# Section 6 Summary and Interpretation

## 6.1 HHCTCP Background and Historic Preservation Regulatory Context

The Honolulu High-capacity Transit Corridor Project (HHCTCP) extends approximately 23 miles (37.0 km) from Kapolei in the west to the Ala Moana Center in the east. The purpose of the transit system is to provide high-capacity rapid transit in the highly congested east-west transportation corridor along O‘ahu’s South Shore via a fixed guideway rail transit system. The project will be funded by the Federal Transit Administration (FTA) and the Honolulu Authority for Rapid Transportation (HART) of the City and County of Honolulu (City). In addition to the guideway, the project will require construction of transit stations and ancillary support facilities. Project construction will also require relocation of existing utility lines within the corridor that conflict with the proposed project design. Minimally, land disturbing activities will include grading of facility locations and excavations for guideway column foundations, subsurface utility relocation and installation, and station and ancillary facility foundation construction. Utility relocation and roadway widening will make up the greatest project-related disturbance.

The HHCTCP is divided into 4 construction sections. From west to east these are as follows: Section 1, West-O‘ahu/Farrington Highway, extending from East Kapolei to approximately Leeward Community College; Section 2, Kamehameha Highway, extending from Leeward Community College to Aloha Stadium; Section 3, Airport, extending from Aloha Stadium to approximately the Middle Street Interchange; and, Section 4, City Center, extending from Middle Street to Ala Moana Center. The focus of this AIS investigation is City Center (Section 4; see Figure 1).

Due to federal funding (and use of federal U.S. Navy lands in Construction Section 3) the HHCTCP is a federal undertaking. With HART funding and the use of State of Hawai‘i and municipal lands, the HHCTCP is also a state project. Accordingly, the HHCTCP’s historic preservation review must comply with both federal (Section 106 of the National Historic Preservation Act) and Hawai‘i State (HRS Chapter 6E-8 and HAR §13-275) historic preservation review legislation. AIS preparation carefully followed the HHCTCP Programmatic Agreement (PA), Final—January, 18, 2011.

## 6.2 The City Center Archaeological Inventory Survey Plan

Following Stipulation III of the PA, this AIS investigation for City Center was carried out following an archaeological inventory survey plan (AISP) that was reviewed and accepted by the SHPD on October 25, 2011 (Log No. 2011.2379, Doc. No. 1110NN08). The AISP was prepared in compliance with the requirements of HAR §13-275-5(c), the Hawai‘i State rules governing AISPs. The AIS was specifically designed to focus on the identification of archaeological cultural resources because other project-related studies have been completed or are currently underway to address other types of cultural resources, such as traditional cultural properties and historic buildings and structures.

The preparation of the City Center AISP (Hammatt et al. 2011) involved thorough background research to compile a detailed predictive model of archaeologically sensitive areas within the City Center AIS study area. The study area is identified as an area of high archaeological sensitivity based on historic and cultural background research and the results of past archaeological research in the vicinity. The City Center archaeological predictive model was overlain on the project's preliminary engineering plans to develop a sampling strategy to test various components of the HHCTCP construction—primarily utility relocations, fixed-guideway support columns, and station touch-down footprints. An initial sampling strategy of 232 test excavations was described in the AISP, with clear guidelines for consultation with the SHPD and HART to expand the testing in areas where archaeological cultural resources were identified or suspected based on initial testing results.

Subsequently consideration was given to an alternate site (Alternate A) for the Kaka‘ako Station located approximately 50 m northeast (*mauka*) of the Kaka‘ako Station location addressed in the Hammatt et al. (2011) AISP for City Center. This alternate station site, and associated minor changes to the immediately adjacent guideway alignment, were addressed in an Addendum AISP (Hammatt et al. 2013). The Addendum AISP was accepted by SHPD on March 1, 2013 (Log No. 2013.1958, Doc. No. 1302SL28).

## 6.3 City Center AIS Fieldwork

The City Center AISP fieldwork effort was summarized as follows (from Hammatt et al. 2011:iii):

A. CSH principal investigators Matt McDermott, M.A. and Hallett H. Hammatt, Ph.D. will direct the City Center AIS.

B. An anticipated field crew of eight to fourteen archaeologists, two field directors, two GPS/GIS specialists, and two GPR specialists will complete the AIS investigation under the direction of the principal investigators. Detailed sample analysis will be provided by International Archaeological Research Institute, Inc., (wood/charcoal speciation), PaleoResearch, Inc., (pollen speciation), and Beta Analytic, Inc., (radiocarbon dating).

C. Six to ten months are estimated to complete AIS fieldwork.

D. Fieldwork will include 100 percent pedestrian inspection of the study area; global positioning system (GPS) data collection; ground penetrating radar (GPR) survey; and subsurface testing. All areas selected for subsurface testing will be surveyed with a Geophysical Survey Systems, Inc., SIR-3000 GPR unit equipped with a 400 MHz antenna. The planned subsurface testing program will be backhoe-assisted. In general, linear trenches measuring approximately 3 m or 6 m (10 ft or 20 ft) long and 0.6 or 0.9 m (2 ft or 3 ft) wide will be excavated within the project footprint (based on preliminary engineering) at selected station locations, guideway column locations, and utility relocation areas. Two hundred and thirty two (232) test excavations are proposed, with provisions for additional testing to refine the boundaries and/or further investigate subsurface archaeological deposits. This additional testing will be designed in consultation with project engineers to seek ways for project construction to avoid significant archaeological cultural resources.

   The subsurface testing sampling strategy was developed giving consideration to sediment types; natural geographic features, such as streams and ponds; background research, including information from historic maps and Land Commission Award (LCA) documents; the results of previous archaeological studies in the vicinity; the results of consultation with the Native Hawaiian community; an assessment of the impact of prior land development; and a consideration of safety concerns for actually carrying out the archaeological work.

E. The greatest factors limiting the AIS survey effort include 1) the survey area’s large (5.6 ha or 13.87 acres) and dispersed (6.9 km or 4.3 miles) area; 2) the survey area’s highly developed and highly active setting (in-use city streets, sidewalks, and buildings); and 3) the dense, complex array of existing subsurface utilities in the survey area.

F. Test excavations (backhoe-assisted trenches) will be the primary means of identifying and documenting archaeological cultural resources.

G. AIS documentation of observed archaeological cultural resources will include stratigraphic profiles and plan views, available cultural resource boundary information based on additional testing, sample collection and analysis, written descriptions, photographs, and artifact analysis.

H. All identified archaeological cultural resources (historic properties) will be documented and located with a Trimble ProXH mapping-grade GPS unit (sub-foot accuracy).

The above AISP summary (A-H) largely reflects actual City Center fieldwork effort. The following four points address modifications that occurred during the project:

1. Pedestrian inspection of the City Center AIS study area was carried out at three separate times: (1) in May 2011 to support the preparation of the City Center AISP (Hammatt et al. 2011), (2) in November 2011 when the City Center AIS fieldwork began, and (3) in February 2013 when the AIS subsurface testing program was complete.

2. A GPR survey was carried out at all test excavation locations prior to testing, and the results were compared to the actual excavation results to evaluate the GPR method.

3. Two hundred fifty (250) machine-assisted test excavations (232 original, 9 abandoned, and 27 added test excavations) were documented as part of the City Center AIS (8% more than the 232 test excavations specified as the initial sampling strategy in the City Center AISP). As outlined in the City Center AISP, consultation among CSH, PB, and the SHPD was effective in determining areas for additional subsurface testing in areas where initial testing results indicated additional investigation was appropriate.

4. Not mentioned in the AISP summary above were geotechnical cores. In consultation with the SHPD, seven geotechnical cores were carried out under archaeological supervision to investigate specific stratigraphic layer distributions and boundaries. These geotechnical cores, carried out at the Chinatown Station (SIHP #50-80-14-7427) and in the vicinity of Test Excavation 124 (SIHP #50-80-14-2963), provided additional stratigraphic information in instances where built environment constraints made additional backhoe testing problematic.

5. Fieldwork was carried out intermittently between November 2011 and February 2013. Fieldwork required approximately 6,300 person hours or 785 person days to complete.

6. A “*Consultation Protocol for Iwi Kūpuna Discovery During the Archaeological Inventory Survey for the City Center (Construction Phase 4)*” (Hammatt 2011) was developed to facilitate consultation regarding the treatment of identified human skeletal remains; this document was

reviewed and approved by FTA in accordance with the PA. Seven City Center AIS test excavations, located within four archaeological cultural resources (SIHP #50-80-14-7427, #50-80-14-5820, #50-80-14-7429, and #50-80-14-2918), documented human skeletal remains. These ranged from previously disturbed single bones within imported fill deposits to complete, previously undisturbed flexed individuals in Jaucas sand deposits. In all cases, the documentation, consultation, and treatment of the remains followed the City Center AISP (Hammatt et al. 2011) and the "*Consultation Protocol for Iwi Kūpuna Discovery*" (Hammatt 2011). This included immediate notification and consultation with the Oʻahu Island Burial Council (OIBC) Kona representatives, the SHPD, and project engineers. Consultation regarding ethnicity, treatment decision jurisdiction (the SHPD or the OIBC), and the applicability of Hawaiʻi State Burial Laws (HRS Chapter 6E-43 and HAR §13-300) is currently underway between the SHPD and the HART. Consultation with potential and recognized cultural descendants of the remains is on-going and will likely culminate in a City Center burial treatment plan (per HAR §13-300).

## 6.4 Division of the City Center AIS Study Area into Geographic Zones

For organization and results presentation, as well as to provide a suitable context to interpret the results of test excavations and the significance of identified archaeological cultural resources, the 6.9 km of the City Center AIS study area were divided into 11 geographic zones. The boundaries of the 11 geographic zones were based on background research and fieldwork results. Areas with similar stratigraphy and geomorphology, and, where feasible, areas within traditional Hawaiian *ahupuaʻa* were grouped together.

## 6.5 Identified Archaeological Cultural Resources

Nineteen (19) archaeological cultural resources were identified within, or immediately adjacent to, the City Center AIS study area. Twelve of these resources were previously identified and documented, while seven cultural resources were newly identified during the City Center AIS. The previously-identified cultural resources consist of SIHP #s 50-80-14-2918, -2963, -5368, -5820, -5966, -6636, -6856, -7124, -7189, -7190, -7193, and -7197. The newly-dentified cultural resources consist of SIHP #s 50-80-14-7425, -7426, -7427, -7428, -7429, -7430, and -7506.

### 6.5.1 Archaeological Cultural Resource Function

Of the 19 archaeological cultural resources identified within, or immediately adjacent to, the City Center study area, 17 cultural resources were documented during test excavations. Two were not identified, but were close enough to warrant consideration of potential project effect (Kawa Fishpond, SIHP #-5966, and a buried, culturally enriched, sand A-horizon, SIHP #-7197). The cultural resources consisted of a wide range of function types including habitation, burial, aquaculture, agriculture, commercial infrastructure, refuse disposal, salt production, cooking, and toilet. Many of the cultural resources encompass multiple functions. It is important to note that the cultural resources ascribed a refuse disposal function may also have functioned as land reclamation. Land reclamation, however, is not provided as a function category in this discussion because it would not represent the number and distribution of all land reclamation fill layers as many fill layers used for land reclamation purposes were not designated as cultural resources during this AIS. This is based on current practice, where SIHP numbers are generally assigned only to fill layers that contain identifiable and datable cultural material.

A habitation function, ascribed to nine cultural resources, constituted the largest percentage (47%), while aquaculture (26%), burial (16%), and refuse disposal (16%) were moderately represented. Several functions were only represented once. Cultural resource functions are described in the following paragraphs from most common to least common and a breakdown of cultural resources by function type is provided in Table 91. Figure 427 through Figure 430 depict the locations of the cultural resources color-coded by function.

Cultural resources with a habitation function were located within generally contiguous geographic zones along the Honolulu/ Kakaʻako coastline, from Downtown Waterfront through Kakaʻako Makai and West Kakaʻako to Kālia (Table 92). The cultural resources with a habitation function consisted of five cultural resources dating to the pre- and post-Contact, one dating to the late pre- to early post-Contact, two dating the the post-Contact, and one undetermined that potentially dated to the pre- and post-Contact. Pre- and post-Contact habitation was represented by subsurface, culturally-enriched A-horizons (former land surfaces) that were determined to span the pre- and post-Contact periods based upon associated archaeological features, burials, and artifacts as well as radiocarbon analysis. Late pre- to early post-Contact habititation at SIHP #-7197 was based on radiocarbon analysis. Post-Contact habitation included subsurface commercial or residential infrastructure remnants comprised of historic building material or subsurface deposits containing solely post-Contact cultural material. The one undetermined, potentially pre- and post-Contact habitation area (SIHP #-7429) was represented by a buried A-horizon with sparse cultural content that lacked definitive evidence of age.

Cultural resources with an aquaculture function consisted of subsurface marine fishpond remnants (SIHP #-5368 and -5966), subsurface inland fishpond remnants (SIHP #-2963 and -6856), and subsurface wetland deposits including unnamed pond remnants (SIHP #-6636). The subsurface marine fishpond remnants (Kūwili and Kawa Fishponds) were located along the shoreline of Iwilei. The subsurface inland fishpond remants (Kolowalu and unnamed ponds)

Table 91. Cultural Resources Categorized by Function

| Function | Number of Cultural Resources | Percentage of Total | SIHP #50-80-14- | Geographic Zone |
|---|---|---|---|---|
| Habitation (pre- or post-Contact) | 9 | 47 | 7427, 7428, 2963, 7124, 7197, 5820, 7429, 2918, 6636 | Downtown Waterfront, West Kakaʻako, Kewalo, Kālia, Kakaʻako Makai |
| Aquaculture | 5 | 26 | 5368, 5966, 2963, 6856, 6636 | Iwilei, West Kakaʻako, Kālia, East Kakaʻako |
| Burial | 3 | 16 | 2963, 5820, 2918 | West Kakaʻako, Kakaʻako Makai |
| Refuse Disposal | 3 | 16 | 7189, 7193, 7506 | West Kakaʻako, Kakaʻako Makai, Kālia |
| Commercial Infrastructure | 3 | 16 | 7124, 7427, 7428 | Downtown Waterfront, West Kakaʻako |
| Agriculture | 2 | 11 | 7426, 6636 | West Kapālama, East Kapālama, Kālia |
| Cooking | 1 | 5 | 7425 | West Kalihi |
| Salt Production | 1 | 5 | 7190 | Kakaʻako Makai |
| Toilet | 1 | 5 | 7430 | Kālia |

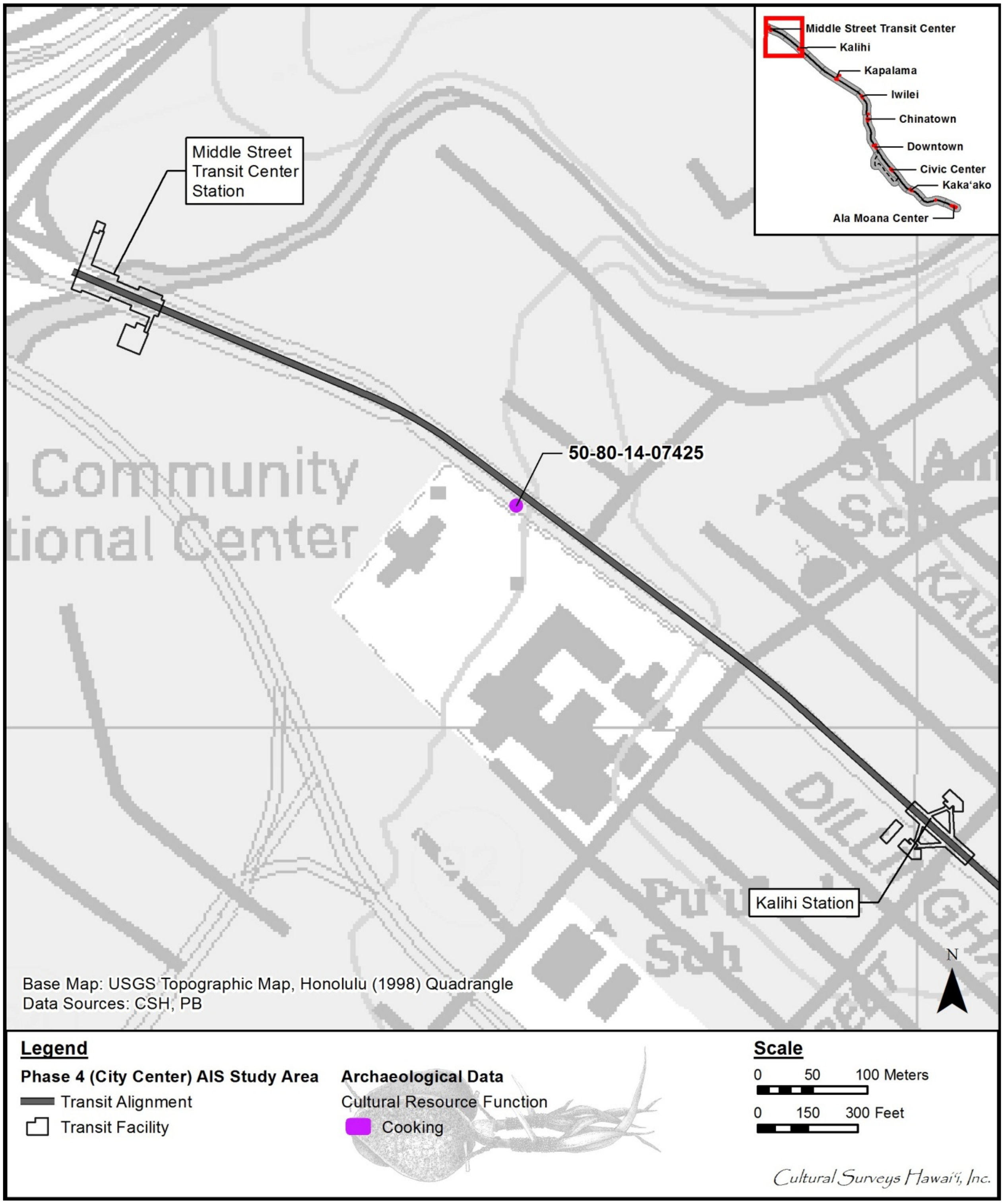



Figure 427. Locations of cultural resources at the west end of the City Center AIS corridor color-coded by function (base map: 1998 U.S.G.S. topographic map, Honolulu Quadrangle)

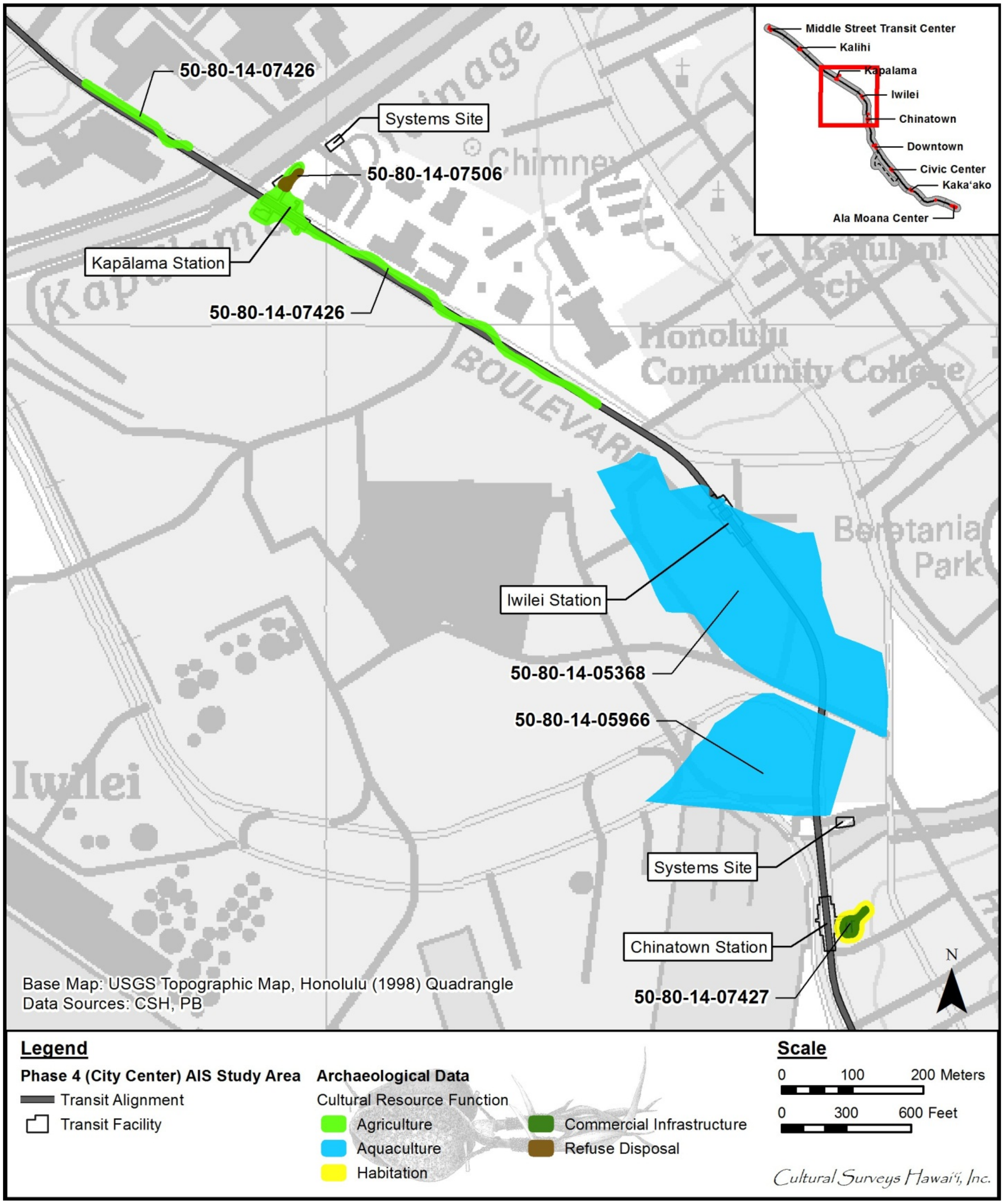



Figure 428. Locations of cultural resources in the center of the City Center AIS corridor color-coded by function (base map: 1998 U.S.G.S. topographic map, Honolulu Quadrangle)

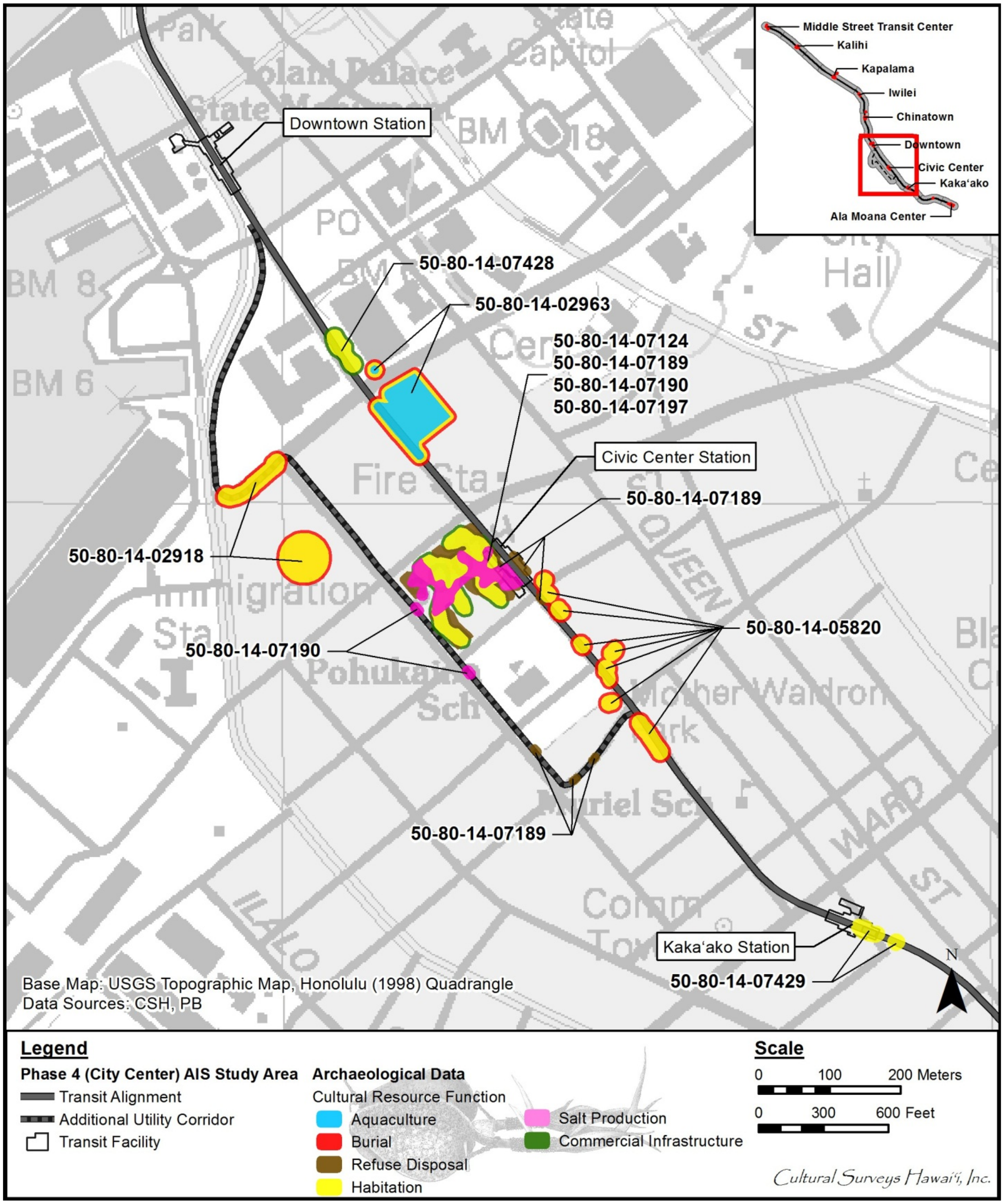



Figure 429. Locations of cultural resources in the center of the City Center AIS corridor color-coded by function (base map: 1998 U.S.G.S. topographic map, Honolulu Quadrangle)

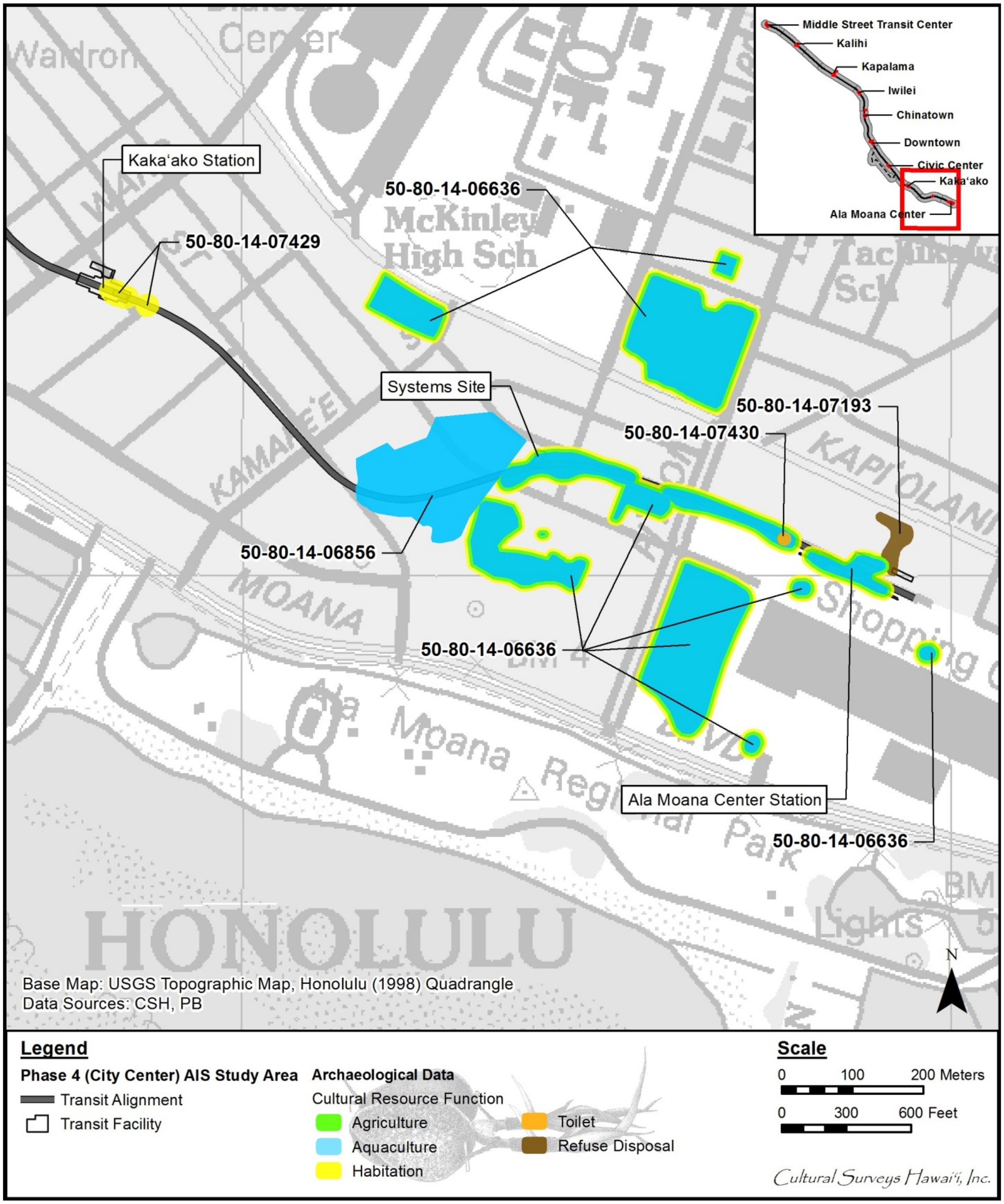



Figure 430. Locations of cultural resources at the east end of the City Center AIS corridor color-coded by function (base map: 1998 U.S.G.S. topographic map, Honolulu Quadrangle)

Table 92. Habitation Sites Identified within the City Center AIS Study Area

| SIHP #50-80-14- | Form | Date | Location |
|---|---|---|---|
| 7427 | Subsurface infrastructure remnants, cultural deposits, and a human skeletal element | Post-Contact | Downtown Waterfront Geographic Zone |
| 7428 | Subsurface cultural deposit and infrastructure remnants | Pre- and post-Contact | West Kakaʻako Geographic Zone |
| 2963 | Subsurface cultural deposit, pond sediments, human burials, and animal burials | Pre- and post-Contact | West Kakaʻako Geographic Zone |
| 7197 | Subsurface cultural deposit and pit feature | Late pre-Contact to early post-Contact | West Kakaʻako Geographic Zone |
| 7124 | Subsurface infrastructure remnants | Post-Contact | West Kakaʻako Geographic Zone |
| 5820 | Subsurface cultural deposit and human burials | Pre- and post-Contact | West Kakaʻako Geographic Zone |
| 7429 | Subsurface cultural deposit and a human skeletal element | Undetermined, potentially pre- and post-Contact | Kewalo Geographic Zone |
| 2918 | Subsurface cultural deposit and human burials | Pre- and post-Contact | West Kakaʻako Geographic Zone |
| 6636 | Subsurface Kewalo wetland deposit | Pre- and post-Contact | Kālia |

were located within the West and East Kaka‘ako geographic zones. The subsurface wetland deposits, including unnamed pond remnants, were located in the East Kaka‘ako and Kālia geographic zones. The cultural resources with an aquaculture function were characterized by dark clay-based sediments, abundant fresh- and brackish-water snails, and organic material. Additonally, these cultural resources were located within the boundaries of former fishponds or unnamed ponds that were depicted on numerous historic maps and/or aerial photographs.

Cultural resources with a burial function were identified within the West Kaka‘ako and Kaka‘ako Makai geographic zones. Human burials documented during the City Center AIS included SIHP #-2918 Feature 13 and Feature 27 and SIHP #-5820 Feature 30. Human burials documented during previous archaeological studies included human skeletal remains representing six incomplete skeletons identified by Ota and Kam (1982) and assigned SIHP #-2963, seven burials identified by Clark (1987) and assigned SIHP #-2963, and five burial pits identified by Yent (1985) and assigned SIHP #-2918.

Cultural resources with a refuse disposal function were located in the East Kapālama, Kaka‘ako Makai, and Kālia geographic zones (SIHP #s -7506, -7189, and -7193). The cultural resources are characterized by abundant historic debris within variable sediment matrices that were typically deposited over wetlands or lowlands. The composition of these cultural resources, as well as their locations over wetland deposits, are consistent with historic land reclamation activity in Kapālama, Kaka‘ako, and Kālia.

Cultural resources with a commercial infrastructure function were located in the Downtown Waterfront and West Kaka‘ako geographic zones. These cultural resources consisted of subsurface structural remnants including concrete slabs, stone and mortar walls and foundations, and brick walls.

Cultural resources with an agriculture function were located in the West Kapālama, East Kapālama, and Kālia geographic zones. These cultural resources included subsurface wetland deposits (SIHP #-7426 and -6636) characterized by highly organic sediment containing marine shell, fresh- and brackish-water snails, plant remains, and charcoal. Backgorund information, historic maps, and aerial photographs document both taro and rive cultivation within these wetland areas.

One cultural resource with a cooking function was documented within the West Kalihi Geographic Zone. The cultural resource consisted of a subsurface fire feature remnant that was interpreted as the remains of a single *imu* or earth oven.

One cultural resource related to salt production was documented in the Kaka‘ako Makai Geographic Zone (SIHP #-7190). The cultural resource is characterized by silty clay with thick lenses of peat and a potential man-made sand berm.

One cultural resource functioned as a toilet or privy and was documented in the Kālia Geographic Zone (SIHP #-7430). The privy consisted of a rectangular wooden structure composed of wood planks and posts and containing deposits of historic refuse and night soil.

## 6.6 Laboratory Results

### 6.6.1 Summary of Traditional Hawaiian Artifacts

Test excavations within the City Center AIS study area produced a total of 63 traditional Hawaiian artifacts. The traditional Hawaiian artifacts consisted of a range of artifact types and function, including: volcanic glass debitage, basalt debitage and possible adze fragments, bone, shell, and basalt fishing tools, a basalt game stone, a basalt sling stone weapon, a bone eating implement, a dog tooth ornament, and a boar tusk ornament. The majority of the traditional Hawaiian artifacts consisted of volcanic glass debitage (71.4%) with the remaining artifacts consisting of basalt flakes (12.7%) and miscellaneous artifacts (15.9%).

