMPs would need to be installed. The Project's park-and-ride facilities may require their own NPDES permit.

Table 5-2: Park-and-Ride Lots

Park-and-Ride Location	Approximate Total Area	Current Impervious Area*	New Impervious Area*	Stormwater could be Discharged to:
West Kapolei	16 acres	None	95%	City and County MS4 or injection wells
Kapolei Parkway	12 acres	None	95%	Injection wells
UH West Oʻahu	15 acres	None	95%	Injection wells
Pearl Highlands	9 acres	Little	95%	HDOT MS4 or Waiau Stream
Aloha Stadium	7 acres	60%	95%	City and County or HDOT MS4

* percentage of approximate total area

The park-and-ride lots would generate the same type of stormwater pollutants that any other parking lot would create. The pollutant load from a parking lot is typically less than from a roadway, because fewer vehicles travel over the impervious surface.

Vehicle Maintenance and Storage Facility

Two locations are being considered for the vehicle maintenance and storage facility: Hoʻopili and a vacant site near Leeward Community College (Table 5-3). Stormwater runoff from the facility at either location would increase the overall stormwater runoff in the vicinity of the site, and would reduce groundwater recharge because both locations are currently primarily undeveloped and unpaved. Storm drains would need to be placed within the facility to collect stormwater, and permanent BMPs would need to be installed. The Project's maintenance facilities may require their own NPDES permit.

Table 5-3: Vehicle Maintenance and Storage Facility Characteristics

Maintenance and Storage Yard	Total Area	Current Impervious Area	Approximate New Impervious Area*	Stormwater could be Discharged to:
Hoʻopili	41 acres	Little	70%	Injection wells or Honoʻuliʻuli Stream
Leeward Community College	43.3 acres	Trace	70%	UH, DOE, or HDOT MS4 or Pearl Harbor

* percentage of approximate total area

Vehicle maintenance and cleaning activities would be conducted at the maintenance and storage facility, resulting in a greater potential for stormwater exposure to pollutants. Along with transit vehicles, a pool of maintenance vehicles (e.g., cars and trucks) would be maintained and stored at the site. The potential for the release of pollutants would be limited by conducting maintenance activities in a covered area. Other equipment and materials such as items associated with the guideway, stations, lighting, and power distribution would be stored at the site. The facility would have substantial unpaved areas, such as ballasted storage track. Therefore, sediment suspension and erosion by stormwater could also be a concern if control measures are not incorporated into system design.

5.2.4 Groundwater

No impacts to the SOBA are anticipated. As discussed in the Stormwater sections, impervious surfaces would be added for the fixed guideway and associated parking areas and transit stations. Stormwater runoff from these surfaces would enter the groundwater system along different paths than previously (i.e., as the water runs off the guideway into the permanent BMPs). However, the groundwater recharge needed to sustain the aquifer system would ultimately continue. There would be no long-term changes to groundwater levels, including artesian conditions, as a result of the fixed guideway system. Runoff from the guideway itself should be relatively free of pollutants and would not threaten groundwater quality.

Stormwater from parking lots may contain oil, grease, and other pollutants associated with automobiles. However, these pollutants must be removed prior to infiltration into the groundwater.

5.3 Construction Impacts

Streams, Marine Waters, and Coastal Zones

Coordination with the USACE and the EPA would occur through the "Memorandum of Understanding for the National Environmental Policy Act/Clean Water Act Section 404 Integration Process for Surface Transportation Projects in the State of Hawai'i" if a CWA Section 404 or Section 10 permit is needed.

A Department of the Army permit under Section 404 of the CWA may be needed to discharge dredge or fill material into waters of the United States. This would be determined by the spacing of the piers. Until the exploratory geotechnical work is complete, it is not known whether a pier would have to be placed in a water of the United States. Wide streams such as Moanalua Stream and the Ala Wai Canal are likely to require piers in the stream. These streams already have bridges that cross next to the guideway. Under Section 401 of the CWA, the need for a Department of Army permit triggers the need for a Section 401 Water Quality Certification from HDOH's Clean Water Branch.

Alterations to stream channels, such as placing piers in streams or on banks, would be regulated by the State Commission on Water Resource Management through issuance of a Stream Channel Alteration Permit. Stream crossings that exceed 130 feet would likely require placing a 6 to 10-foot-diameter supporting column in the stream.

Construction should not interfere with access to recreational facilities within the coastal zone. Accommodations would be made for paddlers and other recreational uses of streams, especially the Ala Wai Canal.

Floodplains

During construction, work would occur in the floodplain, exposing workers and equipment to flood risks.

Stormwater

The construction period for the Project is estimated to be nine years. The length, area, and duration of project construction make this one of the largest in Honolulu's history. Stormwater runoff from construction sites would enter most streams, bays, and harbors along the south shore of O'ahu. BMPs to control stormwater during construction will be detailed in an NPDES permit.

Approximately 300 acres would be disturbed to construct the Project. Since most of this acreage is part of the maintenance facilities and parking lots, the difference in acreage between the alternatives is small. The Airport Alternative would disturb 280 acres, and the Salt Lake Alternative would disturb 279 acres. The Airport & Salt Lake Alternative would disturb 301 acres.

Exposing the ground surface, stockpiled soil, and other materials to stormwater could affect the quality of nearby surface waters during construction. The most extensive excavations would be for the guideway column foundations. The largest areas of soil disturbance would likely be at park-and-ride locations and the vehicle maintenance and storage facility. Sediment loading of stormwater could occur when unstable, exposed soil at excavations and stockpiles are exposed to heavy rain and stormwater runoff. Sediment-laden stormwater could create unacceptable levels of turbidity and high sedimentation rates. If drilled shafts are used, the area of disturbed soil could be greatly limited.

The transportation of excavated soil or other material to and from construction sites may also affect stormwater. As described in the *Honolulu High-Capacity Transit Corridor Project Hazardous Materials Technical Report,* excavated material could contain oil, grease, and other contaminants. Exposing the excavated material during construction could increase the potential for stormwater transport of these contaminants. These potential impacts and mitigation measures will be addressed in additional hazardous material studies during the Project's design phase.

Groundwater

In accordance with a 1984 Sole Source Aquifer Memorandum of Understanding between the FHWA and the EPA, a Groundwater Impact Assessment will be submitted to the EPA. Its purpose is to initiate a Section 1424(e) review under the Safe Drinking Water Act. The assessment evaluates the Project's potential impact on the quality of groundwater. This section discusses potential impacts to the SOBA during construction.

Dewatering, ground amendment, a combination thereof, or other ground stabilization methods would likely be required where excavations extend over several feet below static groundwater levels. Dewatering removes groundwater from an excavation. Although a dewatering method would be determined during later design stages, it would likely consist of pumping from a sump. To achieve satisfactory drawdown, a more sophisticated technique (e.g., a well point system) may be required if a sump cannot keep up with the recharge. Pile caps, utility trenches, and partially or fully embedded structures are possible dewatering scenarios, depending on groundwater conditions at particular sites.

Dewatering disturbs groundwater's natural level and flow characteristics. Depression of the natural groundwater table can induce consolidation of subsoils and subsequent ground settlement, called *subsidence*. Subsidence can cause cracking and other damage to buildings and facilities. Any ground stabilization method would be performed in a manner that protects existing conditions, whether by controlled dewatering, ground modification, installing sheet piling, or reinjection. Performance criteria will be established to limit the extent of any adverse influences beyond the work zone to acceptable and time-proven limits. Induced settlement or movement of nearby facilities will not be permitted. Where this possibility may exist, pre- and post-construction monitoring will be required to detect any unexpected movements or displacements.

Casing will be required at drilled shaft excavations that extend through soft or loose surficial deposits. Where unstable deposits extend to considerable depth, the casing may be incorporated into the shaft's structural design. Where drilled shaft completion depths extend below static water levels, excavation stability will also require maintaining fluid levels within the excavation until concreting is complete. The counterbalancing fluid may simply be water and naturally derived cuttings, or specially formulated drilling mud.

Water removed from the excavations must either be returned to the groundwater system or added to the stormwater drainage system. Any water discharged into the drainage system and surface-water bodies will require an NPDES Dewatering Permit. The discharge must meet water quality standards. Groundwater in the excavation would probably be pumped out with a sump pump. This groundwater would contain suspended sediment and could adversely affect receiving surface-water bodies by increasing their turbidity and sedimentation rates. Groundwater encountered by excavations for pile caps that need to be removed is likely to be contaminated with petroleum products at several locations where excavations are required.

5.4 Indirect and Cumulative Impacts

The President's Council on Environmental Quality regulations implementing the National Environmental Policy Act of 1969 defines indirect effects as those:

> “which are caused by the proposed action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect impacts may include growth inducing effects and other effects related to the induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.”

Cumulative effects are those effects:

> “which result from the incremental consequences of an action when added to other past and reasonably foreseeable future actions” (40 CFR, Section 1508.7)

The indirect and cumulative effects analysis considers the full range of consequences of actions related to project activities. The National Environmental Policy Act, the Council on Environmental Quality regulations, and Hawai‘i’s EIS law, require analysis of cumulative issues within the context of the action, alternatives, and effects.

5.4.1 No Build Alternative

Streams, Marine Waters, and the Coastal Zone – Stormwater and Groundwater

If no fixed guideway is built on O‘ahu, more roads will probably be built. Roads produce more pollutants, such as oil and grease associated with automobiles, than runoff from a fixed guideway. These pollutants would eventually make their way into surface waters, be carried off the roadways by stormwater, and/or make their way into the groundwater system.

Floodplains

Various encroachments on floodplains would occur as a result of continued development on O‘ahu.

5.4.2 Build Alternatives

Streams, Marine Waters, and the Coastal Zone

More stream crossings would be required over streams along the alignment, further increasing the existing urbanization of the waterways.

Floodplains

The fixed guideway would enhance the livability of areas near transit stations and make development more desirable. Where the stations are in proximity to or within floodplains, pressure could increase to develop these areas.

Stormwater

Stormwater runoff would increase and groundwater recharge would decrease as development occurs, creating more impermeable surfaces along the fixed guideway alignment. Increases in development would be most noticeable in the currently undeveloped ‘Ewa Plain area. Given the level of development from Fort Weaver Road to the eastern terminus of the system, no significant increases in stormwater runoff are expected along this section.

Although the area of impermeable surface is anticipated to increase as development occurs along the fixed guideway alignment, the number of roads built and vehicle miles traveled in the corridor are expected to be lower if the fixed guideway is built. Fewer roads and lower vehicle miles traveled translate to an overall lower pollutant load in stormwater.

Recent regulations require that stormwater from transportation systems be controlled. As a result, the Project provides an opportunity to develop new and innovative permanent stormwater controls for transit systems. The permanent BMPs used for the Project could be copied by systems in other parts of the country and the world. The permanent BMPs implemented by the Project could also benefit runoff from more than just the fixed guideway, and could improve the quality of stormwater runoff in the area. Improved water quality would benefit receiving waters and downstream ecosystems in general.

Groundwater

All of the Build Alternatives would increase impermeable surfaces and therefore redirect runoff. The installation of permanent BMPs would direct runoff back into the ground to recharge the groundwater system, resulting in no change in the amount of infiltration. Runoff from the guideway would not likely contaminate groundwater.

6 Mitigation

6.1 Surface Waters

6.1.1 Streams, Marine Waters, and the Coastal Zone

During construction, pollution and turbidity caused by stormwater runoff would be mitigated by BMPs. Agency reviews conducted as part of the NPDES permit process would ensure that proper control techniques are implemented. Specific potential mitigation measures to protect surface-water quality during construction and operation are discussed in the following Stormwater section, because this water eventually discharges into streams and marine waters.

Bridges would be designed to maintain current navigability of the streams. Any piers in streams would be placed to line up with existing bridge structures when feasible.

6.1.2 Floodplains

As a linear feature, the guideway would cut across several floodplains. In order to space the piers close enough to support the guideway, piers would be located in the floodplain. Because the guideway would be elevated and the structure is designed to withstand flooding, no impacts would result and no mitigation would be needed. Facilities in floodplains at ground level (e.g., stairs and elevators) would be designed to function and remain safe during flooding.

Ongoing hydraulic studies will show whether piers in the floodway would raise base flood elevations. If so, increases in base flood elevations may be mitigated by the design. In particular, the Pearl Highlands parking structure would require a design that allows floodwaters to pass unimpeded.

In general, the main beneficial floodplain functions for streams along the alignment are the recharge of groundwater and drainage conveyance. These functions would not be affected by the alternatives.

As required by USDOT Order 5650.2, "Floodplain Management and Protection," floodplain encroachment information will be presented at informational meetings and public hearings. During construction, care would be taken to remove workers and equipment when potential storm conditions indicate the possibility of flooding.

6.1.3 Stormwater

Permitting

Numerous permits and permissions would have to be obtained for the management and discharge of stormwater during construction and from the completed fixed guideway system. During project design, hydraulic analysis will be performed as needed to determine flow and drainage system capacity. Anticipated permits and permissions include:

- CWA Section 402 NPDES permits, including:
  - General construction permit (NOI Form C) for overall construction (due to the Project's size and its many facets, an individual NPDES permit may be required);
  - Construction dewatering permit (NOI Form G) for dewatering of foundation excavations, if needed;
  - Industrial activity permit (NOI Form B) for the completed vehicle maintenance and storage facility; and
  - Potential MS4 permit for the fixed guideway system.
- Permissions to discharge stormwater runoff to these and potentially other MS4 holders:
  - City and County of Honolulu;
  - HDOT (through the "encroachment projects" process);
  - University of Hawai'i; and
  - Honolulu International Airport, if the airport alignment is selected.
- CWA Section 401 Water Quality Certification and 404 Department of Army permit, if a new outfall or other alterations to a water of the United States is required.
- A Drainage Injection Well permit, if stormwater is discharged to an injection well.

Best Management Practices

Temporary Construction BMPs

Temporary BMPs are instituted during construction activities and selected and approved during the NPDES NOI Form C permitting process. Overarching temporary BMPs typically include selecting a construction technique that limits ground disturbance, reducing the area of disturbance to the extent possible (e.g., preserving existing pavement, vegetation, and topography), and limiting the area being disturbed at any one time. Typical physical temporary BMPs stabilized construction area exits, berms to segregate disturbed areas and prevent off-site water from entering the construction site, storm drain inlet protection, and silt fences.

During construction, sedimentation and turbidity caused by sediments suspended in stormwater runoff would be mitigated by BMPs. Agency reviews included in the NPDES permit process will ensure the installation of proper sediment-control techniques. BMPs would likely include:

- Proper design and construction of access roads
- Planting of vegetation and/or mulching on highly erodible or critically eroding areas
- Use of inlet system sediment-control traps

- Installation of debris basins and silt fences
- Use of stilling basins to reduce the levels of sediments and other pollutants entering surface and coastal waters
- Construction of dikes or diversions to avoid runoff across erodible areas

As described in the *Honolulu High-Capacity Transit Corridor Project Hazardous Materials Technical Report* regarding mitigating the impacts of excavating hazardous materials, a variety of remediation techniques could be used to remove contaminants from stormwater. These include the use of oil/water separators, strippers, or other remediation techniques.

Permanent BMPs

Permanent BMPs are those left in place and maintained once construction is complete. Permanent BMPs can be divided into two categories: those that address stormwater quality and those that address stormwater quantity, but some address both. Types of permanent BMPs that primarily address water quality include soil stabilization measures, vegetated buffer strips and channels, slope drains, berms and velocity-control structures that convey runoff to stabilized areas and prevent erosion, oil-water separators, and proprietary hydrodynamic types of structures. Types of permanent BMPs that address both quantity and quality include infiltration facilities (trenches, basins, injection wells, and bioretention), stormwater wetlands (shallow, pocket) and detention ponds (wet or dry), and sand filters (surface, underground, or organic).

Mitigation to control stormwater quality and quantity would promote a natural, low-maintenance, sustainable approach where possible. An integral part of all permanent BMPs is an inspection and maintenance plan that ensures the BMPs are operating as designed. As part of the permitting process, other written plans will be prepared to establish good housekeeping practices and other practices that would help prevent stormwater pollution.

<u>Guideway and Stations</u>

The permanent BMPs employed by similar installations around the U.S. will be examined and considered for use in the Project.

The Project would work closely with MS4 permit holders to incorporate permanent BMPs to meet their requirements. In the more developed areas where open space and even underground space is at a premium or unavailable, permanent BMPs would address water quality more than quantity because there is little to no space to retain large volumes of stormwater. Permanent BMPs would more likely include items such as catch basin inserts, water quality inlets (inlets designed to remove settleable solids), oil/grit separators, or other hydrodynamic devices. These features would likely be installed at ground level (for easier maintenance), where stormwater is routed from the guideway but before it mingles with stormwater from other sources.

In less developed areas, more options are available. However, given the small pollutant load the guideway would generate, permanent BMPs would likely retain some of the BMPs listed above and include items such as vegetated swales (instead of the underground conduits used in more developed areas). If a particular area needs stormwater quantity controls, the Project could implement such items as small detention ponds or sand filters. However, runoff from the guideway would be small compared to surrounding developments, so it is unlikely that stormwater retention would be used, except perhaps at a station site where runoff would be greater due to the roofed area.

Park-and-Ride Lots

The Project would work closely with MS4 permit holders to incorporate permanent BMPs to meet their requirements. Permanent BMPs that may be used include vegetated buffers and swales, hydrodynamic devices to intercept trash and debris, oil/grit separators, infiltration trenches, and injection wells.

Maintenance and Storage Facility

The vehicle maintenance and storage facility would be the most industrial facility within the fixed guideway system. Therefore, it would likely receive the greatest stormwater quality control. Likely BMPs include vegetated swales, berms, and infiltration trenches to route on-site stormwater to an infiltration basin and prevent off-site stormwater from entering the site. Oil/water separators may be used in specific areas where maintenance is routinely performed or where fueling and washing activities occur.

6.2 Groundwater

Pile driving would require excavation for the pile cap. It may be necessary to support the excavation with sheet piling in high congestion areas, to limit the construction area. Dewatering may be required where groundwater is at levels above the base of the pile caps. To mitigate the potential impacts of subsidence induced by a sophisticated dewatering system, a structural survey of buildings, roadways, and other facilities adjacent to the site may be required prior to construction. During construction, a monitoring program would include such techniques as inclinometers (to measure the relative lateral movement of soil at different elevations), settlement points, and observation wells to study groundwater drawdown. Monitoring data would be reviewed immediately to ensure minimal disturbance to existing facilities. In areas where artesian water is used, pumping the groundwater should not impact water flow. Measures such as recharging the groundwater outside the excavation area could be used to help minimize the effects of dewatering.

In areas of loose sands or soft clays, casings or drilling fluids such as a polymer slurry may be necessary to maintain the integrity of the drilled hole during construction. If drilling fluids are used, the quantity of spoils generated that require disposal would increase. Construction-derived wastes (e.g., soil and liquids) would be managed in accordance with prevailing regulations. Uncontrolled releases would not be allowed. Slurry would be recycled through a de-sander and reused. Water would be collected and treated as needed prior to disposal or reuse.

During construction, any water discharged into the drainage system and surface-water bodies would require an NPDES Dewatering Permit. The discharge must meet water quality standards. The water would need to be filtered or allowed to settle in order to remove sediment before discharge. A filtering system using filter fabric and clean gravel could be used around the pump to prevent migration of fine soil material into the pumped-out water. This should ensure that only clean water is pumped out of the excavation. Should there be sediment remaining in the pumped water, the discharge could be processed through a settling basin and/or a secondary filtering system. A monitoring program would ensure compliance with water quality standards.

Groundwater could also be contaminated with petroleum products. These petroleum contaminants would be removed from water pumped from the excavations in accordance with standards established by the HDOH. Petroleum products might require the use of oil/water separators, strippers, or other remediation techniques. Additional studies would be required during the final design phase to determine the precise methods to be employed. The movement of contaminants between the surface layers and the aquifer would be prevented by casing the hole at varying intervals, changing drilling fluids, or other techniques.

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Appendix A:
U.S. Department of Transportation Order 5650.2, "Floodplain Management and Protection," April 23, 1979

Department of Transportation
Office of the Secretary
Washington, D.C.

ORDER

DOT 5650.2

4-23-79

SUBJECT: FLOODPLAIN MANAGEMENT AND PROTECTION

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1. PURPOSE. This Order prescribes policies and procedures for ensuring that proper consideration is given to the avoidance and mitigation of adverse floodplain impacts in agency actions, planning programs, and budget requests.

2. AUTHORITY. This Order is issued pursuant to the following statutes and executive order:

   a. The National Environmental Policy Act of 1969 (NEPA) (P.L. 91-190) establishes a national policy to, among other things, "...promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man...." NEPA requires preparation of an environmental impact statement (EIS) for any major Federal action significantly affecting the quality of the human environment. DOT 5610.1B, Procedures for Considering Environmental Impacts, of 9-30-74, Attachment 2, paragraph 11, requires that information on flood hazards, if relevant, be included in the EIS.

   b. The National Flood Insurance Act of 1968, Title XIII of the Housing and Urban Development Act of 1968 (P.L. 90-448, 8-1-68), provides previously unavailable flood insurance protection to property owners in flood-prone areas. Section 1302(c) of the Act stipulates that "the objectives of a flood insurance program should be integrally related to a unified national program for flood plain management...."

   c. Executive Order 11988 - Floodplain Management, promulgated on 5-24-77, links the need to protect lives and property with the need to restore and preserve natural and beneficial floodplain values. Federal agencies are directed to avoid conducting, allowing, or supporting

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actions on the base floodplain unless the agency finds that the base floodplain is the only practicable alternative location, and to issue procedures for implementing the requirements of the Executive Order.

d. The Flood Disaster Protection Act of 1973 (P.L. 93-234, 87 Stat. 975) requires the purchase of flood insurance as a condition of receiving any form of federal or federally-related financial assistance for acquisition or construction purposes with respect to insurable buildings and mobile homes within an identified special flood, mudslide, or flood-related erosion hazard area.

3. POLICY. It is the policy of the Department of Transportation (DOT) (1) to encourage a broad and unified effort to prevent uneconomic, hazardous, or incompatible use and development of the Nation's floodplains, (2) to avoid, where practicable, encroachments by Departmental actions, (3) to minimize the adverse impacts which such actions may have on base floodplains, including direct or indirect support for development, and (4) to restore and preserve natural and beneficial floodplain values that are adversely affected by such actions.

4. DEFINITIONS.

a. Action - the construction or reconstruction of a federal or federally-financed, licensed, or approved transportation improvement (including any relocation housing built or moved to a new site); and the acquisition, management, or disposition of Departmental lands and facilities.

b. Base Flood - that flood having a one percent chance of being exceeded in any given year (commonly known as a 100-year flood).

c. Base Floodplain - the area which would be inundated by a base flood.

d. Encroachment - an action within the limits of the base floodplain.

e. Environmental Impact Statement - the detailed statement mandated by section 102(2)(C) of the National Environmental Policy Act of 1969 (ref: DOT 5610.1B).

f. Facility - any element of the built environment other than a walled or roofed building.

f. Flood or Flooding - a general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of inland and/or tidal waters, and/or the unusual and rapid accumulation or runoff of surface waters from any source.

g. Flood of Record - the largest historical flood event which has been reliably determined and recorded.

h. Floodplain - the lowland areas adjoining inland and coastal waters which are periodically inundated by flood waters, including flood-prone areas of offshore islands.

i. Floodproofing - the incorporation of design features in, or modifications to, individual structures and facilities, their sites and their contents to protect against structural failure, to keep water out, or to reduce effects of water entry, so that threats to human life and property are reduced.

j. Minimize - to reduce to the smallest practicable amount or degree.

k. Natural and Beneficial Floodplain Values - include but are not limited to: natural moderation of floods, water quality maintenance, groundwater recharge, fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, and forestry.

l. Negative Declaration - a determination by the responsible official that a particular action does not significantly affect the quality of the human environment.

m. Practicable - capable of being done within natural, social, and economic constraints.

n. Restore - to establish a setting or environment in which the natural and beneficial values impacted by the transportation agency action can again operate. In some situations, a transportation improvement may represent a positive enhancement or negligible use of natural and beneficial floodplain values.

o. Risk - the adverse consequences associated with the probability of flooding attributable to an encroachment, specifically including the potential for property loss and the hazard to life.

p. Significant Encroachment - an encroachment resulting in one or more of the following construction or flood-related impacts:

(1) a considerable probability of loss of human life;

(2) likely future damage associated with the encroachment that could be substantial in cost or extent, including interruption of service on or loss of a vital transportation facility; and

(3) a notable adverse impact on "natural and beneficial floodplain values", as defined in item k, above.

It is not contemplated that detailed design would be necessary in order to determine whether there is a significant encroachment.

q. Support Base Floodplain Development - to encourage, allow, serve, or otherwise facilitate additional development in a base floodplain. Direct support results from an action on the base floodplain. Indirect support results from actions out of the base floodplain.

5. APPLICATION.

a. Paragraph 3 of this Order applies to all actions affecting base floodplains. The other provisions apply, except as indicated in subparagraphs b and c below.

b. The provisions of this Order do not apply to or alter decisions, approvals, or authorizations which were given by the Department or its elements pursuant to directives in effect before the date of this Order's publication in the Federal Register, nor do they apply to transportation projects where:

(1) the final EIS is filed with the Environmental Protection Agency within 12 months after the date of this Order's publication in the Federal Register; or any public hearings have been held and a negative declaration has been approved, within 120 days after that publication date; or

(2) the only step being taken in the floodplain is the relocation of persons into existing housing units, except that potential occupants shall be advised at the appropriate stage if the relocation housing is located in a base floodplain and be offered alternative comparable housing at their option.

c. DOT elements may develop categories of projects which are not subject to the requirements of this Order due to their negligible potential, alone or cumulatively, for resulting in adverse impacts associated with the occupancy or modification of floodplains, or the direct or indirect support of floodplain development.

6. <u>FLOODPLAIN IDENTIFICATION</u>. Base floodplain limits shall be determined and encroachments delineated for reasonable alternative actions through the following sources:

a. Federal Insurance Administration (FIA) maps shall be used as the primary reference for establishing base floodplain limits (obtain maps from the U.S. Department of Housing and Urban Development sources listed in 43 FR 6050).

(1) A Flood Insurance Rate Map (FIRM) or Flood Insurance Study Report (FIS) shall be consulted first.

(2) If a FIRM or FIS is not available, a Flood Hazard Boundary Map (FHBM) may be available from the same sources. These approximate maps shall be used to determine if the alternatives under consideration are clearly out of the floodplain. If one or more of the alternatives appears to be near or inside the indicated base floodplain boundary, more detailed information on the floodplain boundary shall be developed or obtained.

b. If a FIRM, FIS, or floodplain delineation from other agency sources as listed in 43 FR 6049-51 is not available and current, or if the site is near or inside the FHBM boundaries, base floodplain limits shall be established by the best available method meeting acceptable professional engineering standards.

c. The delineation of floodplain limits shall take proper account of previous alterations to the floodplain by flood retention works or other elements of the built environment.

7. PUBLIC INVOLVEMENT. Where any of the alternatives identified for accomplishing an action are proposed in the base floodplain, opportunity shall be provided for early public review and comment. The following steps shall be made a part of existing review procedures (including the EIS review process) as appropriate to the nature of the encroachment.

a. Public hearing presentations shall include identification of encroachments.

b. If one or more alternatives under consideration include significant encroachments, any public notices, public hearing notices, notices offering an opportunity for a hearing, and notices of availability for negative declarations shall make reference to that fact.

8. ENVIRONMENTAL REVIEW PROCESS. Whenever appropriate, the procedures established in DOT 5610.1B, Procedures for Considering Environmental Impacts, of 9-30-74, shall be the vehicle through which implementation of this policy is documented.

a. Draft environmental review documents (draft EISs[1/] and any preliminary versions of negative declarations) shall cover the items below for all alternatives involving encroachments:

(1) any risk to, or resulting from, the transportation action;

(2) the impacts on natural and beneficial floodplain values; and

(3) the degree to which the action provides direct or indirect support for development in the base floodplain.

b. Draft environmental review documents shall also include sufficient discussion to permit an initial review of the adequacy of methods proposed to minimize harm, and, where practicable, to restore and preserve the natural and beneficial floodplain values affected.[2/] In most cases, conceptual design (as opposed to detailed engineering studies) should be sufficient to help establish the adequacy of mitigation measures. Commitments to later compliance with special flood-related design criteria or the imposition, in advance, of protective conditions may be warranted in some situations.

c. Final environmental review documents (final EISs and final versions of negative declarations) reflecting a decision on the preferred alternative shall clearly identify the floodplain concerns and impacts associated with that alternative and cover the items listed in subparagraphs a and b above.

1/ DOT elements shall follow a rule of reason in determining how much floodplain information needs to be incorporated in draft EISs circulated during a six-month period after the date of the Order's publication in the Federal Register.

2/ Guidance and examples regarding methods for minimizing harm to floodplains and for restoring and preserving the natural and beneficial floodplain values affected can be found in 43 FR 6047-48.

9. ONLY PRACTICABLE ALTERNATIVE FINDING. Where it is proposed to conduct, support, or allow an action involving a significant encroachment, the final EIS or final version of the negative declaration shall reflect consideration of alternatives to avoid such encroachment, and to reduce its adverse base floodplain impacts.

a. A preferred alternative involving a significant encroachment shall not be approved unless the responsible official can make a finding, in writing, that the proposed significant encroachment is the only practicable alternative, together with:

(1) A description of why the proposed action must be located in the floodplain, including the alternatives considered and why they were not practicable.

(2) A statement indicating that the action conforms to applicable State and/or local floodplain protection standards.

b. The finding shall be incorporated into, or attached to, the final environmental review document.

c. On occasion, a proposal for which an environmental review document is unnecessary may nevertheless have the potential for causing a significant encroachment. Under such circumstances, the above written finding shall still be made and included with the project records.

d. The above written finding, within or together with any final EIS prepared for the proposed action, shall be provided to State and areawide clearinghouses and other interested parties.

e. A determination that a given action outside of a floodplain is or is not practicable requires a careful balancing and application of individual judgment. While such balancing should include the full range of environmental, social, economic, and engineering considerations, special weight should be given to floodplain management concerns.

10. PROGRAM DIRECTIVES

a. DOT elements which have programs potentially affecting base floodplains shall include adequate provision consistent with this Order for the evaluation and consideration of flood hazards and measures to avoid or minimize floodplain impacts. As appropriate, modifications shall be made to regulations and operating procedures for licenses, permits, and loan or grant-in-aid programs to accomplish this purpose. These changes should be submitted to the Assistant Secretary for Policy and International Affairs for review within 120 days after the date of this Order's publication in the Federal Register.

b. Each DOT element shall have the option of applying this Order directly to its programs and activities within 120 days of its date of publication in the Federal Register or of issuing its own floodplain regulations or procedures, consistent with this Order. Such regulations or procedures shall be submitted within the same 120-day period, to the Assistant Secretary for Policy and International Affairs for concurrence.

c. DOT elements may elect to develop project-related engineering design standards reflecting flood hazard and floodplain considerations, for their individual programs.

11. BUDGET REQUESTS. Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if a specific proposal will involve significant encroachment upon a floodplain, that the proposed action is in accord with Executive Order 11988.

12. FEDERAL REAL PROPERTY AND FACILITIES. Departmental elements with responsibilities for Federal real property and facilities shall take the following measures, in addition to those specified in the other sections of this Order.

a. The construction of walled or roofed buildings or other facilities shall be consistent with the intent of the standards and criteria promulgated under the National Flood Insurance Program, and shall deviate only to the extent that the standards of the Flood Insurance Program are demonstrably inappropriate for the given case.

b. If, after compliance with the requirements of this Order, new or rehabilitated buildings are to be located in a floodplain, accepted floodproofing and other flood protection measures shall be applied. To achieve flood protection, DOT elements shall elevate the buildings above the base flood level, wherever practicable, rather than filling in land.

c. If property used by the general public has suffered flood damage or is located in an identified flood hazard area, the responsible DOT element shall provide on buildings or other places, where appropriate, conspicuous delineation of the level of the base flood and flood of record (if larger), in order to enhance public awareness of flood hazards.

d. When property in floodplains is proposed for lease, easement, right-of-way, or disposal to nonfederal parties, the responsible DOT element shall indicate if a flood hazard exists and (1) identify in the conveyance those uses that are restricted under Federal, State, or local floodplain regulations; and (2) attach other restrictions consistent with this Order to the uses of properties by the grantee or purchaser and any successors, except as prohibited by law; or (3) withhold such properties from conveyance.

13. <u>RESPONSIBILITIES</u>.

a. The Assistant Secretary for Administration and Heads of Operating Administrations shall assure that the requirements of this Order are met and that appropriate steps are taken to implement it.

b. The Assistant Secretary for Policy and International Affairs shall oversee the implementation of the policy set forth in paragraph 3, review and concur in any floodplain procedures of the operating administrations, and recommend any modifications of procedures that may be appropriate. The Assistant Secretary shall consult periodically with the Council on Environmental Quality, the Water Resources Council, and FIA to evaluate the Department's implementation of these policies and shall be responsible for the preparation of any required reports on floodplain management, including such monitoring of the floodplain evaluation process as may be appropriate.

14. UNIFIED NATIONAL PROGRAM FOR FLOODPLAIN MANAGEMENT. This Order incorporates by reference "A Unified National Program for Flood Plain Management," a report to the Congress by the Water Resources Council, July 1976 (available from the U.S. Government Printing Office, Documents Department, Washington, D.C. 20402, Order Number GPO 052-045-00047, price $1.95), and future revisions.

15. FLOOD DISASTER PROTECTION ACT. The Flood Disaster Protection Act contains certain provisions which can affect DOT programs. Basically, the Act mandates the purchase of flood insurance as a condition of receiving Federal assistance for the construction or repair of buildings located in areas having special flood hazards as identified by FIA. The requirement also applies when Federal assistance is being used to purchase equipment which will be housed in buildings which are located in such special flood hazard areas. Flood-prone communities may arrange for flood insurance through FIA's National Flood Insurance Program. DOT elements shall take steps to assure full compliance with this requirement (set forth in section 202(a) of the Act), where applicable.

16. EMERGENCY PROVISIONS. Nothing in this Order shall prevent the timely provision of assistance or funds for emergency repairs essential to save lives and to protect property and public health and safety. However, a reasonable effort to comply with the Order shall be made during and/or after the emergency period.

FOR THE SECRETARY OF TRANSPORTATION:

Alan Butchman
Deputy Secretary

Appendix B:
Draft Groundwater Impact Assessment

Draft Ground Water Impact Assessment
Honolulu High-Capacity Transit Corridor Project

July 1, 2008

Prepared for:
City and County of Honolulu

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Acronyms and Abbreviations Used in this Document

bgs	below ground surface
BMP	Best Management Practices
CFR	Code of Federal Regulations
CWA	Clean Water Act
DTS	City and County of Honolulu Department of Transportation Services
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FTA	Federal Transit Administration
HDOH	Hawai‘i Department of Health
HDOT	Hawai‘i Department of Transportation
MLS	Mean Sea Level
MS4	Municipal Separate Storm Sewer Systems
NEPA	National Environmental Policy Act
NPDES	National Pollution Discharge Elimination System
SOBA	Southern O‘ahu Basal Aquifer
UH	University of Hawai‘i
UIC	Underground Injection Control

Summary

The City and County of Honolulu Department of Transportation Services (DTS), in coordination with the U.S. Department of Transportation Federal Transit Administration (FTA), is preparing a Draft Environmental Impact Statement (Draft EIS) to evaluate alternatives that would provide high-capacity transit service on O‘ahu. The study area is the travel corridor between Kapolei and the University of Hawai‘i (UH) at Mānoa.

The Honolulu High-Capacity Transit Corridor Project (the Project)'s Build Alternatives include construction and operation of a grade-separated fixed guideway transit system between East Kapolei and Ala Moana Center. Planned extensions are anticipated to West Kapolei, UH Mānoa, and Waikīkī. The system could use any of a range of fixed guideway transit technologies that meet performance requirements. The guideway and stations would be aerial structures throughout the system.

Light rail transit, rapid rail transit, maglev (magnetic levitation), rubber-tired guided vehicles, and monorail technologies were considered for the fixed guideway system. The system's four main components common to all the technologies considered include foundations, piers (support columns), superstructure (the elevated guideway structure), and stations. The distance between piers varies for each technology and would also depend on the guideway configuration. Typical pier spacing would be 150 feet, with shorter or longer spans used where needed.

Foundations for the various system components would be dictated by structural demands, utilities, existing subsurface conditions, and other construction requirements. Two general foundation construction methods would be used to support the aerial guideway structure: single drilled shafts that would be integral with columns, and driven piles that would require pile caps for connection to columns. Drilled shafts would be used for most of the alignment because they can be installed faster. With this method, a smaller area of soil would be disturbed and it is quieter than with driven piles. The drilled shafts would generally be 6 to 10 feet in diameter. The depth of the shaft depends on local soil conditions, and would likely range between 50 and 150 feet below ground surface, averaging around 85 feet. Generally, a column foundation can be completed in one week.