The largest percentage of volcanic glass debitage was found within the West Kakaʻako Zone of the City Center AIS study area (55%) followed by the Kakaʻako Makai Zone (22%). The majority of the basalt flakes and miscellaneous artifacts were also found within the West Kakaʻako Zone (50%) as well as the Downtown Waterfront Zone (39%). This distribution of traditional Hawaiian artifacts corresponds with the areas of culturally-enriched A-horizon deposits and associated features documented by the City Center AIS, which were concentrated within the Honolulu and Kakaʻako coastal areas.

### 6.6.2 Energy-Dispersive X-ray Fluorescence Analysis

Energy-Dispersive X-ray Fluorescence (EDXRF) analysis was carried out on 27 traditional Hawaiian artifacts to establish geochemical "fingerprints" for comparative purposes. The volcanic glass samples submitted for analysis fall into two geochemical groups (Groups 1 and 2), each with very similar elemental fingerprints. Based solely upon their elemental signature, the two groups originate from two discrete geological sources. Group 1 volcanic glass samples exhibit a geochemical signature similar to volcanic glass known from a Waiāhole, Oʻahu quarry (Cleghorn et al. 1985). There is currently a limited dataset for Honolulu volcanic and other post-shield eruptions on Oʻahu. According to the available data (Cleghorn et al. 1985; unpublished data from H3 Project), Group 1 volcanic glass appears to more closely match the geochemical trend in Waiāhole volcanic glass than any other. It would be impossible, however, to definitively provenience Group 1 volcanic glass to the Waiāhole Quarry given the extremely limited datasets for Oʻahu volcanic glass. The Group 1 samples account for 67% of the volcanic glass samples submitted for analysis. This Waiāhole-like volcanic glass was identified throughout the City Center corridor, as far west as the West Kalihi Geographic Zone to as far east as the West Kakaʻako Zone.

In contrast, the volcanic glass from Group 2 was collected within a 2 km stretch southeast of the Nuʻuanu Stream mouth. Group 2 samples account for the remaining 33% of the volcanic samples. Given that the Group 2 samples do not correspond with any known Oʻahu geochemical trends, two contrary hypotheses are suggested. The Group 2 volcanic glass could relate to a more localized and as-yet unknown source, perhaps in the neighboring leeward south Koʻolau volcanic range, with limited distribution. Variously, assuming that the project area (i.e. downtown Honolulu) was more heavily involved in interisland interchange than most areas of the archipelago, the likelihood of finding imported volcanic glass here may be greater than in other foci of traditional Hawaiian settlement. For example, it seems probable that the Maui and Hawaiʻi Island forces involved in the conquest of Oʻahu and the establishment of the center of

Kamehameha's kingdom in what is now downtown Honolulu in the 1795 to 1810 timeframe, would have transported volcanic glass from their home islands to this immediate area of Oʻahu.

One basalt gaming stone and one basalt waste flake were also submitted for EDXRF analysis. The basalt game stone bears a close elemental signature to a lithic sample from Nuʻalolokai on Kauaʻi, while the basalt flake shows similarities to Big Island samples (Puʻu Waʻawaʻa). Until a larger database for Oʻahu volcanic is established, it remains difficult to source samples.

### 6.6.3 Summary of Historic Artifacts

A total of 1,441 historic artifacts/artifact fragments was collected, consisting of 384 ceramic vessels/ceramic vessel fragments, 541 glass bottles/bottle fragments, and 516 miscellaneous items.

There were mainly two types of historic deposits examined in the test excavations in the HHCTCP City Center study area, a twentieth century deposit found in the western and eastern areas, and a mainly late nineteenth/early twentieth century deposit found in the central Honolulu and Kakaʻako areas. In the West Kalihi (T-018) and East Kapālama (T-060, T-064, T-065, T-066, and T-082) Geographic Zones (western areas), fill layers had machine blown bottles (ABM) dating from the 1930s to 1940s. In the Iwilei area (western area), bottles post-dated ca. 1900, and included both mold-blown bottles and machine-blown bottles (T-086, T-087, and T-089), with bottles dated to the 1910s to 1930s. This is probably an indication of the late development of these areas in the expansion of the urban area of Honolulu or the late date for the use of this area for trash deposit. In the Downtown, West and East Kakaʻako, and Kakaʻako Makai Geographic Zones (central section), test excavations documented mainly fill layers with trash from the late nineteenth century into the early twentieth century. Bottles typically dated from the 1870s to the 1920s, within the mold-blown period (ca. 1800-1920). There was one definitely free-blown bottle with a pontil mark (Kakaʻako Makai, T-227A), which would indicate a pre-1850 date. This bottle was probably made by a British or European company, who were slower to abandon the older manufacturing techniques and made some free-blown bottles with pontils into the 1920s. In the Downtown and Kakaʻako deposits, there were few machine-blown (post-1903 to present) bottles, especially bottles that could be dated to the post-1920s period. In the Kālia Geographic Zone (eastern section), some test excavations (T-214 and T-222) have only post-1920s material, indicating the late commercial development of this area or the late use of this area for trash deposit. There are also test excavations (T-200 and T-202) with the same type of 1870s to 1920s artifacts as the Kakaʻako area, either from deposition of nearby domestic refuse, from open-air burning, or the use of trash to fill in this former low-lying wetland area.

The ceramics dates in these test excavations mirrored the late nineteenth- to early twentieth-century bottle dating results. Some of the Euro-American-made ceramics with datable company marks (T-121, T-130, T-143, T-232A) could have been manufactured as early as the 1850s, but these types of wares may have been passed down through generations, and may have a long deposition lag between the manufacturing date, through the purchase and use date, until they were finally discarded. The exported Asian wares are common artifacts found in nineteenth-century archaeological deposits from American towns with sizeable Chinese and Japanese communities. The Chinese wares have a long manufacturing date range, but the Japanese "Dashed Line" porcelains were made and exported from the 1870s to ca. 1920, and are usually found in deposits dating to that age period (Ross 2012:5, 7).

In the Iwilei Geographic Zone, from test excavations (T-086, T-089, and T-090), near the former OR&L railroad terminal building, several rail spikes, probably part of the old railroad tracks, were recovered. The spikes were found in large in-filled trash pits with bottles dating to the machine-blown era (post-1903) with some bottles dated more narrowly to the 1920s to 1930s. In the Kewalo Geographic Zone (T-164) and in Kaka‘ako Makai (T-227) railroad spikes and a part of a railroad track (T-226D) were found. In this case, the rail may be part of the Honolulu streetcar system that operated from 1898 to 1933. Much of the construction debris (nails, bricks, milled wood, etc.) is probably also the result of some commercial enterprise, as the Honolulu area, especially before the 1900 Chinatown fire, was a mixture of commercial and residential buildings. Before, and especially after, the fire, industries and residences began to move into the Kaka‘ako area to the east. To develop this area, people were encouraged to take their trash and fill in former ponds and swamps (Griffin et al. 1987:13; Hawaii Supreme Court 1915:329). Large sections of Kaka‘ako were also used for open-air trash burning (Young 2005).

### 6.6.4 Faunal Analysis

Faunal analysis was conducted on material that was collected in three ways: (1) through dry screening in the field of bulk sediment samples; (2) through wet screening of bulk sediment samples in the laboratory; and (3) through hand collection of individual faunal remains in the field to verify that the remains were not human skeletal remains. Faunal analysis of bulk sediment samples largely documented invertebrate midden and fish, while the hand-collected faunal material documented terrestrial vertebrates.

The faunal assemblage from bulk sediment samples identified areas of previous wetlands, shallow marine environments, and areas of cultural activity, as evidenced by distinct midden signatures. Terrestrial and marine midden consistent with traditional Hawaiian consumption, as well as historic consumption, was documented in those areas that contained buried A-horizons in Jaucas sand.

The hand-collected, largely terrestrial faunal assemblage which provided evidence primarily of post-Contact food scrap deposition in fill or culturally-enriched layers was represented by a high percentage of cow and other large species. Very few unmodified dog and pig fragments were identified in culturally-enriched layers. No other traditional Hawaiian terrestrial food scrap deposition was identified during hand collection.

Identified vertebrates included horse, cow, pig, sheep/goat, dog, cat, bird, chicken, duck, turkey, rat, sea turtle, shark, and a variety of bony fish. Identified invertebrates included crustaceans, sea urchins, and a variety of mollusks. The density and nature of the faunal remains supported the identification of areas of more intense habitation.

### 6.6.5 Analysis of Non-marine Mollusks

Dr. Carl C. Christensen prepared an “Analysis of Nonmarine Mollusks from Selected Sites for the City Center Section AIS” that analyzed 11 samples from eight test excavations. The eight test excavations were located within three distinct areas of the project corridor: the Kapālama wetlands (T-057, T-075, and T-078); the West Kaka‘ako wetlands (T-131); and the Kewalo wetlands (T-186, T-189, T-207, and T-219). Three of the test excavations (Kapālama Zone) were located within agricultural wetland sediment previously utilized for taro, and subsequently rice, production. The remaining five test excavations were located in areas of natural wetlands, including the intermittent wetlands of Kakaʻako and the relatively extensive wetland area of Kewalo.

Aquatic snails characteristic of fresh- or brackish-water environments predominated in all the samples analyzed, while strandline/shoreline species were also present to a lesser degree in all samples. This result is consistent with the coastal location of these sites. *Melanoides tuberculata*, a species that requires permanent water, was present within all samples except T-131, indicating that T-131 may have periodically dried out while all the other sites retained permanent water. The absence of two (presumed) Polynesian-introduced species within T-131 (*M. tuberculata* and *Tarebia granifera*) and the presence of a (presumed) native species (*Tryonia porrecta)* within T-131 also suggests the possibility that the sample from T-131 represents sediments from an age prior to human settlement.

Sites that contained only native and Polynesian-introduced snails consisted of T-075, T-186, T-189, and T-207. Sites that also contained historically-introduced snails consisted of T-057, T-078, and T-219. The presence of historically-introduced snails in these test excavations is consistent with rice cultivation. The absence of historically-introduced species within T-075, which was also located within the area of rice cultivation within the Kapālama wetlands, is not necessarily significant as the numbers of historically-introduced species is normally very small. It is also noted that T-075 was unusual in the absence of the normally abundant native species *T. porrecta* and the heavily eroded state of the snail shells identified.

### 6.6.6 Wood Taxa Analysis

This project included an extensive charcoal taxa analysis, carried out by Gail Murakami of the International Archaeological Research Institute, Inc. This analysis served two purposes: (1) to aid in the selection of charcoal samples for radiocarbon dating; and (2) to identify plant species present to aid in the reconstruction of the environment and its potential change over time. A surprisingly large number of taxa were identified (31), which aided in a reconstruction of the environment in late pre-Contact and early post-Contact times. The wide variety of species represented in the samples may indicate that the lowland leeward forests were once populated with a diverse array of flora, consisting predominantly of shrub-like species. Within the samples with the earliest radiocarbon dates, between the mid-1400s to mid-1600s (T-020 and T-020A in Kalihi; and T-124, T-142, T-145, T-146A, and T-151 in West Kakaʻako), the most common species consisted of *kukui*, *niu* (Polynesian-introduced), *lama*, *ʻōhiʻa lehua, hōʻawa*, and *ʻaʻaliʻi* (native species). Other species represented in these early samples consisted of native *ʻakoko*, *ʻūlei*, *pūkiawe*, *ʻāheahea*, *kōpiko*, *koʻokoʻolau*, and *ʻilima*. Of the samples which were dated to the late pre-Contact to post-Contact time period, the dominant taxa represented consisted of *kukui* followed by *hau*, *ʻakoko*, *ʻāheahea*, *ʻilima* (native), *kolomona* (native or historic), and cf. *Syzygium* sp. (*ʻōhiʻa ʻai*, roseapple, or Java plum – Polynesian-introduced or historic). A decrease in the percentage of *hōʻawa, pūkiawe,* and *lama* in the archaeological record suggests that these species were in a state of decline by post-Contact times. The prevalence of cultigens within the Kakaʻako area supports the view that Hawaiians at western contact were living in a botanical environment that was to a remarkable extent of their own making.

### 6.6.7 Radiocarbon Dating

Twenty-eight charcoal samples of identified, short-lived, native Hawaiian plant species, *kukui (Aleurites moluccana)* nut shell, and coconut (*niu, Cocos nucifera*) shell were sent to Beta Analytic, Inc., of Miami, Florida for carbon dating. Carbon samples from contexts including post-Contact artifacts or typically post-Contact wood (conifer and temperate hard wood) were excluded from selection for dating. Hence, there was a deliberate bias in sample selection for what were believed to be pre-Contact deposits.

The 28 charcoal samples were distributed within the Kalihi, West Kakaʻako, and Kakaʻako Makai geographic zones. The vast majority were located within the Kakaʻako area (79% within West Kakaʻako and 14% within Kakaʻako Makai), which corresponds with the geographic location of the majority of the buried culturally-enriched A-horizons documented during the City Center AIS. Within the Kalihi Zone, two samples were dated from an *imu* feature (T-020, SIHP #-7425) and a nearby charcoal lens (T-020A). Within the West Kakaʻako Zone, nine samples were taken from SIHP #-7428 (T-119A, T-120, and T-120A), four sample were taken from SIHP #-2963 (T-124), and nine samples were taken from SIHP #-5820 (T-142, T-145, T-146A, T-150, and T-151). Within the Kakaʻako Makai Zone, four samples were taken from SIHP #-2918 (T-226B and T-227A).

A total of 26 features were dated, 25 of which are associated with a buried culturally-enriched loamy sand A-horizon, with the exception of the T-020 *imu* feature which is located within alluvial sediments with no discernible A-horizon. Of the 26 features, two are possible postmolds, two are *imu* features, 22 are pits of indeterminate function, and one is a builder's trench derived from A-horizon sediments.

Of the 28 samples, 20 (71%) yielded carbon dates with 2-sigma date ranges extending into the twentieth century. These 20 "late" dates typically span the past three centuries (AD 1650-1950) with stronger probabilities for nineteenth and twentieth century calendar ages. This very large percentage of "late" dates is suggested to reflect the extraordinary growth of the greater Honolulu area in the early post-Contact period particularly following the conquest of Oʻahu by Kamehameha I in 1795 and his encouragement of Honolulu as a center of commerce. It must be kept in mind, however, that these dates are inconclusive due to the negligible radiocarbon calibration curve for the period between AD 1650 and 1950, which makes chronological distinctions during this time period difficult.

Six samples had exclusively pre-Contact dates that clustered relatively tightly in the AD 1440 to 1660 time period (T-020 *imu*, T-020A charcoal lens, T-124 Fe. 11, T-145 Fe. 9, T-146A Fe. 14, and T-151 Fe. 25). An additional two samples had only a very small likelihood of dating to the post-1670 time period, with an 88.9-95.4% probability of dating to AD 1490-1670 (T-124 Fe. 5 and T-142 Fe. 8); see corresponding SIHP #s above. These early dates were documented only within the Kalihi and West Kakaʻako Zones. Significantly, all test excavations within West Kakaʻako that contained these early dates also contained features dating to the late pre-Contact to post-Contact time period, thus indicating continued usage of the area through time.

It was somewhat surprising that no earlier dates were acquired. A lack of earlier dates may be due to the fact that the present City Center AIS study missed areas of earlier settlement by virtue of being too seaward. Much of the present alignment was actually off-shore of this Downtown Honolulu area of particular interest for relatively early settlement.

### 6.6.8 Pollen Analysis

Results of pollen analysis were prepared in a report, "*Pollen Analysis of Samples from the Honolulu High-Capacity Transit Corridor Project, Honolulu, Hawaiʻi*" by Linda Scott Cummings with assistance from R. A. Varney, of PaleoResearch Institute, Golden, Colorado. The pollen analysis report indicated that the former environment along the City Center AIS corridor was primarily one of sedges and grasses representing marshy land and grasslands. Indigenous, Polynesian-introduced, and Western-introduced (post-Contact) pollen species were identified. Several of the pollen samples suggest post-Contact environmental change as evidenced by the presence of pollen from exotic species. Alternatively, it is possible that some of the exotic pollen species represent post-depositional contaminants. A decrease in specific pollen types associated with the wetland environment (i.e. Cyperaceae) appears to correspond with post-Contact land reclamation efforts throughout the project area. Samples indicated that several plant varieties were formerly cultivated, including taro, rice, cow pea, cotton, and sugar cane. Rice and taro agriculture were shown to be far more widespread than cotton and sugar cane cultivation. The lack of traditional Hawaiian cultigens within the pollen record does not necessarily negate their presence within the former landscape. Several of these plants including taro, *kukui*, and noni are insect-pollinated and, therefore, more likely to be under-represented in the pollen record.

## 6.7 AISP Research Focus

As described in Section 2.2 of this volume, the City Center AISP outlined five research foci for which, based on extensive AISP background research, the City Center AIS could be expected to provide significant additional information. The five research foci deal with settlement along the City Center AIS corridor, GPR utility, pre-Contact landforms and shorelines, human-induced environmental change, and burials. The results of research on each of these foci are described in detail, below.

### 6.7.1 Depositional Sequences

The linear, dispersed nature of the City Center guideway alignment increased the informational value of the AIS study in that it provided a long cross-section transect through the majority of the most archaeologically sensitive portion of Oʻahu's south shore. This cross-section traversed four *ahupuaʻa*, Kalihi, Kapālama, Honolulu, and Waikīkī, and passed through distinct environmental and cultural settings. An evaluation of depositional sequences within the 11 City Center AIS geographic zones and identified archaeological cultural resources provides insight into pre- and post-Contact settlement and land use.

The western portion of the West Kalihi Geographic Zone is characterized by thick fill deposits over natural estuary alluvium. These estuary sediments contain a mix of terrestrial gravels, silts, and sands, with marine shell and some charcoal and historic artifacts—the charcoal and artifacts represent activity in the immediate watershed, which would have been extensive from pre-Contact times into the modern era. The area has been greatly disturbed and altered by historic and modern development, particularly by the introduction of massive fill deposits.

The various fill layers directly overlying the natural alluvial deposits were originally deposited during the construction of roadways (i.e., West Queen Street/Kamehameha Highway and Dillingham Boulevard). A review of historic maps shows that West Queen Street (now Dillingham Boulevard) was just beginning to encroach into the West Kalihi Geographic Zone from the east in 1919 and a completed roadway was present along the HHCTCP corridor by 1933 (Figure 431 and Figure 432).

The eastern portion of the West Kalihi Geographic Zone has similar thick fill deposits, but these cap a distinct layer of terrestrial alluvium, which in turn overlies the Kalihi Stream estuary sediments near the water table. Preserved within this deep terrestrial alluvium layer were the remains of a single subsurface fire feature remnant that was interpreted an a single *imu* or earth oven (SIHP #-7425). This pre-Contact feature (radiocarbon dated to the fifteenth or sixteenth century) is a remnant of the use of this resource-rich estuarine and wetland locality. No additional preserved remains of traditional Hawaiian activity were found in this area. This lack of additional preserved remains may be the result of disturbance related to the construction and subsequent expansion and redevelopment of Kamehameha Highway and Dillingham Boulevard.

Further east, the East Kalihi and West Kapālama Geographic Zones are located on the raised Pleistocene coral shelf related to the 7.5 m Waimanalo stand of the sea (Macdonald et al. 1983). The stratigraphy observed consists of roadway-related fill over naturally deposited alluvium and the shallow (often 0.5 to 1.0 mbs) coral shelf. No archaeological cultural resources were observed in these two geographic zones. The alluvial deposits would have been suited for dry-land agriculture, although rainfall probably was a limiting factor. Because of the higher elevation of the coral shelf, irrigated agriculture was probably not feasible. The lack of observed archaeological cultural resources may be due to the construction and subsequent expansion of West Queen Street (now Dillingham Boulevard). A review of historic maps indicates an unnamed roadway (presumably West Queen Street) was present along a portion of the HHCTCP corridor in the East Kalihi Geographic Zone as early as 1904 (Figure 433). Within the West Kapālama Geographic Zone, West Queen Street is shown along the City Center transit alignment by 1919 (Figure 434).

At Waiakamilo Road, the West Kapālama Geographic Zone ends and the HHCTCP corridor drops down off the coral shelf into the East Kapālama Geographic Zone (Figure 435). These low-lying alluvial lands were well-watered by both Niuhelewai and Kapālama Streams. Historic research clearly indicates that these areas were productive agricultural wetlands, first for taro and later for rice. These agricultural wetland sediments were designated SIHP #50-80-14-7426 and were most likely developed beginning in the pre-Contact period, as evidenced by the LCA descriptions for this area which predominantly listed *lo‘i* for the claims, with continued use into the twentieth century (see Volumes II and III). It is not surprising that, aside from these wetland sediments, no other pre-Contact or early post-Contact archaeological cultural resources were observed. The environment was less well suited for habitation, burial interment, or other activities given the shallow water table. While some LCA claims do list house lots in addition to *lo‘i*, the majority of these are in areas where the Pleistocene shelf begins to rise (see Volume II).

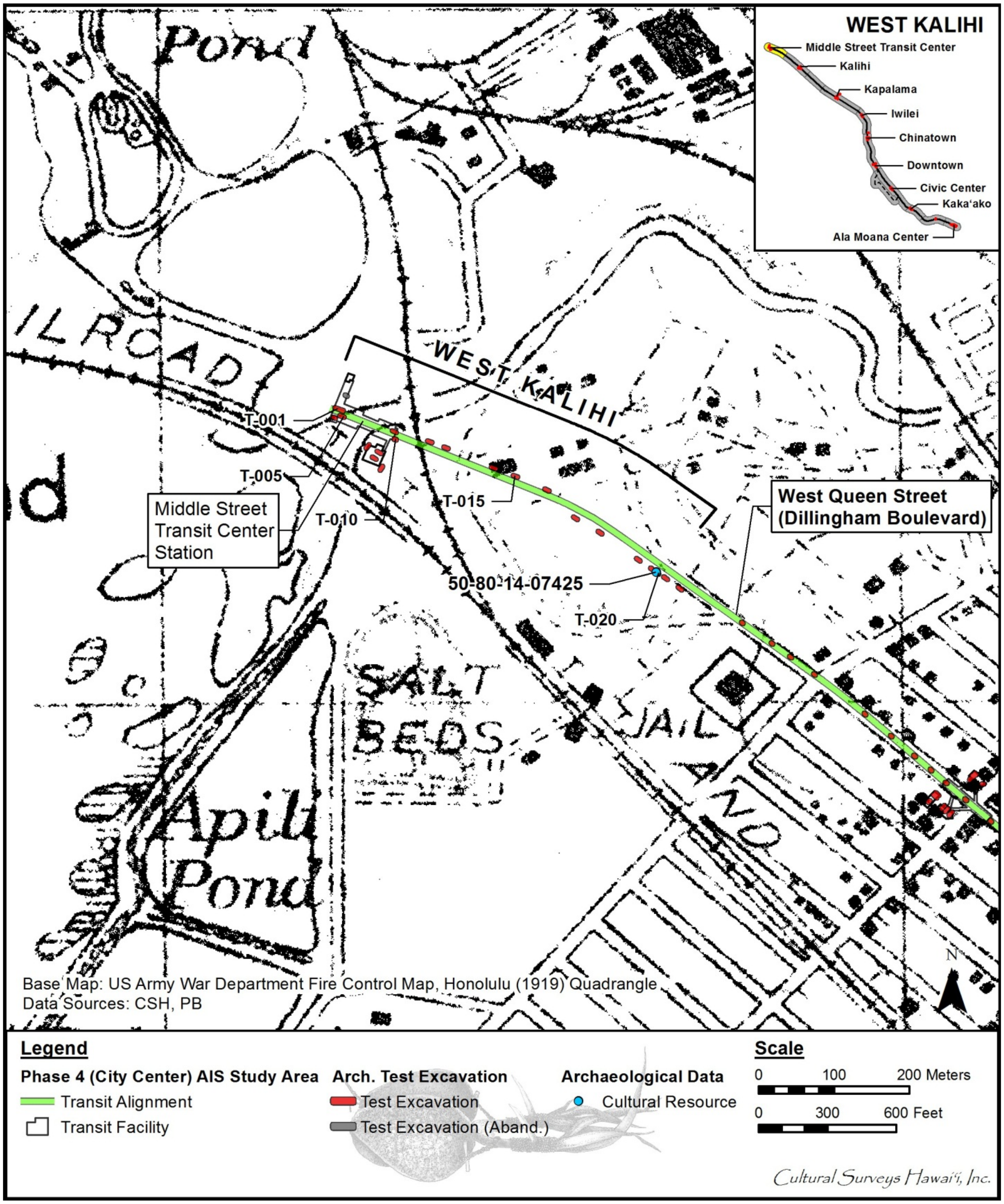



Figure 431. 1919 US Army War Department Fire Control Map, Honolulu Quadrangle, showing Dillingham Boulevard extending into the HHTCTP corridor in the West Kalihi Geographic Zone


Figure 432. 1933 US Army War Department Fire Control Map, Honolulu Quadrangle, showing Dillingham Boulevard extending along the HHCTCP corridor in the West Kalihi Geographic Zone

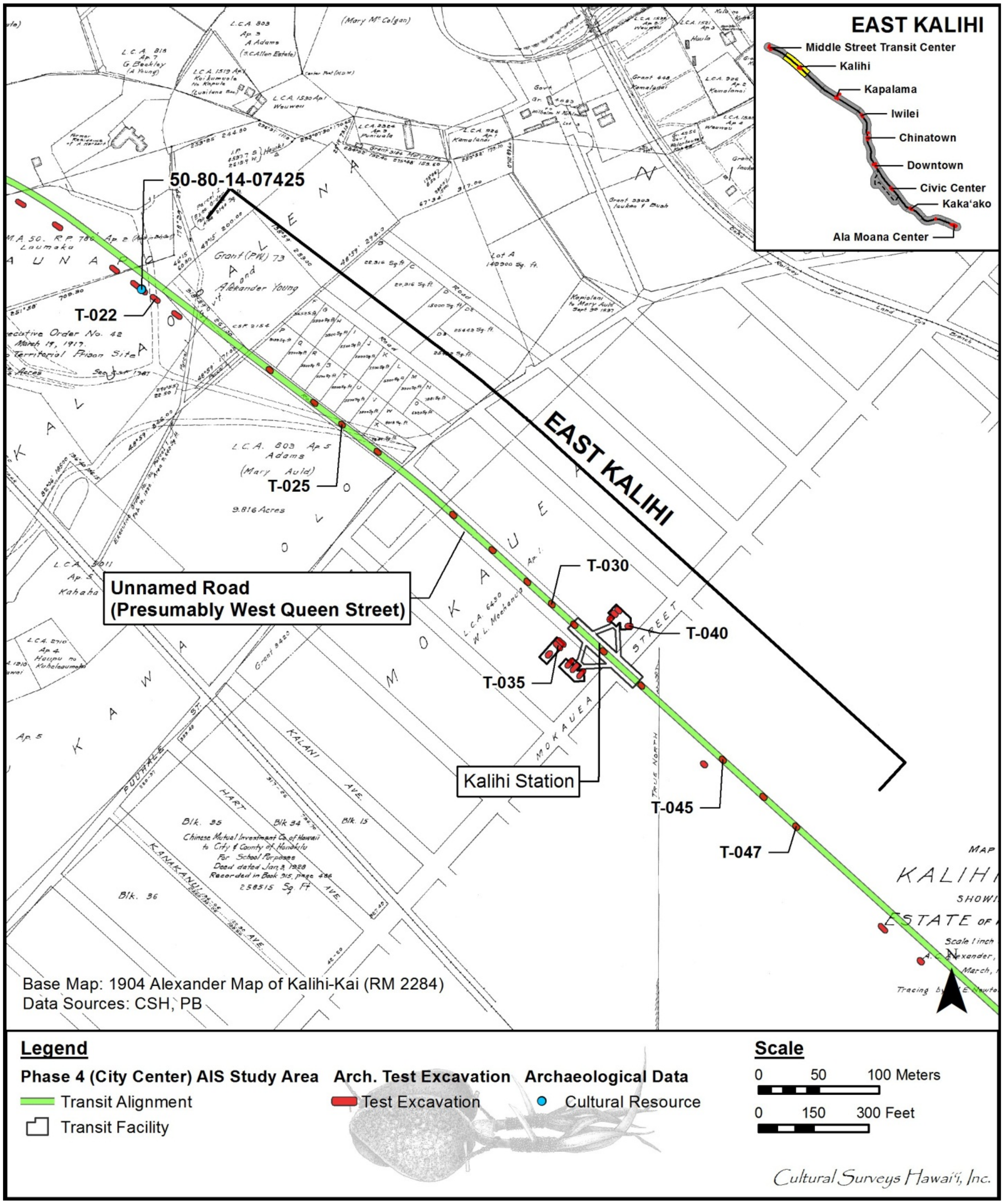



Figure 433. 1904 Alexander Map of Kalihi-Kai (RM 2284) showing an unnamed roadway (presumably West Queen Street) present along a portion of the HHCTCP corridor in the East Kalihi Geographic Zone

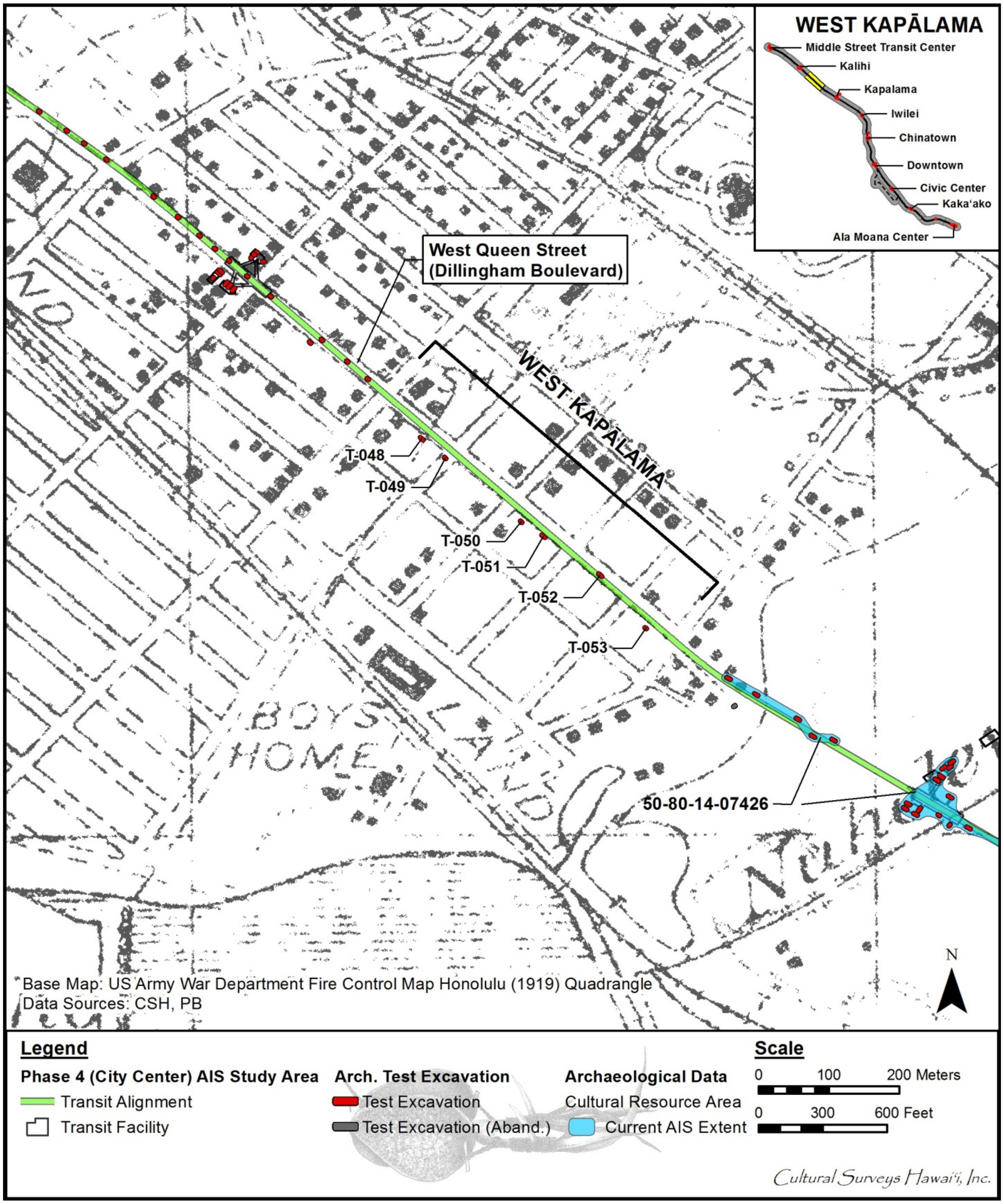



Figure 434. 1919 US Army War Department Fire Control Map, Honolulu Quadrangle, showing Dillingham Boulevard along the HHCTCP corridor in the West Kapālama Geographic Zone

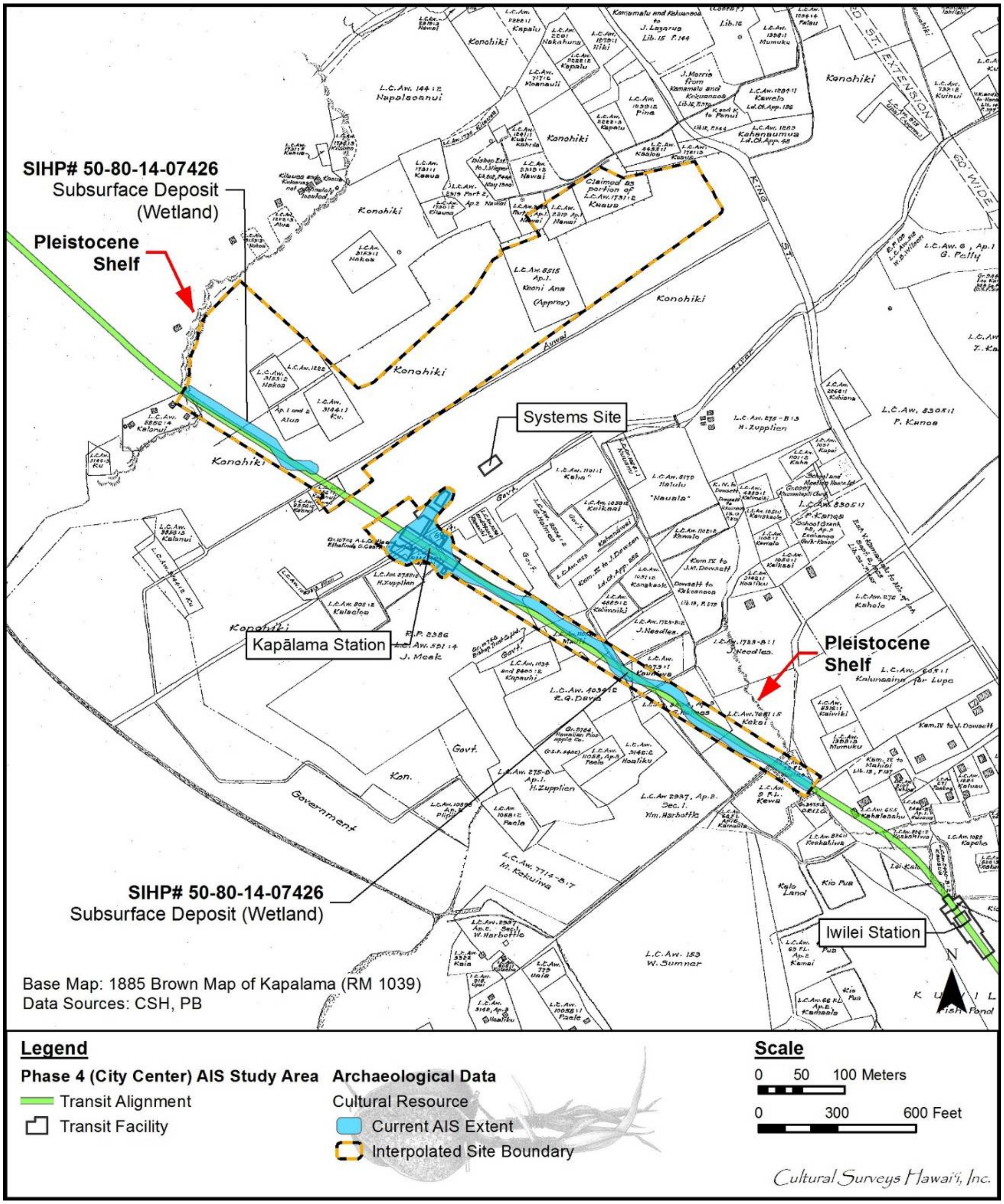



Figure 435. 1885 map of Kapālama by J. F. Brown (RM 1039), depicting the Pleistocene shelf (red arrows) at the east and west boundaries of the East Kapālama Geographic Zone

The stratigraphy in the East Kapālama Geographic Zone is characterized by thick modern and historic fill deposits over the natural wetland sediments (SIHP #-7426) that lay on top of the Pleistocene coral shelf. Similar to the West and East Kalihi and West Kapālama Geographic Zones, the various fill layers directly overlying the natural sediments were originally deposited during the construction of roadways. A review of historic maps reveals that no roadways were present within the East Kapālama Zone in 1919, but by 1927 West Queen Street, from the west, and Dillingham Boulevard, from the east, had begun to encroach on the East Kapālama Zone (Figure 436 and Figure 437). By 1933, Dillingham Boulevard and West Queen Street had converged to become Dillingham Boulevard, which extended along the HHCTCP corridor throughout the entire East Kapālama Zone (Figure 438). A subsequent reclamation event is represented by a 0.11-acre portion of land *mauka* of the transit alignment and Dillingham Boulevard. This area contained an incinerated trash deposit (designated SIHP #-7506) that directly overlaid the natural wetland sediments (SIHP #-7426). This trash deposit was dated to the mid-twentieth century (post-1948). The dates provided from the artifact assemblage of SIHP #-7506 suggest some material may have come from the nearby City and County of Honolulu Kapalama Incinerator (Figure 439).