The Island of O‘ahu was built by the extrusion of basaltic lavas from two shield volcanoes, Wai‘anae and Ko‘olau. The study corridor is located along the southern flank of the volcanoes, and this area's geomorphology and subsurface are directly related to glacial-eustatic fluctuations of sea level. Overlying the basalt basement are layers of coral reef, lagoonal muds, and alluvium along with later-stage volcanics and pyroclastics.

The Southern O‘ahu Basal Aquifer (SOBA) is a freshwater lens that floats on saline ground water over most of southern O‘ahu. In accordance with the 1984 *Sole Source Aquifer Memorandum of Understanding* between the U.S. Environmental Protection Agency (EPA) and the Federal Highway Administration, this Ground

Water Impact Assessment is being prepared to meet the coordination requirements of Section 1424(e) of the Safe Drinking Water Act. The Project should have no significant impacts on groundwater, either during long-term operation of the system or during its construction.

Drinking water is obtained from the SOBA by wells that penetrate into the basalt. Shallow wells penetrating into the caprock also obtain groundwater, but this water is not potable and is only used for irrigation and industrial purposes.

The deep foundations needed to support the guideway could potentially provide a conduit for pollutants to enter the SOBA. However for several reasons, evidence has demonstrated that project construction would not contaminate the SOBA.

The first reason is that most of the piers would only penetrate the surficial materials or caprock overlying the basalt aquifer. In places where piles or shafts would extend into the basalt, the penetration would be only a few tens of feet at most. The exact depths of penetration are predicated on meeting foundation axial and lateral load demands, and will not be determined until construction.

In places where shafts or piles would extend into the basalt and there are concerns about surficial contamination (e.g., petroleum products floating on groundwater or pesticides in the soil), the contaminated interval can be cased, drilling muds can be changed, and other methods used to prevent cross contamination. Inert, non-polluting drilling muds or plain water can be used when drilling in basalt. Construction-derived wastes (e.g., soil and liquids) would be managed in accordance with prevailing regulations. Uncontrolled releases would not be allowed. No contaminated soils would be disposed of in the Sole Source Aquifer area.

The second reason the Project should not contaminate the SOBA is that the shafts would only stay open long enough to set the rebar and pour the concrete. This short time interval would minimize the chance of pollutants entering directly through the open pathway. Once the shaft is filled with concrete, there would no longer be an open pathway for surficial contaminants to travel down the side of the shaft, because the flowable concrete used for shaft construction would seal against the ground.

A third reason the Project should not contaminate the SOBA is that the project alignment would typically be downgradient of the drinking water wells on O‘ahu, and the overall groundwater flow direction is seaward. Upward hydraulic pressure caused by caprock along portions of the alignment would keep groundwater from entering the SOBA. Drinking water wells draw from a depth of several hundreds of feet below ground surface. All wells makai of the alignment are either inactive or used for irrigation. The wells drawing from near-surface groundwater in the caprock are for irrigation or industrial use and not potable.

Furthermore, much of the proposed alignment would be located makai of the Underground Injection Control (UIC) line (the boundary between non-drinking water aquifers and underground sources of drinking water). This is an indication that the Hawai‘i Department of Health (HDOH) Safe Drinking Water Branch has determined that the underlying aquifer is not a source of drinking water.

During construction, water quality at the construction site would be regulated by a National Pollution Discharge Elimination System (NPDES) construction stormwater permit, and if necessary by an NPDES dewatering permit. These permits dictate the handling of hazardous material, fueling products, and other potential groundwater contaminates.

Once in operation, the Project would increase impermeable surfaces and therefore redirect runoff. However, much of the area is urban and already paved. Stormwater runoff from the fixed guideway and associated parking areas and transit stations would enter the groundwater system along different paths than previously (i.e., as the water runs off the guideway into the permanent BMPs or the stormwater system).

No long-term changes to groundwater levels, including any artesian conditions, would result from the fixed guideway system. Runoff from the guideway itself should be relatively free of pollutants and should not threaten ground water quality. Stormwater from parking lots may contain oil, grease, and other pollutants associated with automobiles. However, these pollutants must be removed prior to discharge into the existing stormwater system or infiltration into the ground water. The installation of permanent BMPs would direct runoff back into the existing stormwater system or into the ground to recharge the ground water system. The sites being considered for a vehicle maintenance and storage facility are both located mauka of the UIC line, and the facility would be designed to prevent pollutants from reaching the ground water.

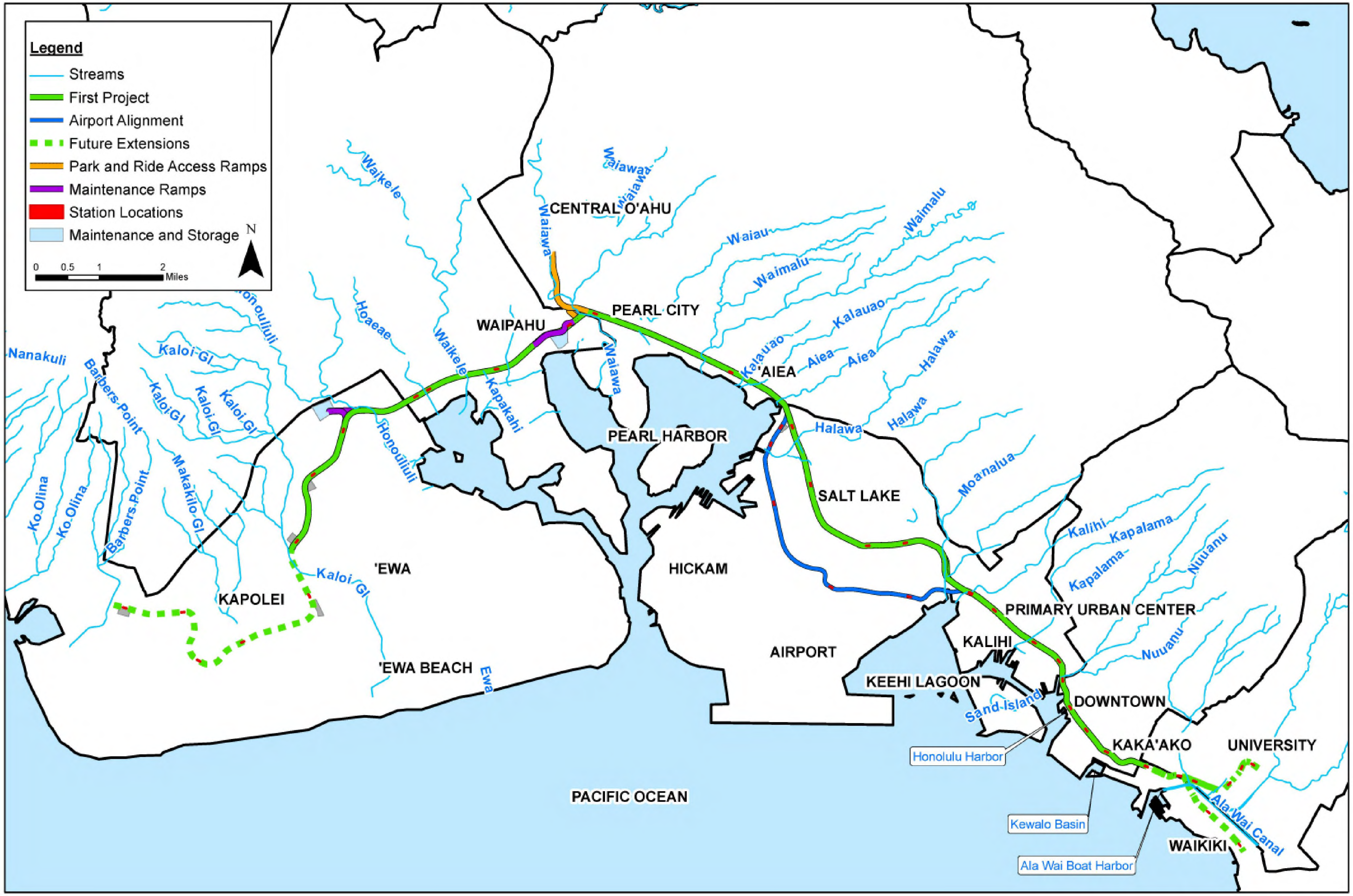


Figure S-1: Streams in the Study Corridor

AR00037509

1 Project Description

1.1 Alternatives Evaluated

The City and County of Honolulu Department of Transportation Services (DTS), in cooperation with the U.S. Department of Transportation Federal Transit Administration (FTA), is evaluating fixed guideway alternatives that would provide high-capacity transit service on O‘ahu. The study area is the travel corridor between Kapolei and the University of Hawai‘i at Mānoa (UH Mānoa) (Figure 1-1). The east-west length of the corridor is approximately 23 miles. The north-south width is, at most, 4 miles because the Ko’olau and Wai’anae Mountain Ranges bound much of the corridor to the north and the Pacific Ocean to the south.

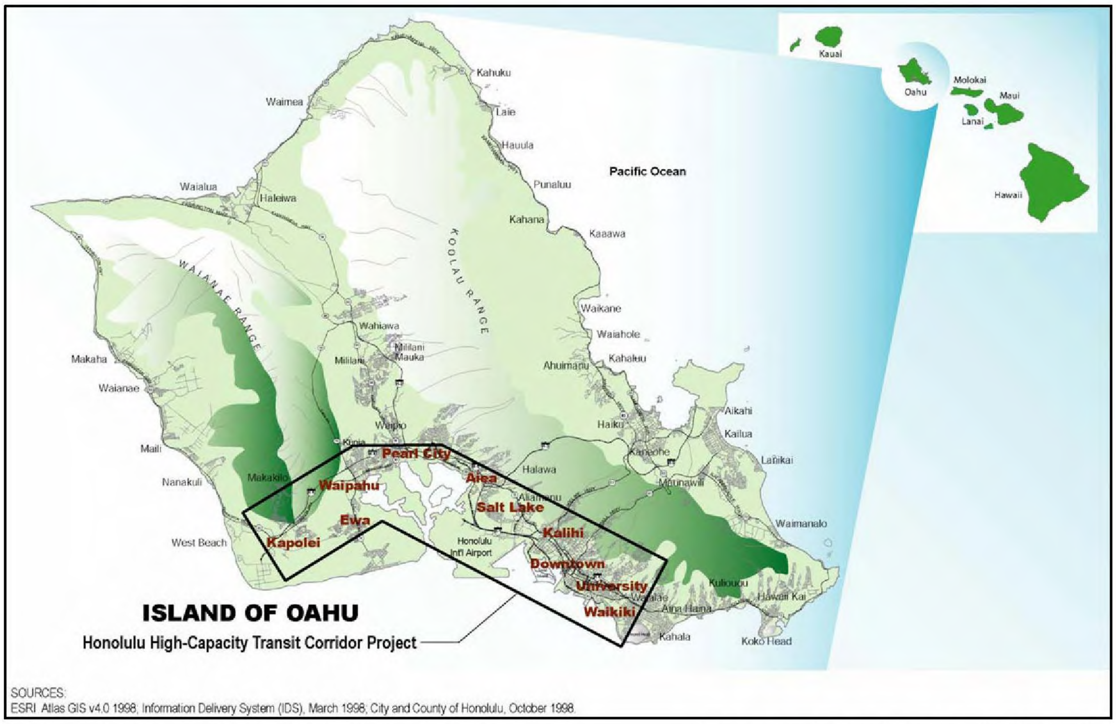


Figure 1-1: Project Vicinity

The Honolulu High-Capacity Transit Corridor Project (the Project) would extend from Kapolei in the west (Wai‘anae or ‘Ewa direction) to UH Mānoa in the east (Koko Head direction). It is confined by the Wai‘anae and Ko‘olau Mountain Ranges in the mauka direction (toward the mountains, generally to the north within the study corridor) and the Pacific Ocean in the makai direction (toward the sea, generally to the south within the study corridor).

Four alternatives will be evaluated in the Environmental Impact Statement (EIS):

1. No Build Alternative
2. Fixed Guideway Transit Alternative via Salt Lake Boulevard (Salt Lake Alternative)

3. Fixed Guideway Transit Alternative via the Airport (Airport Alternative)
4. Fixed Guideway Transit Alternative via the Airport and Salt Lake (Airport & Salt Lake Alternative)

The fixed guideway alternatives would include the construction and operation of a grade-separated fixed guideway transit system between East Kapolei and Ala Moana Center. Planned extensions are anticipated to West Kapolei, UH Mānoa, and Waikīkī (Figure 1-2 to Figure 1-5). Steel-wheel-on-steel-rail transit technology was selected through a comparative process, based on each technology's ability to cost-effectively meet project requirements. Among the technologies considered were light rail transit, rapid rail transit, maglev (magnetic levitation), rubber-tired guided vehicles, and monorail.

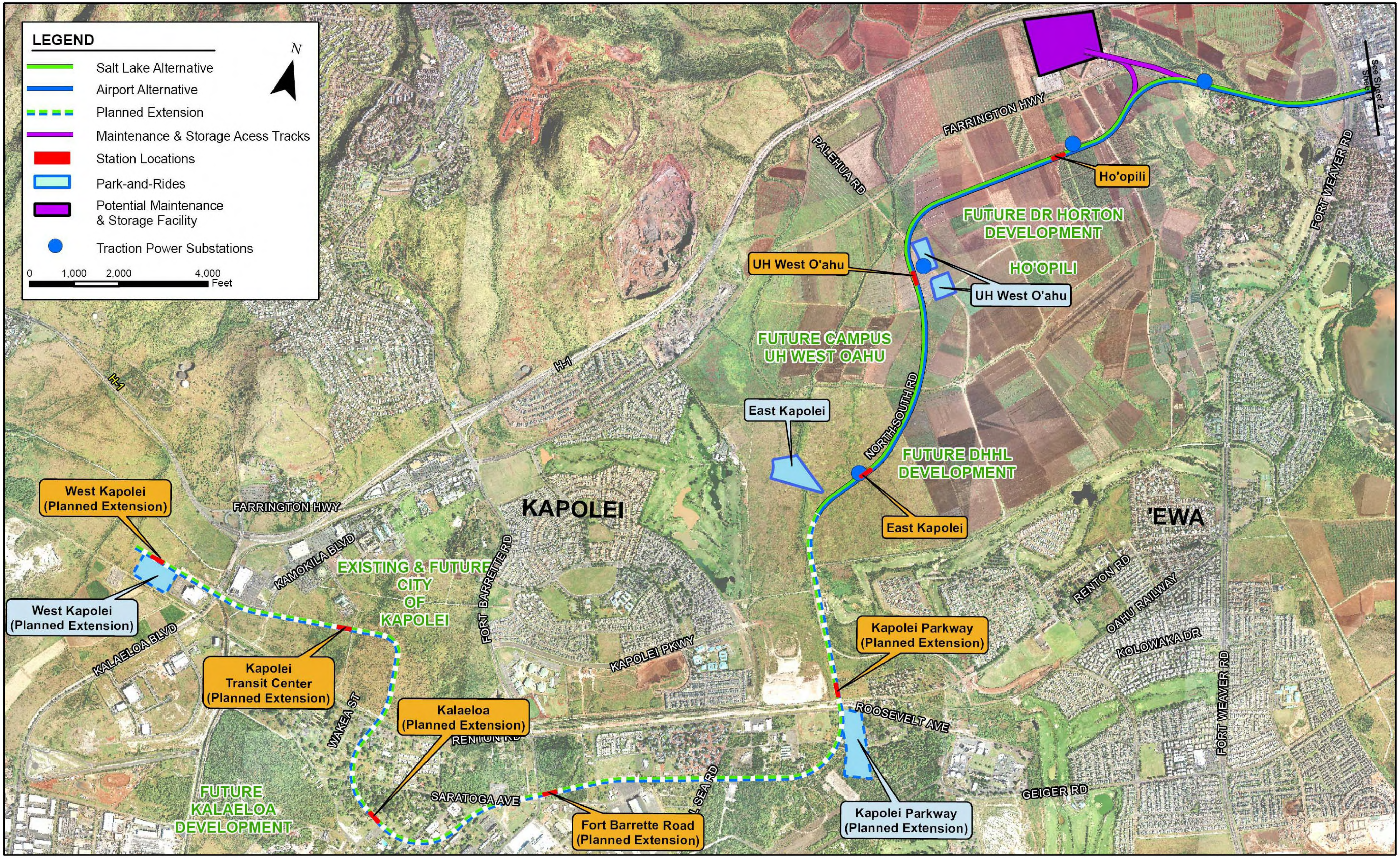


Figure 1-2: Fixed Guideway Transit Alternative Features (Kapolei to Fort Weaver Road)

Figure 1-3: Fixed Guideway Transit Alternative Features (Fort Weaver Road to Aloha Stadium)