The Iwilei Geographic Zone is within the footprints of the former Kūwili and Kawa Fishponds (SIHP#s -5368 and -5966, respectively). Kūwili Fishpond, covering the northern extent of the Iwilei Zone, may have been constructed as early as AD 1100 and used into the latter part of the nineteenth century (McGerty et al. 1997). The depositional sequence for Kūwili Fishpond consists of natural estuary sediments overlain by fishpond sediments and historic and modern fills. Filling of the fishpond bagan in the 1890s due to both health concerns and the development and urbanization of Honolulu (Figure 440). The filling was completed by 1899 by the O‘ahu Railway and Land Company (OR&L) in order to accommodate the new railroad and its facilities (Figure 441). From 1948 through 1951, the OR&L railroad was dismantled. Following this time period, additional fill layers that contained railroad remnants were deposited on the land surface during further urbanization and development of Honolulu.

Kawa Fishpond, covering the southern end of the Iwilei Geographic Zone, may have been constructed in pre-Contact times or in the early nineteenth century with continued use into the latter part of the nineteenth century. The depositional sequence for Kawa Fishpond consists of natural lagoonal sediment overlain by fishpond sediments and historic to modern fills. Filling of the fishpond occurred in the late 1890s (alongside the filling of Kūwili Fishpond) due to health concerns. A later fill episode represented by concrete and associated sediment is believed to correspond to development infrastructure during the mid-twentieth century. More modern fill deposits were present above that episode.

The Downtown Waterfront Geographic Zone extends east from Nu‘uanu Stream to Richards Street. This area was the site of the early development of the Village of Kou into the Port of Honolulu, and the zone passes through or immediately adjacent to sites important in the development of Honolulu, such as the family compound of Don Francisco de Paula de Marin (advisor to Kamehameha the I), the Kamehameha I royal residential compound at Pākākā, and the Honolulu Fort (1816–1857) (Figure 442 and Figure 443). Despite several test excavations within the footprint of the former Honolulu Fort and in the vicinity of the Kamehameha compound at Pākākā, no archaeological remains of these structures or associated items were observed. Test excavation results in this geographic zone indicate that the HHCTCP corridor

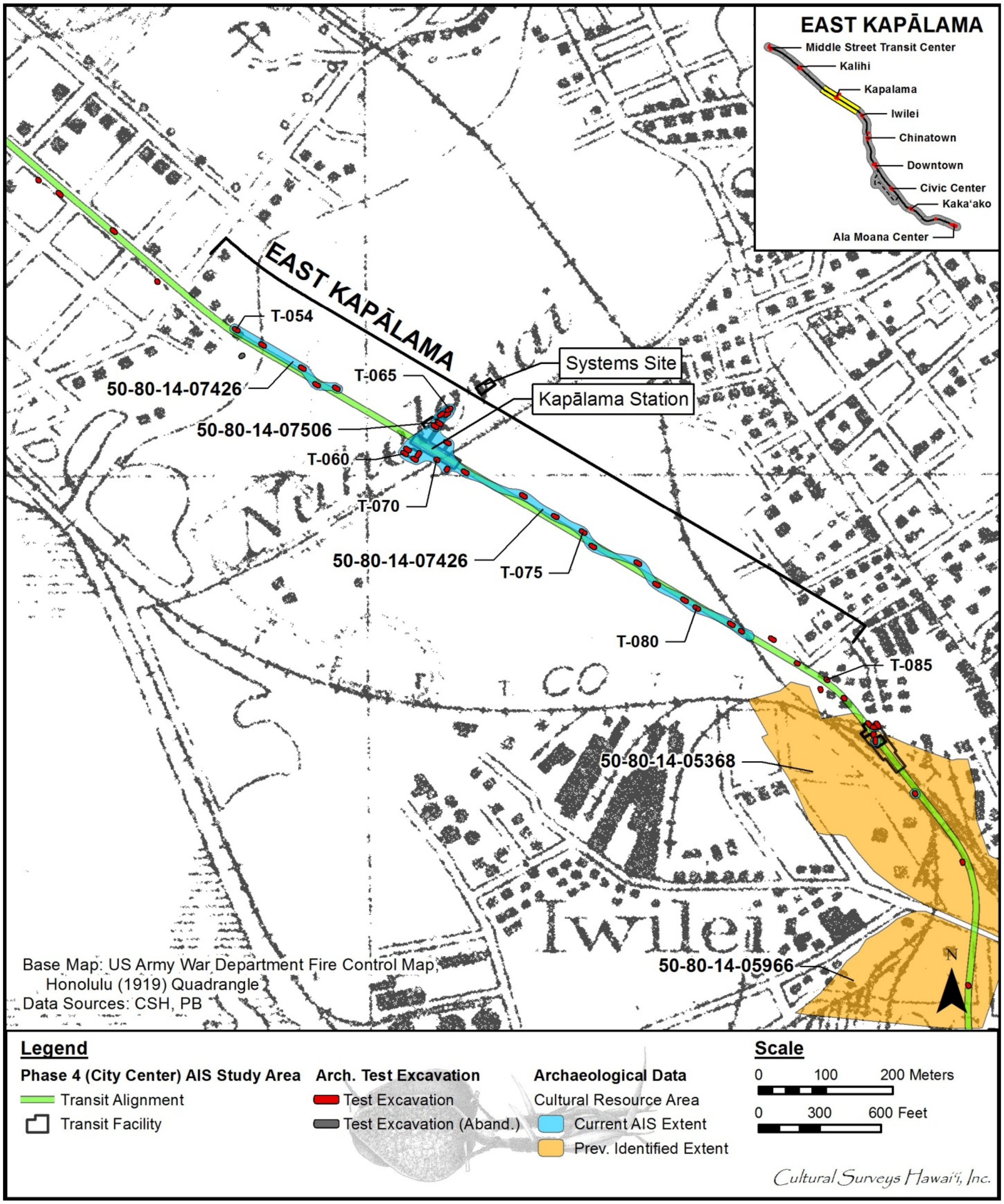



Figure 436. 1919 US Army War Department Fire Control Map, Honolulu Quadrangle, showing no roadways in the East Kapālama Geographic Zone

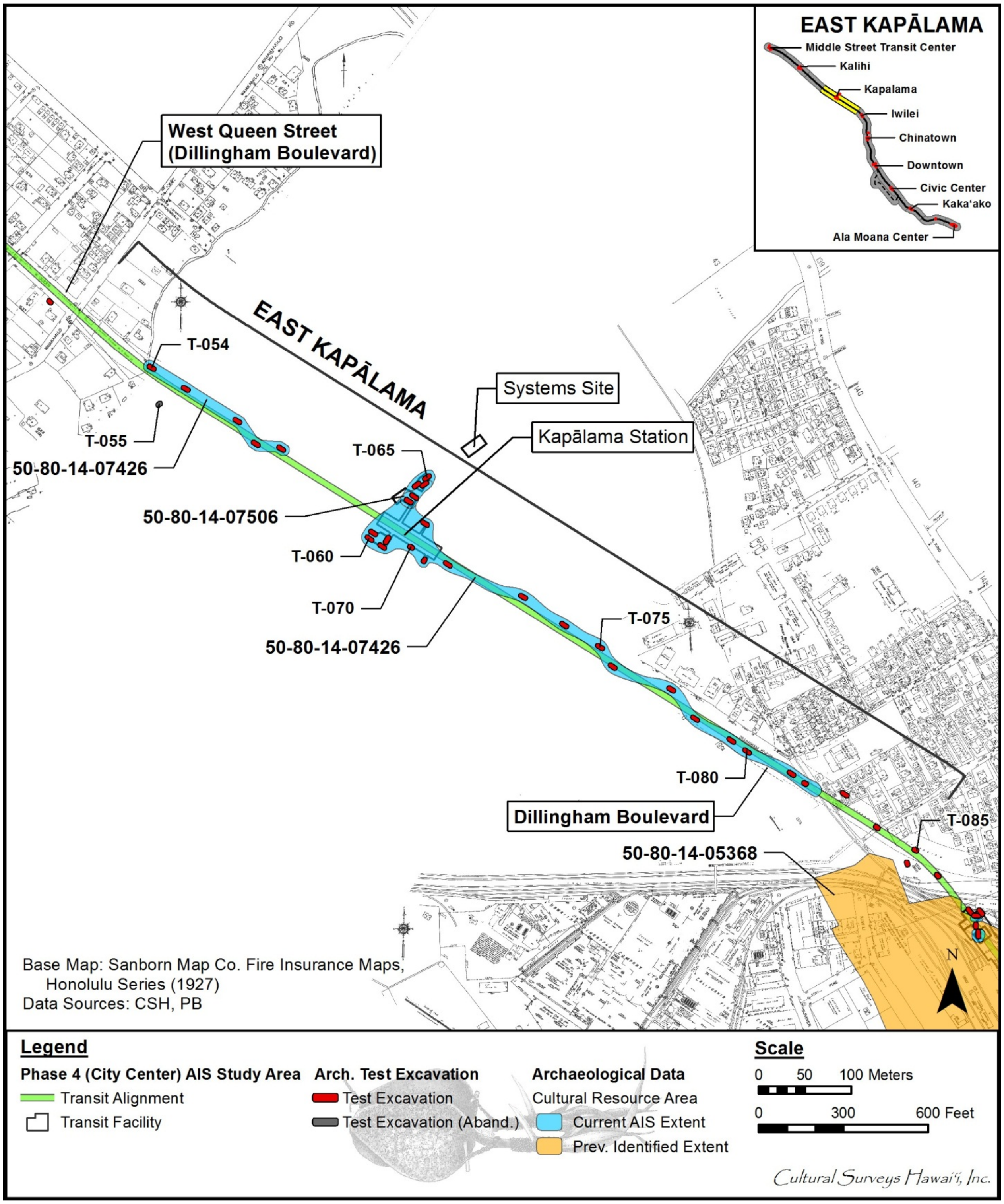



Figure 437. 1927 Sanborn Map Co. Fire Insurance Map showing West Queen Street and Dillingham Boulevard encroaching on the East Kapālama Zone


Figure 438. 1933 US Army War Department Fire Control Map, Honolulu Quadrangle, showing Dillingham Boulevard and West Queen Street converging (becoming Dillingham Boulevard) and extending along the HHCTCP corridor in the East Kapālama Zone

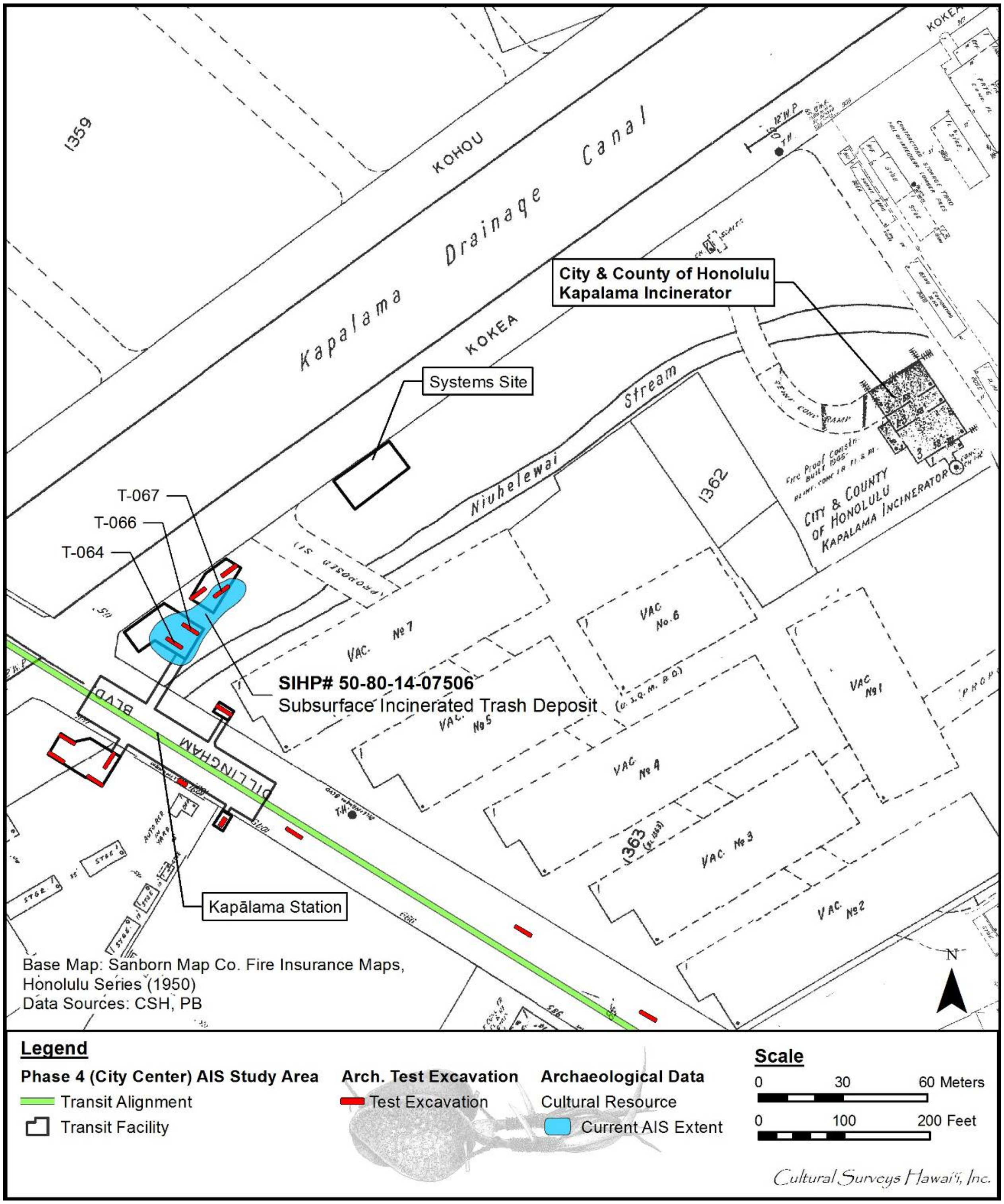



Figure 439. 1950 Sanborn Map Co. Fire Insurance Map showing SIHP #-7506 in relation to the Kapalama incinerator

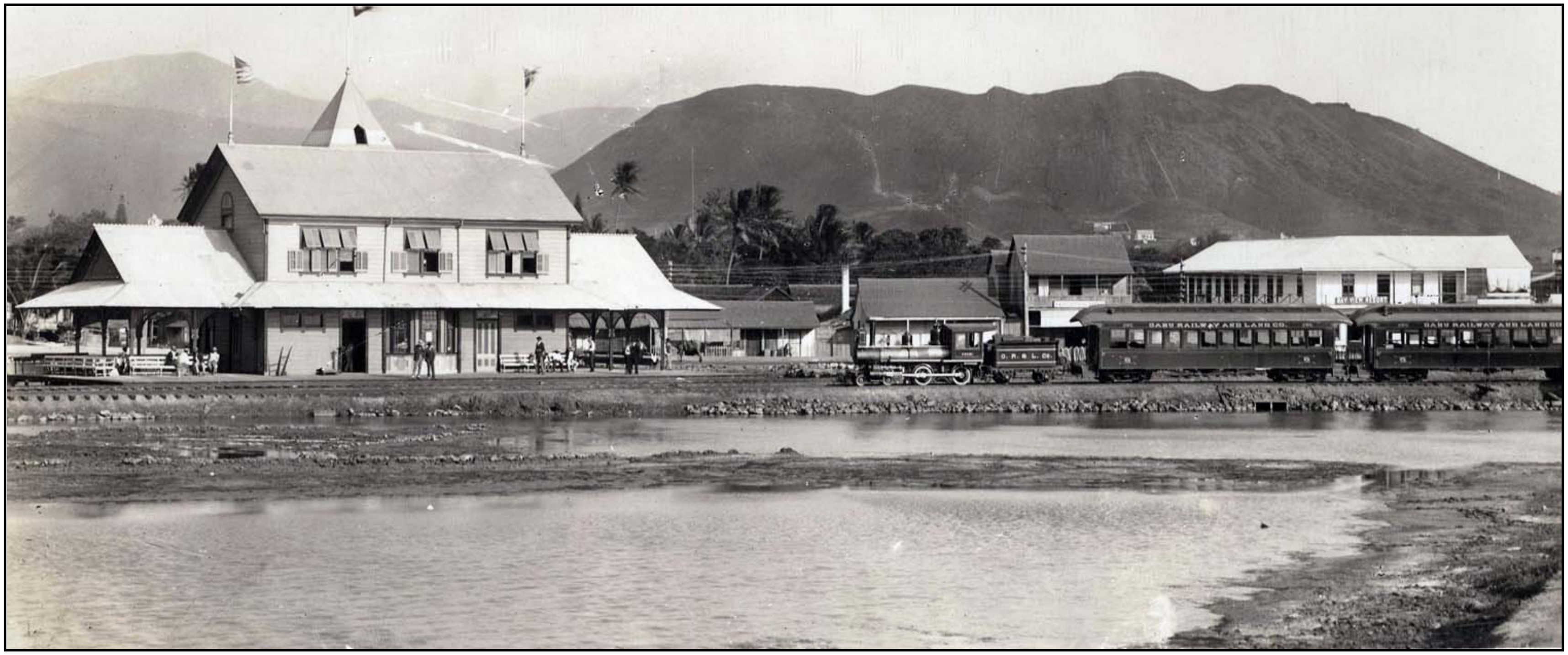


Figure 440. Photograph showing a partially filled Kūwili Fishpond and OR&L Depot building in 1890 (Hawaiʻi State Archives)

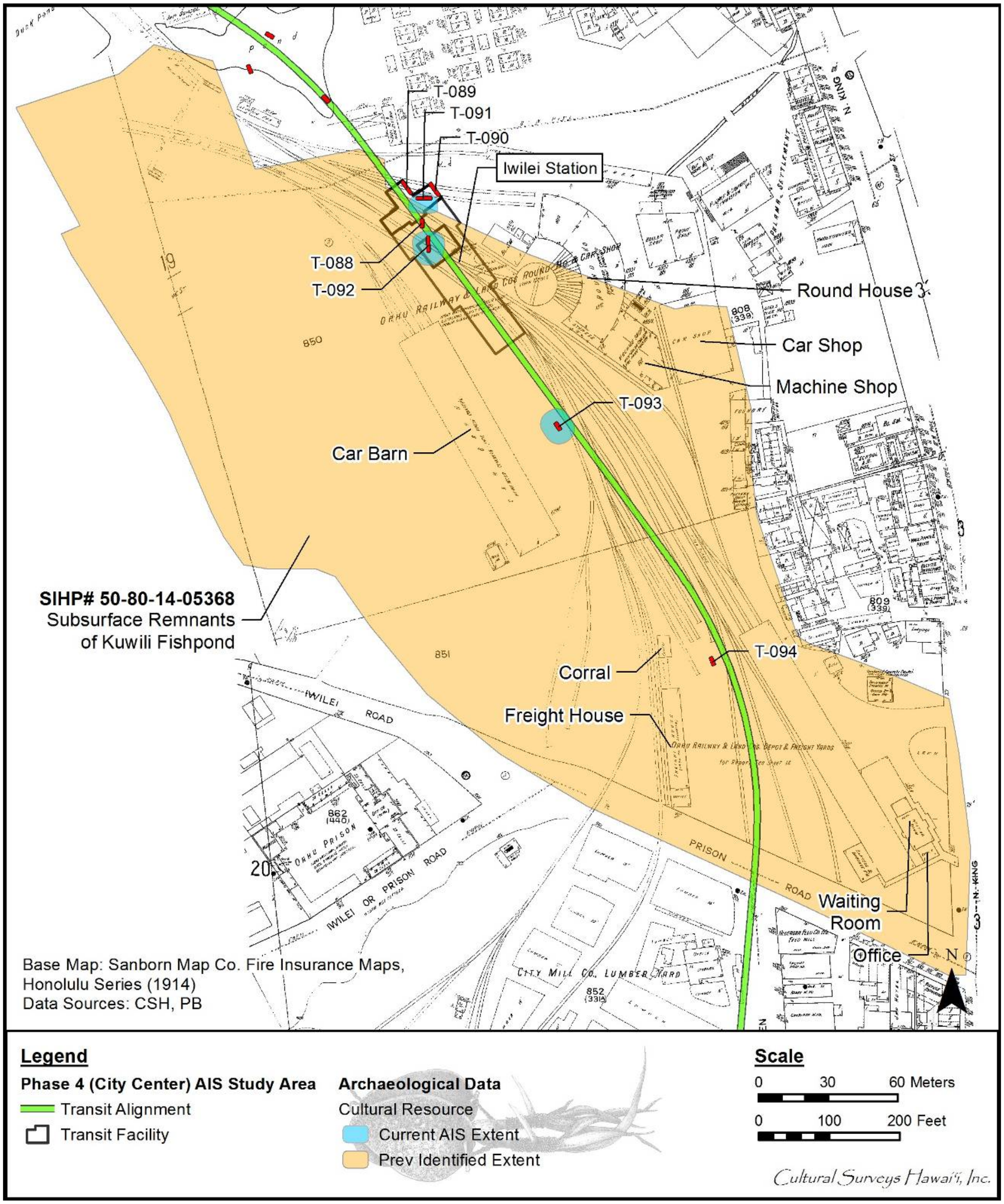



Figure 441. 1914 Sanborn Map Co. Fire Insurance Map with an overlay of Kūwili Fishpond showing the extensive OR&L facilities constructed within the fishpond footprint following the infilling between 1890 and 1899

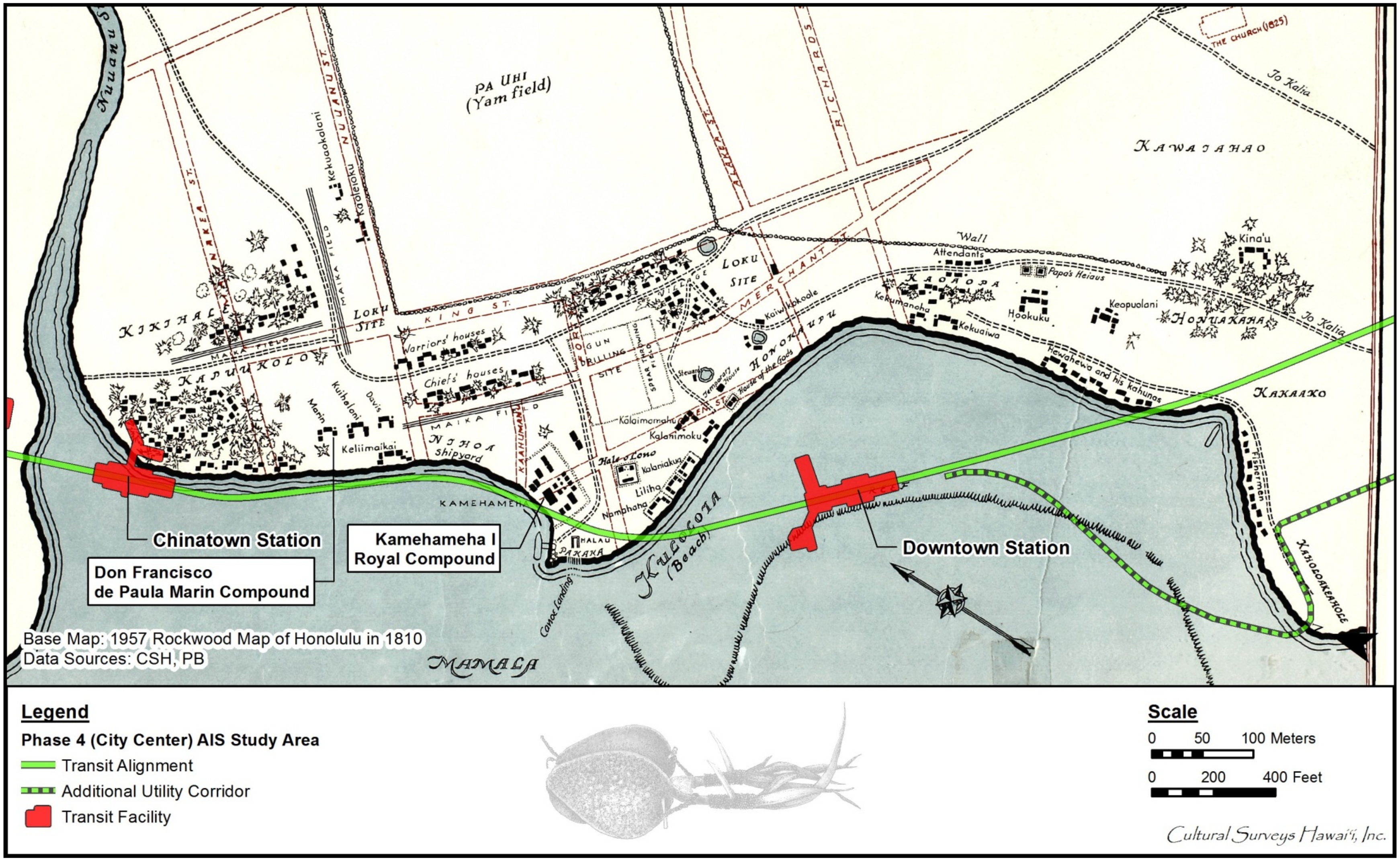



Figure 442. 1957 Rockwood Map of Honolulu in 1810 showing the Village of Kou, the family compound of Francisco de Paula de Marin (advisor to Kamehameha the I), and the Kamehameha I royal residential compound at Pākākā

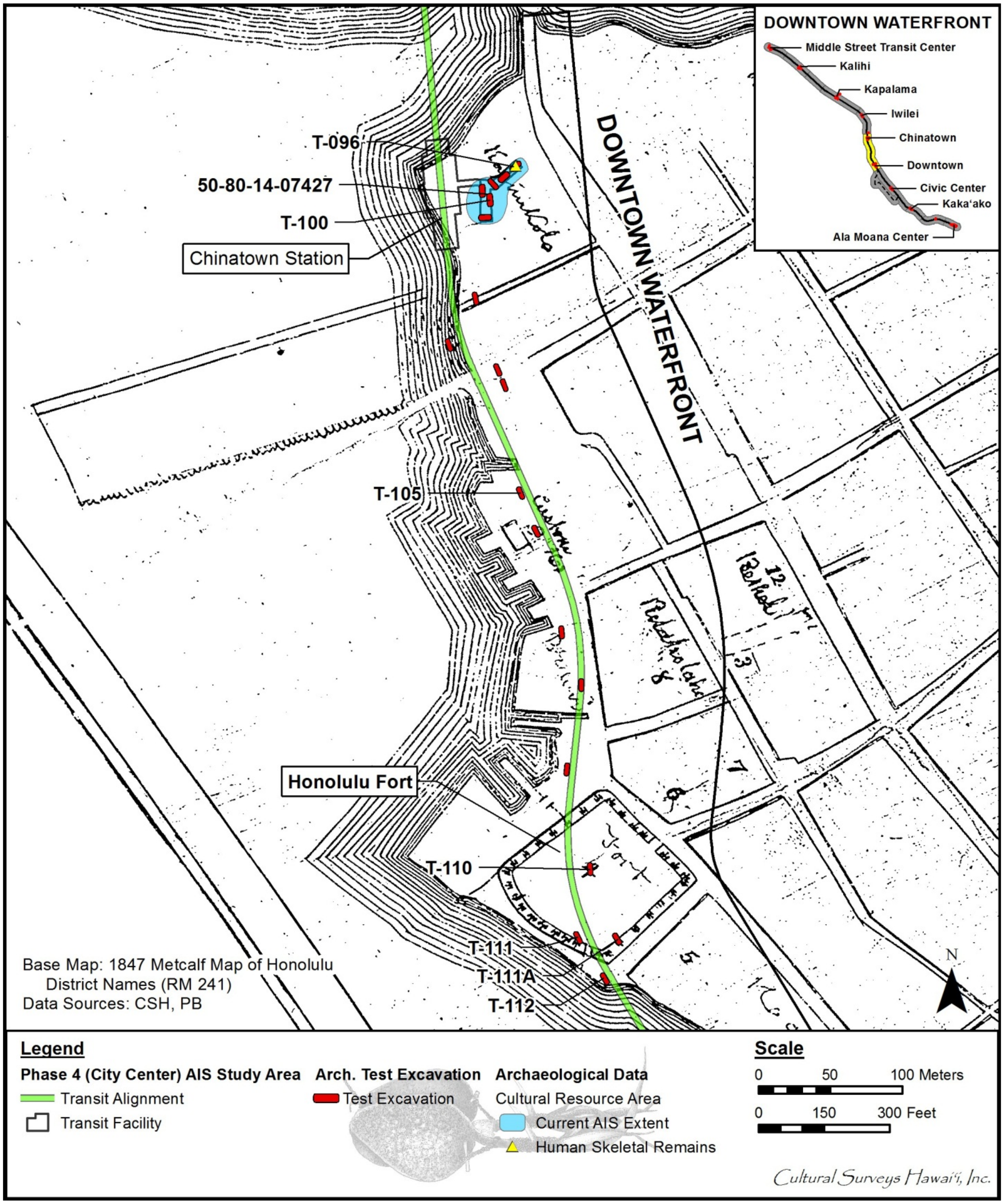



Figure 443. 1847 Metcalf Map of Honolulu (RM 241) showing the Honolulu Fort and the mid-nineteenth century coastline in relation to the HHCTCP corridor

is located *makai* of the more extensive archaeological remains that have been documented *mauka* of Nimitz Highway/Ala Moana Boulevard (see Figure 442).

Much of the Downtown Waterfront Geographic Zone consists of former off-shore areas that were filled/reclaimed in the latter half of the nineteenth century as part of the development of Honolulu Harbor (see Figure 443). This began with the creation of wharves along the harbor to serve the trading and whaling vessels. The wharves were created, for example, by the hulk of an old ship in 1825 and the demolished remains of the Honolulu Fort in 1857. Subsequently, from 1857 to 1870 and during the 1890s and 1900s, material dredged from the harbor was used for land reclamation activities. In the Chinatown portion of the Downtown Waterfront Geographic Zone, depositional fill layers are present that may relate to the 1900 fire that was set to help control the bubonic plague. Above these layers are more historic and modern fill layers that represent various periods of development. In general, the stratigraphy observed in the zone consisted of thick fill layers over marine sediments at the northern and southern ends, with fill over Pleistocene limestone in the central portion.

At the intersection of Richards Street and Ala Moana Boulevard the HHCTCP alignment leaves the Honolulu Waterfront and extends across the area that is today known as Kakaʻako. The remaining five geographic zones to the east of Richards Street, including West Kakaʻako, East Kakaʻako, Kakaʻako Makai, Kewalo, and Kālia, are all located in fairly similar geologic and cultural settings. They are all part of the coastal Honolulu Plain, which is stratified with late-Pleistocene coral reef substrate overlaid with calcareous marine sand or terrigenous sediments and stream-fed alluvial deposits (Armstrong 1983:36). Before its infilling as a part of land reclamation in the late nineteenth and early twentieth centuries, the relatively low-lying area was a mosaic of natural Jaucas sand berms, often forming swales, open water ponds, and marshy areas. Native Hawaiians used the area for salt making, aquaculture, wetland agriculture, habitation, and burial interment, and many of these uses continued into the late nineteenth and early twentieth centuries, at least in some areas. Archaeological inventory survey results from the five geographic zones east of Richards Street documented markedly more intensive archaeological deposition than was observed in the six geographic zones to the west.

Within the West Kakaʻako, Kakaʻako Makai, and Kewalo Geographic Zones, buried sand A-horizons with remnants of pre- and post-Contact land use, including habitation, commercial infrastructure, and burial interment were well represented (SIHP #s 50-80-14-7428, 50-80-14-2963, 50-80-14-7197, 50-80-14-5820, 50-80-14-7429, and 50-80-14-2918). Formally known as "subsurface cultural deposits," these buried, culturally enriched A-horizons are the former land surface that predates the massive fill deposits that were brought into Kakaʻako in the late nineteenth and early twentieth centuries. Along the shoreline of the western portion of the West Kakaʻako Zone, salt pan remnants (SIHP #50-80-14-7190) were documented (Figure 444). Background research indicates that these salt pans were utilized in both pre- and post-Contact times for salt production.

Pre- and early post-Contact land surfaces remained in use until these areas were developed and buried during the urbanization of Honolulu. A trash layer (SIHP #50-80-14-7189) documented in the West Kakaʻako and Kakaʻako Makai Zones may have acted as fill material during development (land reclamation) around. 1920. This trash layer was found overlying

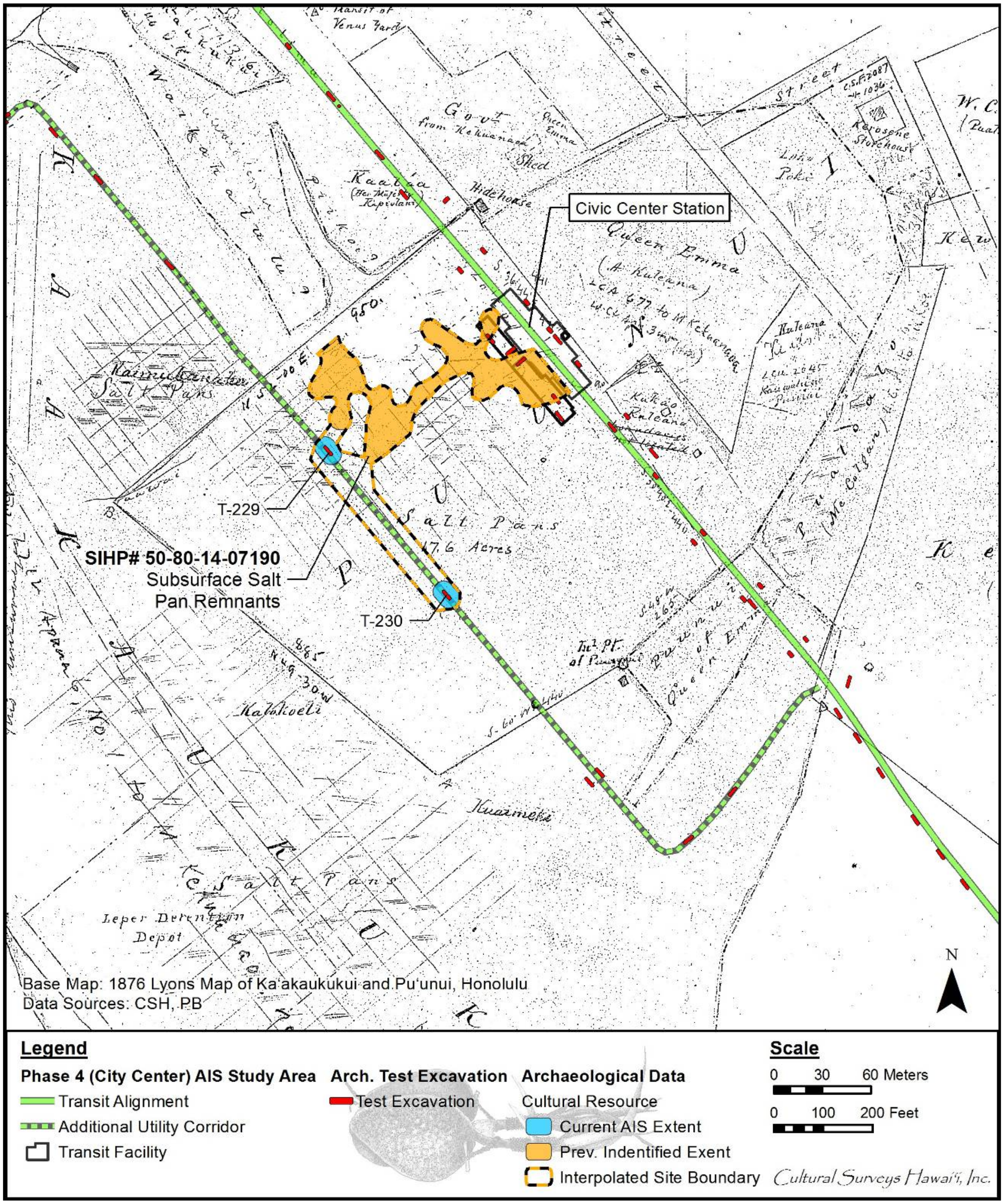



Figure 444. 1876 Lyons Map of Kaʻakaukukui and Puʻunui, Honolulu, showing the total extent of salt pans in relation to the identified extent of subsurface salt pan remnants (SIHP #-7190)

portions of the salt pan remnants listed above (SIHP #-7190). Buried building remnants dated from 1910 to the modern era (SIHP #50-80-14-7124) were also documented overlying the salt pan remnants.

The East Kakaʻako and Kālia Geographic Zones are characterized by thick fill deposits over natural pond and wetland sediments. The western portion of the East Kakaʻako Zone is within the footprint of the former Kolowalu Fishpond (SIHP #50-80-14-6856) (Figure 445). Kolowalu Fishpond may have been constructed during the pre-Contact period, although its use continued into historic times. According to historic documents and maps, Kolowalu Fishpond was filled using various materials in the early part of the twentieth century (late 1920s or early 1930s) during land reclamation activities. Due to its location inland, the pond was likely freshwater or partially brackish. As with Kūwili and Kawa Fishponds, Kolowalu Fishpond is an example of resource procurement intensification to support larger populations and/or an elite ruling class.

The eastern portion of the East Kakaʻako Zone and the majority of the Kālia Zone are characterized by thick fill deposits over natural Kewalo wetland sediments (SIHP #50-80-14-6636). Historic research clearly indicates that these areas were productive wetland agricultural lands, first for taro and later for rice (Figure 445 and Figure 446). These agricultural wetland deposits were most likely developed in the pre-Contact period, with continued use into the early twentieth century, at which time they were drained and filled during land reclamation activities in the 1920s and 1930s for the expanding urbanization of Honolulu (Figure 447). A trash layer dated to ca. the 1930s to 1970 (SIHP #50-80-14-7193) documented at the east end of the Kālia Zone may have acted as fill material during these land reclamation activities (conversely, it could simply represent a trash disposal area). A privy (SIHP #50-80-14-7430) dated to the mid-nineteenth to early twentieth century (based on ceramics, glass bottles, and metal fasteners) was documented at the east end of the Kālia Zone intruding into the natural wetland sediment (SIHP #50-80-14-6636). This demonstrates the historic-era use and habitation in the natural wetland environment.

### 6.7.2 Ground Penetrating Radar

The primary focus of the GPR survey was to test the efficacy of GPR analysis within the context of urban Honolulu archaeology. Part of this study was designed to determine the ability of GPR technology to locate discrete objects in areas containing multiple fill events that are heavily disturbed by urban development. The results of this study suggest that it is very difficult to determine the difference between signal reflections caused by significant discrete objects and reflections caused by historic disturbance, subsurface infrastructure (utilities, old foundations, etc.), and imported fill layers. A statistical study was conducted using utilities to determine the accuracy of locating discrete objects in the range of clean signal return and it was found that less than half of the objects were detected in the GPR results. Location of discrete objects has traditionally been the role of GPR analysis within the context of modern archaeology. While GPR technology has been shown to be effective in other depositional environments, the results of this study suggest that further refinement is needed to increase the reliability of GPR as a tool for discrete object detection in urban fill environments.

This study was able to demonstrate that GPR can be a useful tool to map subsurface stratigraphy. By comparing the GPR results to the test excavation profiles, it was statistically

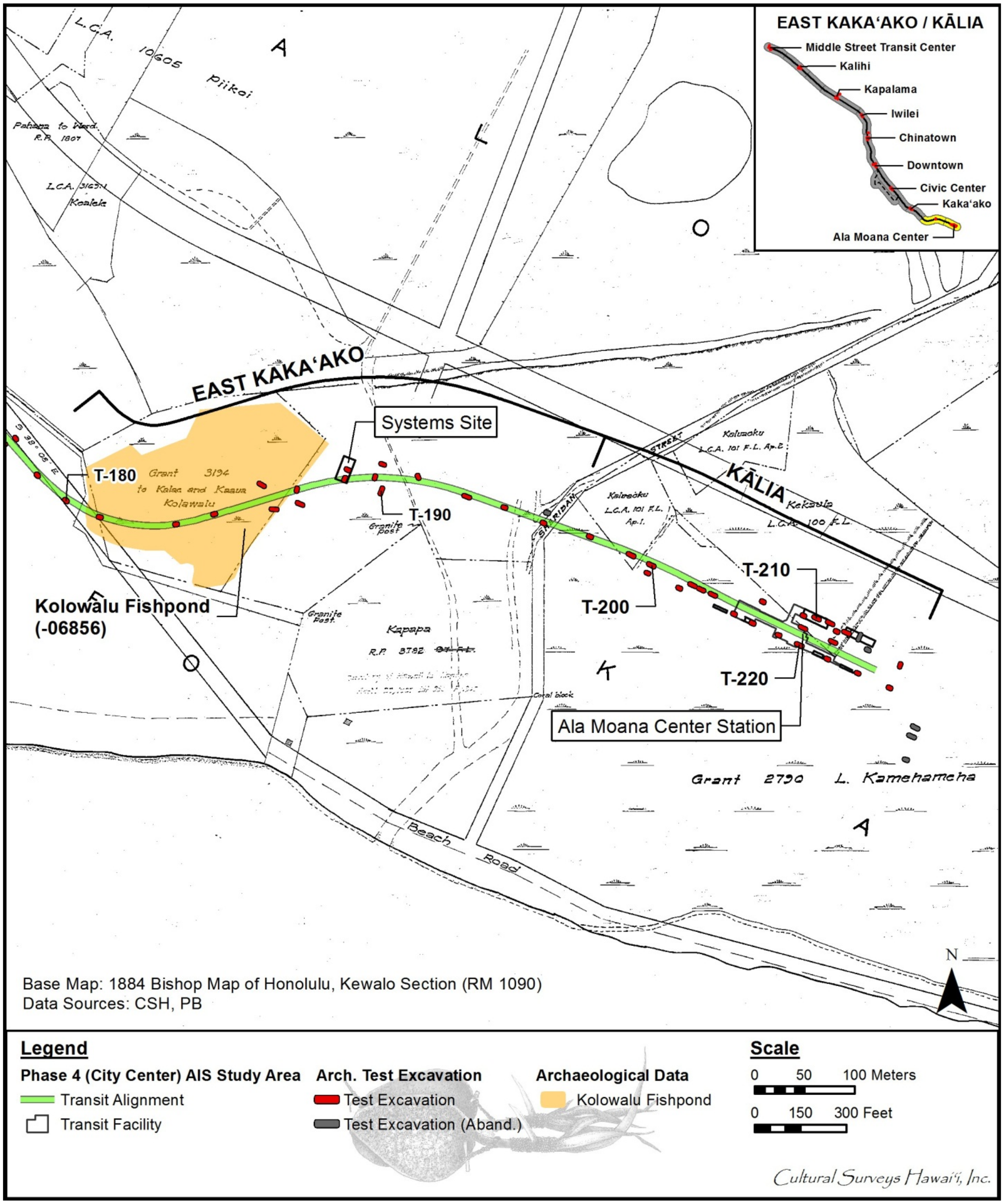



Figure 445. 1884 Bishop Map of Honolulu, Kewalo Section (RM 1090), showing Kolowalu Fishpond (SIHP #-6856) and the extent of the Kewalo wetland (SIHP #-6636) within the East Kakaʻako and Kālia Geographic Zones

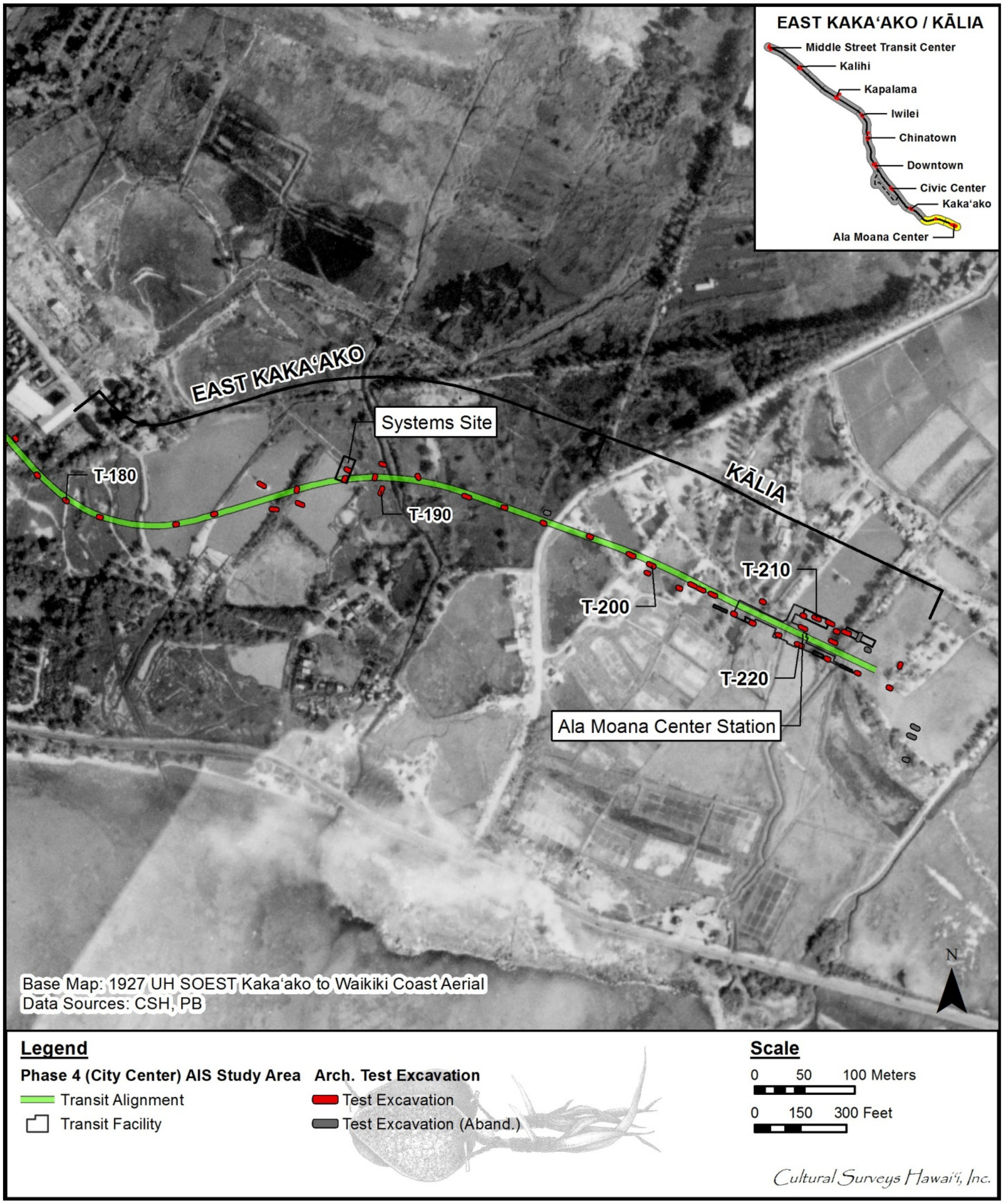



Figure 446. 1927 US SOEST Kakaʻako to Waikiki Coast Aerial showing the Kewalo wetland (SIHP #-6636) just prior to land reclamation within the East Kakaʻako and Kālia Geographic Zones

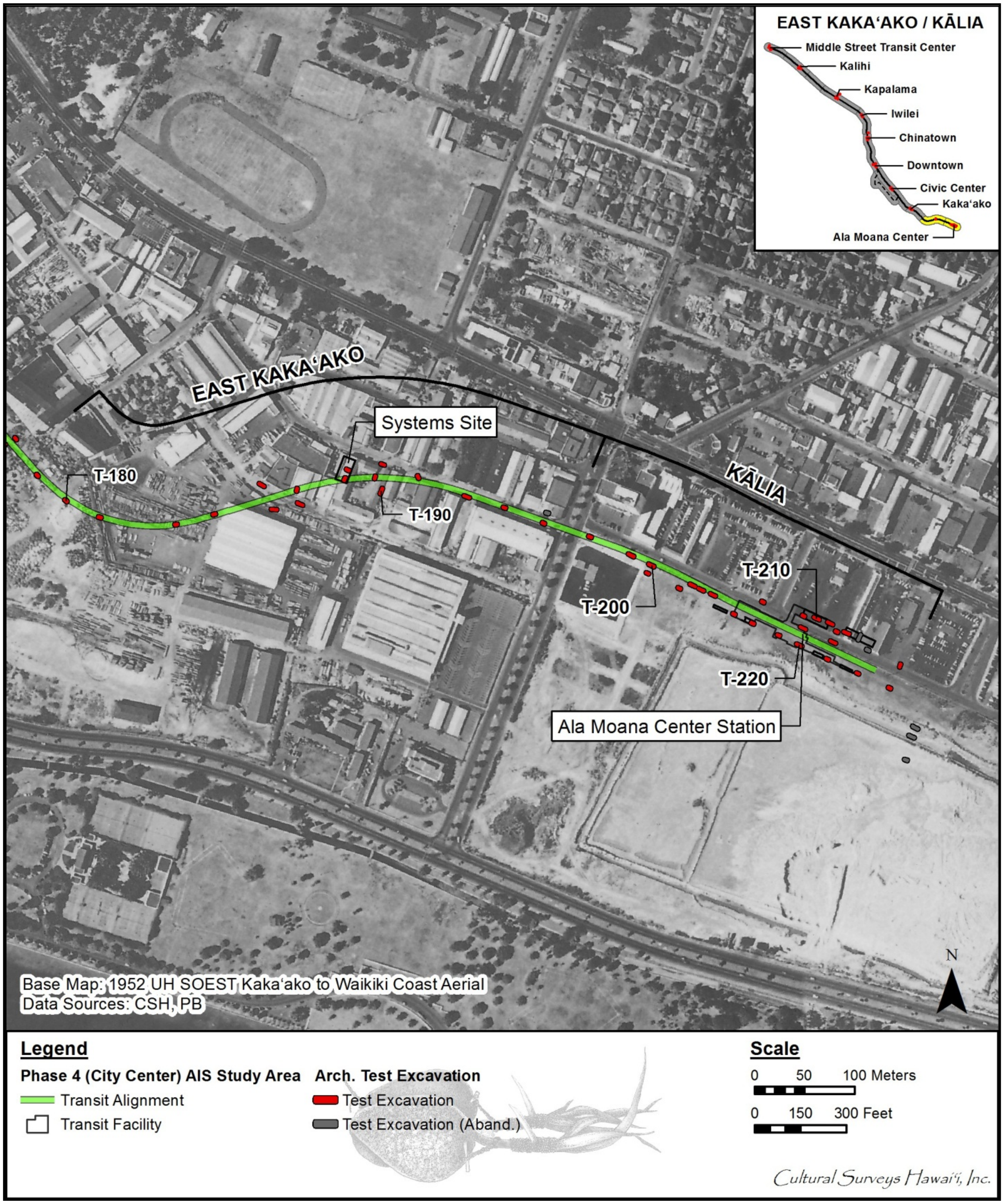



Figure 447. 1952 US SOEST Kakaʻako to Waikiki Coast Aerial showing the East Kakaʻako and Kālia Geographic Zones following extensive land reclamation and urbanization

shown that GPR data can accurately display stratigraphic transitions even in areas that are disturbed with multiple fill events. The results of the statistical study showed that 82 percent of the “ground-truthed” stratigraphic transitions that were in the range of clean signal return were within 0.25 m of the reflected signal transition observed in the GPR profiles. This information can be important when looking for stratigraphic transitions that represent boundaries between fill layers and naturally deposited layers. The number of stratigraphic transitions observed in a GPR profile also can be used to determine the probability of encountering naturally deposited sediments. For instance, a high number of stratigraphic transitions observed in the data may suggest an environment with multiple fill events, decreasing the odds of encountering naturally deposited sediments. The ability of GPR to determine stratigraphic transitions is limited to the depth of clean signal return. In the City Center AIS study area, many of the naturally deposited sediments were located below the depth of clean signal return (approximately 0.75 to 1.0 mbs). It is for this reason that using GPR in the City Center AIS study area to locate stratigraphic transitions as a way of determining the probability of encountering naturally deposited sediments had limited results.

GPR was also tested for its ability to approximate subsurface sediment material in a non-invasive way. This study found that GPR is capable of determining sediment material based on signal reflectivity and topography (signal texture). Clear patterns in signal texture were consistent in both HHCTCP Construction Section 3 and Section 4 GPR surveys, suggesting that the results can be applied to other urban project areas with similar depositional environments. Utilizing GPR signal texture analysis, coupled with soil maps and data collected from previous archaeological projects conducted in the vicinity, the probability of encountering naturally deposited sediments can be determined. This analysis could greatly enhance the general understanding of the area and provide a targeted approach to future test unit placement.

Finally, determining the effectiveness of GPR to locate human burials was a focus of this study. Burials can be considered discrete objects with stratigraphic and sediment transitions associated with burial pit features. Three potentially fully articulated human burials were encountered during the entirety of the City Center AIS (T-142, T-226C, and T-227A). The apparently fully articulated burial located in T-142, and the much smaller infant burial in T-227A, were discovered in naturally deposited Jaucas sand with a slight pit feature associated with the burial. An articulated human pelvis was also discovered in T-226C and may represent an in situ burial located in a disturbed former A-horizon associated with a lower layer of Jaucas sand. The burials in T-226C and T-227A were both located deeper than the range of clean signal return and could not be clearly resolved during processing. No distinct hyperbolic reflection could be directly linked to the location of any of the burials. Hyperbolic responses to burials tend to be ephemeral, which is problematic to locate in Jaucas sand that generally exhibits high reflectivity and undulating signal topography. No stratigraphic transition or changes in signal texture representing sediment materials were observed in the GPR analysis for any of the burials that indicated the associated pit features found during excavation. Burials are subjected to the same limitations in terms of deciphering signal reflections in a highly disturbed urban context. Depth of signal penetration is also a large limiting factor in the City Center AIS study area, as most human burials are located beyond (deeper than) the range of clean signal return (0.75 to 1.0 mbs).

Overall, this study suggests that GPR technology has potential for use in Hawaiian urban archaeology but due to the limited depth of clean signal return and the highly disturbed nature of the City Center AIS study area, results were limited. This corroborates the USDA GPR suitability rating of low to very low for this area. No cultural deposits or archaeological features were clearly observed in the results, although they were rarely within the “visible” range of the GPR. Discrete objects were located with less than 50 percent accuracy in the Section 4 study area. The greatest potential use of GPR in this area is in determining the location of naturally deposited sediments and using this analysis to access the probability of encountering culture within these deposits. Again, this capability is limited to the depth of clean signal return (0.75 to 1.0 mbs for the City Center section). Further research should be conducted utilizing a lower frequency GPR antenna to gain increased depth of penetration. Some signal resolution will be lost for use in locating discrete objects, but stratigraphic transition and sediment material analysis could be conducted at greater depths where most of the transitions from fill to naturally deposited sediments occur in the City Center AIS study area.

### 6.7.3 Pre-Contact and Pre-Fill/Land Reclamation Landforms

The modern configuration of the coastline and coastal areas of O‘ahu’s south shore, including the vast majority of the City Center AIS study area, is primarily the result of the following.

1) The extent and topography of late Pleistocene calcareous reef and lithified dune deposits that had been undergoing both sub-aerial accretion and erosion during various Pleistocene sea stands (Grigg 1998);
2) Rising sea level following the end of the Pleistocene (see Macdonald et al. 1983 and Stearns 1978);
3) The mid- to late-Holocene c. 1.5–2.0 m high-stand of the sea (see summary in Dye and Athens 2000:18–19);
4) Prehistoric and historic human landscape modification; and
5) Historic and modern dredging and fill deposition.

At the end of the Pleistocene, between approximately 20,000 and 5-6,000 years ago, water previously locked in glacial ice returned to the world’s oceans and sea level rose over 100 m to approximately its current level. In the vicinity of the City Center AIS study area, rising sea levels flooded the previously dry, earlier Pleistocene coral reef and dune deposits, which had formed hundreds of thousands of years previously when sea level was comparable to modern levels. In the mid-Holocene, when sea level reached approximately modern levels, the now coastal regions became depositional environments, where for tens of thousands of years previously, during the lower sea levels, they had been erosional environments. This resulted in the deposition of both terrigenous and marine sediments, leading to the accumulation of thick deposits of soft/loose sediments along the current coastlines in areas that had formerly been valleys, drainage ways, and exposed limestone (former reef) plains (Geolabs Hawai‘i, Inc. 1993:9).

More recently, between 4,500 and 2,000 years ago, a high stand of the sea occurred, ca. 1.5 to 2.0 m above present sea level, which has been well documented for the Northern Main Hawaiian Islands (Kaua‘i and O‘ahu) (see Athens and Ward 1991; Fletcher and Jones 1996; Grossman et al. 1998; Grossman and Fletcher 1998; Harney et al. 2000; Stearns 1978). During this high stand, there appears to have been an increase in production of coral reef and of detrital reef sediments. Littoral environments appear to have been augmented substantially by the deposition of marine sediments. “What this means is that the great shoreline sand berms must have developed around the islands at this time because this was when calcareous sand was being produced and delivered to the shorelines in large quantities” (Dye and Athens 2000:19). The subsequent drop in sea level to its present level, by at least 2,000 years ago, most likely created a slightly erosional regime that may have removed sediments deposited during the preceding period of deposition (Dye and Athens 2000:19). However, the net gain in sediments would have been substantial, largely creating the coastal environment that was first inhabited by early Hawaiians.

It is this change from an erosional environment to a depositional environment that created much of the City Center AIS study area’s natural (pre-fill) land surface. Equally important was the mid-Holocene high-stand of the sea, which produced increased sediment budgets for deposition in areas like the Kalihi and Nu‘uanu Stream estuaries and the Kaka‘ako, Kewalo, and Kālia areas. It was these combined forces that resulted in the estuaries and “mosaic landscape” of open water ponds, marshy wetlands, and higher Jaucas sand swales that were first used by Native Hawaiians, with continued land use into the late nineteenth and early twentieth centuries when fill deposits permanently capped the natural surfaces. These historic and modern fill deposits have largely capped and preserved the pre-fill natural land surface.

In order to better evaluate the pre-Contact landforms and their distribution throughout the AIS study area, histograms and maps were created to illustrate the observed patterns. The landform analysis histograms show natural sediment distribution (and depth of fill) within the City Center AIS study area. Each histogram presents geologic and landform data collected during the City Center AIS. Figure 448 presents data from excavations T-001 through T-115, covering Zone 1 (West Kalihi) through Zone 6 (Downtown Waterfront). Figure 449 presents data from excavations T-116 through T-222, covering Zone 7 (West Kaka‘ako ) through 10 (Kālia).

The histograms present a stratigraphic cross-section of the City Center corridor. Each column represents one test excavation. The stratigraphy of each trench is color coded, and has been simplified to clearly show the boundary between modern fill and the remaining natural land surfaces. The data are arranged according to excavation unit number (T-001 through T-115 for the western portion of the City Center AIS study area, and T-116 through T-222 for the eastern portion).

In general, excavations were numbered from northwest to southeast, so the histogram approximates a northwest-southeast stratigraphic cross-section. However, numbering became more complex at station locations. Presenting the data in ordinal form simplifies unit identification; however, this means the histograms show only relatively, not absolutely, spatially adjacent units. Additionally, the histograms do not show linear distance along the City Center corridor. Subsequent units may be 10 m or 100 m apart. Spatial distribution trends for the different landform types can be seen for the western half of the study area on Figure 450, Figure 451, and Figure 452, which show the distribution of these pre-fill landforms on an aerial photograph and two historic maps. Spatial distribution trends for the different landform types can be seen for the eastern half of the study area on Figure 453, Figure 454, and Figure 455, which

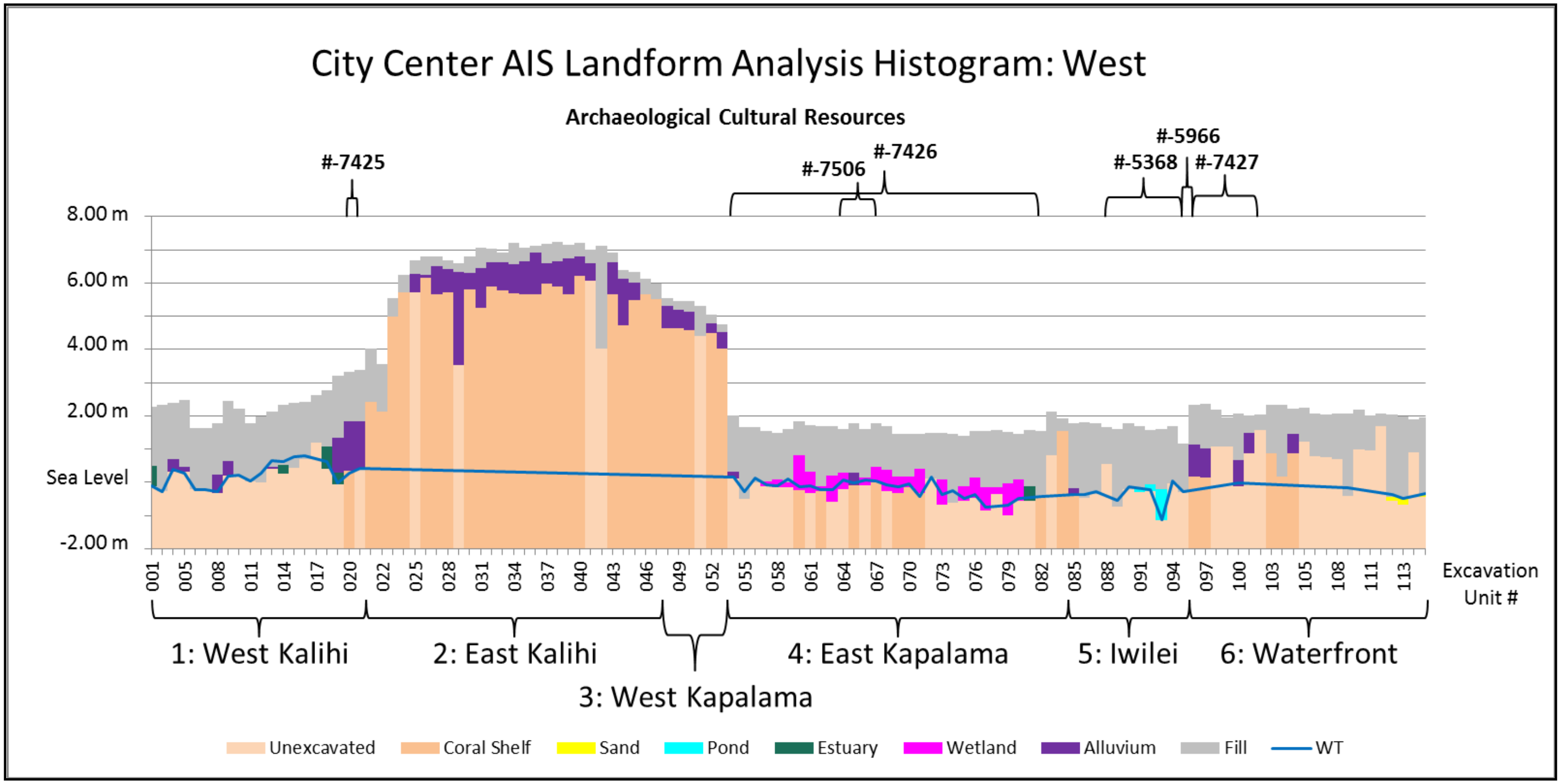



Figure 448. The subsurface natural geomorphology and overlying fill layers of the western portion of the City Center AIS study area; locations of archaeological cultural resources are also depicted

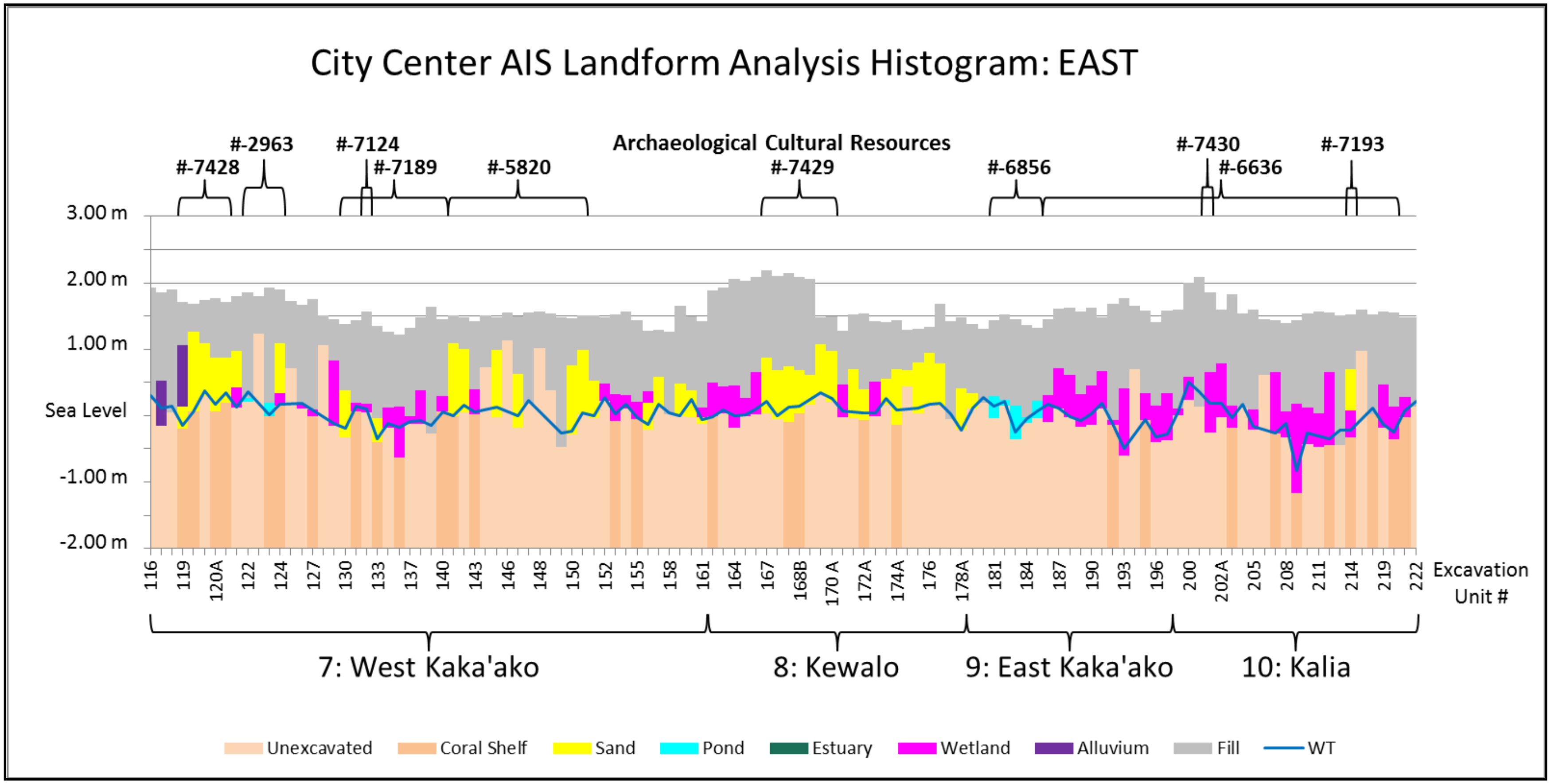



Figure 449. The subsurface natural geomorphology and overlying fill layers of the eastern portion of the City Center AIS study area; locations of archaeological cultural resources are also depicted