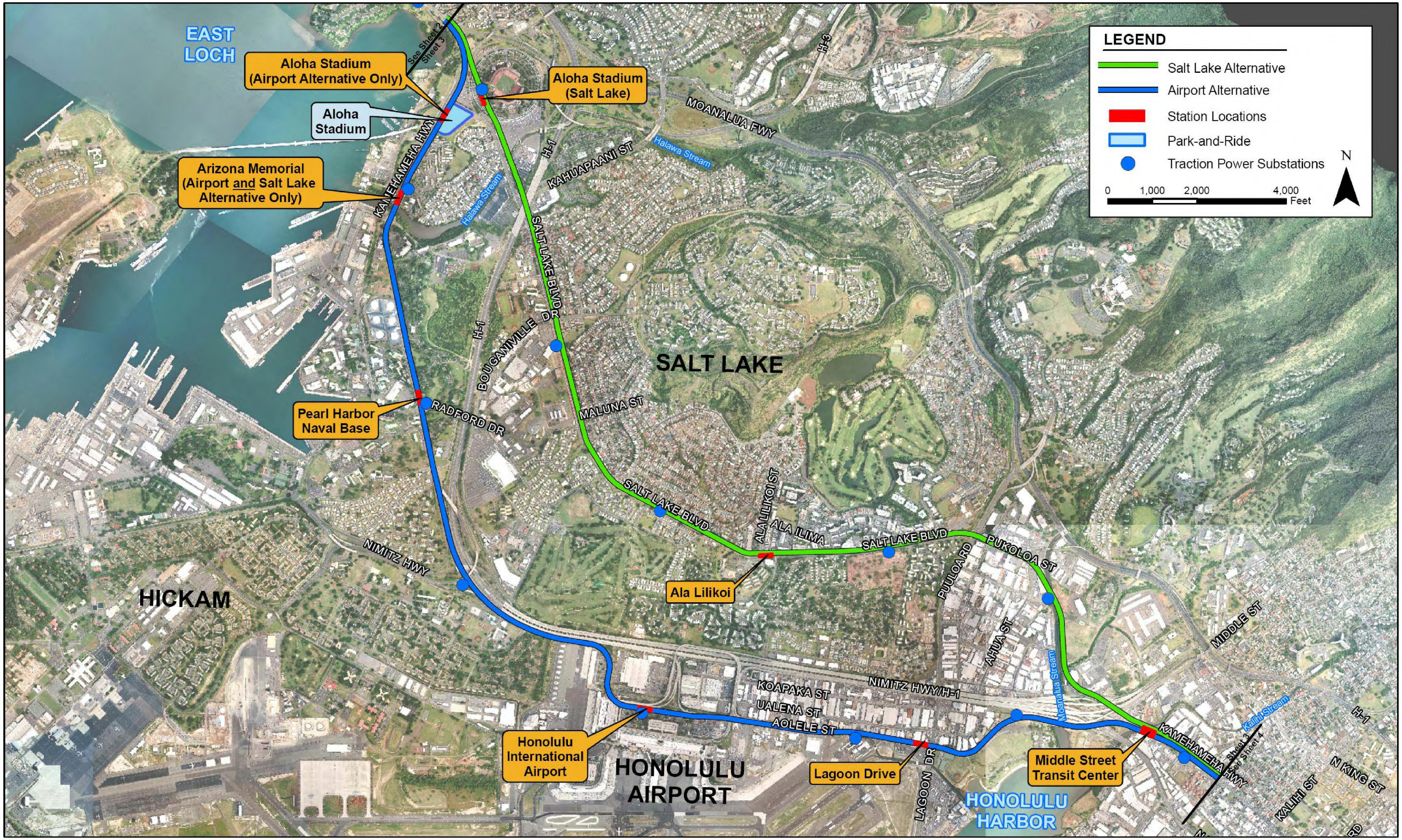


Figure 1-4: Fixed Guideway Transit Alternative Features (Aloha Stadium to Kalihi)

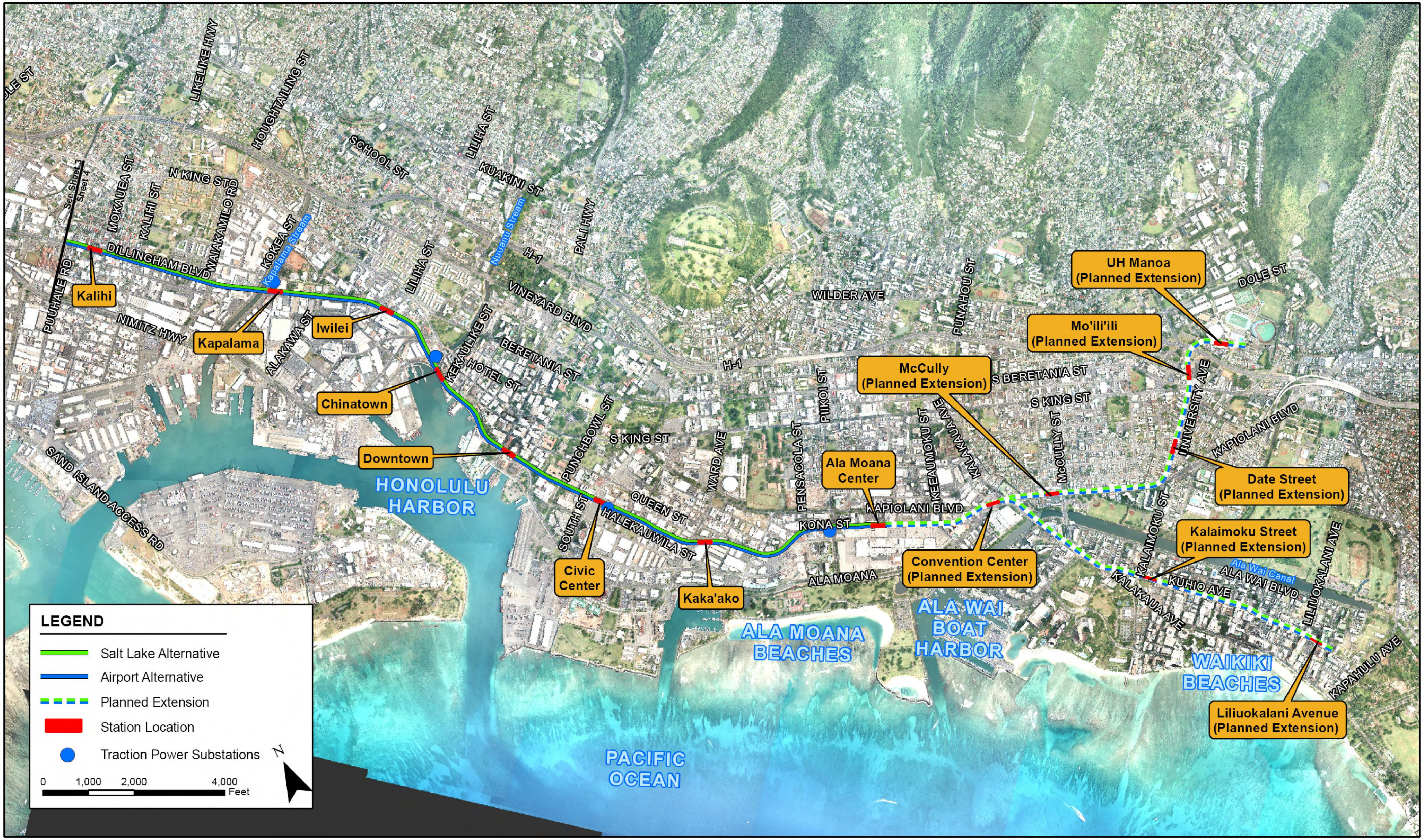


Figure 1-5: Fixed Guideway Transit Alternative Features (Kalihi to UH Mānoa)

1.2 Features Common to All Build Alternatives

In addition to the guideway, the Project would require construction of stations and supporting facilities. Supporting facilities would include a vehicle maintenance and storage facility, transit centers, park-and-ride lots, and traction power substations.

1.2.1 Station Characteristics

All fixed guideway stations would be elevated and would have similar design elements, including platforms that are between 270 and 300 feet long and a minimum of 10 feet wide.

1.2.2 Park-and-Ride Lots

Park-and-ride lots would be constructed at several stations to provide commuters an option of driving to the fixed guideway transit system. With the exception of Pearl Highlands which would be a garage, all park-and-ride lots are expected to be constructed as surface parking.

1.2.3 Vehicle Maintenance and Storage Facility

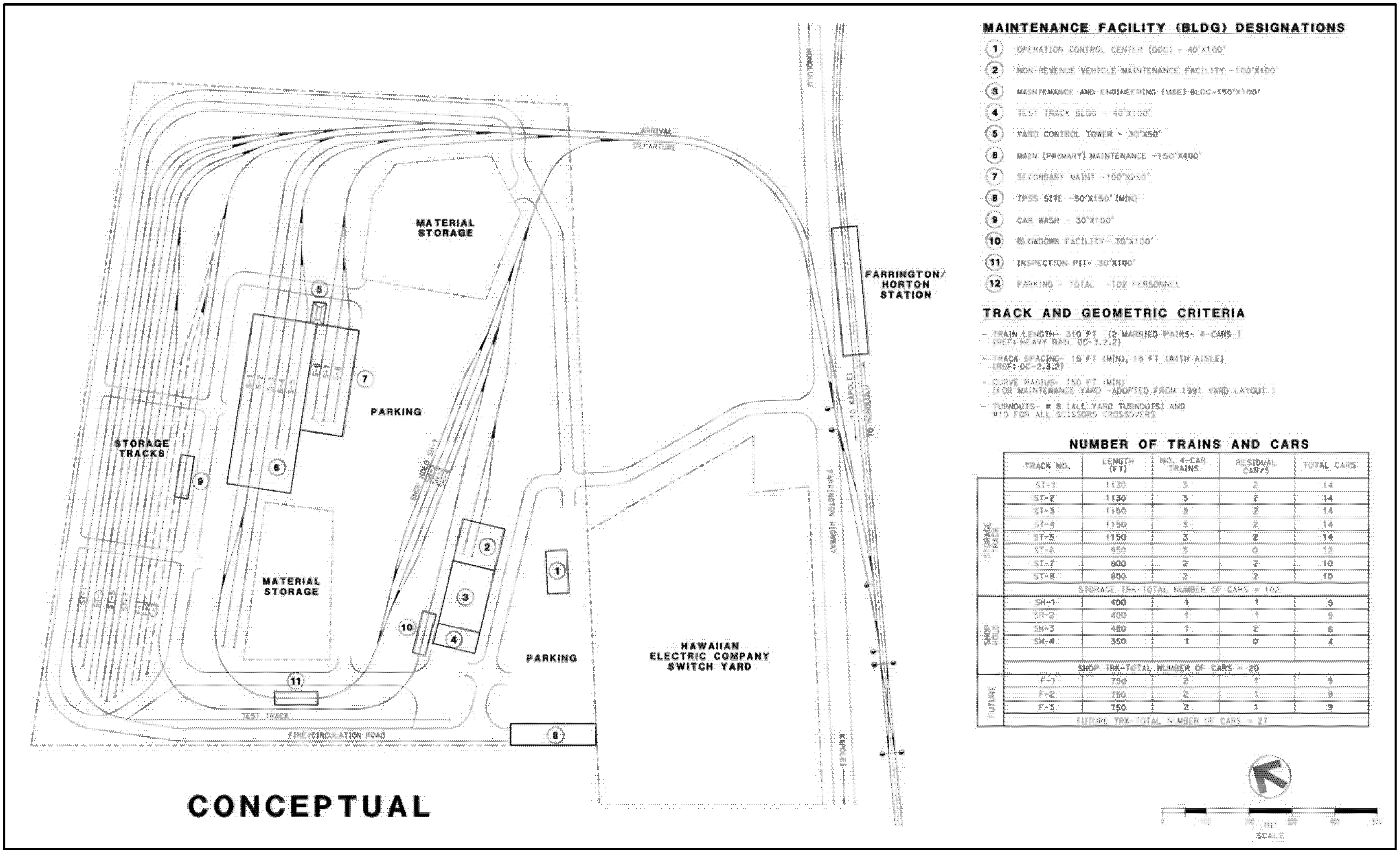
The Project would include a vehicle maintenance and storage facility to maintain and store up to 100 system vehicles. Two locations are being considered for this facility: an area currently in agricultural use at Ho'opili (Figure 1-6) and a vacant site near Leeward Community College (Figure 1-7). Only one maintenance and storage facility site would be selected. Either site would include a number of buildings, maintenance facilities, a vehicle wash area, storage tracks, and employee parking.

1.2.4 Traction Power Substations

The Project would require traction power substations approximately every mile along the alignment to provide vehicle propulsion and auxiliary power. The planned locations are shown in Figure 1-2 to Figure 1-5. Each substation would be approximately 50 feet long, 30 feet wide, and 10 feet high. Substations would include transformers, rectifiers, batteries, and ventilation equipment and would be connected to the existing power grid.

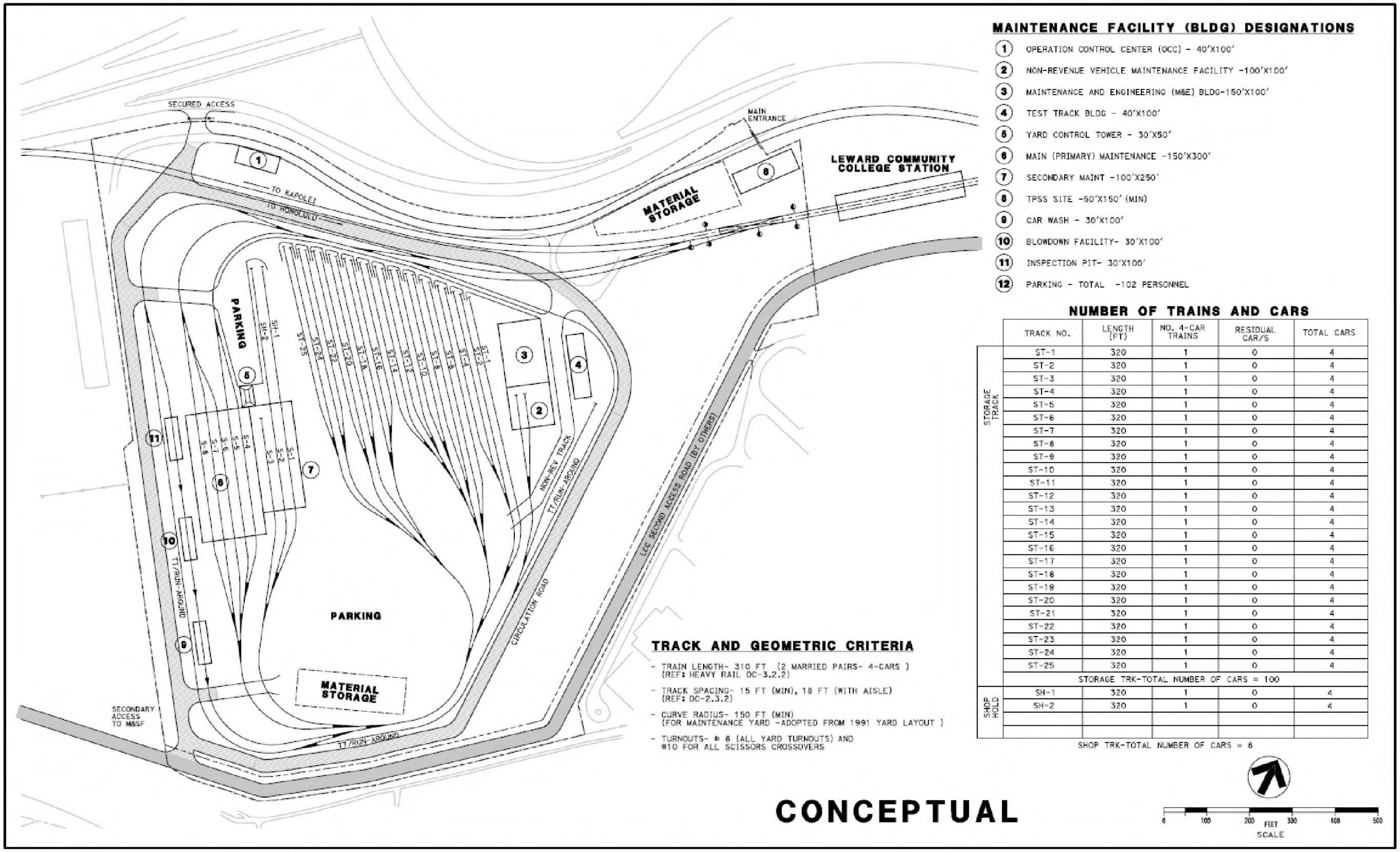
1.3 Transit Technologies

The Project would use steel-wheel on steel-rail transit technology. This choice of technology was made after consideration of light rail transit (LRT), rapid rail transit, maglev (magnetic levitation), rubber-tired guided vehicles, and monorail.



	TRACK NO.	LENGTH (FT)	NO. 4-CAR TRAINS	RESIDUAL CARS	TOTAL CARS
STORAGE TRACK	ST-1	1130	3	2	14
	ST-2	1130	3	2	14
	ST-3	1150	3	2	14
	ST-4	1150	3	2	14
	ST-5	1150	3	2	14
	ST-6	950	3	0	12
	ST-7	800	2	2	10
	ST-8	800	2	2	10
	STORAGE TRK-TOTAL NUMBER OF CARS = 102				
SHOP HOLD	SH-1	400	1	1	5
	SH-2	400	1	1	5
	SH-3	480	1	2	6
	SH-4	350	1	0	4
	SHOP TRK-TOTAL NUMBER OF CARS = 20				
FUTURE	F-1	750	2	1	9
	F-2	750	2	1	9
	F-3	750	2	1	9
	FUTURE TRK-TOTAL NUMBER OF CARS = 27				

Figure 1-6: Ho'opili Maintenance and Storage Facility Option Concept



NUMBER OF TRAINS AND CARS

	TRACK NO.	LENGTH (FT)	NO. 4-CAR TRAINS	RESIDUAL CAR/S	TOTAL CARS
STORAGE TRACK	ST-1	320	1	0	4
	ST-2	320	1	0	4
	ST-3	320	1	0	4
	ST-4	320	1	0	4
	ST-5	320	1	0	4
	ST-6	320	1	0	4
	ST-7	320	1	0	4
	ST-8	320	1	0	4
	ST-9	320	1	0	4
	ST-10	320	1	0	4
	ST-11	320	1	0	4
	ST-12	320	1	0	4
	ST-13	320	1	0	4
	ST-14	320	1	0	4
	ST-15	320	1	0	4
	ST-16	320	1	0	4
	ST-17	320	1	0	4
	ST-18	320	1	0	4
	ST-19	320	1	0	4
	ST-20	320	1	0	4
	ST-21	320	1	0	4
	ST-22	320	1	0	4
	ST-23	320	1	0	4
	ST-24	320	1	0	4
	ST-25	320	1	0	4
	STORAGE TRK-TOTAL NUMBER OF CARS = 100				
SHOP HOLD	SH-1	320	1	0	4
	SH-2	320	1	0	4

SHOP TRK-TOTAL NUMBER OF CARS = 8

Figure 1-7: Leeward Community College Maintenance and Storage Facility Option Concept

1.4 Foundation Construction Process

The fixed guideway and stations would be aerial structures throughout the system. The fixed guideway system's four main components that are common to all the technologies considered (i.e., light rail transit, rapid rail transit, maglev [magnetic levitation], rubber-tired guided vehicles, and monorail) include foundations, piers (support columns), superstructure (the elevated guideway structure), and stations. The distance between piers varies for each technology and would also depend on the guideway configuration. Typical pier spacing would be 150 feet, with shorter or longer spans used where needed. The size of other system components (e.g., guideway width) also varies for each technology considered.

The dimensions stated in this report are general and may be adjusted as the project design proceeds.