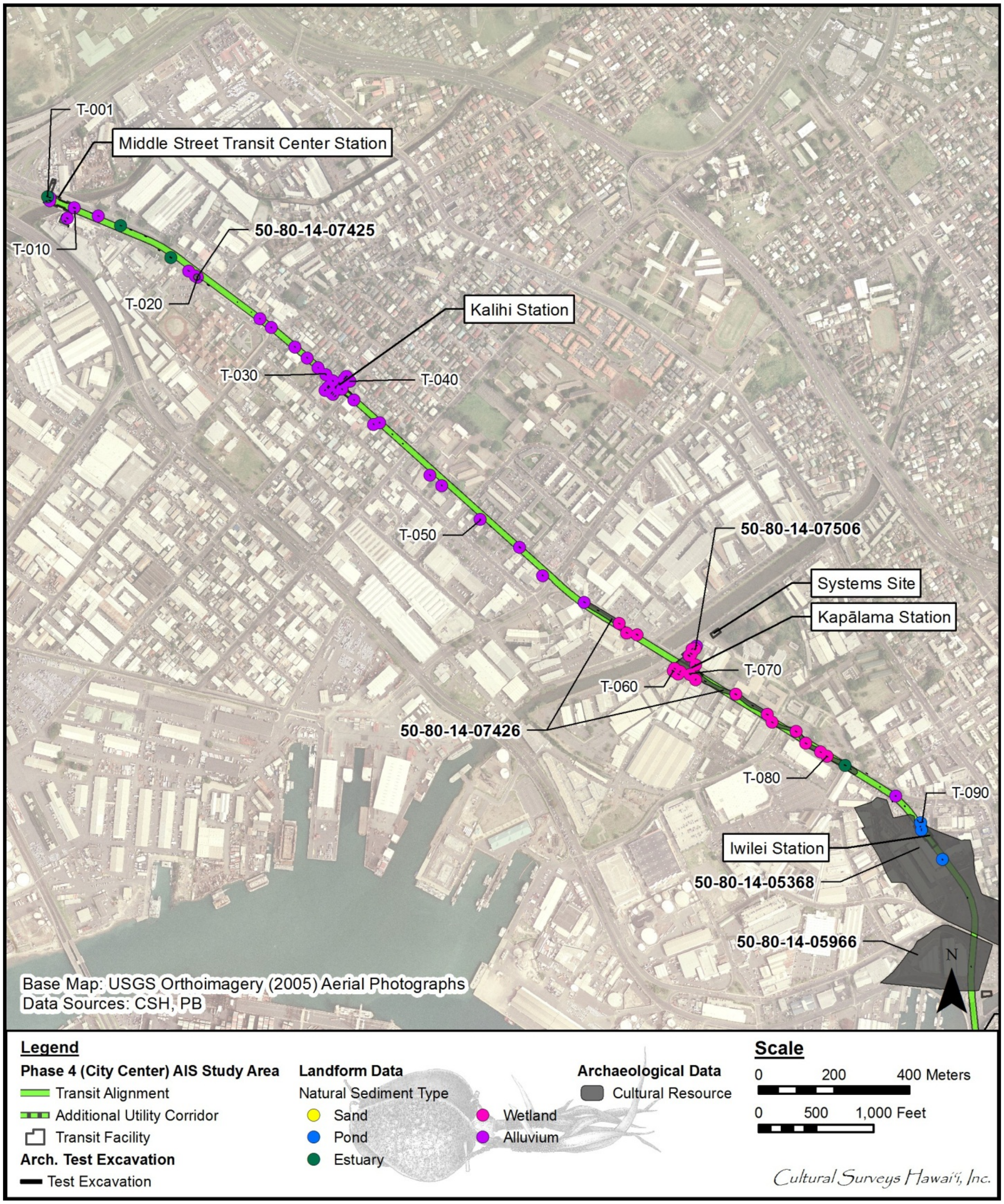



Figure 450. Aerial photograph showing the distribution of natural sediments beneath fill layers in the test excavations in the western portion of the City Center AIS (source: 2005 U.S.G.S. orthoimagery)

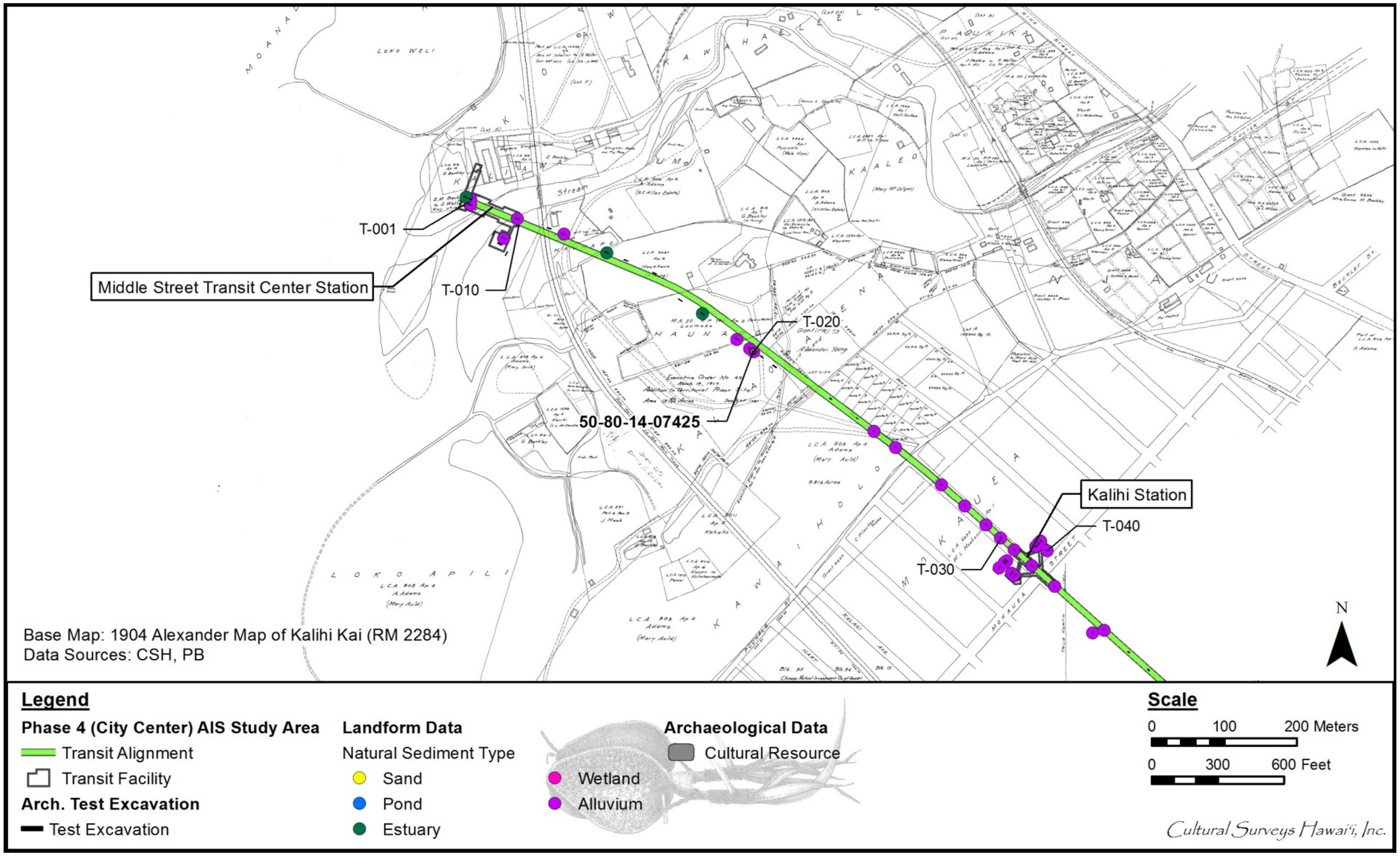



Figure 451. Portion of the 1904 Alexander Map of Kalihi Kai showing the distribution of the different natural landform types observed beneath fill layers in the City Center AIS test excavations in the vicinity of the Middle Street Transit Center Station and Kalihi Station

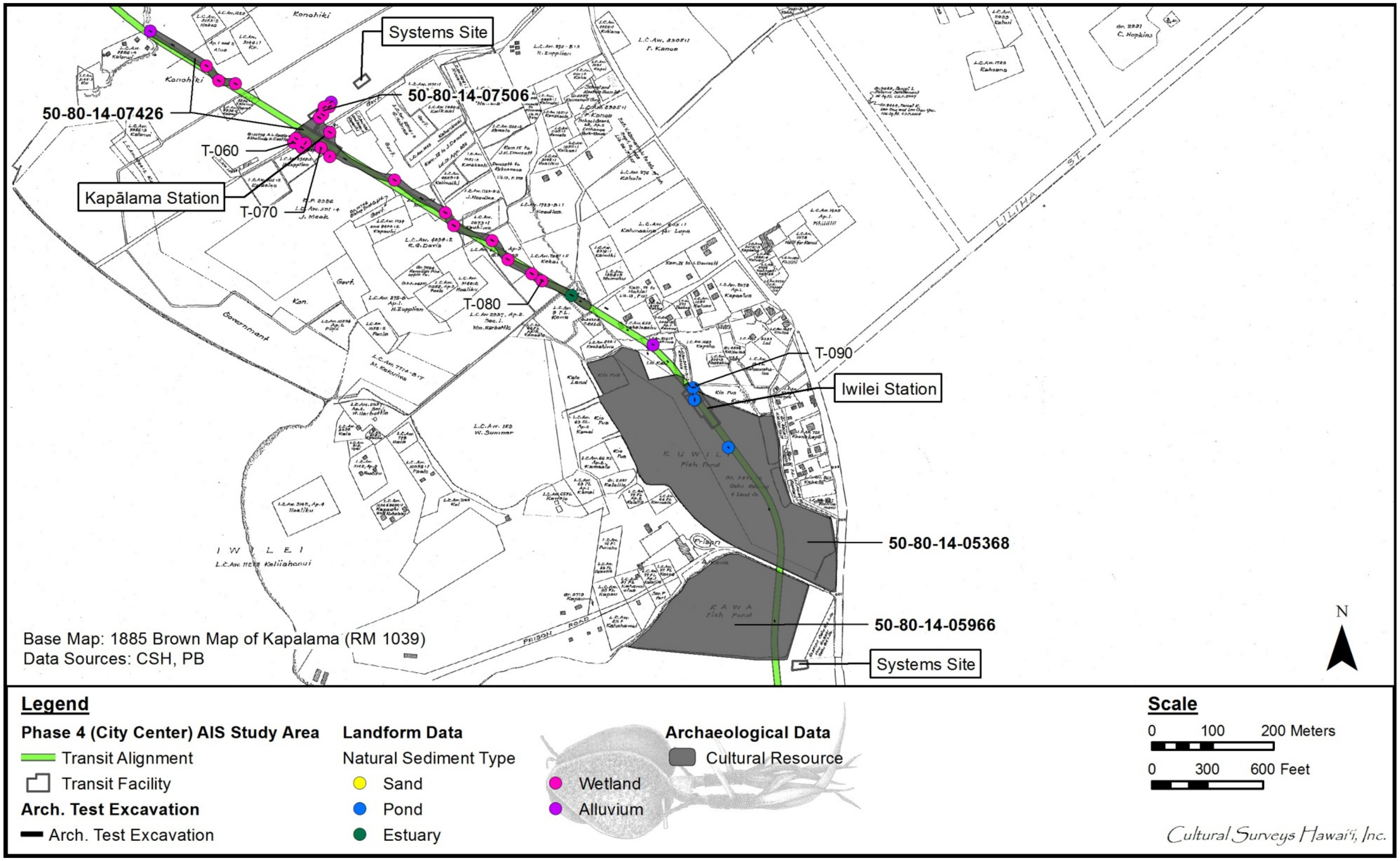



Figure 452. Portion of the 1885 Brown Map of Kapālama showing the distribution of the different natural landform types observed beneath fill layers in the City Center AIS test excavations in the vicinity of the Kapālama and Iwilei Station

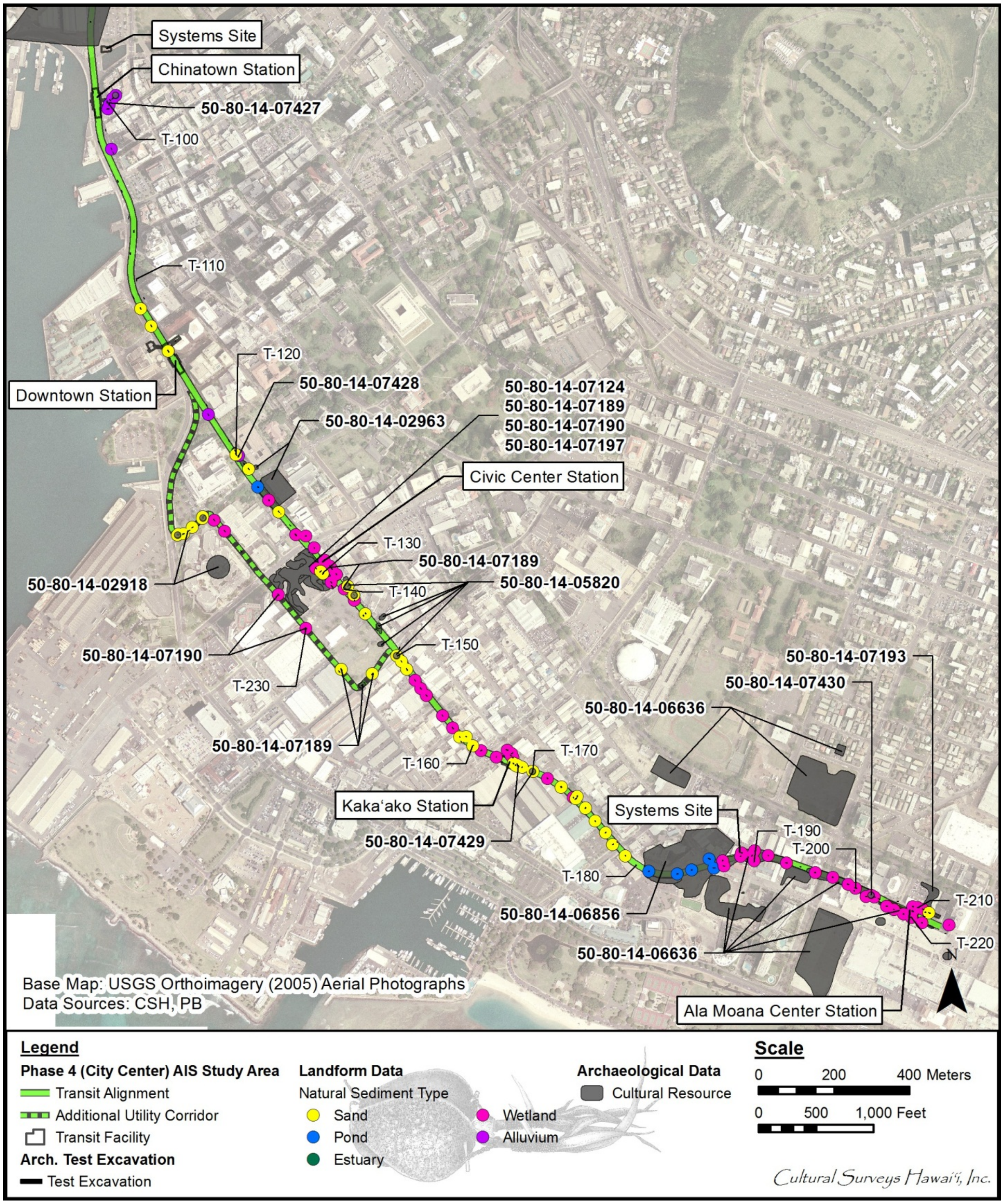



Figure 453. Aerial photograph showing the distribution of Jaucas Sand (Sand), wetlands, and pond sediments observed beneath fill layers in the Downtown and Kaka‘ako areas, including City Center AIS test excavations (source: 2005 U.S.G.S. orthoimagery)

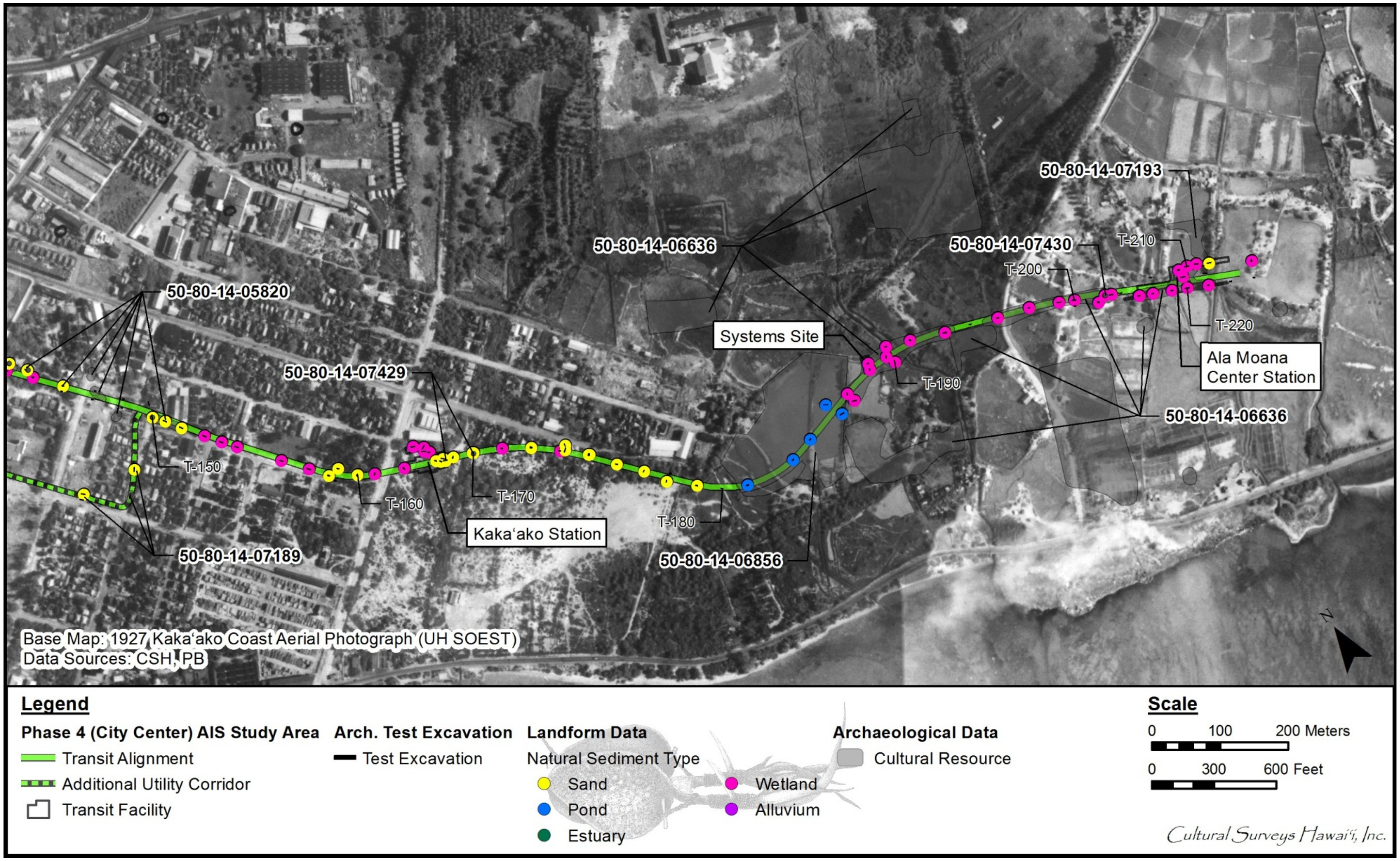



Figure 454. 1927 Kaka'ako Coast aerial photograph (source: U.H. SOEST) showing the distribution of Jaucas sand (Sand), wetlands, and pond sediments observed beneath fill layers in the Kaka'ako area within City Center AIS test excavations

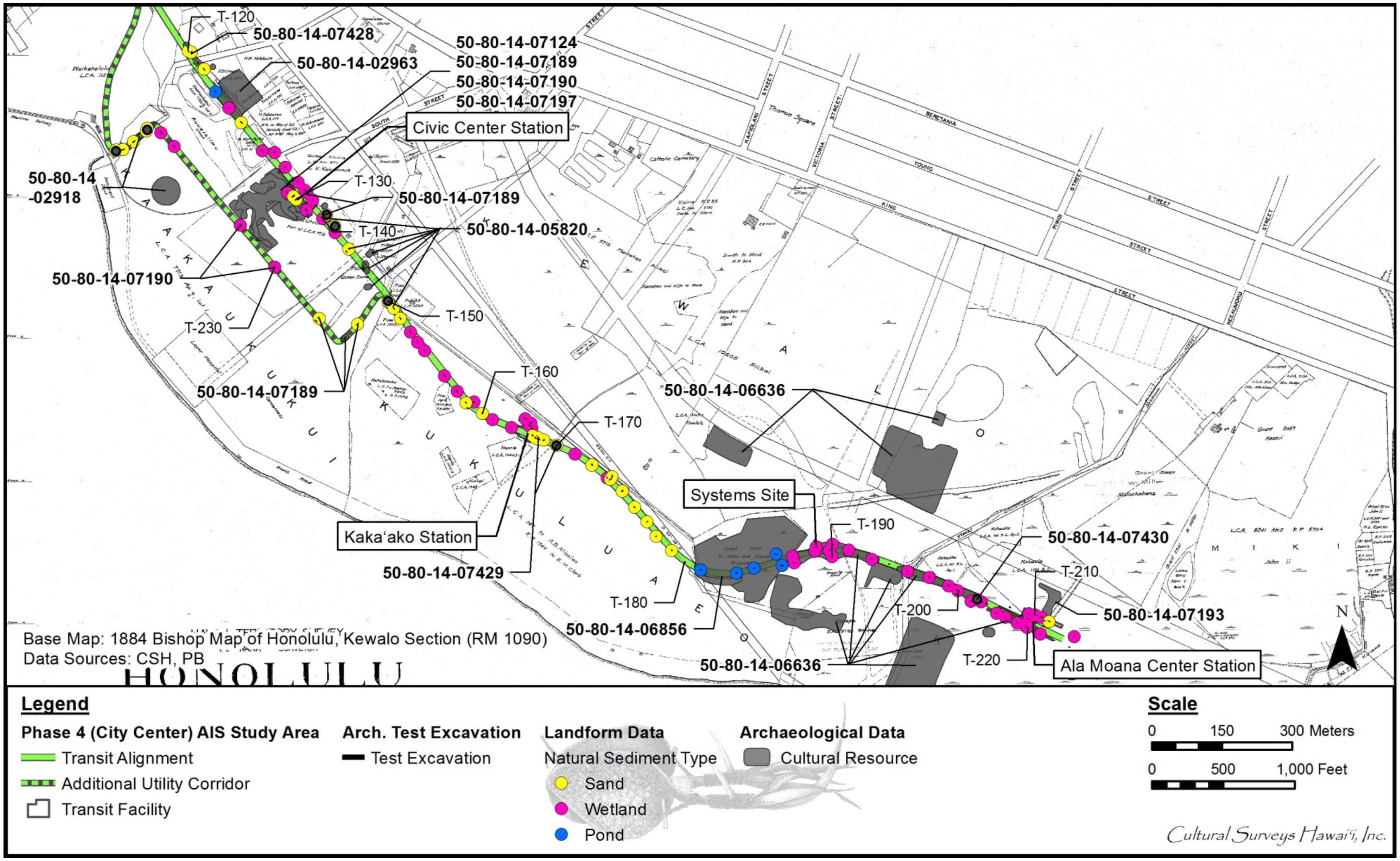



Figure 455. Portion of an 1884 map of Honolulu by S. E. Bishop, showing the distribution of Jaucas Sand (Sand), wetlands, and pond sediments observed beneath fill layers in the Kakaʻako area, including City Center AIS test excavations

show the distribution of these pre-fill landforms on two aerial photographs and an 1884 map of the area by S. E. Bishop.

Each histogram has three layers: modern/historic fill, natural land surfaces, and unexcavated deposits. Reasons for why some deposits remain unexcavated vary (see Section 4.2 for discussion). All data were corrected for elevation, thus all stratigraphic layers are shown in correct relative position to each other. The height of each column represents elevation above mean sea level as recorded by project surveyors. The top of the grey (fill) layer represents the modern surface of Honolulu.

Excavation stratigraphy was simplified for landform analysis. All deposits were coded with one of six designations: Fill, Sand, Pond, Estuary, Wetland, or Alluvium. Excavations often encountered complex deposits, and often fit in multiple categories. The natural stratigraphy of each unit was examined and assigned a code that best approximated the overall depositional environment. Historic context and in-field assessment were given the most weight in assigning a designation. Multiple natural surface designations were assigned only when there was a significant and clear transition between depositional events.

All excavations contained various layers of historic and modern fill deposits. In 28.7% of the excavations (72 out of 250 instances) fill was the only type of deposit encountered. Deposits from historic land reclamation and modern develpment, including modern construction and grading activities, were all classified as fill, regardless of type or material source. This designation encompasses a wide variety of deposits, including concrete and asphalt surfaces, layers of grading coral, dredged fill, trash dumps and redeposited land surfaces.

Natural land surfaces (wetlands, ponds, and Jaucas sand) were encountered in 71.3% of the excavations (179 out of 250 instances). The distribution of natural land surfaces encountered during the AIS is displayed in four pie charts (two each for the eastern and western portions of the City Center AIS study area) (Figure 456, Figure 457, Figure 458, and Figure 459). These charts show frequency based on presence/absence criteria; if an excavation encountered a natural surface it was scored as present.

The thickness of deposits was not considered. Units were counted twice if two natural land surfaces were assigned based on field observations.

Sand designates a predominance of Jaucas sand, a loamy sand surface, or primarily sandy deposits within the excavation. These deposits typically vary in color from yellow or very light brown to very dark brown. This category does not include silty sand marine deposits that fall under the wetland designation. It also does not include the excavated portions of degrading coral shelf, often described as sandy in the field.

There are three designations for variations of wetland deposits: estuary, pond, and wetland. All three types of deposits were fairly similar, and existed on a continuum. The designations serve to differentiate between known wetland environments, such as the Kalihi Stream estuary and the historic fishponds. In general, the pond and wetland categories were quite similar in sedimentary composition. Often the pond sediments were composed of finer grained silts and clays overlying marine sands and clays. The similar wetland sediments were comprised of silty, clayey and sandy sediments that had considerable organic content (including peaty layers of organics). Often both the wetland and pond sediments included abundant fresh- and brackish-

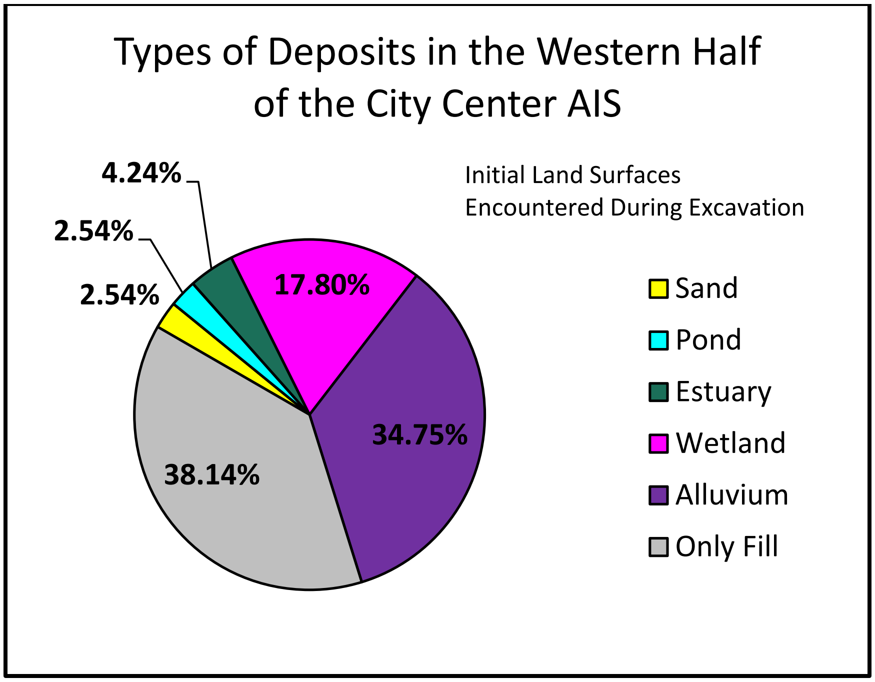



Figure 456. Percent distribution of each type of landform encountered in the western portion of the study area including those with only historic and/or modern fill deposits (Test Excavations 1 through 115)

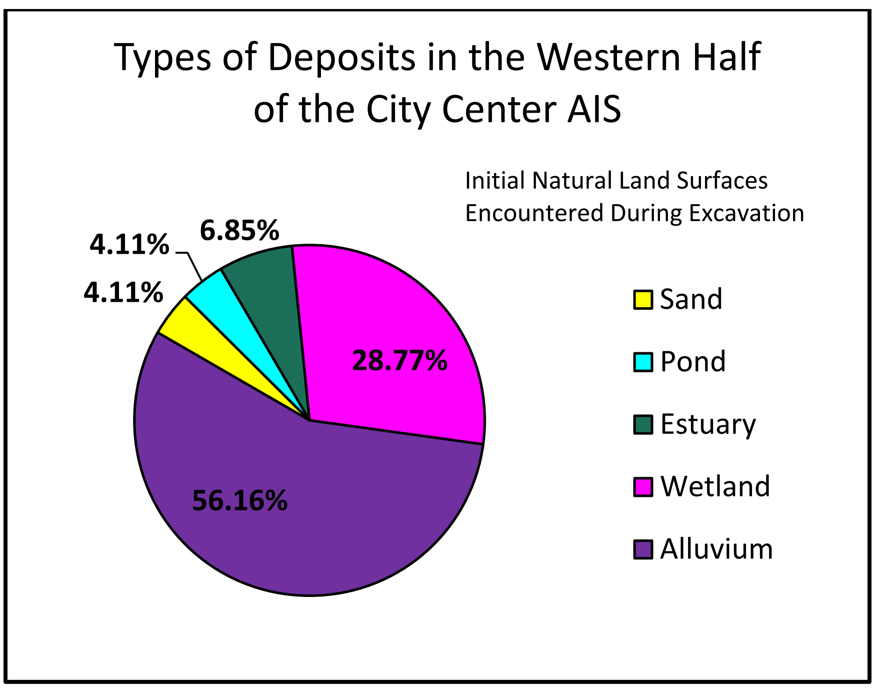



Figure 457. Percent distribution of each type of natural landform encountered in the western portion of the study area beneath layers of historic and/or modern fill (Test Excavations 1 through 115)

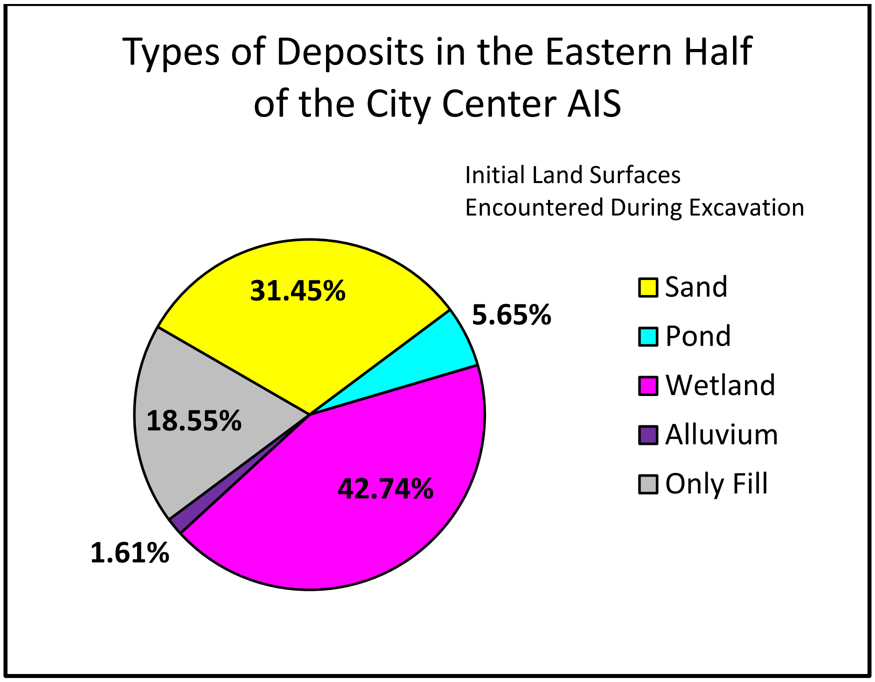



Figure 458. Percent distribution of each type of landform encountered in the eastern portion of the study area including those with only historic and modern fill deposits (Test Excavations 116 through 222—not including Kaka'ako Makai T-226 though T-232A)

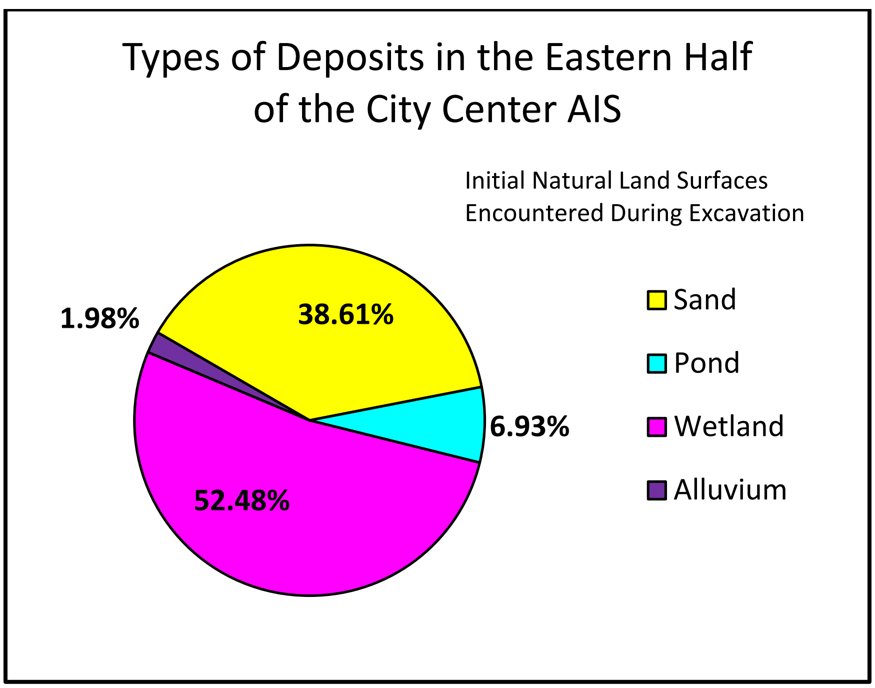



Figure 459. Percent distribution of each type of natural landform encountered in the eastern portion of the study area beneath historic and/or modern fill deposits (Test Excavations 116 through 222—not including Kaka'ako Makai T-226 through T-232A)

water snail shells. The estuary deposits were more distinct in that they had higher energy alluvial sediments, such as gravels, and fairly abundant marine shell and coral fragments. Field crews had access to historic maps and aerial photographs, allowing information on the locations of historic ponds and wetlands to be used in the field during the interpretation of test excavation sediments.