The construction industry uses a variety of specialized terminology. The following terms are used in describing the construction process:

- *Tremie* is a method that places concrete underwater using a submerged pipe from the bottom to the top of a hole, to ensure minimal contamination with water.
- *Slurry* is a wet mix of bentonite or polymer placed in an excavation to support the excavation until the concrete placed.
- *Battered piles* are piles placed at an angle to improve horizontal resistance.
- A *pile cap* is a structural connection between pile(s) and a pier column.

Foundations for the various system components would be dictated by structural demands, existing subsurface conditions, and other construction factors. Two general foundation construction methods would be used to support the aerial guideway structure: drilled shafts that would be integral with columns, and driven piles that would require pile caps for connection to columns.

Drilled shafts (Figure 1-8) would be used for most of the alignment because they can be installed faster, a smaller area of soil is disturbed, and there is less vibration and potentially less noise than driving piles. Drilled shafts would generally be 6 to 10 feet in diameter. The depth of the shaft depends on local soil conditions and would likely range between 50 and 150 feet below ground surface, averaging around 85 feet. Generally, a column foundation can be completed in one week. The procedure for constructing drilled shafts follows:

1. Drill a hole of prescribed size to the design depth.
2. Stabilize unstable ground conditions by suitable means to achieve the design completion depth. Use slurry or water for drilled shafts completed below the prevailing ground water level, to counterbalance the adverse effect of an inward seepage gradient.

3. Clean the bottom of the drilled shaft thoroughly, and where water or slurry is used, clean out the medium to verify there is no excess detritus in suspension that could compromise the quality of the placed concrete.
4. Install a rebar cage in the completed shaft.
5. Fill the shaft with concrete from the bottom up by the tremied-placing method, using strict tolerances on means and methods. The tremied concrete displaces the drilling fluid (slurry or water) upward and scours any raveling materials upward.
6. Treat and manage drilling slurry, if used, in accordance with local requirements. Slurry would be recycled through a de-sander and reused. Water would be collected and treated as needed prior to disposal or reuse.

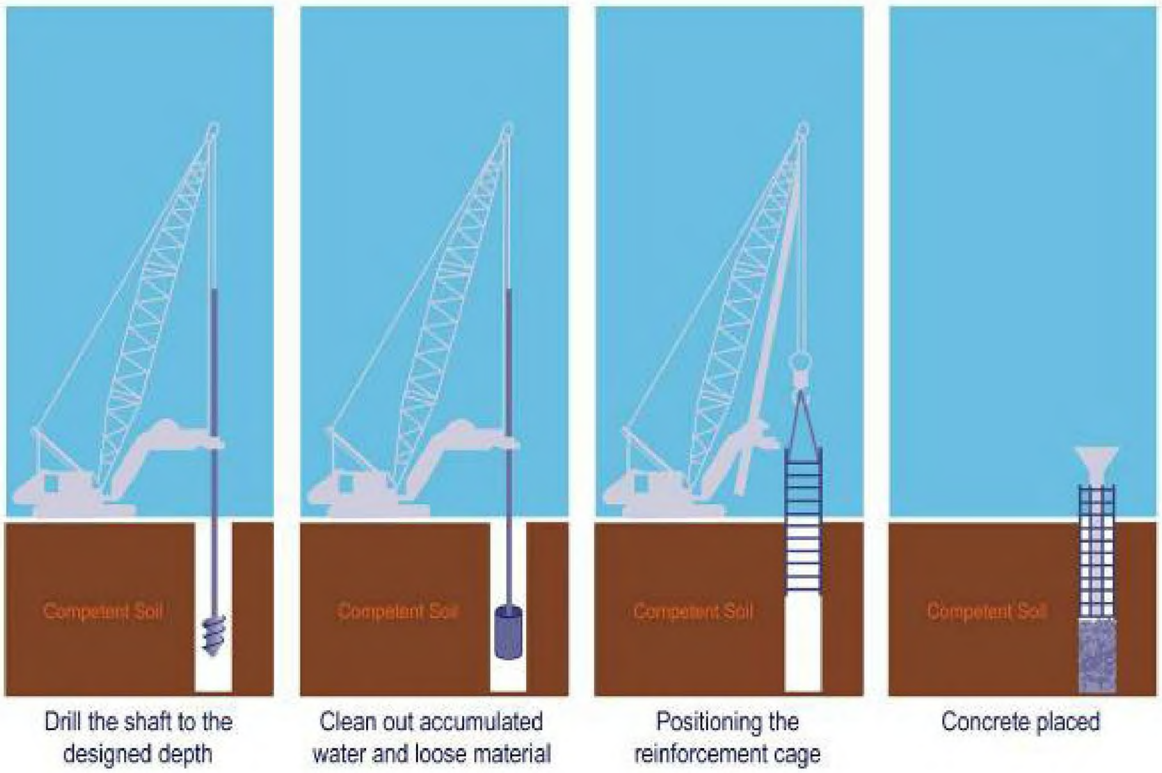


Figure 1-8: Typical Drilled Shaft

In cases where lateral loads are too large for drilled shafts or where geotechnical conditions prohibit their use, foundations would consist of piles with pile caps (Figure 1-9). Piles around the perimeter of the foundation may be battered to improve the foundation's lateral load resistance. Construction of these foundations would entail the following:

1. Driving each pile. Pre-drilling may be required in areas where hard layers or strata otherwise impenetrable to driven piles are encountered at depths above targeted completion.

2. Excavating to accommodate the pile cap. It may be necessary to support the excavation with sheet piling in high congestion areas to limit the construction area. Additionally, dewatering would be required where groundwater is at levels above the base of the pile caps.
3. Field verification testing (including restrike) to ensure minimum design pile capacity is being achieved.
4. Placing rebar for a connection to the column and forming, casting, and curing the pile cap.
5. Restoration to design grade

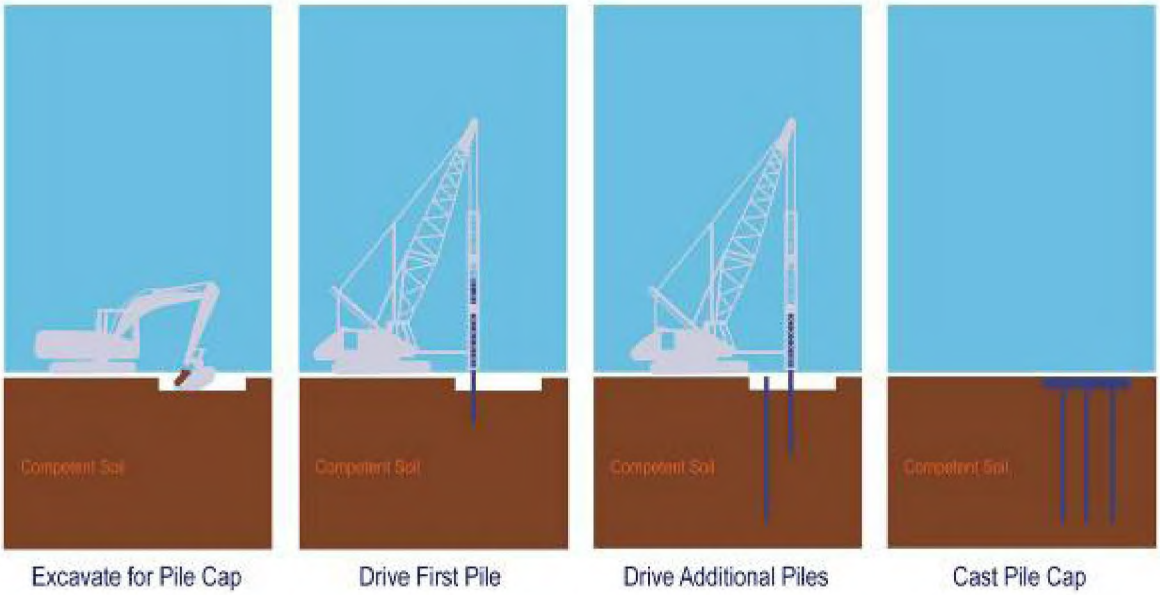


Figure 1-9: Typical Driven Pile

The piers would be cast in place on top of the foundations. The cast-in-place structure would include the column and pier table. Work on piers can begin once the foundations are cured – approximately one week after it is poured. It is expected to take about a week to complete each column.

2 Geohydrology

2.1 Regional Geology

The Island of O‘ahu was built by the extrusion of basaltic lavas from two shield volcanoes, Wai‘anae and Ko‘olau (Figure 2-1). The older Wai‘anae Volcano is estimated to be middle to late Pliocene in age and forms the bulk of the western third of the Island. The younger Ko‘olau Volcano is estimated to be late Pliocene to early Pleistocene in age and forms the majority of the eastern two-thirds of the Island. The Wai‘anae Volcano became extinct while the Ko‘olau Volcano was still active, and its eastern flank was partially buried below the Ko‘olau lavas.

The study corridor is located along the southern flank of these volcanoes, and the area's geomorphology and subsurface conditions are directly related to glacial-eustatic fluctuations of sea level during the Pleistocene Epoch.

Evidence from deep wells indicates that the Island of O‘ahu has subsided by as much as 6,500 to 13,000 feet since the cessation of this early volcanic activity (Moore 1987, Nichols et al. 1996). During that period of subsidence coral-algal reefs began to grow on the southern coast of O‘ahu, forming bays with barrier reefs across the mouth of the bays. The growth of the reefs related to the rate of subsidence. A series of lagoons formed behind the barrier reefs, and both terrigenous and marine sediments accumulated in the lagoons.

During the Pleistocene Epoch, sea level changed as a result of widespread glaciations on the continents. As the continental glaciers accumulated, the level of the ocean fell because there was less water available to fill the oceanic basins. Conversely, as the glaciers receded or melted, global sea levels rose because more water was available.

The higher sea level stands caused the formation of deltas and fans of terrigenous sediments in the bays, the accumulation of reef deposits at high elevations, and the deposition of lagoonal/marine sediments in the quiet waters protected by fringing reefs.

The lower sea level stands caused streams to carve valleys in the sediments and reef deposits. Subariel exposure of the sediments and calcareous materials caused consolidation of the soft deltaic materials and lagoonal deposits and induration of the calcareous reef materials. In addition, renewed subariel erosion of these upper areas of the volcanic dome deposited terrigenous alluvial soils under relatively high-energy conditions.

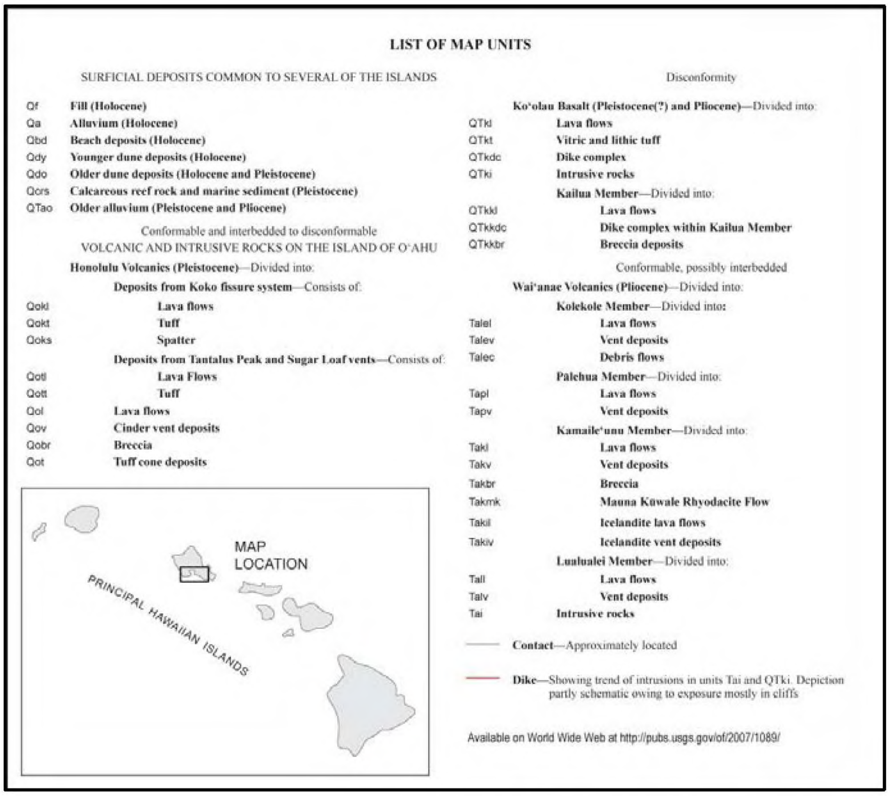
This geologic history is complicated further by the deposition of recent pyroclastic materials and lava flows resulting from eruptions of the vents of the Honolulu Volcanics (including the Āliamanu-Salt Lake-Makalapa, Kamanaiki, Punchbowl, Roundtop-Tantalus-Sugarloaf) and other minor vents. These post-erosional volcanic events were contemporaneous with the Pleistocene sea level fluctuation.

Many of the eruptions were explosive due to the interaction of ground water with the rising magma, which resulted in steam explosions that expelled large quantities of pyroclastic material – predominantly ash and cinder. These deposits of pyroclastics have consolidated to form volcanic tuff.

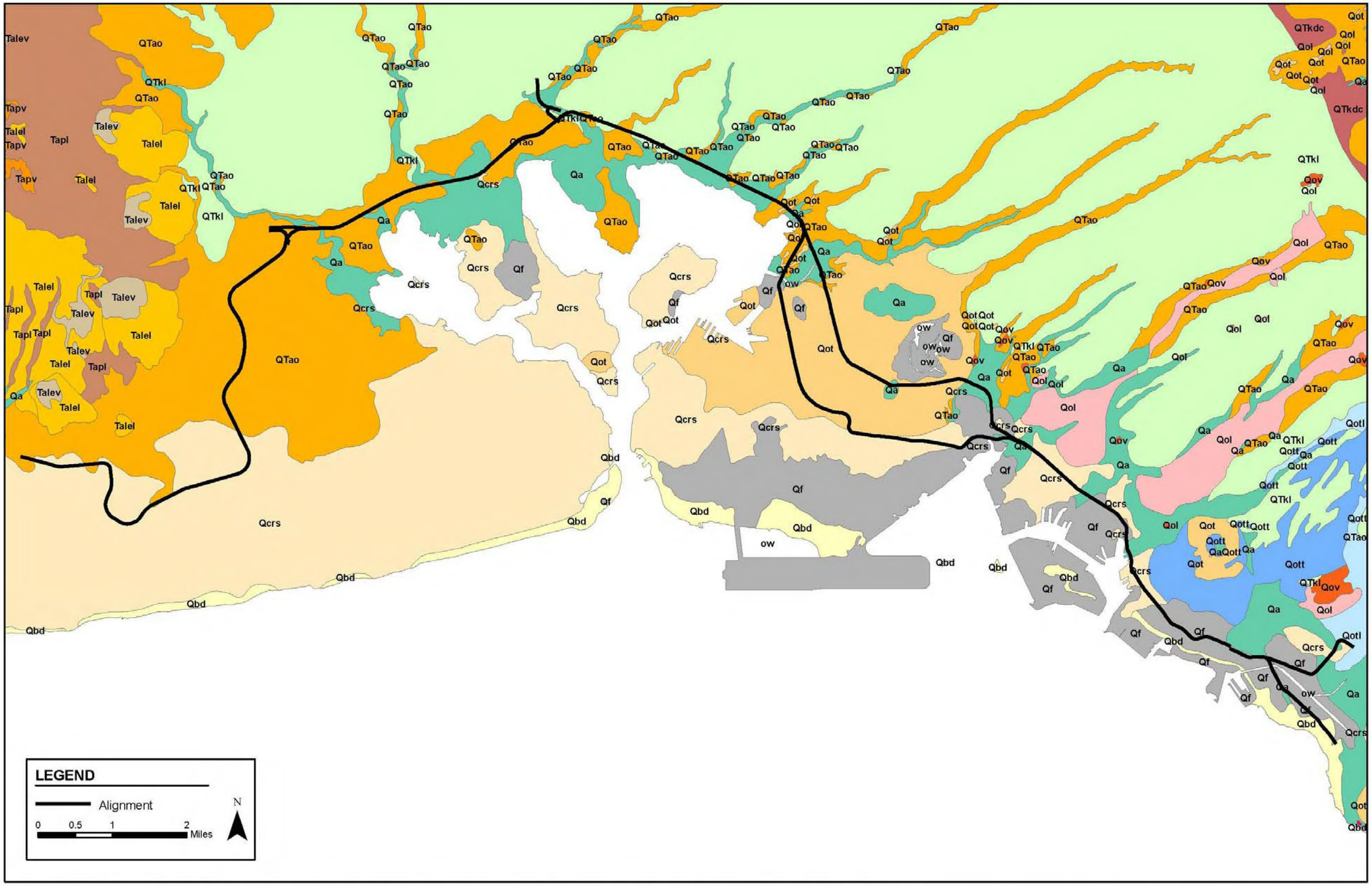
Eruptions of the Roundtop-Tantalus-Sugarloaf volcanoes blanketed much of what is now metropolitan Honolulu with a fine black cinder. These eruptions also produced a thick lava flow that filled the bottom of Mānoa Valley.

About 15,000 years ago, a relatively rapid rise in sea level occurred. During that rise, the deep valleys in the study area were drowned. In the last 10,000 years, sea level has adjusted to its present stand. Terrigenous and marine sediments have continued to accumulate in low-energy estuarine or lagoonal environments, resulting in thick deposits of soft harbor sediments along the coast in areas that were formerly valleys and drainageways.

Land development and reclamation projects within the last 50 to 100 years have brought the ‘Ewa-Honolulu area to its present form, including large areas of re-graded and filled coastal areas. Many of these projects were originally constructed for agricultural, residential, or military development. Many of the resulting fills are of poor quality in terms of supporting large structures.



Key to Figure 2-1 (figure follows)



Source: Sherrod, David R., John M. Sinton, Sarah E. Watkins, and Kelly M. Brunt. Geologic Map of the State of Hawai'i. U.S. Geological Survey, Hawai'i Volcano Observatory.

Figure 2-1: Geological Map of the Study Corridor

2.2 Regional Hydrology

The SOBA is the basal freshwater lens floating on saline ground water (as described by Ghyben-Herzberg principles) over most of southern O‘ahu. The EPA has designated the SOBA as the sole or principal source of drinking water for O‘ahu. It is recharged by rainfall that falls on the mauka areas of the Island. Within this lens, fresh water generally flows from inland areas to coastal discharge areas. The water is stored in the porous basalt rock of thin lava flows, and drinking water removed from the SOBA comes from wells that penetrate deep into this basalt.