Alluvium encompasses all non-marine deposits of eroded soil. Specifically it refers to ‘Ewa Silty Clay Loam (EmA) encountered predominantly in the West Kalihi, East Kalihi and West Kapālama Geographic Zones. ‘Ewa Silty Clay Loam soils are described as:

> …well-drained soils in basins and on alluvial fans… [that] developed in alluvium derived from basic igneous rock... These soils are used for sugarcane, truck crops, and pasture. The natural vegetation consists of finger grass, kiawe, koa haole, klu, and uhaloa. (Foote et al. 1972:29)

Coral shelf or solid rock was encountered in 33% of the excavations (83 of out 250 instances). This designation also includes basalt bedrock and coarse deposits of degrading coral reef. Some 67% of the units did not reach coral shelf or bedrock. In these instances the area beneath the last excavated stratum is simply coded as unexcavated.

The water table is demarcated by a jagged blue line. It shows the elevation where each excavation initially encountered ground water. Not all excavations reached the water table; where there are no data, the trend line continues to next available data point. The water table level fluctuates and depends on numerous factors, including tide, porosity of the surrounding matrix, surface water drainage, and surface development.

#### *6.7.3.1 Western City Center (Geographic Zones 1-6: West Kalihi, East Kalihi, West Kapālama, East Kapālama, Iwilei, and Downtown Waterfront, Test Excavations 1 through 115)*

In the western portion of the City Center AIS study area, alternating estuary/wetland environments and alluvial/raised Pleistocene reef areas are prevalent. Natural land forms documented in test excavations in the western portion of the study area can be broken down into five categories: (1) sand, (2) pond, (3) wetlands, (4) alluvium, and (5) estuary. The majority of these deposits are part of the Kapālama/Niuhelewai terrigenous floodplain. Alluvium refers to the thin deposits of ‘Ewa silty clay loam encountered in the East Kalihi/West Kapālama area. These sediments rest on top of a Pleistocene coral shelf, part of the 7.5 m Waimānalo stand of the sea. Estuary sediments were encountered in the Kalihi Stream drainage as well as Iwilei, and consisted of terrigenous gravels and silty clays mixed with tidal zone marine shells. Figure 458 and Figure 459 show the percentage breakdown of landforms in the western half of the study area.

#### *6.7.3.2 Eastern City Center (Zones 7-11: West Kaka‘ako, Kewalo, East Kaka‘ako, Kālia and Kaka‘ako Makai, Test Excavations 117 through 232A)*

In the eastern portion on the study area, a mosaic of landform types is present: generally a lagoonal/wetland environment behind a prograding beach berm, with both fresh- and brackish-water and pockets of higher elevation sand deposits. Native Hawaiians used Kaka‘ako prehistorically for resource procurement, agriculture, burial interment, at least limited habitation, and as a transportation route. This native Hawaiian use of the area would have resulted in changes to Kaka‘ako’s landform. By early historic times, the *mauka* portions of Kaka‘ako had become a dusty plain interspersed with freshwater courses fed by springs and *mauka* streams. Kaka‘ako’s *makai* (Figure 460) portions were dotted with salt-making areas, marshes, fishponds, and taro fields.

Natural landforms documented in test excavations in the eastern portion of the study area can be broken down into three categories: (1) wetlands, (2) ponds, and (3) sand. The West Kaka‘ako and Kewalo Zones contained all three categories, although wetland and sand sediments strongly predominated. In the Kālia Zone pond and wetland sediments were predominant with only a small isolated area of sand. In the Kaka‘ako Makai Zone only sand and wetland deposits were encountered. Figure 456 and Figure 457 show the percentage breakdown of landforms in the eastern half of the study area.

*6.7.3.3 Conclusion*

The graphic presentation of natural sediment types encountered in the test excavations informs the discussion of archaeological cultural resource distribution. There are clear correlations between landform type and the types of archaeological cultural resources observed. For example, as would be expected, the higher sand deposits in Kaka‘ako have habitation and burials/human skeletal remains while the pond and wetland areas have evidence of agriculture and salt pan function. In Kapālama and Kālia the low-lying areas have the wetland agricultural and fishpond sediments.

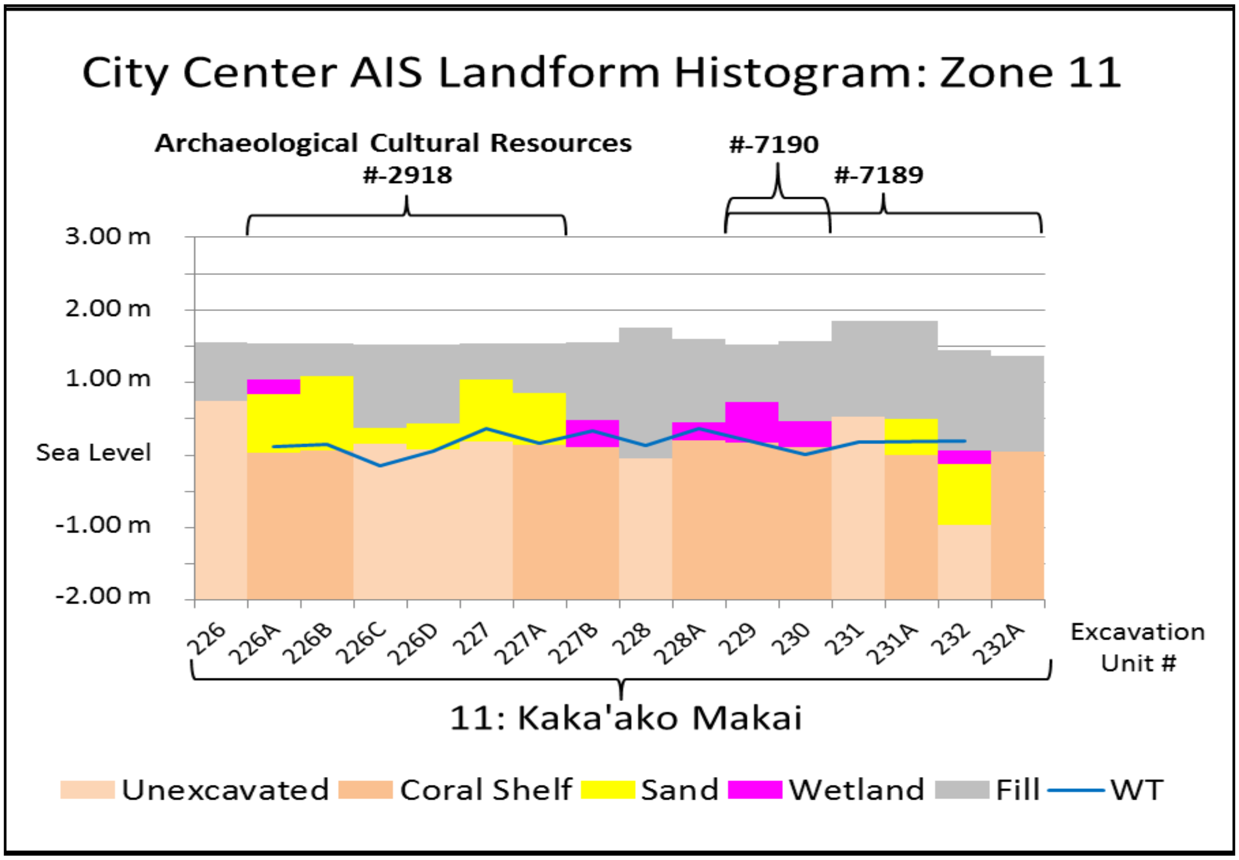



Figure 460. Additional Landform Histogram for Kaka‘ako Makai Zone 11 which runs parallel to a portion of the eastern City Center AIS Study Area; this section (T-226 through T-232A) continues the mosaic pattern observed throughout the eastern half of the study area

### 6.7.4 Human-Induced Environmental Change

The focus of the present inquiry is a reconstruction of the flora in the vicinity of the City Center AIS corridor from the late pre-Contact period up through the period of intensive rice cultivation (circa 1900) for which this study has developed significant data in the form of the direct taxa identification obtained through charcoal and pollen analysis. The environment in the late pre-Contact period had already been massively changed from that prior to human arrival, but would be radically and rapidly changed further by Western-induced changes following contact. This analysis seeks to elucidate the immediate environment of the City Center section from pre-Contact times through this period of rapid change.

#### *6.7.4.1 Time Depth for the Consideration of Environmental Change*

The 28 charcoal samples submitted in the course of the City Center AIS produced relatively late radiocarbon dates. Twenty dates typically span the past three centuries. The predominance of calendar ages extending into the nineteenth and twentieth century are an indication of intestive historic land use in the AIS study area. Only six carbon samples produced exclusively pre-Contact date ranges which clustered relatively tightly in the AD 1440–1660 period. The oldest date range was AD 1440–1640. Thus, data developed in this City Center AIS is believed to reflect the environment of the western Kona District of Oʻahu from late pre-Contact times up into the twentieth century.

International Archaeological Research Institute, Inc. (IARII) carried out two studies (Athens and Ward 1994, 1997) in close proximity to the City Center corridor that report details of environmental changes pre-dating Polynesian arrival, and the reader is referred to these studies for a discussion of longer-term change extending back before the common era.

Interpretation of datable pollen results has long supported the conclusion that radical change to the environment occurred fairly early in the course of Hawaiian colonization of the archipelago. For example, an IARII Fort Shafter Flats paleoenvironmental and archaeological investigation was confident that:

> …one conclusion is firm: the picture of a lowland *Pritchardia* (*loulu*) forest with a high diversity of dryland to mesic forest types offers a new level of understanding of the pre-Contact natural lowland vegetation, very different from the vegetation seen today or even during the period represented by Pollen Zone A around A.D. 768–997. (Wickler et al. 1991:51)

IARII reports that in the oldest Pollen Zones in the Fort Shafter flats, testing indicated that *Pritchardia* remained quite constant, accounting for 25% to 28% of the pollen, but by the AD 768-997 sample it dropped to 2% (Wickler et al. 1991:49-50). Data such as this has supported the conclusion that prior to AD 1200, the Hawaiian environment had been very much modified by direct human activity and secondary impacts (from introduced rats, pigs, dogs, and extensive deliberate burning and accidental impacts of range fires).

When Cuddihy and Stone published their *Alteration of Native Hawaiian Vegetation: Effects of Humans, Their Activities, and Introductions*, they emphasized the general point that "[b]y the time of Captain James Cook's arrival in the Hawaiian Islands in 1778, the original vegetation of the lowlands had been greatly altered by more than 1,000 years of Hawaiian occupation" (1990:103). They emphasized that "Agricultural practices of the Hawaiians were the major cause of environmental change in the Islands" citing the clearing of the original dry and mesic vegetation over large tracts of the lower leeward slopes for irrigated taro and dryland field systems. They also cite the use of fire, use of thatching grasses, firewood gathering, and removal of timber for construction purposes as significant factors in the degradation of natural vegetation.

While radical transformation to the native ecosystem clearly occurred in pre-Contact times, the rapid damage to lowland forests following western contact is well documented in a general sense. There were many factors contributing to the loss of these lowland forests, such as the western desire for forest resources such as sandalwood, *pulu* ("wool on the base of tree-fern leaf stalks," from Pukui and Elbert 1984:327), and cordage from such forest plants as *olonā* (*Touchardia latifolia*). By one estimate, it took 6,000 sandalwood trees to fill the hold of just one ship (Cuddihy and Stone 1990:38). A potentially greater ancillary impact "was the use of fire to detect sandalwood by the fragrant smoke produced when the tree burned" (Cuddihy and Stone 1990:39). The need of western ships for firewood may have been generally underestimated. As Cuddihy and Stone (1990:38) point out, this demand for firewood would have been particularly pronounced "near leeward ports." By 1810, Honolulu would have been a premier leeward port and the demand for firewood may well have been fierce, especially coupled with the domestic demands of the growing urban center. The rapid population growth of goats, sheep, cattle, and horses in the greater Honolulu area would have further decimated native shrubs and trees in the vicinity.

#### *6.7.4.2 Methodological Considerations Regarding Species Represented in Charcoal as Representative of Immediate Biota*

The following analysis explores the implications of charcoal species identified for environmental reconstruction as if the species present in charcoal were an indicator of the immediate environment. The general premise is that typically people will not carry wood to burn as fuel very far. Hence the concept is that typically the species indicated in charcoal taxa analysis grew within a kilometer or so of where the wood was burned. This may not always be so due to a variety of factors, including the following.

- There is reason to believe that Polynesian occupation (and associated introductions of rats, dogs, pigs, and the use of fire) transformed pristine climax forests into shrub land and grass land. As wood to burn became less available, it may have been transported for significantly greater distances (even transported by canoe). If all the wood native to the dry lowlands had been used up, wood may have been transported down from significantly wetter environs where it was still available.
- Wood that grew in the uplands, or even on distant continents, could be transported long distances by streams and sea (as drift wood).
- It is certainly possible that sources of wood from a much earlier time could have been covered and preserved by natural processes (hurricanes, tsunamis), that this wood supply would have been utilized as fire wood as much as centuries later, and that this "old wood" would not be indicative of the environment at the time of burning.
- It is certainly possible that wood gathered for the purposes of construction or for tool manufacture at a significant distance would be later utilized as firewood. For example a pre-Contact Hawaiian may have travelled many kilometers to acquire straight, long

*ʻōhiʻa lehua* timber for a house post and after the passage of time and natural decay, the post would be used as firewood.

Taxa identified in charcoal samples are summarized in Table 93, below, by test excavation. Columns arrange the data into three general types of plants: "Native Trees/Shrubs," "Polynesian Cultigens," and "Exotic Wood."

For the purposes of this analysis (Table 93) we have lumped *kukui* (wood) in with "Native Trees/Shrubs," for although it is understood as a Polynesian introduction, it quickly naturalizes and is understood as part of the native ecosystem in which Hawaiians lived (the vast majority of *kukui* was never "planted").

Under "Polynesian Cultigens" are four Polynesian introductions that were typically planted: *niu* or coconut (wood), *ipu* or *Lagenaria* sp. gourd, *kī* or ti, and *ʻulu* or breadfruit.

"Exotic Wood" includes two types of identifications: "Conifer" and "Temperate hardwood." Samples with "Conifer" or "Temperate hardwood" indicated as present were discounted on the grounds that these are exotic woods and most likely post-Contact (resulting from the mass importation of lumber). It should be noted however, that driftwood from the Pacific Northwest has always been common and such "fuel" at the coast would almost certainly have been burned by pre-Contact Hawaiians.

*Kukui* and *niu* "nutshells" and *hala* "fruit keys" were regarded as particularly likely to be transported over long distances and hence not necessarily indicative of local environmental factors (other than indicating Polynesian activity). In contrast, *kukui* "wood" and *niu* "wood" were thought to be indicators of the likely growth of these trees in the vicinity.

The identifications of *Syzygium* sp. was not addressed in this analysis as the source could be a Polynesian introduction *(ʻōhiʻa ʻai,* mountain apple) or a post-Contact exotic introduction (roseapple, Java plum). The same with *Senna* sp. that may have originated in native *kolomona* or may have been post-Contact introductions.

*6.7.4.3 Pre-Contact Environmental Change*

Given that the vast majority of dated archaeological features have date ranges into modern times and that the oldest date range does not pre-date AD 1440, nothing can be said with certainty regarding environmental change in pre-Contact times based on this AIS data. There is, however, a suggestion of biota change from the oldest charcoal samples to the later taxa assemblages that may merit consideration in future studies.

The exclusively pre-Contact dated charcoal (believed to most likely date from the sixteenth and early seventeenth centuries) included taxa found in more contemporary proveniences, such as *ʻōhiʻa lehua* and coconut, but also included the only identifications of *hōʻawa* (identified twice in older charcoal) and *pūkiawe.* It may be the case that *hōʻawa* and *pūkiawe* were less common in the lowlands in late pre-Contact times than previously. It may also be notable that *lama* is found in 4 out of 6 (66%) of the solidly pre-Contact charcoal assemblages, but in only 2 of the 19 later charcoal assemblages. The suggestion is that *hōʻawa*, *pūkiawe*, and *lama* became scarcer before other species.

Table 93. Taxa identified in the City Center AIS Charcoal Analysis

| Provenience | Native Tree/Shrub Indicated[1, 2] | Polynesian Cultigen Present | Exotic Wood Present | Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold] |
|---|---|---|---|---|
| T-020, (Feat. 1, 2.35–2.50 mbs), SIHP# -7425 | *Lama, Hōʻawa, Akoko, ʻAʻaliʻi,* ***ʻŪlei*** | - | - | Date range: AD 1440–1640<br>95.4% probability:<br>▪ **AD 1440–1530 (61.6%)**<br>▪ AD 1550–1640 (33.8%)<br>68.2% probability:<br>▪ AD 1450–1520 (54.1%)<br>▪ AD 1590–1620 (14.1%) |
| T-020A (2.30–2.34 mbs, Str. II) | ***Pūkiawe****, ʻAʻaliʻi, ʻŪlei* | - | - | Date range: AD 1480–1650<br>95.4% probability:<br>▪ **AD 1480–1650 (95.4%)**<br>68.2% probability:<br>▪ AD 1510–1600 (53.3%)<br>▪ AD 1610–1640 (14.9%) |
| T-075 (1.68–1.95 mbs, Str. IIb) | *Naio, ʻŌhiʻa lehua* | - | Conifer | |
| T-078 (1.8-1.9 mbs, Str.IIb) | *ʻŌhiʻa lehua* | *Niu* (wood) | Conifer | |
| T-119A (Feat. 1a, 0.80–0.93 mbs), SIHP# -7428 | *ʻŌhiʻa lehua, Akoko,* ***Kukui*** **(nutshell)** | - | - | Date range: AD 1660–1960<br>95.4% probability:<br>▪ **AD 1660–1890 (78.2%)**<br>▪ AD 1900–1960 (17.2%)<br>68.2% probability:<br>▪ AD 1720–1780 (28.9%)<br>▪ AD 1910–1950 (13.4%)<br>▪ AD 1670–1700 (12.3%)<br>▪ AD 1790–1820 (7.7%)<br>▪ AD 1830–1880 (5.8%) |

| Provenience | Native Tree/Shrub Indicated[1, 2] | Polynesian Cultigen Present | Exotic Wood Present | Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold] |
|---|---|---|---|---|
| T-119A (Feat. 1a, 1.25–1.50 mbs), SIHP# -7428 | *Kōpiko, ʻŌhiʻa lehua,* ***Kukui*** **(nutshell),** *ʻĀheahea, ʻāweoweo* | *Ipu* | | Date range: AD 1690–1940<br>95.4% probability:<br>▪ **AD 1800–1940 (65.6%)**<br>▪ AD 1680–1770 (29.8%)<br>68.2% probability:<br>▪ AD 1810–1920 (49.2%)<br>▪ AD 1690–1730 (19.0%) |
| T-120 (Feat. 4, 1.12–1.26 mbs), SIHP# -7428 | ***Kukui*** **(nutshell)**, *Hau, Loulu, Pilo, ʻAhakea. ʻĀkia, ʻIlima, ʻĀheahea, Akoko, ʻAhakea* | *Ipu* | | Date range: AD 1670–1940<br>95.4% probability:<br>▪ **AD 1790–1940 (62.7%)**<br>▪ AD 1670–1780 (32.7%)<br>68.2% probability:<br>▪ AD 1800–1890 (40.7%)<br>▪ AD 1680–1740 (18.8%)<br>▪ AD 1900–1930 (8.7%) |
| T-120 (Feat. 5, 1.10–1.18 mbs), SIHP# -7428 | ***Kukui*** **(nutshell)**, *ʻŌhiʻa lehua, Hau, Pilo, Akoko,ʻIlima,* | | | Date range: AD 1690-1960<br>95.4% probability:<br>▪ **AD 1810-1920 (67.1%)**<br>▪ AD 1690-1730 (19.1%)<br>▪ AD 1950-1960 (9.2%)<br>68.2% probability:<br>▪ AD 1880-1920 (41.3%)<br>▪ AD 1700-1720 (10.6%)<br>▪ AD 1950-1960 (8.6%)<br>▪ AD 1810-1840 (7.7%) |

| Provenience | Native Tree/Shrub Indicated[1, 2] | Polynesian Cultigen Present | Exotic Wood Present | Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold] |
|---|---|---|---|---|
| T-120 (Feat. 7, 1.04–1.07 mbs, SIHP# -7428 | ***Kukui* (nutshell)**, *‘Ilima, ‘Āheahea, ‘A‘ali‘i, ‘Ūlei* | | | Date range: AD 1680–1930<br>95.4% probability:<br>▪ **AD 1800–1930 (68.9%)**<br>▪ AD 1680–1740 (26.5%)<br>68.2% probability:<br>▪ AD 1870–1920 (29.6%)<br>▪ AD 1690–1730 (21.4%)<br>▪ AD 1810–1850 (17.2%) |
| T-120A (1.10–1.18 mbs), SIHP# -7428 | *Kōpiko, ‘Ōhi‘a lehua, Hao,* ***Kukui* (nutshell)**, *Pilo, Lama, ‘Ūlei, ‘A‘ali‘i, Akoko* | *‘Ulu* | | Date range: AD 1660–1960<br>95.4% probability:<br>▪ **AD 1660–1890 (78.2%)**<br>▪ AD 1900–1960 (17.2%)<br>68.2% probability:<br>▪ AD 1720–1780 (28.9%)<br>▪ AD 1910–1950 (13.4%)<br>▪ AD 1670–1700 (12.3%)<br>▪ AD 1790–1820 (7.7%)<br>▪ AD 1830–1880 (5.8%) |
| T-120A (Feat. 9, 1.28–1.36 mbs), SIHP# -7428 | *Kōpiko, Hau,* ***Pilo*** | | | Date range: AD 1660-1960<br>95.4% probability:<br>▪ **AD 1660-1890 (77.3%)**<br>▪ AD 1910-1960 (18.1%)<br>68.2% probability:<br>▪ AD 1720-1810 (42.3%)<br>▪ AD 1660-1690 (13.0%)<br>▪ AD 1920-1950 (12.9%) |

| **Provenience** | **Native Tree/Shrub Indicated[1, 2]** | **Polynesian Cultigen Present** | **Exotic Wood Present** | **Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold]** |
|---|---|---|---|---|
| T-120A (Feat. 10, 1.25–1.37 mbs), SIHP# -7428 | ***Kukui (nutshell)***, *Lama, Kōpiko, ʻĀheahea, ʻAʻaliʻi* | | | Date range: AD 1660–1960<br>95.4% probability:<br>▪ **AD 1660–1890 (77.3%)**<br>▪ AD 1910–1960 (18.1%)<br>68.2% probability:<br>▪ AD 1720–1810 (42.3%)<br>▪ AD 1660–1690 (13.0%)<br>▪ AD 1920–1950 (12.9%) |
| T-120A (Feat. 12, 1.28–1.32 mbs), SIHP# -7428 | *ʻŌhiʻa lehua, Kukui* (wood), ***ʻAkoko*** | *ʻUlu* | | Date range: AD 1650–1960<br>95.4% probability:<br>▪ **AD 1720–1820 (50.7%)**<br>▪ AD 1910–1960 (18.9%)<br>▪ AD 1650–1700 (17.6%)<br>▪ AD 1830–1880 (8.3%)<br>68.2% probability:<br>▪ AD 1730–1810 (41.9%)<br>▪ AD 1920–1950 (14.3%)<br>▪ AD 1660–1690 (12.0%) |

| Provenience | Native Tree/Shrub Indicated[1, 2] | Polynesian Cultigen Present | Exotic Wood Present | Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold] |
|---|---|---|---|---|
| T-124 (Feat. 1, 1.38–1.44 mbs), SIHP# -2963 | ***ʻĀheahea***, *ʻAkoko* | *Kī, Niu* (nutshell) | | Date range: AD 1690–1960<br>95.4% probability:<br>▪ **AD 1810–1920 (67.1%)**<br>▪ AD 1690–1730 (19.1%)<br>▪ AD 1950–1960 (9.2%)<br>68.2% probability:<br>▪ AD 1880–1920 (41.3%)<br>▪ AD 1700–1720 (10.6%)<br>▪ AD 1950–1960 (8.6%)<br>▪ AD 1810–1840 (7.7%) |
| T-124 (Feat. 2, 1.18–1.25 mbs), SIHP# -2963 | *Hau*, *Lama, ʻĀheahea, Akoko*, ***ʻIlima*** | | | Date range: AD 1660–1950<br>95.4% probability:<br>▪ **AD 1790–1950 (52.5%)**<br>▪ AD 1660–1780 (42.9%)<br>68.2% probability:<br>▪ AD 1830–1880 (19.9%)<br>▪ AD 1720–1780 (19.8%)<br>▪ AD 1910–1940 (11.8%)<br>▪ AD 1670–1700 (9.3%)<br>▪ AD 1790–1820 (7.4%) |
| T-124 (Feat. 5, 1.40–1.63 mbs), SIHP# -2963 | *Lama*, *Kukui* (wood), ***ʻĀheahea,*** *ʻAʻaliʻi* | | | Date range: AD 1490–1800<br>95.4% probability:<br>▪ **AD 1490–1670 (93.1%)**<br>▪ AD 1780–1800 (2.3%)<br>68.2% probability:<br>▪ AD 1520–1580 (38.2%)<br>▪ AD 1630–1660 (30.0%) |

| Provenience | Native Tree/Shrub Indicated[1, 2] | Polynesian Cultigen Present | Exotic Wood Present | Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold] |
|---|---|---|---|---|
| T-124 (Feat. 11, 1.20–1.32 mbs), SIHP# -2963 | ***Lama***, *Hōʻawa* | | | Date range: AD 1450–1640<br>95.4% probability:<br>▪ **AD 1450–1640 (95.4%)**<br>68.2% probability:<br>▪ AD 1460–1530 (39.0%)<br>▪ AD 1570–1630 (29.2%) |
| T-141 (Feat. 4, 0.75–0.95 mbs), SIHP# -5280 | *Kukui* (wood) | | | |
| T-142 (Feat. 8, 0.55–0.70 mbs), SIHP# -5280 | ***Kukui* (nutshell** and wood), *Kōpiko* | *Niu* (nutshell) | | Date range: AD 1510–1800<br>95.4% probability:<br>▪ **AD 1610–1670 (46.7%)**<br>▪ AD 1510–1600 (42.2%)<br>▪ AD 1780–1800 (6.6%)<br>68.2% probability:<br>▪ AD 1630–1670 (41.0%)<br>▪ AD 1520–1560 (27.2%) |
| T-145 (Feat. 9, 0.81–0.95 mbs), SIHP# -5280 | *Lama, ʻŌhiʻa lehua,* ***ʻIlima*** | | | Date range: AD 1480–1650<br>95.4% probability:<br>▪ **AD 1480–1650 (95.4%)**<br>68.2% probability:<br>▪ AD 1510–1600 (53.3%)<br>▪ AD 1610–1640 (14.9%) |
| T-145 (Feat. 10, 0.95–1.10 mbs), SIHP# -5280 | *Kukui* (nutshell) | | Conifer | |

| Provenience | Native Tree/Shrub Indicated[1, 2] | Polynesian Cultigen Present | Exotic Wood Present | Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold] |
|---|---|---|---|---|
| T-146A (Feat. 12, 0.75–0.90 mbs), SIHP# -5280 | ***Kukui*** **(nutshell** and wood), *Hau, Akoko, ‘A‘ali‘i* | *Niu* | | Date range: AD 1520–1960<br>95.4% probability:<br>▪ **AD 1630–1690 (51.3%)**<br>▪ AD 1730–1810 (30.8%)<br>▪ AD 1930–1960 (8.0%)<br>▪ AD 1520–1560 (5.3%)<br>68.2% probability:<br>▪ AD 1640–1670 (45.0%)<br>▪ AD 1780–1800 (23.2%) |
| T-146A (Feat. 13, 0.83–0.94 mbs), SIHP# -5280 | ***Kukui*** **(nutshell),** *‘Ōhi‘a lehua, Hau* | | | Date range: AD 1520–1960<br>95.4% probability:<br>▪ **AD 1630–1690 (51.3%)**<br>▪ AD 1730–1810 (30.8%)<br>▪ AD 1930–1960 (8.0%)<br>▪ AD 1520–1560 (5.3%)<br>68.2% probability:<br>▪ AD 1640–1670 (45.0%)<br>▪ AD 1780–1800 (23.2%) |
| T-146A (Feat. 14, 0.85–0.95 mbs), SIHP# -5280 | *‘Ōhi‘a lehua* | ***Niu (nutshell)*** | | Date range: AD 1490–1670<br>95.4% probability:<br>▪ **AD 1490–1670 (95.4%)**<br>68.2% probability:<br>▪ AD 1520–1580 (45.7%)<br>▪ AD 1620–1660 (22.5%) |

| **Provenience** | **Native Tree/Shrub Indicated[1, 2]** | **Polynesian Cultigen Present** | **Exotic Wood Present** | **Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold]** |
|---|---|---|---|---|
| T-146A (Feat. 15, 0.81–0.92 mbs), SIHP# -5280 | *Kukui* (wood), ***Pilo*** | | | Date range: AD 1640–1960<br>95.4% probability:<br>▪ **AD 1720–1820 (53.5%)**<br>▪ AD 1640–1700 (22.3%)<br>▪ AD 1910–1960 (19.6%)<br>68.2% probability:<br>▪ AD 1730–1810 (41.6%)<br>▪ AD 1660–1690 (14.2%)<br>▪ AD 1930–1960 (12.4%) |
| T-150 (Feat. 19, 0.70–0.75 mbs), SIHP# -5280 | ***Kukui* (nutshell),** *‘Ōhi‘a lehua, ‘Ilima, ‘Āheahea* | | | Date range: AD 1690–1960<br>95.4% probability:<br>▪ **AD 1810–1920 (67.1%)**<br>▪ AD 1690–1730 (19.1%)<br>▪ AD 1950–1960 (9.2%)<br>68.2% probability:<br>▪ AD 1880–1920 (41.3%)<br>▪ AD 1700–1720 (10.6%)<br>▪ AD 1950–1960 (8.6%)<br>▪ AD 1810–1840 (7.7%) |

| Provenience | Native Tree/Shrub Indicated[1, 2] | Polynesian Cultigen Present | Exotic Wood Present | Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold] |
|---|---|---|---|---|
| T-150 (Feat. 20, 0.90–1.30 mbs), SIHP# -5280 | ***Kukui* (nutshell)** | | | Date range: AD 1520–1960<br>95.4% probability:<br>▪ **AD 1630–1690 (51.3%)**<br>▪ AD 1730–1810 (30.8%)<br>▪ AD 1930–1960 (8.0%)<br>▪ AD 1520–1560 (5.3%)<br>68.2% probability:<br>▪ AD 1640–1670 (45.0%)<br>▪ AD 1780–1800 (23.2%) |
| T-151 (Feat. 25, 0.86–1.08 mbs), SIHP# -5280 | *Kukui* (nutshell), ***Ko‘oko‘olau*** | | | Date range: AD 1480–1660<br>95.4% probability:<br>▪ **AD 1480–1660 (95.4%)**<br>68.2% probability:<br>▪ AD 1520–1590 (50.1%)<br>▪ AD 1620–1650 (18.1%) |
| T-167 (Feat. 3, 1.45–1.48 mbs), SIHP# -7429 | *‘Ōhi‘a lehua* | | Conifer | |
| T-168B (Feat. 5, 1.60–1.65 mbs), SIHP# -7429 | *‘Ōhi‘a lehua* | | Conifer | |
| T-189 (1.55-1.65 mbs), SIHP# -6636 | *Hao*, *Kukui* (wood), *‘A‘ali‘i* | | Temperate hardwood | |
| T-226A (0.60–0.97 mbs), SIHP# -2918 | *Lama*, *Kukui* (nutshell), *Hau*, *Naio*, *‘Ōhi‘a lehua*, *‘A‘ali‘i*, *Akoko*, *‘Ilima* | *Niu* (nutshell) | Conifer, Temperate hardwood | |

| **Provenience** | **Native Tree/Shrub Indicated[1, 2]** | **Polynesian Cultigen Present** | **Exotic Wood Present** | **Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold]** |
|---|---|---|---|---|
| T-226A (Feat. 1, 0.98–1.03 mbs), SIHP# -2918 | *Kōpiko, ‘Ōhi‘a lehua, Hau, Kukui* (nutshell), *Hala* (fruit key), *‘Ilima, ‘Āheahea, ‘āweoweo*, *Akoko* | *Ipu* | Temperate hardwood | |
| T-226A (Feat. 2, 0.82–0.88 mbs), SIHP# -2918 | *Kukui* (nutshell), *‘Ōhi‘a lehua*, *Hau, Pūkiawe, Akoko* | *Niu* (nutshell), *‘Ulu* | Conifer | |
| T-226A (Feat. 3, 0.87–1.02 mbs), SIHP# -2918 | *Kōpiko, Kukui* (nutshell), *‘Ōhi‘a lehua, Lama*, *Akoko, ‘Āheahea, ‘āweoweo, ‘Ūlei, ‘Ilima* | *Kī, Ulu, Ipu* | Temperate hardwood | |
| T-226B (Feat. 4, 0.81–0.87 mbs), SIHP# -2918 | *‘Ōhi‘a lehua*, *Kukui* (wood and nutshell), *Pilo, ‘Āheahea* | *‘Ulu* | | |
| T-226B (Feat. 5, 0.80–0.90 mbs), SIHP# -2918 | *Kukui* (nutshell), *Akoko* | | | |
| T-226B (Feat. 6, 0.82–0.93 mbs), SIHP# -2918 | *Hau, ‘Ōhi‘a lehua*, *Kukui* (nutshell and wood) | *Niu* (nutshell), *Kī* | | |
| T-226B (Feat. 7, 0.80–0.95 mbs), SIHP# -2918 | | *Niu* (nutshell) | | |
| T-226B (Feat. 8, 0.76–0.90 mbs), SIHP# -2918 | *Kukui* (nutshell), *Lama, Akoko, ‘Ilima, ‘Āheahea* | *Niu* (nutshell), *Kī* | | |
| T-226B (Feat. 9, 0.76–0.85 mbs), SIHP# -2918 | - | - | - | - |
| T-226B (Feat. 10, 0.75–0.87 mbs), SIHP# -2918 | *‘Ōhi‘a lehua*, *‘Ilima* | | | |

| Provenience | Native Tree/Shrub Indicated[1, 2] | Polynesian Cultigen Present | Exotic Wood Present | Calibration (and likely date ranges from OxCal) at Two Standard Deviations [highest probability date range in bold] |
|---|---|---|---|---|
| T-226B (Feat. 11, 0.78–0.94 mbs), SIHP# -2918 | *Kukui* (nutshell), *'Ilima* | *Niu* (nutshell) | | |
| T-227A (Feat. 23, 1.08–1.31 mbs), SIHP# -2918 | ***Kōpiko***, *Lama* | | | Date range: AD 1640–1960<br>95.4% probability:<br>▪ **AD 1720-1810 (51.6%)**<br>▪ AD 1640-1690 (25.5%)<br>▪ AD 1920-1960 (18.3%)<br>68.2% probability:<br>▪ AD 1760-1810 (35.4%)<br>▪ AD 1650-1680 (18.9%)<br>▪ AD 1930-1960 (13.9%) |

[1]Although *Kukui* is understood as a Polynesian introduction, it was not treated as a Polynesian Cultigen but rather as a "Native Tree" as it readily naturalizes

[2]Plant sources for the radiocarbon dates are listed in bold

### *6.7.4.4 The Environment in the Timeframe of Western Contact*

Charcoal selected for carbon dating was preferentially selected to be from what appeared to be likely proveniences for pre-Contact dates. Charcoal from proveniences with post-Contact artifacts or indications were not selected for taxa analysis. Because the vast majority of the carbon dates span the past three centuries with stronger probabilities for nineteenth and twentieth century calendar ages it is believed that the environment represented by the charcoal typically falls relatively close to the time of Western contact. For the lay person, a surprisingly wide variety of species is represented in the charcoal as summarized in Table 47 and described in detail in Section 1.7.4.8, Description of Plant Species indicated as Common in the City Center Corridor, below. The explanation may largely lie in the conclusion (promulgated by the botanist J. F. Rock) that lowland leeward forests were “the richest of all Hawaiian forests in terms of numbers of tree species and unique plants, but today they have been reduced to mere remnants over much of their original range” (Cuddihy and Stone 1990:13).