The entire study area is underlain by the SOBA (Figure 2-2). In accordance with the 1984 *Sole Source Aquifer Memorandum of Understanding* between EPA and the Federal Highway Administration, this Ground Water Impact Assessment is being prepared to meet the coordination requirements of Section 1424(e) of the Safe Drinking Water Act.

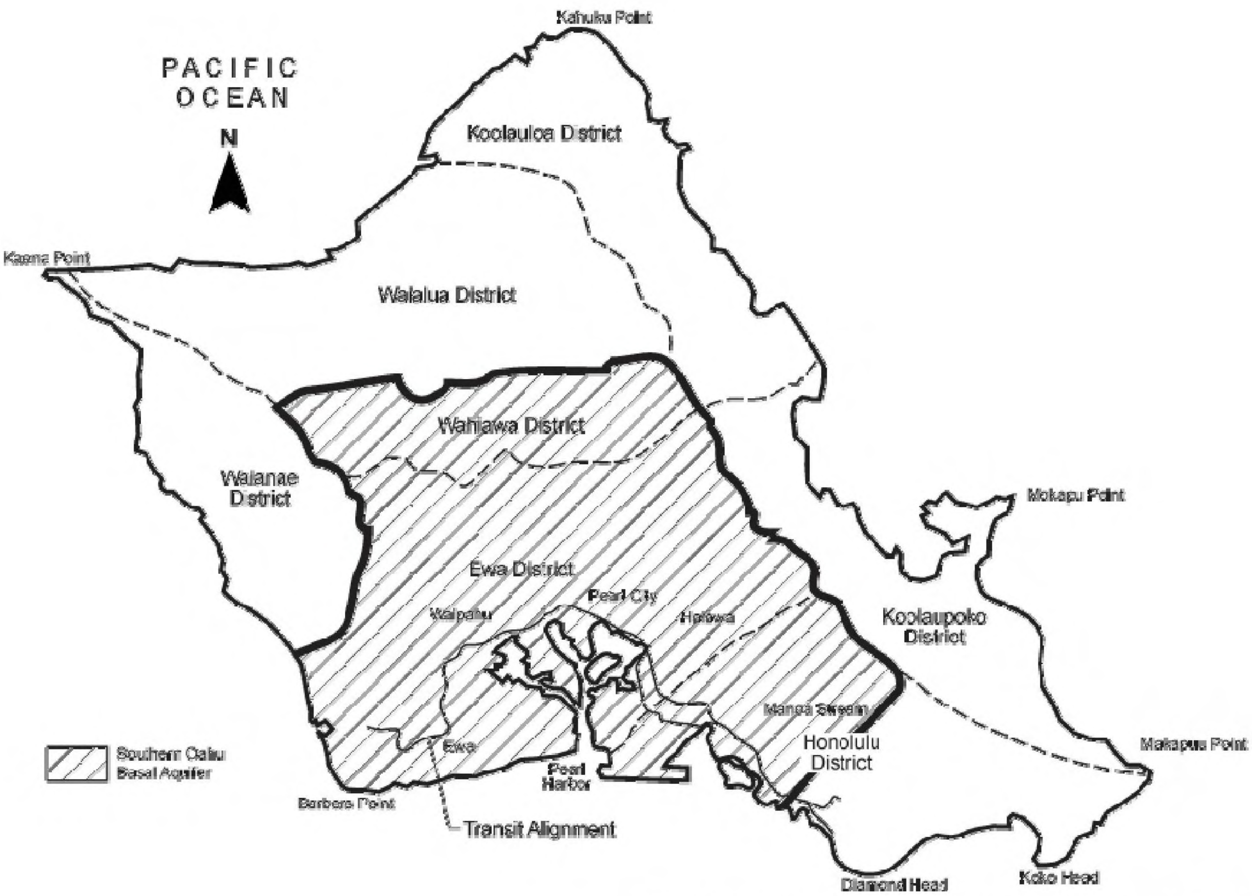


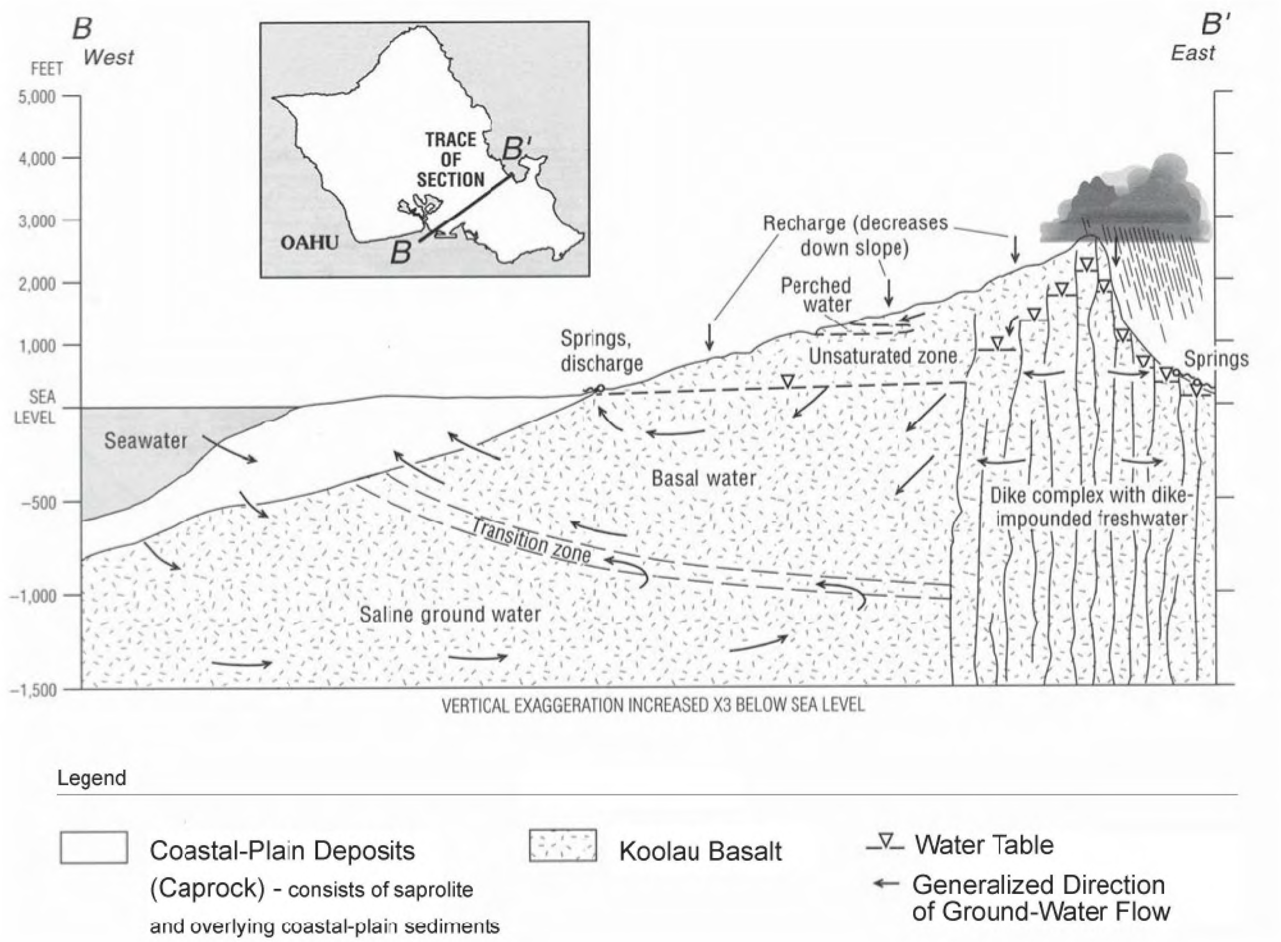
Figure 2-2: Extent of the SOBA on O‘ahu

As described by Mink and Lau 1990 and Honolulu BWS 2007, ground water aquifers within the study corridor can also be divided (based mostly on valley-fill type hydrologic boundaries) into the Pearl Harbor Aquifer Sector containing the ʻEwa, Waipahu, Waiawa, and Waimalu Aquifer Systems and the Honolulu Aquifer Sector containing the Moanalua, Kalihi, and Nuʻuanu Aquifer Systems. Each hydrologic unit contains a basal freshwater lens confined by the coastal plain. There is varying amounts of communication between these units (Mink and Lau 1990). Based on Hawaiʻi status codes related to the protection of drinking water, the aquifers are generally designated as currently used sources of fresh drinking water that are both irreplaceable and highly vulnerable to contamination.

Caprock overlies the SOBA and impedes the escape of ground water from this basaltic aquifer (Figure 2-3). Water in the caprock is brackish and not potable. Only the water in the upper portion of the caprock has a low enough salinity to be used for irrigation. Layers in the caprock are less permeable than water-bearing lava flows, and constitute a barrier that retards the seaward flow of ground water (Figure 2-4). The caprock thins with distance from the shoreline and ends at varying distances inland, and basalt is exposed or underlies superficial materials (Figure 2-5). As a consequence of the caprock, some inland areas in southern Oʻahu have high water tables and some artesian wells and springs, especially in the Pearl Harbor Area (Figure 2-6) (Nichols et al. 1996).

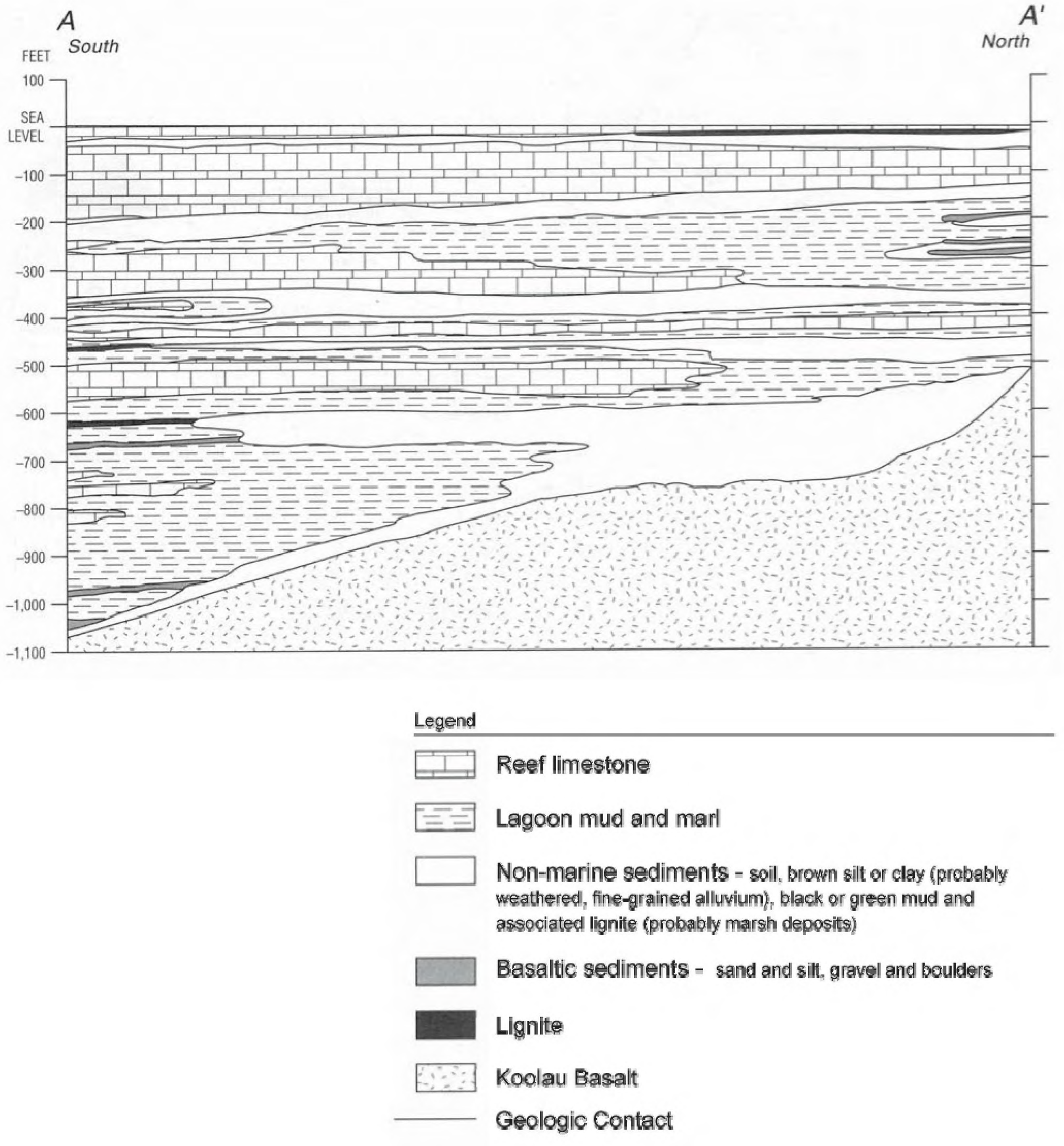
Beneath the caprock and underlying all of southern Oʻahu, the SOBA is heavily used because it contains large supplies of fresh water. Although the caprock's capacity to store and transmit water is small compared to the basalt aquifer, the caprock contains large quantities of water accumulating from rainfall, irrigation return, and leakage upward from the artesian portion of the basalt aquifer. Caprock water is generally of poor quality because of its relatively high chloride content, but the upper portion has been developed for agricultural and industrial purposes. Groundwater levels in the caprock along the study corridor vary with ocean tides and may also be influenced locally by streams. Changes in salinity have been related to land use and irrigation history (Bauer 1996, Hunt 2004, Mink and Yuen 1994, Oki et al. 1996, Yuen and Assoc. 1988).

The boundary between non-drinking water aquifers and underground sources of drinking water is referred to as the Underground Injection Control (UIC) line by the HDOH (Figure 2-7). Restrictions on injection wells differ, depending on whether the area is mauka or makai of the UIC line. Restrictions are allowed both mauka and makai of the UIC line, but injection wells mauka of the UIC line are required to meet higher water quality standards and public notification is required during the permit application process. The UIC program is administered by HDOH's Safe Drinking Water Branch. The following portions of the alignment are makai of the UIC line: part of the future extension in Kapolei, part of the Salt Lake Alternative, a significant portion of the Downtown Honolulu area, and the future Waikīkī extension. These areas are considered by the HDOH as not being underlain by an aquifer that is a source of drinking water. Therefore, although these areas are still part of the SOBA, the HDOH can grant permits in this area for underground injection wells to inject water or other fluids into the ground water aquifer.



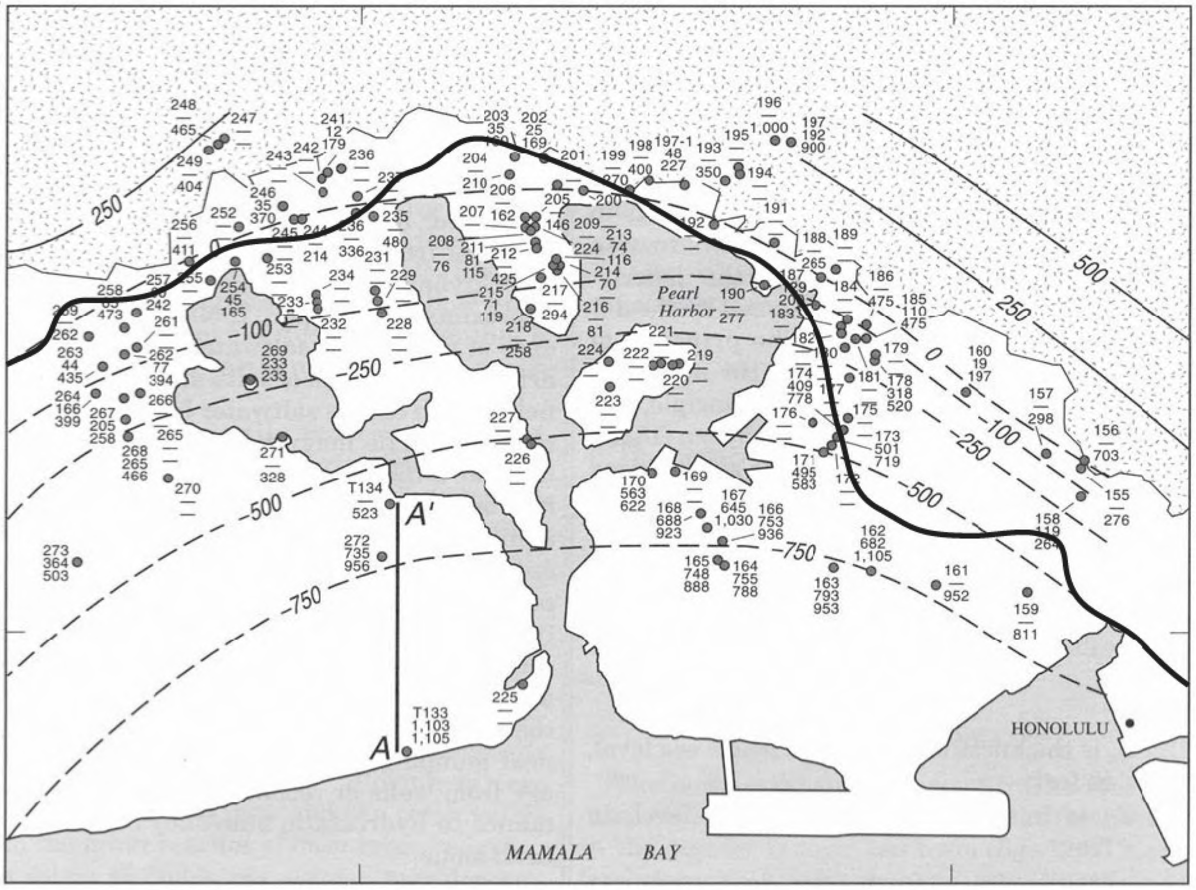
Source: Hunt, 1996.

Figure 2-3: Modes of Groundwater Occurrence on O'ahu



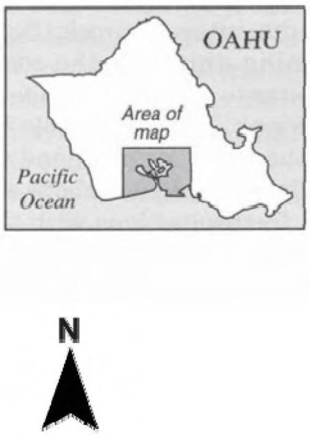
Source: Hunt, 1996.