A generalization regarding this assemblage would be to note the general absence of large diameter, long-lived species such as *Acacia koa* (*koa*), *Pritchardia* (*loulu*), and *Erythrina sandwicensis* (*wiliwili)*. It appears that any climax forest of such species in the vicinity was long gone by the time period indicated, with more shrub-like species predominating. The one exception among native species is *ʻŌhiʻa lehua* that shows up a number of times in the charcoal record. Notably *ʻŌhiʻa* can be quite shrub-like.

Table 94. Charcoal Taxa Identified

| Taxon | Common/Hawaiian Name | Origin/Habitat |
|---|---|---|
| *Aleurites moluccana* | *Kukui* | Polynesian Introduction/Tree |
| *Artocarpus altilis* | *ʻUlu,* breadfruit | Polynesian Introduction/Tree |
| *Bobea* sp. | *ʻAhakea* | Native/Tree |
| *Chamaesyce* sp. | *Akoko* | Native/Shrub |
| *Chenopodium oahuense* | *ʻĀheahea, ʻāweoweo* | Native/Shrub |
| *Cocos nucifera* | *Niu,* coconut | Polynesian Introduction/Tree |
| *Coprosma* sp. | *Pilo* | Native/Shrub-Tree |
| *Cordyline terminalis* | *Kī,* ti | Polynesian Introduction/Shrub |
| *Diospyros sandwicensis* | *Lama* | Native/Tree |
| *Dodonaea viscosa* | *ʻAʻaliʻi* | Native/Shrub |
| *Hibiscus tiliaceus* | *Hau* | Native/Shrub-Tree |
| *Lagenaria siceraria* | *Ipu* | Polynesian Introduction/Vine |
| *Metrosideros polymorpha* | *ʻŌhiʻa lehua* | Native/Tree |
| *Myoporum sandwicensis* | *Naio* | Native/Tree |
| *Osteomeles anthyllidifolia* | *ʻŪlei* | Native/Shrub |

| **Taxon** | **Common/Hawaiian Name** | **Origin/Habitat** |
|---|---|---|
| *Pittosporum* sp. | *Hōʻawa* | Native/Tree |
| Poaceae | Grass | Indeterminate |
| *Pritchardia* sp. | *Loulu* | Native/Tree |
| *Psychotria* sp. | *Kōpiko* | Native/Tree |
| Pteridophyta | Fern | Indeterminate |
| *Rauvolfia sandwicensis* | *Hao* | Native/Shrub-Tree |
| *Senna* sp. | *Kolomona* | Native and Historic Introductions |
| *Sida fallax* | *ʻIlima* | Native/Shrub |
| *Styphelia tameiameaie* | *Pūkiawe* | Native/Shrub |
| *Syzygium* sp. | *ʻŌhiʻa ai*, roseapple, Java plum | Native and Historic Introductions/Tree |
| *Wikstroemia* sp. | *ʻĀkia* | Native/Shrub |

It was surprising how abundant *kukui* (wood) was in the charcoal record, appearing in charcoal from eight test excavations. This suggests that *kukui* was one of the most common tree species in the vicinity in late pre-Contact times.

A surprisingly large number of identifications of cultigens (not including coconut shell) were made (identifications in 13 test units). These identifications of cultigens were particularly common in the Kakaʻako area (see Figure 461). This supports the view that Hawaiians at western contact were living in a botanical environment that was to a remarkable extent of their own making.

*6.7.4.5 Cultigens in the Pollen Record*

Identified Polynesian cultigens included *Cocos nucifera* (*niu* or coconut, in T-014, T-080, T-122, T-181, and T-184), *Cordyline* sp. (*kī* or ti, in T-093), and *Colocasia* sp. (taro or *kalo*, in T-041, T-080, and T-093).

There was only one spore of *Saccharum* sp. (sugar cane, *kō*) identified in T-067 near the Kapālama Drainage Canal. It is unclear whether this represents traditional Hawaiian cultivation or later commercial cultivation.

*Morinda* pollen representing *noni* was noted from T-093 and is indicated in Cummings and Varney (2013) Figure 2 as also present in T-067.

It appears from Cummings and Varney (2013) Figure 1 that a very small quantity of *Artocarpus* (breadfruit or *ʻulu*) was identified from T-207.

The Cummings and Varney (2013:13) report notes that in two of the three instances of the documentation of taro pollen, there are indications that this represents post-Contact taro cultivation. In the case of T-041, the *Colocasia* pollen was accompanied by *Leucaena* (*koa-haole*), *Prosopis* (*kiawe*), and *Oryza*-type pollen. In the case of the T-080, the presence of *Commelina* and *Oryza*-type pollen indicated post-Contact cultivation. Only in T-092 was there no post-Contact (introduced) pollen captured with the taro pollen, which may suggest pre-Contact taro cultivation.

The seeming complete absence of *kukui* (*Aleurites moluccana*) from the pollen record in the Cummings and Varney (2013) report is difficult to understand as *kukui* would be expected to have been ubiquitous in the valleys upwind and was remarkably common among the charcoal species identifications.

With the exception of coconut palms (presence suggested in the pollen from test excavations T-080, T-122, T-132, T-181, and T-184), the pollen record suggests a notable lack of traditional Hawaiian agriculture. This is understood to at least in part reflect the generally low rainfall of the City Center corridor (the Aloha Tower rain gauge, for example, averages 9.3 inches (210 mm) of annual rainfall (source: Pacific Disaster Center).

*6.7.4.6 Characterization of the Native Landscape*

Cyperaceae appears to be the largest pollen contributor with Poaceae a strong second in abundance. The environment indicated throughout the pollen record is one of sedges and grasses representing marshy land and grasslands. The next most abundant component is the

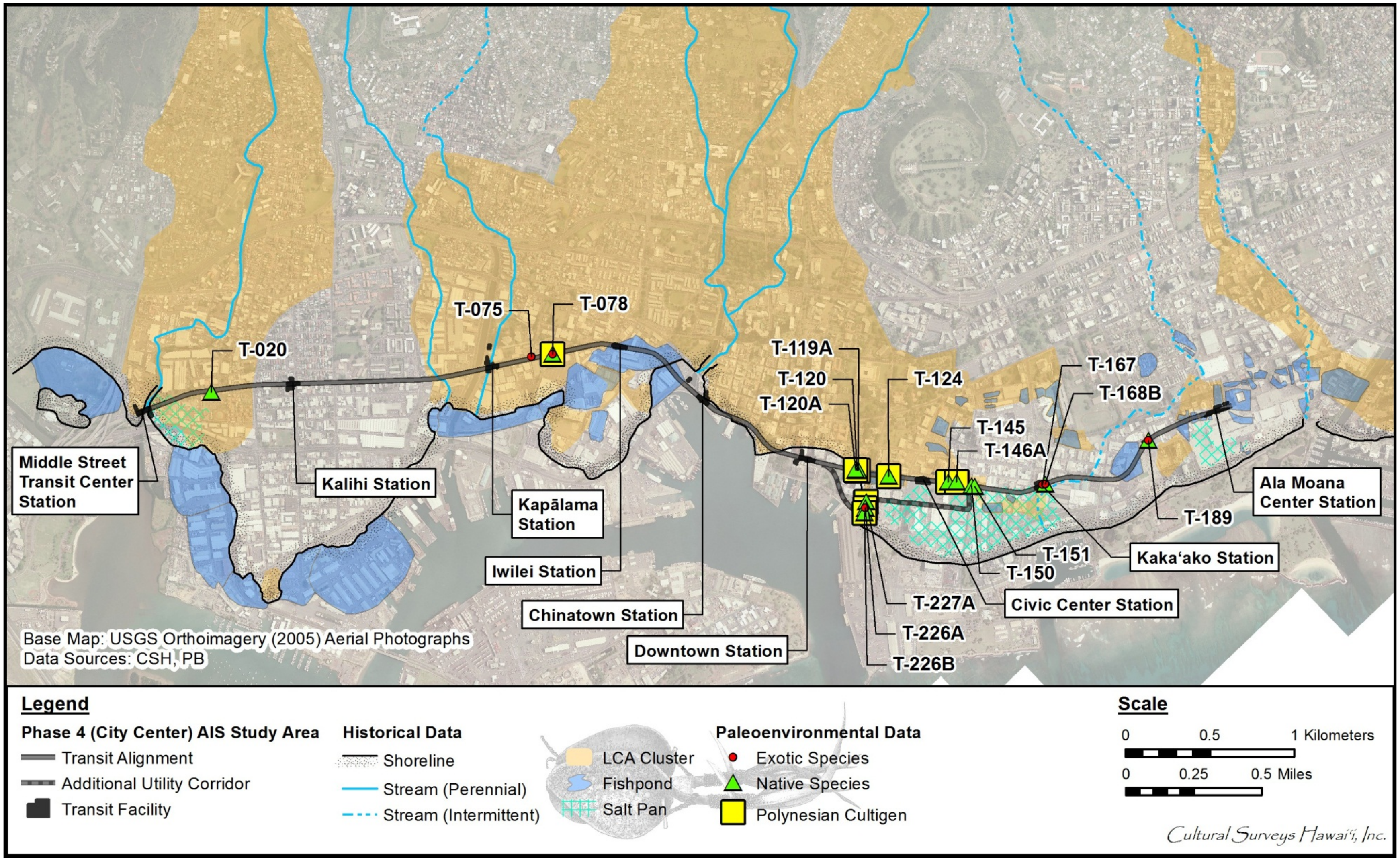



Figure 461. Map of the City Center project area and vicinity showing the locations of identifications of native trees, Polynesian cultigens, and exotic wood from the charcoal taxa analysis

"cheno-am," understood to be produced by a variety of dry land species such as *Chenopodium oahuense* (*‘aweoweo* or goosefoot) and *Amaranthus* sp. Wagner et al. (1990:536) insightfully describes *Chenopodium* species as "subshrubs," which captures their herbaceous, "rarely woody," and weedy nature. Cuddihy and Stone (199012) characterize such a landscape as dry leeward lowland grasslands and shrub lands. They posit that dominant grass species might have included *pili* (*Heteropogon contortus*), *kākonakona* (*Panicum torridum*), and *‘emoloa* (*Eragrostis variabilis*), and that a common sedge might have been *Fimbristylis cymosa* (*mau‘u*) that Wagner et al. (1990:1405) describe as "common on sandy beaches, and in shallow sand or soil on and among rocks and cracks." Cuddihy and Stone (1990:12) note that such extensive lowland grasslands "were probably largely the result of the Hawaiian practice of burning." Clearly pre- and post-Contact agriculture and post-Contact grazing were also factors in the creation and maintenance of grass lands.

While these data alone suggests that the landscape was a somewhat monotonous plain of grasses, sedges, and weedy cheno-am subshrubs, a complete picture must acknowledge that significant species diversity is in fact represented. Cuddihy and Stone (1990:12) posit that "native shrubs that are dominants in these communities" included *‘a‘ali‘i* (*Dodonaea viscosa*), *‘ākia* (*Wikstromia* sp.), *‘aweoweo* (*Chenopodium oahuensis*), *ko‘oko‘olau* (*Bidens menziesii*), *pūkiawe* (*Styphelia tameiameiae*), *alahe‘e* (*Canthium odoratum*), low-growing *‘ōhi‘a* (*Metrosideros polymorpha*), and possibly also *‘akoko* (*Chamaesyce* sp.), *nehe* (*Lipochaeta* sp.), *kulu‘i* (*Nototrichium sandwicense*), and *‘ohai* (*Sebania tomentosa*). This posited list of dominants actually has fairly minimal overlap with the pollen taxa identified in the City Center AIS (compare species mentioned above with the charcoal taxa listed in Table 47). This suggests that the shrubs and trees of this grassland may have been more diversified than previously understood.

*6.7.4.7 Post-Contact Cultigens*

The only post-Contact cultigens identified in the pollen record were rice and *Vigna* pollen (cf. *Vigna sinensis*, cow pea, or "yard-long beans") from T-067 located at Honolulu Community College suggesting use of this area for growing these introduced beans used in Chinese cooking.

Rice was surprisingly common in the pollen record (identified in test excavations T-014, T-041, T-067, T-092, T-093, T-122, and T-161) suggesting that rice cultivation may have been extensive in the vicinity. Coulter (1937:21) documents that in 1892 there were many hundreds of acres under rice cultivation in Kalihi, the vicinity of Kewalo, Pālama, and Waikīkī.

*6.7.4.8 Description of Plant Species indicated as Common in the City Center Corridor*

***‘A‘ali‘i***

**Hawaiian Name(s)**: *‘a‘ali‘i, ‘a‘ali‘i kū makani, ‘a‘ali‘i kū ma kua, kumakani*

**Scientific Name**: *Dodonaea viscose*

**Vernacular Name**: None

**Family**: Sapindaceae

**Status**: Indigenous

**Description**: Shrub/tree

**Habitat**: Found on open sites, ridges, lava, low pastures, shrublands, dry to mesic and wet forest, and subalpine shrubland, 3-2,347 m on all main islands except Kaho‘olawe (Wagner et al. 1990).

**Medicines**: In a treatment termed *holoina*, *‘a‘ali‘i* leaves are mixed with *ala‘a* bark (*Pouteria sandwicensis*) and *puakala ku kula* root (*Argemone glauca*) then ground and strained. The liquid is heated in a steam bath, which is followed with a purge of ground *pilikai* fruit (*Stictocardia tiliifolia*) to treat skin rash (*‘ohune* or *mane‘o*) (Chun 1994).

**Non-Medicinal Uses**: Wood is hard, heavy, durable; sometimes used for house posts and spears; many uses for fruits, such as a medicine, dye, and in *lei*, flowers also used in *lei* (Abbott 1992; Krauss 1993; Little and Skolmen 1989; Malo 1951). Pioneer species (Lamb 1981); made into “bait sticks,” these were shaped and then charred in the fire (Krauss 1993).

***‘Ahakea***

**Hawaiian Name(s)**: *‘ahakea*, *‘ahakea lau li‘i* (*B. brevipes*), *‘akupa* (*B. brevipes*), *‘ahakea lau nui* (*B. elatior*)

**Scientific Name**: *Bobea* (4 species)

**Vernacular Name**: None

**Family**: Rubiaceae

**Status**: Endemic

**Description**: Trees, all four species up to 10 m tall, wood is a dull orange-brown and becomes dark gold when rubbed with *kukui* oil.

**Habitat** *B. brevipes* in mesic to wet forests from 250–1280 m (Kaua‘i and O‘ahu); *B. elatior* in mesic valleys to mesic to wet forests 250–100 m (Kaua‘i, Moloka‘i, Maui, Hawai‘i); *B. sandwicensis* in dry to mesic forest and open lava flows 100–1220 m (O‘ahu, Moloka‘i, Lana‘i, Maui); *B. timoniodes* dry to mesic forest 250–580 m on Maui and Hawai‘i (Wagner et al. 1990).

**Medicines**: In a treatment for abscesses ‘*ahakea* bark is ground with *puakala ku kula* root bark (*Argemone glauca*), ‘*ohi‘a ‘ai* bark (*Syzygium malaccense*), and ‘*auko‘i* (*Senna occidentalis*) and then placed in a *mai‘a* (banana, *Musa* spp.) and used as a poultice (Chun 1994).

**Non-Medicinal Uses**: Yellow wood used for canoes; most favored for gunwales (Krauss 1993), *poi* pounding boards, canoe paddles (Malo 1951), and door and doorframes (Krauss 1993).

### *ʻAheahea/ʻAweoweo*

**Hawaiian Name(s)**: *ʻāheahea*, *ʻahea*, *ʻāhewahewa*, *alaweo*, *alaweo huna* (Niʻihau), *ʻāweoweo*, *kāhaʻihaʻi*

**Scientific Name**: *Chenopodium oahuense*

**Vernacular Name**: None

**Family**: Chenopodiaceae

**Status**: Endemic

**Description**: Lightly scented shrubs, sometimes tree-like.

**Habitat**: Occurring as a common or occasional element of dry habitats, ranging from 0–2,520 m from coastal zones to dry forest and subalpine shrubland (Wagner et al. 1990) on most main islands and some NWHI.

**Medicines**: This plant is used to treat *ʻea* (thrush, etc.) and *paʻaoʻao* (ailments). The leaf buds are used to treat children; the bark is ingested sometimes with *niu* (coconut, *Cocos nucifera*), *kukui* (*Aleurites moluccana*), *lipoa* (*Dictyopteris* spp.), or *poi* as a cosmetic for children. For *ʻea*, ʻ*aweoweo* is ground together with *uluhe* (*wawae ʻiole kuahiwi*, cf. *Huperzia* spp. or *Lycopodium* spp.), ʻ*alaʻula* (*wawae ʻiole kahakai*, cf. *Codium edule*), *ʻilima* (*Sida fallax*), and marine shells, then mixed with water and fed to children in *poi* or possibly *ʻuala* (sweet potato, *Ipomoea batatas*) (Chun 1994).

**Non-Medicinal Uses**: Leaves cooked and eaten as greens (Hillebrande 1888; Malo 1951). Part of composite fishhooks (Kamakau 1976; Krauss 1993). "The *kahuna* hoʻomanamana called this plant *ʻiloe holokula*, because it was used everywhere to induce death…[also used] with the *ʻākia lau nui* (*Wikstroemia*) and some bitter plants as firewood in the fireplaces used to send prayers" but also positive medicinal qualities (Chun 1994). The wood of the ʻ*aheahea* is not true wood, but secondary growth (Lamb 1981).

## *‘Ākia*

**Hawaiian Name**: *‘ākia, kauhi*, *‘ākia manolo*

**Scientific Name**: *Wikstroemia uva-ursi*

**Vernacular Name:** None

**Family:** Thymelaeacae

**Status:** Endemic

**Description**: Shrubs/small trees; height of 1–3 ft, spreads laterally up to 10 ft

**Habitat:** This endemic plant can easily be seen in numerous landscapes throughout Honolulu and the rest of the state. This plant, along with *naupaka* (*Scaevola sericea*), *pohinahina* (*Vitex rotundifolia*), and *pualoalo* (*Hibiscus arnottianus*) are among the most used native plants in Hawaiian landscapes today. Although, in the wild it is not common at all, found only in dry, open, often disturbed, lowland or coastal habitats on Kaua‘i, O‘ahu, Moloka‘i, and Maui where it is also reported as far inland as ‘Iao Valley.

**Medicines**: The sap—together with *niu* flesh (coconut, *Cocos nucifera*) and *kō kea* (white sugarcane, *Saccharum officinarum*)—is ingested with *‘uala* (sweet potato, *Ipomoea batatas*) as a purgative. The leaves and leaf buds are mixed with the bark of *‘ohi‘a ‘ai* (*Syzygium malaccense*) and *‘uhaloa* root (*Waltheria indica*), flesh of *niu*, *kō ‘aina kea* (sugarcane variety, *Saccharum officinarum*). Pounded, water added, strained, and the liquid ingested for *wai‘opua pa‘a* and *nae kulou* (Chun 1994).

**Non-Medicinal Uses**: Wood used as *‘auamo* (carrying sticks), leaves, branches and berries, beaten and used to stupify fish (Lamb 1981; Degener 1930); fruits as *lei* (Abbott 1992; Krauss 1993); cordage made from bast fibers, with bark removed (Abbott 1992; Rock 1913). Extremely poisonous, for suicide or execution, also used for binding (Degener 1930).

***‘Akoko***

**Hawaiian Name:** *‘akoko*, *koko*, *ekoko kōkōmālei*, *‘akokoko*

**Scientific Name:** *Chamaesyce degeneri*

**Vernacular Name:** Spurge

**Family:** Euphorbiaceae

**Status:** Endemic

**Description:** Shrubs and annual herbs

**Habitat:** Habitats vary, but most are found in dry to mesic vegetation (Wagner et al. 1990)

**Medicines**: Leaf buds fed to children or to lactating mothers to treat *‘ea* and *pa‘ao‘ao*. To insure or augment mothers’ milk, *‘akoko* sap with *kalo* leaves (taro, *Colocasia esculenta*), ingested in *poi*. For the ailment *‘ala‘ala hamani*, sap is mixed with powdered *‘ahu‘awa* stem as an ointment. Treatment for *kohepopo* and *wai‘opua hinanawe* (womens’ weakness, debilitation) combines *‘akoko* leaf buds, *‘ohi‘a ‘ai* bark, mature *noni* fruit (*Morinda citrifolia*), *kō kea* (white sugarcane, *Saccharum officinarum*), *‘ala‘ala wainui pehu* (*Peperomia* spp.), and *pia* (*Tacca leontopetaloides*) (Chun 1994).

**Non-Medicinal Uses**: *C. celastroides* (as *C. lorifolia*) noted as “much used as firewood” by Hillebrand 1888; sap used in paint (Krauss 1993); leaves and sap medicinal (Chun 1994).

***Hala***

**Hawaiian Name:** *hala*, *pū hala*, *lauhala*

**Scientific Name:** *Pandanus tectorius*

**Vernacular Name:** Screw pine

**Family:** Pandanaceae

**Status:** Endemic

**Description:** Small trees up to 10 m tall supported at base by several thick, rigid roots exposed above soil. Four types of *hala* based on color of fruit: common *hala* is yellow, *hala ‘ula* is orange, *hala lihilihi ‘ula* is red fading to yellow, and *hala pia* is small and pale yellow.

**Habitat:** Commonly occurs in mesic coastal sites and into low elevation slopes of mesic valleys further inland 0–610 m (Wagner et al. 1990).

**Medicines**: The *hala* fruit is made part of a treatment for *‘ea* and *pa‘ao‘ao*. The aerial roots are used in medications for childbirth and a skin disorder. They are combined with *pohepohe* (*Hydrocotyle verticillata*), *kohekohe* (*Eleocharis* spp.), *hala* leaf buds, *‘ala‘ala wai nui pehu* (*Peperomia* spp.), *‘ihi makole* (*Oxalis corniculata*), *naio* leaf buds, fruit, and leaves (*Myoporum sandwicense*), *niu* (coconut, *Cocos nucifera*), *kukui* flowers (*Aleurites moluccana*), *noni* fruits (*Morinda citrifolia*), and *kō* (*Saccharum officinarum*). For childbirth, a treatment includes *‘uhaloa* root (*Waltheria indica*), *noni* fruits, *hala* leaf buds and aerial roots, *‘ahu‘awa* leaf buds (*Cyperus javanicus*), *kō kea*, and *‘alaea* clay. For chest pains and *kohepopo* a drink of *hala* aerial roots, *pa‘ihi* (*Nasturtium sarmentosum*), *‘uhaloa*, *pōpolo* root bark (*Solanum americanum*), *‘ala‘ala wai nui pehu* stems (*Peperomia*), *‘ohi‘a lehua* bark (*Metrosideros* spp.), *noni* fruit, and *kō kea*) (Chun 1994).

**Non-Medicinal Use:** Leaves are prepared and woven into mats, pillows, and thatch (Abbott 1992). Seeds and fruit are edible (Abbott 1992), and roots may be used as cordage fiber (Summers 1990). For some *‘uli‘uli* (hula rattles), the handles were made of *lauhala*. Phalanges (fruit parts or “keys”) used in *lei* and when dried, as brushes for painting *kapa* (Abbott 1992).

***Hao***

**Hawaiian Name:** *Hao*

**Scientific Name:** *Rauvolfia* sandwicensis

**Vernacular Name:** None

**Family:** Apocynaceae

**Status:** Endemic

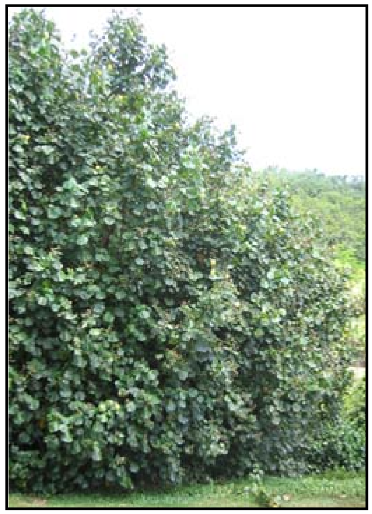
**Description:** Small shrub to tree

**Habitat:** *R. sandwicensis* is most commonly found on ridges, slopes, gulches of mesic forest between 100–500 m; occasionally in low, open dry areas (Wagner et al. 1990)

**Medicines:** The root contains small amounts of reserpine, used to treat high blood pressure and mental illness, but different related species from Africa and India are the ones commercially harvested.

**Non-Medicine Uses:** Little and Skolmen (1989) state that the wood was “not used by the Hawaiians for fuel because the smoke was thought to be poisonous, nor for charcoal because it burned completely to ashes. It was however, considered a good wood for construction.” Yet Malo states: “…*hao* and others…are ‘no doubt’ used for fuel” (Malo 1951). *Hao* often found at *heiau*, thought by some to have religious significance (Lamb 1981).

## *Hau*



**Hawaiian Name:** *Hau*, *hau ka‘eka‘e*

**Scientific Name:** *Hibiscus tiliaceus*

**Vernacular Name:** *None*

**Family:** *Malvaceae*

**Status:** Introduced

**Description:** Shrubs, to small trees

**Habitat:** Commonly occurring along coasts, streams, and other wet areas to 300 m on most main islands and some NWHI (Wagner et al. 1990)

**Medicines:** The flower buds and sap used as laxative and for *‘ea* and *pa‘ao‘ao*. That may be followed with an enema made from *noni* fruit (*Morinda citrifolia*). Sap from the bark was scraped and mixed with sap from the *kikawaio* fern (*Christella cyatheoides*) and *‘uwi‘uwi* (cf. *Conyza* spp.), with root bark from *‘uhaloa* (*Waltheria indica*) and *pōpolo* (*Solanum americanum*) for chest congestion. The leaf buds were chewed/swallowed for dry throat. The inner bark (with sap) was soaked and drunk for labor pains and rubbed on stomach (Chun 1994). Sap used as an internal lubricant as a mild laxative and to facilitate the passage of a fetus through the birth canal (Abbott 1992).

**Non-Medicine Use:** *Hau*’s bast fibers can be used for cordage, its light wood for the spars of outriggers and floats for fishnets (Handy et al. 1972), also used in firemaking with the harder wood of the Perrottetia (*olomea*). The *hau* “log” (*‘aunaki*) was slightly hollowed and the pointed stick (*‘aulima*) of *olomea* was rubbed in it to start fires. Branches also used in *‘ohai* sport known from Kaua‘i, where oiled, burning branches were tossed from cliffs (Degener 1930); bark for sandals (Krauss 1993); used on *hula* altars (*kuahu*) (Emerson 1909). Cordage used to sew *kapa* sheets together or tie sandals, also for *kapa* design sticks (*lapa*), slingshots, string of a bow, branches set along shorelines to indicate *kapu* fishing zones, kite frames and adz handles (Lucas 1982).

***Hō‘awa***

**Hawaiian Name:** *hō‘awa*, *hā‘awa*, *papahekili* (*P. glabrum*), *a‘awa* (*P. hosmeri*), *‘a‘awa hua*, *hō‘awa lau nui* (*P. kauaiense*)

**Scientific Name:** *Pittosporum* (11 species)

**Vernacular Name:** *None*

**Family:** Pittosporaceae

**Status:** Endemic

**Description:** Leaves 4–10” long and 1–2.5” wide, fruits 2–3” long, and 2-4 valved.

**Habitat:** Habitats vary greatly within and by species; many restricted to single islands (Wagner et al. 1990).

**Medicines**: For a swollen neck *(‘a‘i palaha*) or other similar illnesses, the inner flesh of the *hō‘awa* fruit is mixed with dried *kukui* nuts (*Aleurites moluccana*), leaves and root of *kupukupu hohonu* (cf. *Nephrolepis* spp.), and leaves, root, and bark of *‘ilie‘e* (*Plumbago zeylandica*) added to ‘*okolehao* (distilled from *ki*, *Cordyline fruticosa*) (Chun 1994).

**Non-Medicinal Uses**: Wood was “‘no doubt’ good for fuel” (Malo 1951). Sometimes used as gunwales (canoe part) (Krauss 1993); fruits as medicines (Neal 1965). Used by certain *kahuna* for “evil and troublesome work” (Chun 1994).

*‘Ilima*

**Hawaiian Name:** *‘ilima, apiki, ‘ilima lei, kapuaokanakamaimai. ‘ilima ku kala, ‘ilima makana‘a*

**Scientific Name:** *Sida fallax*

**Vernacular Name:** None

**Family:** *Malvaceae*

**Status:** Endemic

**Description:** Shrubs, 0.2–1.5 m.

**Habitat:** Common along coasts in rocky or sandy habitats, also in low open dry forest to mixed mesic forests, rare in low wet forest between 0–1,980 m (Wagner et al. 1990).

**Medicines**: There are numerous different types of *‘ilima* that have different Hawaiian names. In one publication (Chun 1994) they are listed separately. For *‘ilima lei*, he notes that the buds are fed to very young babies. To treat *pu‘ao ha‘ule* (and maybe *pu‘ao pelu*), the flowers of *‘ilima lei* are combined with leaf buds and flowers of the *pōpolo* (*Solanum americanum*), and dried *niu* fruit (coconut, *Cocos nucifera*). For the treatment of *‘ea and pa‘ao‘ao*, the root bark of the *‘ilima lei* is used with the flowers and leaf buds of *‘uhaloa* (*Waltheria indica*), flowers leaf buds, and stems of *‘ala‘ala wai nui pehu* (*Peperomia* spp.), flowers, leaf buds, and leaves of *pōpolo* (*Solanum americanum*), *noni* fruit (*Morinda citrifolia*), and *kō kea* (white sugarcane, *Saccharum officinarum*). For *nae* and *hano nae* the leaf buds, flowers and root bark if the *‘ilima lei* are mixed with the root bark of the *pukamole* (*Lythrum maritimum*), and *kō honua‘ula* (red-brown sugarcane, *Saccharum officinarum*) (Chun 1994).

**Non-Medicinal Uses**: Often said that the flowers were used in *lei* that were for the *ali‘i* (Degener 1930). Pukui notes that this is not strictly true (Handy et al. 1972); stems used in house frames, and lashed together to encircle taro-planting mounds in swampland; vines as rough basketry and floor covering under sleeping mats (Handy et al. 1972); used on *hula* altars (*kuahu*) (Emerson 1909).

***Ipu***


**Hawaiian Name:** *ipu*, *ipu nui*, *hue*, *pōhue*, *ipu ‘awa‘awa*

**Scientific Name:** *Lagenaria siceraria*

**Vernacular Name:** Bottle gourd

**Family:** Cucurbitaceae

**Status:** Polynesian introduction (not naturalized)

**Description:** Climbing vine

**Habitat:** Annual, that thrives only under cultivation. It grows best in dry areas with some type of support so the fruit won‘t spoil (Lucas 1982).