Figure 2-4: Cross-Section of the Caprock



Legend

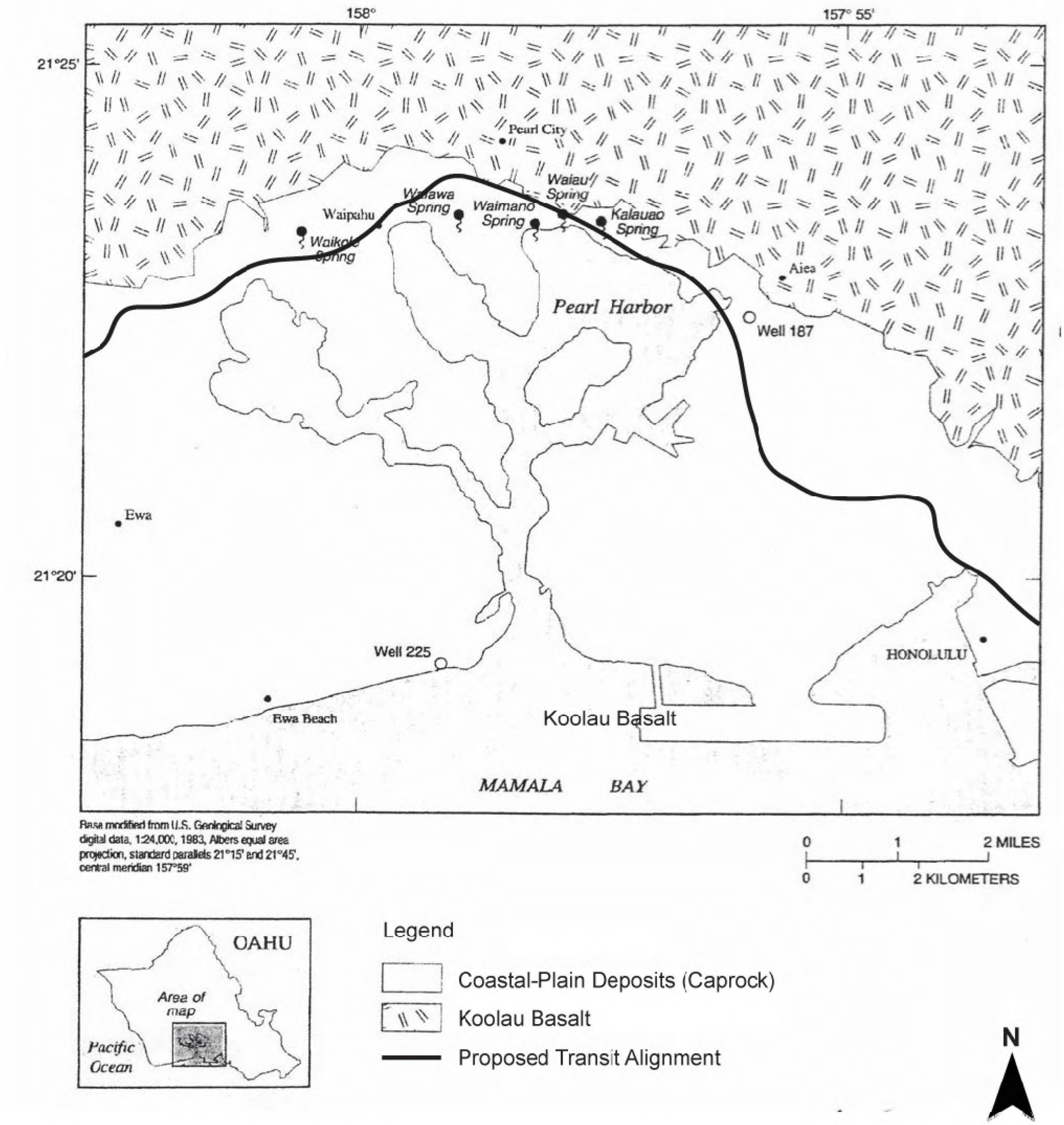
- Coastal-Plain Deposits (Caprock)
- Koolau Basalt
- Geologic Contact
- −250 — — Structure Contour - Shows altitude of top of Koolau basalt. Interval, in feet, is variable. Dashed where uncertain. Datum is mean sea level.
- A — A′ Trace of Geologic Section
- 165 / 748 / 888 Drilled Well - Top number is well number, middle number is casing depth, and bottom number is well depth. Long dash indicates no data. Depths are in feet below mean sea level.
- Proposed Transit Alignment



Source: Modified from Hunt, 1996.

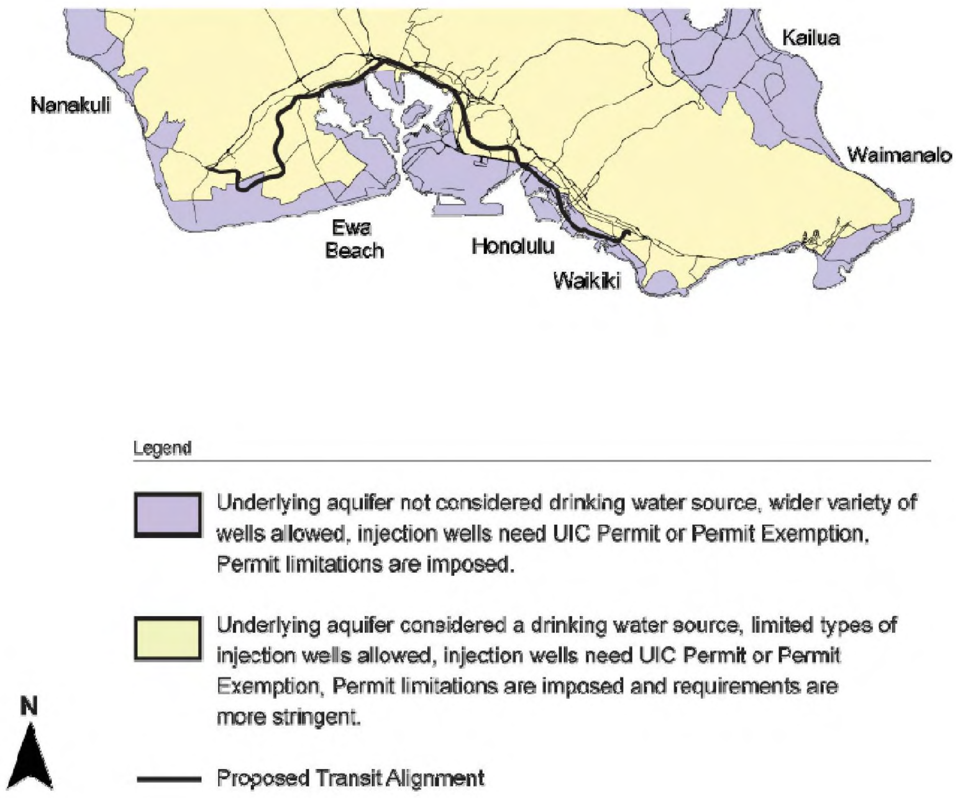
NOTE:
Structural contours on top of Kookau Basalt in the Pearl Harbor area, island of Oahu (modified from Wentworth, 1951, fig. 21) and section showing stratified coastal-plain sediments (modified from Resig, 1969, fig. 6 and Strearns and Chamberlain, 1967, fig. 2).

Figure 2-5: Contours on the Base of the Caprock



Source: Modified from Nichols, et al, 1996.

Figure 2-6: Location of Pearl Harbor Springs

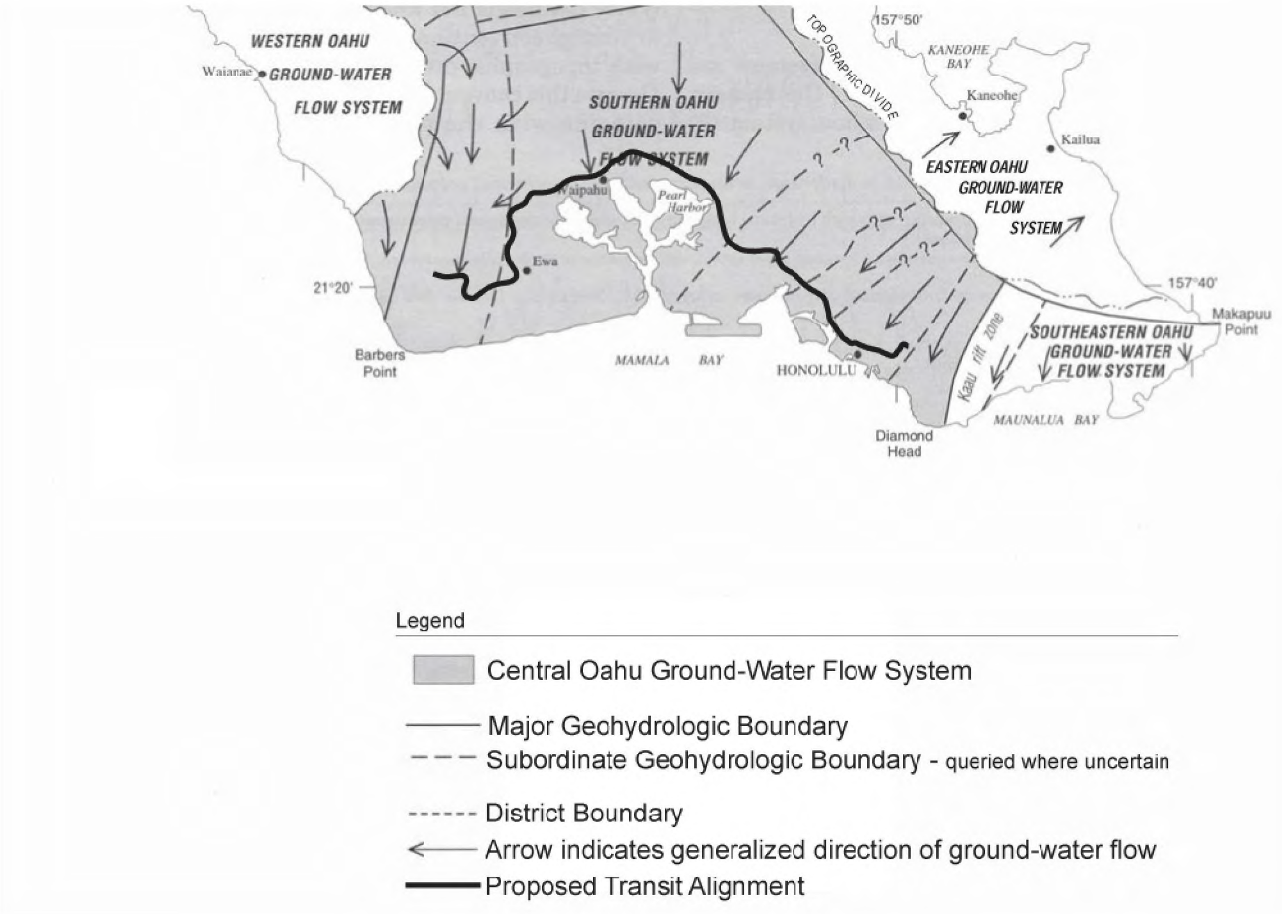


Source: Department of Health EGIS 9.99.

Figure 2-7: Location of the UIC Line

Department of Health Administrative Rules, Title 11, Chapter 23 provides conditions governing the location, construction, and operation of injection wells so that injected fluids do not migrate and pollute underground sources of drinking water. In these areas makai of the UIC, construction of the guideway shafts should not be considered detrimental to the ground water if injection wells are allowed.

The project alignment would be downgradient of the drinking water wells on O‘ahu and the overall ground water flow direction is seaward (Figure 2-8). In addition to establishing the location of the UIC line, the HDOH’s Safe Drinking Water Branch publishes ground water contamination maps (SDOH 2005). Figure 2-9 (modified from their report) shows that most of the water wells are located mauka of the proposed alignment. All wells makai of the alignment are either inactive or used for irrigation. Therefore, potential contamination from the guideway would not migrate to drinking water wells. These water wells are drawing from a depth of several hundreds of feet below ground surface, and the shafts would not penetrate anywhere near those depths.



N

NOTE:
Base modified from U.S. Geological Survey digital data, 1:24,000, 1983, Albers equal area projection, standard parallels 21 degrees, 15' and 21 degrees, 45', central meridian 157 degrees, 59' Contours from U.S. Geological Survey digital elevation model data, 1:250,000, 1986.

Source: Modified from Hunt, 1996.

Figure 2-8: Groundwater Flow Systems

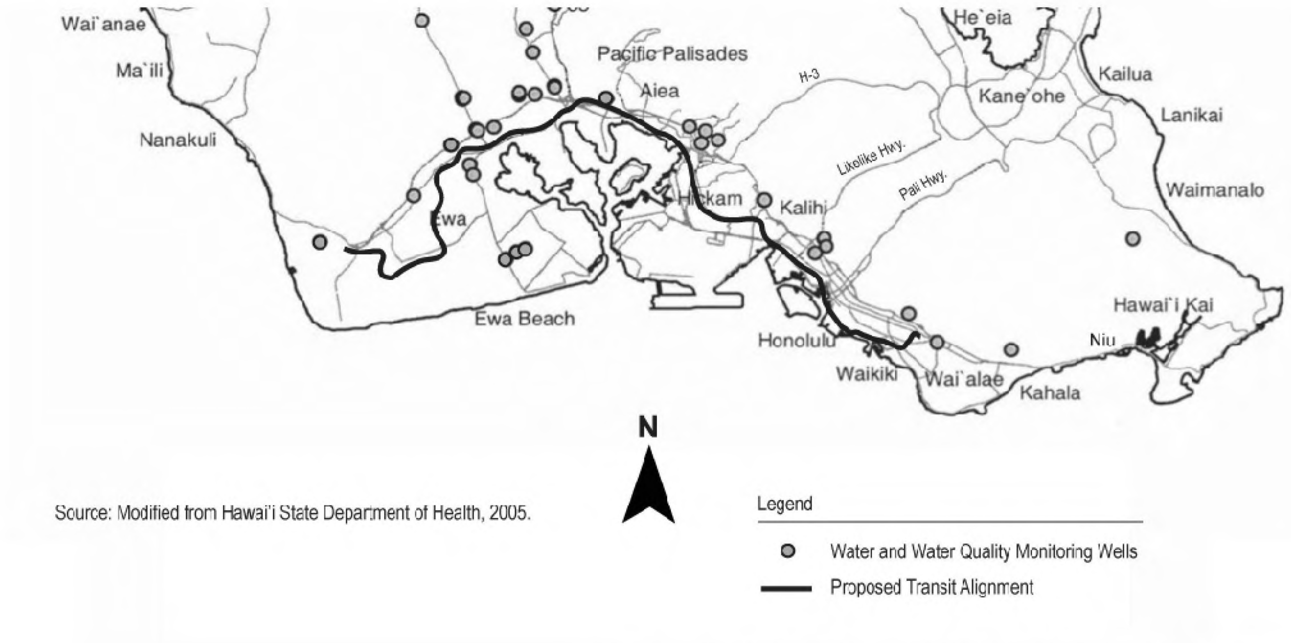


Figure 2-9: Water Wells near the Alignment

2.3 Geology and Hydrology along the Corridor

This section describes, in general terms, the geologic and hydrological conditions that would be encountered along the proposed alignment. Further details on geology can be obtained from the geotechnical reviews and borings being performed for the Project. Borings specifically made for the Project will be required for design.

2.3.1 Planned Future Extension – West Kapolei

The volcanic rocks exposed toward the ‘Ewa end of the study corridor near Kapolei are part of the Wai‘anae Volcanic Series. The surface deposits are interbedded layers of recent alluvium, consisting mainly of clayey organic silt with variable amounts of sand and some pockets of gravel and cobbles, as well as competent coralline materials. These ancient coral-algal reefs with layers of alluvial and marine sedimentary deposits are referred to as *caprock*. The caprock rests on the underlying basalt core of Pliocene-age Wai‘anae Volcanics. In this area, basalt rock can be found at depths of up to 1000 feet. As described previously, the caprock layers were formed as worldwide climatic changes and crustal adjustments led to large fluctuations in sea level. These layers retard the seaward migration of potable ground water.

The type of ground water varies in this area. Brackish ground water occurs at shallow depths in the caprock. Potable water occurs at great depths below the caprock in the SOBA.

2.3.2 East Kapolei to Leeward Community College

This portion of the proposed alignment would generally parallel the North-South Road (currently under construction) for a mile, turn northwestward across open/agricultural fields for approximately 2 miles to Farrington Highway and 0.5 miles west of Fort Weaver Road, and travel eastward thereafter parallel to and coincident with Farrington Highway for approximately 4 miles to Leeward Community College. Subsurface conditions along this stretch of the proposed alignment generally consist of typical caprock, alluvial and marine deposits and residual soils interlayered with coralline materials, and/or basalt bedrock.

As the alignment cuts across the boundary between caprock and basalt, depth to ground water or basal water is expected to be variable with existing ground surface elevation variations and distance from the shore line. General water-level elevations along the portion of the alignment overlying the caprock are expected to vary between Elevation +10 and +20 feet above mean sea level (MSL) (Hunt 1996, Nichols et al. 1996) where the ground water is confined by the caprock. Based on existing ground elevations that are typically Elevation +40 to +100 feet MSL and higher, depth to ground water for the area overlying basalt is expected to vary from 20 feet below ground surface (bgs) to tens of feet bgs. In the Waipahu area where existing ground elevations are Elevation 20 feet or less, ground water elevations are expected within 10 feet of the ground surface.

2.3.3 Leeward Community College to Aloha Stadium

Eastward of Leeward Community College the alignment would cross over Kamehameha Highway and thereafter generally follow the highway alignment to the vicinity of Aloha Stadium. Subsurface conditions along this portion of the alignment generally consist of alluvium overlying residuals tuffs that are underlain by basalt bedrock. Historical information shows that soils and a soil-like saprolite mantle vary in depth from as little as 20 feet to upwards of 60 feet, and the underlying bedrock is of variable weathering. However, there are several reaches (e.g., in the area of Waimalu and Kalauao Streams) that consist of 5 to 10-foot-thick fills placed over harbor mud underlain at depth by old alluvium, volcanic tuff, and 'mudrock' or basalt bedrock. The harbor mud in these two areas is known to extend down to depths of about 100 feet below ground level before older alluvium or weathered basalt is encountered.

Depth to ground water, as measured in previously completed investigations, generally depends on ground surface elevation, as discussed previously. Groundwater elevations along this nearshore portion of the alignment have been observed to be at Elevation +20 feet MSL in the Leeward Community College area and decreasing eastward to about Elevation +10 feet MSL just east of Aloha Stadium. Relative to existing ground surface elevations, which range from about Elevation +100 feet near Leeward Community College to about Elevation +10 feet, the depth to ground water through this portion of the proposed alignment has been measured at 10 to 30 feet bgs. Exceptions to these typical groundwater depths have been observed where a combination of low existing ground elevations and artesian flows from the basalt bedrock penetrated resulted in artesian flows rising above existing ground (Figure 2-6)

(Nichols et al. 1996).

2.3.4 Aloha Stadium to Māpunapuna (Salt Lake Boulevard Alignment)

The Salt Lake Alternative would generally proceed eastward from Aloha Stadium along Salt Lake Boulevard to the Māpunapuna area (e.g., Pu'uloa and Pukoloa Roads) just east of Moanalua Stream. Subsurface conditions along this section of the proposed alignment are interpreted as consisting of surface fills placed over volcanic tuff formation overlying alluvial deposits at greater depths. However, in the area of the Hālawa Stream crossing, a thick sequence of harbor mud upwards of 100 feet in thickness is expected.

Existing ground surface elevations are highly variable along this section of the proposed alignment. They typically range from Elevation +20 to +40 feet MSL, with a significant topographic high–typically Elevation +120 feet MSL–that stretches from Bougainville to Radford Road/Likini Street. Except in the Hālawa Stream drainage area where relatively shallow ground water is expected, static ground water is not anticipated within the depths of the drilled shaft foundations along the rest of the alignment, except for seepage ground water conditions. The caprock thickness through this area is 100 feet or thicker and has been mapped to -90 to -500 feet MSL.

2.3.5 Aloha Stadium to Māpunapuna (Airport Alignment)

The geology along the proposed alignment for the Airport Alternative generally contains surface fills over thick lagoonal deposits underlain by alluvial soils and coralline detritus. Groundwater may be tidally influenced and is anticipated at shallow depths of approximately 10 feet.

2.3.6 Māpunapuna to Middle Street

This segment of the proposed alignment would traverse the Māpunapuna industrial area to Moanalua Stream, turn south along the stream for approximately 2,000 feet, and thereafter travel southeasterly over the Ke'ehi Interchange to the intersection of Middle Street with Dillingham Boulevard. In addition to Moanalua Stream, this section of the alignment would cross Kahauiki and Kalihi Streams, which like Moanalua provide major drainage off the leeward slope of the Koolau Mountain Range. Extensive investigations were completed for the Ke'ehi Interchange circa 1980, and historical investigation in the immediate area has provided a reliable source of information on subsurface conditions.

Subsurface conditions along this segment of the proposed alignment generally consist of artificial fills approximately10 feet thick, placed over thick stratum of recent alluvium over lagoonal and estuarine deposits extending to depths of 80 to over 150 feet bgs. Sands, coral detritus, and silty clays underlie the soft soils and extend to the approximately 200-foot maximum depth explored.

This segment of the alignment is generally low lying, with existing ground surface elevation ranging from +5 to +15 feet MSL. Local areas may have been built up by the addition of fill to maintain grades above tidal influences from nearby waters. Brackish ground water due to the nearby ocean in this area is expected within 10 feet of the ground surface.

2.3.7 Middle Street to Ka'ahi Street along Dillingham Boulevard

This approximately one-mile-long segment of the alignment would extend eastward down Dillingham Boulevard. The Kapālama Stream is the only visible drainage crossing.

Subsurface conditions through this section generally consist of surface fills placed over lagoonal deposits overlying both alluvial soils and coralline detritus materials underlain at depth by basaltic bedrock. The surficial fills are approximately 5 to 10 feet thick and of variable composition. Depth to bedrock ranges from approximately 25 to over 100 feet bgs.

Topography through the first half this segment is generally flat and then descends eastward. West of Kapālama Stream, the ground surface is at about Elevation +20 feet MSL. At McNeil Street the ground profile descends from +17 to +5 feet MSL at the stream, and essentially maintains this elevation eastward. Groundwater elevations through the area are typically measured as being at or near MSL. Therefore, depth to ground water is estimated at 5 to 20 feet bgs depending on the surface elevation. Available ground water level data does not indicate artesian conditions through this area, and published literature (Visher and Mink 1964) indicates a caprock thickness in excess of 100 feet.

2.3.8 Ka'ahi Street to Richards Street along Nimitz Highway

Beyond Ka'ahi Street, the alignment would turn southward to follow Nimitz Highway along the makai side of Chinatown/Downtown and extend to where Nimitz Highway joins Ala Moana Boulevard at its intersection with Richards Street. This section of the alignment would cross over Nu'uanu Stream and essentially borders the coastal shoreline. Existing ground surface elevations range from +5 to less than +10 feet MSL.

Subsurface conditions for the portion extending from Ka'ahi Street to one block south of River Street (Kekaulike Street) were extrapolated from investigations completed along nearby Hotel and King Streets that only extended to a depth of 100 feet bgs. Subsurface conditions in the area of Nu'uanu Stream reflect genesis as an ancestral stream that incised basaltic rock and/or older alluvium and was subsequently infilled by organic silts and sands in a back reef lagoonal swamp. Underlying this are vesicular basalt lava flows with cavities or voids approaching 1 foot in size. Clinker zones containing gravel to boulder-sized basaltic fragments are commonly present near the top margins of bedrock.

Historical information from investigations in the Nu'uanu Stream area indicate that the erosional channel extends down to approximately 85 feet bgs, and was infilled with soft organics (estimated at 60 feet) and recent alluvium. The lower portion of the infill contains boulder layers estimated as being approximately 10 feet thick.

Along the westerly portion of this section, subsurface conditions consist of reef deposits overlying alluvial sands, silts, clays, and basaltic boulders. It has been speculated that basaltic flows may occur at depths in excess of 110 feet bgs. Surficial fills are typically approximately 5 feet thick and underlain by up to 10 feet of cinder sands in the southerly portion of this section. The underlying reef deposits vary in thickness, extending to a depth of approximately 45 feet bgs. Below a depth of about 45 feet bgs, alluvium was observed to the maximum 100-foot depth explored.

Groundwater is anticipated within about 10 feet of the existing ground surface for this segment of the proposed alignment. This ground water is brackish and not a potable water source.

2.3.9 Richards Street to Ward Avenue

This section of the alignment would generally follow Halekauwila Street through the Kakaʻako area. Subsurface conditions between Richards Street and Ward Avenue generally consist of surface fills over lagoonal deposits or coralline detritus underlain by alluvial soils. Surficial fills, as in other low-lying coastal areas, are approximately 5 feet thick. The fills are locally underlain by up to 8 feet of cinder sands. Reef deposits are estimated at 50 feet or greater in depth, and generally comprised of sands and sandy gravel with lenses of clayey silt. Alluvium was observed beneath the coralline and corals at depths of approximately 85 feet in the area of Punchbowl. An approximately 10-foot-thick volcanic tuff interbedded with the reef deposits was also observed in some borings in this general area.

A review of the literature (Ferrall 1976) indicates an approximately 15-foot-thick coral ledge at about Elevation -20 feet MSL that extends across this entire area and eastward to Waikīkī . Additionally, these historical interpretations suggest that basalt may be encountered at depths as shallow as 80 feet bgs in the Ward Avenue area.

Lagoonal deposits also occur in the vicinity of Ward Avenue. At estimated depths ranging from 60 to 80 feet bgs, alluvial deposits in the incised channel are interbedded with cinder sands and coralline debris. Alluvium and coralline debris are expected at depths of approximately 200 feet bgs.

Groundwater is anticipated within about 10 feet of the existing ground surface for this segment of the proposed alignment. No known artesian conditions have been identified.

2.3.10 Ward Avenue to Ala Moana Center

This section of the proposed alignment would transition from Halekauwila Street across Queen Street to its intersection with Kona Street, and follow it to the back side of Ala Moana Shopping Center (Kona Street). Subsurface conditions along this segment of the alignment generally consist of surface fills placed over lagoonal deposits underlain by coralline detritus materials interbedded with hard coral ledges. The lagoonal deposits are estimated to range in thickness from about 10 feet east of Ward Avenue to as much as 20 feet at the Ala Moana shopping center area.

Groundwater is anticipated within 10 feet or less of the existing ground surface for this low-lying section of the alignment.

2.3.11 Planned Future Extension – UH Mānoa

In the area between Ala Moana Center and UH Mānoa where this extension would be located, the geology consists mainly of surface fills overlying alluvial soils and volcanic ash deposits. Thick lava deposits from the recent Roundtop-Tantalus-Sugarloaf volcanoes are also present.

Groundwater is anticipated to range greatly in depth, from quite shallow near Ala Moana Center to below the depths of the drilled shafts near the terminus at UH Mānoa.

2.3.12 Planned Future Extension – Waikīkī

The Waikīkī Extension segment generally contains substantial amounts of surface fills over lagoonal deposits underlain by alluvial soils and coralline detritus. Groundwater is anticipated at shallow depths of approximately 10 feet.

3 Potential Impacts to the SOBA and Mitigation

3.1 Construction Impacts and Mitigation

The depth of a shaft or driven pile depends on local soil conditions, and for the Project would likely range from 50 and 150 feet below ground surface, averaging around 85 feet. A boring program is currently being conducted to estimate how deep each shaft or pile may have to extend into the subsurface. Based on the previous discussion, locations where the shafts for piles might extend into the SOBA are identified in this section.

Most of the piers would only penetrate surficial materials or caprock overlying the basalt aquifer. In places where the piles or shafts would extend into the basalt, penetration would be at most only a few tens of feet. The exact depths of penetration are predicated on meeting foundation axial and lateral load demands and would not be determined until design, but the piers or piles would never penetrate deep into the basalt. Drinking water pumped from the SOBA comes from depths much greater than those anticipated or practical for pile foundations.

The excavations would remain only long enough to set the rebar and pour the concrete. This would minimize the chance that pollutants could enter directly through the open pathway.

The alignment would be typically downgradient of the drinking water wells on O‘ahu (Figure 2-9), and the overall ground water flow direction is seaward (Figure 2-8). These water wells draw from a depth of several hundreds of feet below ground surface. All wells makai of the alignment are either inactive or used for irrigation. In addition, much of the alignment is located makai or very near the UIC line (Figure 2-7). This indicates that the HDOH’s Safe Drinking Water Branch has determined that injected fluids do not migrate to pollute underground sources of drinking water. In areas where the caprock overlies the SOBA, artesian pressure prevents the overlying ground water from entering the SOBA.

3.1.1 Interaction with the SOBA along the Proposed Alignment

Groundwater in the SOBA is stored in porous basalt rock. Therefore, the proposed alignment has been evaluated to determine whether shafts or piles would be likely to penetrate the basalt. Their location in relationship to the UIC line has also been considered, to determine whether fluids from foundation construction would be likely to migrate into drinking water.

Planned Future Extension – West Kapolei

This planned future extension’s alignment would all be on thick caprock, and the foundations for the guideway structure would not intersect the SOBA.

East Kapolei to Leeward Community College

As the proposed alignment follows North-South Road, it would cut across the boundary between caprock and basalt, and depth to basalt bedrock would vary. At some distance makai of this boundary, shafts or piles can be finished in the caprock. Mauka of the boundary, foundations would intersect the basalt. This area is mauka of the UIC line.

Leeward Community College to Aloha Stadium

Along this portion of the proposed alignment, basalt is likely to be encountered between 20 to 60 feet bgs. However, there are several reaches (e.g., in the area of Waimulu and Kalauao Streams) where 100 feet of soft mud is underlain at depth by old alluvium. Therefore, some shafts or piles in the area would penetrate the basalt while others would be placed in surficial deposits. Artesian conditions may be encountered. This area is mauka of the UIC line.

Aloha Stadium to Māpunapuna (Salt Lake Boulevard Alignment)

Caprock thickness through this is area is 100 feet or thicker and has been mapped to -90 to -500 feet MSL. The shafts or piles are not expected to penetrate to the basalt, but a more detailed boring program is required for a definitive determination. This area is mauka of the UIC line.

Aloha Stadium to Māpunapuna (Airport Alignment)

Caprock through this area has been mapped at up to approximately 750 feet in thickness. The foundations would not penetrate into the bedrock basalt. The proposed alignment would mostly follow or be located makai of the UIC line.

Māpunapuna to Middle Street (Ke‘ehi Interchange Area)

This area has thick deposits of artificial fills, recent alluvium, lagoonal and estuarine deposits, sands, coral detritus, and silty clays that extend to the approximately 200-foot maximum depth explored for the Ke‘ehi Interchange. Therefore, the foundations for the piers would not likely extend to the underlying basalt. In this area, the proposed alignment would generally follow along the edge of the UIC line.

Middle Street to Ka‘ahi Street (Dillingham Boulevard)

Depth to bedrock in this area varies from as little as 25 feet bgs near Kalihi to100 feet bgs. Therefore, some of the foundations would be completed in basalt bedrock. However, most of this segment would generally follow along the edge of the UIC line.

Ka‘ahi Street to Richards Street (Nimitz Highway)

Along this section of the proposed alignment, the depth to basalt varies and some shafts and piles would potentially extend into the bedrock. Based on previous studies in the area, slightly weathered vesicular basalt lava flows are present approximately 30 feet bgs. The alignment would generally follow or be located makai of the edge of the UIC line.

Richards Street to Ward Avenue

Historical interpretations (Ferrall 1976) suggest that basalt may be encountered at depths as shallow as 80 feet bgs in the Ward Avenue area. Therefore, whether the pier foundations would penetrate into the underlying basalt and the amount of potential penetration would have to be determined for each individual pier, depending on the subsurface and construction requirements. In this area, the proposed alignment would generally follow along the edge of the UIC line.

Ward Avenue to Ala Moana Center

Subsurface conditions along this segment of the proposed alignment generally consist of surface fills placed over thick lagoonal deposits underlain by coralline detritus materials interbedded with discontinuous hard coral ledges. The pier foundations may penetrate into the underlying basalt, and the amount of penetration would have to be determined for each individual pier depending on the subsurface and construction requirements in this area. The proposed alignment would generally follow along the edge of the UIC line.

Planned Future Extension – UH Mānoa

Between Ala Moana Center and UH Mānoa, some of the foundations would penetrate into the basalt bedrock. This area is clearly mauka of the UIC line.

Planned Future Extension – Waikīkī

The proposed Waikīkī Extension area generally contains substantial amounts of surface fills over lagoonal deposits underlain by alluvial soils and coralline detritus. Shafts or piles should not penetrate the basalt. The area is below the UIC line.

3.1.2 Protecting the SOBA during Construction

As discussed previously, several areas may require shafts that penetrate into the underlying basalt bedrock.

Groundwater in the shafts or excavations for pile caps could be contaminated with petroleum products or other chemicals. Preliminary studies for the Project have identified areas where subsurface contamination might be expected. These contaminants would be removed from water pumped from the excavations in accordance with standards established by the HDOH. Petroleum products might require the use of oil/water separators, strippers, or other remediation techniques. Additional studies would be required during the final design phase to determine the precise methods to be employed.

The water removed from the excavations or shafts must either be returned to the ground water system or added to the stormwater drainage system. Any water discharged into the drainage system and surface water bodies would require an NPDES Dewatering Permit. This discharge must meet water quality standards. Groundwater in the excavation would probably be pumped out of the excavation with a sump pump. A monitoring program would ensure compliance with water quality standards.

An NPDES Construction Stormwater Permit would dictate that hazardous material and other pollutants are handled properly on site. This permit would be required before any construction could begin.

Construction of each pier is expected to take less than one week. The shafts would only be open long enough to install a rebar cage in the completed shaft and fill it with concrete. Once the shaft is filled with concrete, it is unlikely that an open pathway that allows surficial contaminants to travel down the side of the shaft would remain, because the flowable concrete used for shaft construction would seal against the ground.

Casing would be required at drilled shaft excavations that extend through soft or loose surficial deposits. Where these unstable deposits extend to considerable depth, the casing may be incorporated into the shaft's structural design. Additionally, where drilled shaft completion depths would extend below static water levels, for excavation stability the fluid levels within the excavation must be maintained until concreting is completed. The counterbalancing fluid may simply be water and naturally derived cuttings, or specially formulated drilling mud. In areas of loose sands or soft clays, casings or drilling fluids such as an environmentally inert polymer slurry may be necessary to maintain the integrity of the drilled hole during construction. In either case, this fluid would be managed in accordance with Best Management Practices to protect the environment from uncontrolled releases. At a minimum, this would entail removing sediments and reusing/recycling fluid for continued drilling operations. Any construction wastes would be managed in accordance with prevailing environmental standards.

Construction-derived wastes (e.g., soil and liquids) would be managed in accordance with prevailing regulations. Uncontrolled releases would not be allowed. Slurry would be recycled through a de-sander and reused. Water would be collected and treated as needed prior to disposal or reuse. No contaminated soils would be disposed of in the Sole Source Aquifer area.

The movement of contaminants between surface layers and the basalt aquifer would have to be prevented. Areas where contaminants (e.g., petroleum products or pesticides in soil) are known to exist can be mitigated by a combination of methods to be determined at the time of construction. These methods could include the following:

- Requiring a minimum of one boring at each bent location prior to final design
- Isolating near-surface contaminants by using casing (permanent or temporary) to a sufficient depth to seal off the zone of potential contaminant migration
- Using the following mitigation methods in areas where floating product is encountered at depths too deep for casing:
  - using special deep foundations such as mini-piles or driven piles to minimize the duration of exposure
  - using a closed slurry system to ensure that contaminated slurry is not released to the environment
  - using ground treatment to stabilize/fixate the contaminated zone

The actual solution would need to be based on the nature of the contaminant of concern, and construction considerations relative to structural load demands.

3.2 Long-Term Impacts

No long-term impacts to the SOBA are anticipated. Once a shaft is filled with concrete or a driven pile is in place, surficial contaminants would not travel down the side of the shaft because the flowable concrete used for shaft construction would seal against the ground.

Once the Project is in operation, impervious surfaces would have been added for the fixed guideway, associated parking areas and transit stations, and a vehicle maintenance and storage facility. Stormwater runoff from these surfaces would enter the ground water system along different paths than previously (i.e., as the water runs off the guideway into the permanent BMPs or stormwater system). The ground water recharge needed to sustain the aquifer system would continue. There would be no long-term changes to ground water levels, including artesian conditions, as a result of the fixed guideway system. Runoff from the guideway itself should be relatively free of pollutants and should not threaten ground water quality in the SOBA.

Stormwater from parking lots may contain oil, grease, and other pollutants associated with automobiles. The potential vehicle maintenance and storage facilities would both be located mauka of the UIC line and designed to prevent pollutants from reaching the ground water. Any pollutants would have to be removed by permanent BMPs prior to infiltration into the ground water.

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