**Medicines**: For treatment of *hehena a moe‘ole a ka po*, young leaves are ingested in conjunction with dried *niu* (coconut, *Cocos nucifera*) and *‘uala* (sweet potato, *Ipomoea batatas*). For illnesses such as *papaku*, *hoaka*, and *wai‘opua* the flesh of the *ipu* is combined with *noni* fruit (*Morinda citrifolia*) and water and delivered as an enema. For *pu‘ao pelu* and maybe *ha‘ule*, the treatment combines *ipu* fruit flesh with leaf buds, leaves, and stems of the *kukaepuaa* (*Digitaria setigera*) (Chun 1994).

**Non-Medicinal Uses**: The hardened fruit is made into a variety of containers, for water, food, dyes, etc. (Krauss 1993). Also used for musical instruments, such as the bases of *‘uli‘uli* (*hula* rattles), knee drums, *‘ulili*, *pa ipu* or *ipu heke* (a percussion instrument made by joining two *ipu*, one atop the other) (Abbott 1992; Krauss 1993). The *ipu* was also used to chase away sharks (Lucas 1982:39); fisherman carried their lines and hooks in gourds and taken on sea voyages so if the canoe overturned the gourds would float and could be retrieved (Kamehameha Schools 1994).

***Kī***

**Hawaiian Name:** *kī*

**Scientific Name:** *Cordyline fruticosa*

**Vernacular Name:** ti

**Family:** Asparagaceae

**Status:** Polynisian introduction

**Description:** Shrubs, 2–3.5 m, green thin leaves 40–80 cm long

**Habitat** Found in cultivated and mesic valleys and mesic forest 5–610 m (Wagner et al. 1990)

**Medicines**: *Kī* has many medicinal uses. For treatment of *i'aku o ka ihu* (nasal growth), *kī* flowers are combined with rhizomes (underground stems) of *'ōolena* (*Cucurma longa*), *'awapuhi kuahiwi* (*Zingiber zerumbet*), and *'awapuhi lei* (Hedychium coronarium), as well as powdered *'iliahi* (*Santalum* spp.) and *naio* (*Myoporum sandwicense*). For *hano* (ho) *maka'u i ke kanaka*, *kī* flowers are added to pith of the *'ama'uma'u* fern (*Sadleria cyatheoides*) and *'ōkaha* (birdsnest fern, *Asplenium nidus*), and taken internally with *poi* and other foods. Treatment for shortness of breath/asthma (*nae*, *nae'oiku*, *nae hokale 'ano ohaohao*), *kī* flowers and leaf buds are mixed with *'uhaloa* root bark (*Waltheria indica*), *'ala'ala wai nui pehu* (*Peperomia* spp.), *noni* fruit (*Morinda citrifolia*), *'uala huamoa* (sweet potato, *Ipomoea batatas*), possibly *pu* (squash, Cucurbita spp.), and *kō kea* (white sugarcane, *Saccharum officinarum*).

**Non-Medicinal Uses**: Many uses, including leaves as food wrappers in *imu* and for footwear; the sweet roots baked as a "treat or famine food;" in historic period distilled into an alcoholic beverage, *'okolehao* (Handy et al. 1972). The earliest account of *kī* use come from the late eighteenth century (Cpt. Portlock 1789), who says that sweet potatoes, taro, sugarcane, yams, and "tee" were "met in great abundance." Abbott suggests that the term "famine food" for *kī* may be inappropriate, and says perhaps it was more commonly consumed (Abbot 1992). Commonly cooked and eaten in many other island groups, such as New Zealand, Samoa, Society Islands (Pollock 1992). It is of note that Portlock made beer from the boiled roots for curing scurvy, it is possible that this was a forerunner of *'okolehau*, which is distilled in iron pots, hence the name "ironbottom

***Kolomona***

**Hawaiian Name:** *kolomona*, *kalamona*, *heuhiuhi*, *uhiuhi*

**Scientific Name:** *Senna gaudichaudii*

**Vernacular Name:** None

**Family:** Fabaceae

**Status:** Endemic

**Description:** Shrubs 0.5–4 m

**Habitat** The native *Kolomona* occurs primarily on leeward sides on talus slopes, lava flows, or rocky sites in coastal shrubland, dry to mesic forest 5–920 m on most main islands (Wagner et al. 1990).

**Medicines:** No known uses for *Kolomona*.

**Non-Medicinal Uses**: Flowers used in *lei* (McDonald 1989).

***Kōpiko***

**Hawaiian Name:** *kōpiko*, *kōpiko ula* (*P. hawaiiensis*), *‘ōpiko* (*P. hawaiiensis*, *P. mauiensis*), *kōpiko kea* (*P. kaduana*)

**Scientific Name:** *Senna gaudichaudii*

**Vernacular Name:** None

**Family:** Rubiaceae

**Status:** Endemic

**Description:** Trees/shrubs

**Habitat:** *P. fauriei* windswept summits (450–) 520–860 m (O‘ahu), *P. grandiflora* mesic to wet forest 1040–1230 m (Kaua‘i), *P. greenwelliae* mesic to wet forest 610–1280 m (Kaua‘i), *P. hathewayi* mesic to dry forest 360–940 m (O‘ahu), *P. hawaiiensis* wet forest (occasionally dry to mesic forest) (50–) 150–1590 m (Hawai‘i, Moloka‘i, Maui), *P. hexandra* mesic to wet forest 360–1250 m (Kaua‘i, O‘ahu), *P. hobdyi* mesic forest 600–610 m (Kaua‘i), *P. kaduana* mesic valleys, mesic and wet forests (15–) 180–1220 m (most main islands), *P. mariniana* mesic to wet forest (60–) 180–1220 m (most main islands), *P. mauiensis* mesic to wet forest 215–1,470 m (most main islands), *P. wawrae* mesic forest 120–850 m (Kaua‘i) (Wagner et al. 1990).

**Medicines:** No known traditional medicinal uses.

**Non-Medicinal Uses:** Wood used for *kua kukukapa* (*kapa* anvil) and for fuel (Malo 1951).

***Kukui***

**Hawaiian Name:** *kukui, kuikui*

**Scientific Name:** *Aleurites moluccana*

**Vernacular Name:** Candlenut, tung tree

**Family:** Euphorbiaceae

**Status:** Polynesian introduction

**Description:** Trees, to 25 m tall, silvery-gray powder on leaves.

**Habitat:** Common in mesic valleys especially between 0–700 m on most main islands (Wagner et al. 1990).

**Medicines**: For *‘ea* and *paa‘ao‘ao* the flowers and endosperm (nut) of the *kukui* are combined with *‘ala‘alawainui pehu* stems (*Peperomia* spp.), *‘ohi‘a ‘ai* bark (*Syzygium malaccense*), *‘aka‘akai ‘oliana* (?onion, *Allium cepa*) bulb, *noni* fruit (*Morinda citrifolia*), *kō kea* (white sugarcane, *Saccharum officinarum*), and possibly *kikania* (*Desmodium sandwicense*). Ingedients are mashed and strained, and liquid ingested. For infected sores, including *puho ‘a‘ai*, the green flesh of the *kukui* fruit is cooked in *kī* leaves (ti, *Cordyline fruticosa*) and combined with *‘ulu* sap (*Artocarpus altilis*), powdered *‘ahu‘awa* (*Cyperus javanicus*), and powdered *lama* (*Diospyros* spp.); the mixture is applied as a salve. For *pu‘ao pehu* the “shell” (endocarp) is burned and the smoke is used from inside an *ipu*. To build strength after an illness the endocarps (nut meat) are ground, along with cooked *kalo* (taro, *Colocasia esculenta*), the flesh of *kikawaioa* (fern, *Christella cyatheoides*), these are eaten with fish and *‘uala poi* (sweet potato, *Ipomoea batatas*) with a *ko‘oko‘olau* infusion.

**Non-Medicinal Uses**: The light-weight wood can be used for canoes (Abbott 1992; Malo 1951); the bark for dye and fruits and oil for light (Hillebrande 1888); “nuts” (oily endosperm) placed inside bamboo as torch (*kali kukui*) or oil burned in lamps (Abbott 1992), fish floats from wood (Degener 1930), oil for fishing, polishing; soot collected on smooth, clean pebbles under which *kukui* nuts had been burned for tattooing (Abbott 1992; Handy et al. 1972), dye also from the fleshy part of the green part of fruit also for tattooing (not as good), the “meat” of the seed (endosperm) used for *hula* altars (Pukui 1942); “nuts” for *lei* (Krauss 1993); wood for house timbers (Handy et al. 1972).

***Lama***

**Hawaiian Name:** *lama*, *ēlama*

**Scientific Name:** *Diospyros* (2 species)

**Vernacular Name:** Persimmon, ebony

**Family:** Ebenaceae

**Status:** Endemic

**Description:** Tree 7–13 m tall, leaves thick, leathery and dull

**Habitat:** *D. sandwicensis*: dry to mesic to wet forest, 5–1,220 m, *D. hillbrandii* 15–-760 m, diverse mesic forest (Wagner et al. 1990).

**Medicines**: *Lama* is not a primary medicinal plant, but can be found as a secondary ingredient in many remedies. For cuts, boils, abscesses, bruises, and cold sores powdered *lama* is mixed with crushed *‘ahu‘awa* (*Cyperus javanicus*) (Chun 1994). In the cleansing of *puho* and *kaupo* the bark of *‘ahakea* (*Bobea* spp.), *‘āla‘a* (*Pouteria sandwicensis*), and *‘auko‘i* stalk (*Senna occidentalis*) are used, and then *‘ulu* sap (*Artocarpus altilis*) with powdered *‘ahu‘awa* and *lama* are placed on the affected area (Chun 1994). For “burns on the rear end” and *puho puhi ka‘oka‘o lama* ashes are combined with *kawa‘u* (*Ilex anomala*?) and *‘ahu‘awa* as a salve (Chun 1994). For infected sores, including *puho ‘a‘ai*, the green flesh of the *kukui* fruit is cooked in *kī* leaves (ti, *Cordyline fruticosa*) and combined with *‘ulu* sap, powdered *‘ahu‘awa*, and powdered *lama*; the mixture is applied as a salve (Chun 1994).

**Non-Medicinal Uses**: Hard wood used for god images, house posts, and house fences (Malo 1951), fences of mapele or *unu o Lono* (type of *heiau*) (Malo 1951); fruits eaten (Hillebrande 1888; Krauss 1993). *Lama* is a sacred plant, and an un-carved block of wood placed on *hula* altar (*kuahu*) wrapped in yellow *kapa* (usually *wauke*, *Broussonetia papyrifera*, scented with *‘ōolena*, *Cucurma longa*) to represent Laka (Mitchell 1992); sticks in fish traps (Krauss 1993:41), name means “light,” and connotes “enlightenment” (Pukui and Elbert 1986).

***Loulu***


**Hawaiian Name:** *loulu*, *loulu hiwa* (*P. martii*)

**Scientific Name:** *Pritchardia* (22 species)

**Vernacular Name:** Native fan palm

**Family:** Arecaceae

**Status:** Endemic

**Description:** Palms, up to 30 m

**Habitat:** Most common in mesic to wet forest up to 1220 m. All highly restricted in distribution: *P. affinis*, *P. beccariana*, *P. schattaurei* (Hawai‘i); *P. arecina*, *P. forbesiana*, *P. glabrata* (Maui); *P. aylmer-robinsonii* (Ni‘ihau); *P. hardyi*, *P. minor*, *P napaliensis*, *P. viscosa*, *P. waialealeana* (Kaua‘i); *P. hillebrandii*, *P. lowreyana*, *P. munroi* (Moloka‘i); *P. kaalae*, *P. lanigera*, *P. martii* (O‘ahu); *P. remota* (Nihoa) (Wagner et al. 1990).

**Medicines**: *Loulu* is used to treat *‘ea* and *pa‘ao‘ao* in children and adults. The leaf bud and inner flesh are combined with *niu* (coconut, *Cocos nucifera*), *kō kea* (white sugarcane, *Saccharum officinarum*), *‘ōhi‘a* bark (*Metrosideros* spp.) and *‘ala‘alawainui pehu* (*Peperomia* spp). All of the items are pounded into a liquid form and drunk three times a day (Chun 1994).

**Non-Medicinal Uses**: *Loulu* palm were erected to signify a temporary, special "*heiau loulu*," where gods of fishing were seasonally propitiated (Abbott 1992).

***Naio***

**Hawaiian Name:** *naio*, *naeo*, *naieo*

**Scientific Name:** *Myoporum sandwicense*

**Vernacular Name:** False sandalwood, bastard sandalwood, and *Naio*

**Family:** Scrophulariaceae

**Status:** Indigenous

**Description:** Shrub/small 1–15 m tall

**Habitat:** *M. sandwicensis* occurs in a number of different habitats from strand vegetation, to dry forest, lava flows, mesic to wet forest, and in subalpine forest 0–2,380 m (Wagner et al. 1990).

**Medicines**: To treat *nae kulou* and *waiopua paa*, or stubborn case of asthma, *ʻākia manalo* leaves (*Wikstroemia* spp.), *naio* leaf buds and leaves, the bark of *ohiʻa ai* (*Syzygium malaccense*) and *hiʻaloa* (*ʻuhaloa*, *Waltheria indica*) tap roots, dried *niu* (coconut, *Cocos nucifera*), and *kō aina kea* (sugarcane, *Saccharum officinarum*) are pounded into a mash and the mixture is strained with *ahuʻawa* (*Cyperus javanicus*). The liquid is drunk cold for five days, twice a day. (Chun 1994). For the illness *maʻi hemo keiki o na wahine hanau nui i ke keiki* (child birth of women who have had many children), *hala* aerial roots (*Pandanus tectorius*), *niu*, *kohekohe* (*Eleocharis* spp.), *hala* leaf buds, *alaʻalawainui pehu* stems (*Peperomia* spp.), *ʻihi makole* (*Oxalis* spp.), and *naio* leaf buds, fruit and leaves, *kukui* flowers (*Aleurites moluccana*), *noni* fruits (*Morinda citrifolia*), and *kō kea* (white sugarcane, *Saccharum officinarum*) are pounded into a mash and strained with *ʻahuʻawa*. The liquid mixture is heated. Once cool, the medicine is taken two times a day, once in the morning and again in the evening (Chun 1994).

**Non-Medicinal Uses**: Wood has odor similar to sandalwood (Degener 1930). Used for house posts (Degener 1930; Krauss 1993). Burns well and long, used for torches (Lamb 1981). Wood used for fish net gauge (*haha ka ʻupena*) (Krauss 1993).

***Niu***

**Hawaiian Name:** *Niu*, *ololani*

**Scientific Name:** *Cocos nucifera*

**Vernacular Name:** Coconut

**Family:** Arecaceae

**Status:** Polynesian introduction

**Description:** Trunk up to 30 m tall, leaves up to 6 m long

**Habitat:** Widely cultivated and occasionally naturalized, especially along sandy coasts (Wagner et al. 1990).

**Medicines**: *Niu* flesh, oil, leaf buds, and water were used in numerous medicines. These include formulations for *lepo pa‘a* (constipation), *‘ea* (thrush), *pa‘ao‘ao*, and the “illness related to *lolo*;” in addition, the leaf bud is made into a topical medicine for *‘eha moku kukonukonu* and *‘eha ‘ulia wale* (Chun 1998).

**Non-Medicinal Uses**: *Niu* (coconut) has many uses. The trunks used to make house posts, small canoes, hula drums, or food containers (Handy et al. 1972). Leaves (*launiu*) used for baskets, thatch, and for fans, known as some of the finest in Polynesia (Abbott 1993; Summers 1990). Leaf sheaths used as food or fish-bait wrappers (Handy et al. 1972). Husk fibers also used for cordage to make nets or lashing, known as *‘aha* (Summers 1990); the cordage could be coarse or fine. The cordage can be made into supports for *‘umeke* (bowls) or other round-based objects. Shell of fruit was used for eating utensils, such as spoons, bowls, plates, as well as *‘awa* cups and strainers for *‘awa*. *Niu* shells also served for storage containers, lids, and knee drums or *puniu* (Krauss 1993; Handy et al. 1972); the fibers are made into a drum beater. A musical instrument, the *hokiokio*, can also be made from coconut shell. Small mortars and bull roarers (*oeoe*) are also made from the *niu* shell (Krauss 1993). *Niu* water used as a drink, and flesh eaten raw or with *poi* (Handy et al. 1972). Some of the most familiar preparations of *niu* were not developed by ancient Hawaiians.

***ʻŌhiʻa ʻai***

**Hawaiian Name:** *ʻōhiʻa ʻai*, *ʻōhiʻa*, *ʻōhiʻa ʻai keʻokeʻo*, *ʻōhiʻa hākea*, *ʻōhiʻa kea*, *ʻōhiʻa leo*, *ʻōhiʻa ʻula*

**Scientific Name:** *Syzygium malaccense*

**Vernacular Name:** Mountain apple, Malay apple

**Family:** Myrtaceae

**Status:** Polynesian introduction

**Description:** Tree, to 20 m tall

**Habitat:** Occurring most commonly in mesic valleys at low elevations at mesic to wet sites between 200–310 (–550) m (Wagner et al. 1990).

**Medicines**: The bark is pounded with salt and strained through a *niu* leaf sheath (coconut, *Cocos nucifera*) for a topical medicine for open and deep cuts. For *ʻea* (thrush) and *paʻaoʻao*, the bark, leaves, and leaf buds are combined with *kukui* flowers (*Aleurites moluccana*), flowers, leaf buds, and leaves of the *hinahina ku kahakai* (*Heliotropium anomalum* var. *argenteum*), *ʻakaʻakai ʻoliana* bulbs (*Allium cepa*), leaves, leaf buds and flowers of the *ʻuhaloa* (*Waltheria indica*), and *kō honuaʻula* (red sugarcane, *Saccharum officinarum*). The mixture is strained through the *ʻahuʻawa* (*Cyperus javanicus*) and drunk. Foods suitable to consume while using this medicine are fish, *luʻau*, *kukui*, *ʻuala* (sweet potato, *Ipomoea batatas*), and fresh *poi*. For *hauna o ka waha* (bad breath) and *waha pala* (coated mouth), the bark is combined with *moa holokula* (cf. *Psilotum nudum*) and *kō kea* (white sugarcane) (Chun 1994). The bark chewed for a sore throat. Leaves were crushed and ingested for bronchitis (Abbott 1992).

**Non-Medicinal Uses**: Fruit eaten (Lucas 1982; Malo 1951). Used at *hula* altars (*kuahu*) (Emerson 1909). Dyes made from inner bark of trunk and root (brown) as well as the fruit skin (red) (Krauss 1993). Wood for posts, house rafters, and enclosures for *heiau* (Wagner et al. 1990), as well as being used for carved idols (Rock 1913).

***ʻŌhiʻa lehua***

**Hawaiian Name:** *ʻōhiʻa lehua*, *lehua*, *ʻōhiʻa*

**Scientific Name:** *Metrosideros* (2 species)

**Vernacular Name:** None

**Family:** Myrtaceae

**Status:** Endemic

**Description:** Shrub/tree, to 100 ft

**Habitat:** *M. polymorpha* (the more common species) is found in a wide variety of habitats (early successional species on lava, shrublands, mesic to wet forest) between 0–2,200 m on most main islands; *M. macropus* on Oʻahu only (Wagner et al. 1990)

**Medicines**: The flower of the "*ʻōhiʻa a-pane*" is used as a medicine for childbirth. Also the young leaf buds are used to treat *muheʻe kea* (paleness) in babies (Chun 1998).

**Non-Medicinal Uses**: Wood for images (*kiʻi*), posts and rafters, fences for temples, firewood, canoes (Malo 1951), construction of *luakini heiau* (Malo 1951), flowers and young leaf buds for *lei* (Abbott 1992); bowls (but difficult to work, see Abbott 1992). Placed on *hula* altars for *Kukaʻohiʻa Laka* (Abbott 1992). Musical instruments (Krauss 1993).

***Pilo***

**Hawaiian Name:** *pilo, hupilo, maiapilo, pua pilo, koi* (*C. kauensis*), *olena* (*C. waimeae*)

**Scientific Name:** *Coprosma* (12 species)

**Vernacular Name:** None

**Family:** Rubiaceae

**Status:** Endemic

**Description:** Shrub to small trees

**Habitat:** *C. cymosa* in mesic forest, 500–1000 m (Hawaiʻi); *C. elliptica* bogs and wet forest (Kauaʻi); *C. foliosa* mesic to wet forest between 300–1830 m (Kauaʻi, Oʻahu, Molokaʻ, Lānaʻi, Maui); *C. kauensis* wet to mesic forest 600–1330 m (Kauaʻi); *C. longifolia* mesic to wet forest 360–1200 m (Oʻahu); *C. menziesii* mesic forest 270–1220 m (Hawaiʻi); *C. montana* supalpine shrubland and woodland, mesic forest 1830–3050 m (Maui, Hawaiʻi); *C. ochraecea*, wet habitats, occ. mesic forest, 790–2290 m (most main islands); *C. pubens* wet to mesic forest 360–1900 m (Maui, Hawaiʻi, Molokaʻi, Lāniʻi); *C. rhynchocarpa* mesic to wet forest, subalpine shrubland 490–2260 m (Hawaiʻi); *C. ternata* mesic to wet forest 760–1400 m (Molokaʻi); *C. waimeae* mesic forest 580–1070 m (Kauaʻi) (Wagner et al. 1990).

**Medicines**: The berries of the *pilo* are used as a laxative (Degener 1930).

**Non-Medicinal Uses**: Wood variable from hard to soft between species (Little and Skolmen 1989).

***Pūkiawe***

**Hawaiian Name:** *pūkiawe*, *a‘ali‘i mahu*, *kānehoa*, *kāwa‘u* (Lāna‘i, Maui), *maiele*, *maieli*, *puakiawe*, *puakeawe*, *pūpūkiawe*

**Scientific Name:** *Leptecophylla tameiameiae*

**Vernacular Name:** None

**Family:** Ericaceae

**Status:** Indigenous

**Description:** Shrubs

**Habitat:** Scattered to very common in mesic forest to open areas, low elevation to montane wet forest, to alpine shrublands and bogs rarely windward coastal sites 15–3230 m (Wagner et al. 1990).

**Medicines**: Leaves of the *pūkiawe* or *‘a‘ali‘i mahu* are ground with salt, mixed with water, and inhaled through the nose to treat congestion (*holopani upe nui*) (Chun 1994).

**Non-Medicinal Uses**: The fruit often used in *lei* (Abbott 1992); when *‘ali‘i* wished to mingle with commoners (with no harm to them or himself), would be smudged with smoke from *pūkiawe* while *kahuna* chanted for “dispensation” (Degener 1930), “this is the plant that a person would burn to sanctify the *kapu* of the chiefs” (Malo 1951); wood used for cremating bodies of outlaws (Little and Skolmen 1989); wood for *kua kuku* (*kapa* anvil) (Krauss 1993).

***Uhihi***

**Hawaiian Name:** *uhiuhi*, *kāwa‘u* (Maui), *kea* (Maui)

**Scientific Name:** *Caesalpinia kavaiensis*

**Vernacular Name:** None

**Family:** Fabaceae

**Status:** Endemic; endangered

**Description:** Shrubs or tree, 4–10 m tall

**Habitat:** Now rare in mesic or dry forest at Waimea Canyon, Kaua‘i; central leeward Wai‘anae Mountains, O‘ahu; *Hualalai, Hawai‘i* (Wagner et al. 1990).

**Medicines**: To purify the blood, combine and mash young leaves and leaf buds and bark of *uhiuhi*, along with the inner bark of *hāpu‘u* (*Cibotium* spp.), *okolehao* (usually of *ki*, *Cordyline fruticosa*), *‘ulu* bark (*Artocarpus altilis*), *‘uhaloa* tap roots (*Waltheria indica*), and sections of *kō kea* (white sugarcane, *Saccharum officinarum*). Strain mixture through *‘ahu‘awa* (*Cyperus javanicus*) and drink three times a day (Chun 1994).

**Non-Medicinal Uses**: Extremely hard wood used to make weapons (Abbott 1992), *‘o‘o* or digging stick (Krauss 1993), house posts (Kamakau 1976; Krauss 1993), *kapa* beaters (Kamakau 1976: Krauss 1993), *la‘au kahi wauke* or a board for scraping *wauke* to make *kapa* (Krauss 1993); sled runners (for *holoa*) (Culliney and Koebele 1999). Also for fish hooks (Kamakau 1976; Krauss 1993); octopus or fish spears (Kamakau 1976; Krauss 1993).

***‘Ūlei***

**Hawaiian Name:** *‘ūlei*, *u‘ulei*, *eluehe* (Moloka‘i)

**Scientific Name:** *Osteomeles anthyllidifolia*

**Vernacular Name:** None

**Family:** Rosaceae

**Status:** Indigenous

**Description:** Shrubs; glossy green leaves with white fragrant blossoms and round fruit.

**Habitat** Occurring in a wide variety of habitats including dry open shrubland, dry to mesic forest, disturbed sites, lava fields; between 2–2,320 m on most main islands (Wagner et al. 1990).

**Medicines**: To treat *‘ea* and *pa‘ao‘ao*, the leaf buds and seeds, *‘ūlei*, are eaten until the illnesses are gone. To treat open cuts or injuries, the *‘ūlei* bark , leaves, and salt are pounded into a mass and applied to the cut (*kahi ‘eha*) (Chun 1994).

**Non-Medicinal Uses**: Mature, hard wood used for *‘o‘o* (digging sticks) (Krauss 1993), musical instrument; *ukeke*, musical bow (Krauss 1993); short spears, including octopus spears (Kamakau 1976) and *ihe pahee* (javelin) (Malo 1951); younger, flexible branches for fish net loops (Malo 1951); fruits as famine or casual food, lavender dye and *lei* (Krauss 1993).

***‘Ulu***

**Hawaiian Name:** *‘ulu*

**Scientific Name:** *Artocarpus altilis*

**Vernacular Name:** Breadfruit

**Family:** Moraceae

**Status:** Polynesian introduction (not naturalized)

**Description:** Trees, grow up to 30 ft with diameter up to 4 ft

**Habitat:** *A. altilis* is not considered naturalized but is cultivated in hot, moist areas (Lucas 1982; Wagner et al. 1990).

**Medicines**: To treat *koko‘ino* (bad blood), one can combine the bark of *‘ulu* with that of *‘ahakea* (*Bobea* spp.), *‘ohi‘a* (*Metrosideros* spp.), *‘uhaloa* (*Waltheria indica*), *‘auko‘i* (*Senna occidentalis*), and *kō kea* (white sugarcane, *Saccharum officinarum*) along with the flowers and leaves of *ko‘oko‘olau* (*Bidens* spp.); these items are mixed into a liquid form and to be taken three times daily (Chun 1994). *‘Ulu*, especially the sap, is used as a secondary ingredient in numerous other remedies.

**Non-Medicinal Uses**: Large fruit eaten and made into *poi* (Abbott 1992; Malo 1951); sweet dish made from *ulu* and coconut (*niu*) cream (Krauss 1993). It is said that the original *ulu maika* was disk cut from immature breadfruit (Krauss 1993). The lightweight wood used for drums (*pahu*) (Abbott 1992), surfboards (*papa he‘enalu*) (Krauss 1993); house doors and canoes (Kamakau 1976; Malo 1951). Trunks used to make *poi* boards (*papa ku‘i ‘ai*) (Krauss 1993). Inner bark fibers for a low-grade *kapa* (Abbott 1992; Malo 1951). A yellow-brown dye is made from male flowers (Krauss 1993); sap for birdlime and leaves as sandpaper (Handy et al 1972); used on *hula* altars (*kuahu*) (Emerson 1909). Sap as gum from stem chewed by children, and also used as glue to join gourds to make *ipu heke* (Handy et al. 1972).

### 6.7.5 Human Skeletal Remains

*6.7.5.1 City Center Human Skeletal Remains Synthesis*

Seven test excavations during the current AIS yielded human skeletal remains (T-096, T-141, T-142, T-150, T-170, T-226C, and T-227A) located within four archaeological cultural resources. From west to east:

| | |
|---|---|
| T-096 | SIHP #50-80-14-7427 |
| T-141, T-142, and T-150 | SIHP #50-80-14-5820 |
| T-170 | SIHP #50-80-14-7429 |
| T-226C and T-227A | SIHP #50-80-14-2918 |

The remains ranged from isolated single elements and fragments to complete *in situ* burials. The following paragraphs describe each set of human skeletal remains with a brief synthesis of the burials given at the end. As the number of human skeletal remains identified during the current City Center Section 4 AIS was relatively minimal, the general analyses of the burials are limited. Additionally, once skeletal remains were conclusively identified as human, no further analysis was permitted, which leads to a dearth of information on the remains themselves and burial practices in general.

T-096 contained an isolated human talus (ankle bone) from the backfill pile. It was estimated to have originated from approximately 0.70 mbs – possibly from a gravelly sandy loam layer (Stratum If in the northwest sidewall). The fill material also contained faunal bones, rusted metal, slag, ceramic fragments, bottle glass fragments, and charred material. The talus appeared to be from an adult or older adolescent individual. Neither sex nor ancestry was determinate. The talus could be from a previously disturbed native Hawaiian or historic-era burial. It is not uncommon in Hawai‘i to find isolated remains in disturbed contexts within fill material. Previous archaeological studies have documented fill deposits that contained known displaced remains from Hawaiian burials. For example, Allen and Reveal (2012) documented numerous native Hawaiian remains within fill deposits during archaeological monitoring and screening for the Mololani Housing Area Project on Marine Corp Base Hawaii. The remains and associated fill material were known to be from the Mōkapu Burial Area, a native Hawaiian burial ground. It has been documented in the *Hawaiian Gazette* (January 1896:5; February 1896:4) that Chinese compatriots living in Chinatown (in the vicinity of T-096) disinterred their countrymen’s remains for shipment back to China. Once the remains were disinterred, they would scrape remaining tissue from the bones and bundle them in satchels. It is not improbable that some remains could become “lost” during this process. The talus is considered part of SIHP #50-80-14-7427, designated during the current AIS to refer to the subsurface infrastructure remnants, subsurface cultural deposits, and human skeletal element found within the proposed Chinatown Station footprint. Despite the potential Chinese derivation, the location of the talus in a disturbed context within downtown Honolulu (previously known as Kou in pre-Contact times and heavily utilized over long periods by Native Hawaiians) supports a demographic argument that the talus is more likely Native Hawaiian than another ethnicity.

T-141 contained several isolated human skeletal remains from a disturbed context within a buried, culturally-enriched, loamy sand A-horizon and a contemporaneous pit feature (Feature

1). The upper portion of the feature had been previously disturbed and the human skeletal remains also were found within the adjacent pit of mixed fill. The remains consisted of several elements from both infant and adult individuals. Based on the presence of adult and infant remains as well as duplication of adult elements, the minimum number of individuals represented within this assemblage is three. Due to the paucity and fragmentary nature of the remains, neither sex nor ancestry was determinate. Based on the stratigraphic context of the remains and associated cultural material, the remains are most likely native Hawaiian. Cultural material found within the buried A-horizon and associated features included an in situ horse burial, faunal bones, a sea urchin spine, and a minimal amount of assorted marine shell and charcoal. A basalt stone sinker was encountered within the Jaucas sand immediately adjacent to Feature 1. The human skeletal remains and buried A-horizon from T-141 have been incorporated into SIHP #50-80-14-5820, originally identified by Winieski and Hammatt (2000) to document human skeletal remains and a buried, culturally-enriched, sand A-horizon within Kaka‘ako Improvement District 3.

T-142 contained in situ human skeletal remains, believed to represent a complete burial (Feature 30). The remains were located within a pit within natural Jaucas sand beneath a buried, culturally-enriched A-horizon. Based on the observable remains and the size of the burial pit, the burial was flexed or partially flexed. The size and morphology of the remains suggests an adult or older adolescent individual. Neither sex nor ancestry was determined; however, based on burial context (location and position of the burial and associated cultural material), the burial is likely native Hawaiian. The Feature 30 human skeletal remains and the buried A-horizon from T-142 have been designated as SIHP #50-80-14-5820, originally identified by Winieski and Hammatt (2000) to document human skeletal remains and a buried, culturally-enriched, sand A-horizon within Kaka‘ako Improvement District 3. Additionally, human skeletal remains consisting of a mandibular incisor, a tooth fragment, and cancellous bone were identified within a bulk sediment sample collected from the culturally-enriched buried loamy sand A-horizon of T-142.

T-150 contained a modified posterior-proximal fragment of a human tibia that may have been used in tool manufacture (possibly for a fishhook). Kirch (1985) provides the following summary of the use of human long bones to make fishhooks:

> The largest one-piece and two-piece hooks were made from human long bones, prized not only for their size and strength, but also because it was believed that the *mana* of the deceased would render the hook particularly efficacious. The practice of making hooks from human bones was also used to humiliate enemies defeated in war, and chiefs went to considerable lengths to camouflage their burial places so that their bones would not fall into the hands of would be fishhook-makers! The use of human bone for fishhooks seems to have greatly increased in the late prehistoric period, and was relatively uncommon earlier in Hawaiian prehistory. [Kirch 1985:204]

The tibia fragment was located in a pit feature (Feature 18) that extended from a buried, culturally-enriched, loamy sand A-horizon. The thickness of the tibia fragment and development of the muscle markings suggest a fully formed bone indicative of either an adult or older adolescent individual. Neither sex nor ancestry was determinate; however, based on burial context (location and associated cultural material) and the modification of the bone fragment, the human skeletal remains are most likely of native Hawaiian origin. Cultural material found within the buried A-horizon and associated features included a possible adze or sharpening stone fragment, volcanic glass debitage, fire-cracked rock, marine shell midden, fish bone, and charcoal. Feature 18, including the tibia portion, and buried A-horizon within T-150 have been incorporated into SIHP #50-80-14-5820, originally identified by Winieski and Hammatt (2000) to document human skeletal remains and a buried, culturally-enriched, sand A-horizon within Kakaʻako Improvement District 3.

T-170 contained an isolated human cranial fragment identified as a left temporal bone portion, located within a buried A-horizon, containing both traditional Hawaiian cultural material and post-Contact historic artifacts. The mastoid process was notably gracile which suggests a possible female or young adult individual. Based on the depositional context (location) the cranial portion is more likely native Hawaiian than another ethnicity. The cranial portion was designated as Feature 6 of SIHP #50-80-14-7429, identified during the current City Center Section 4 AIS to refer to a subsurface cultural deposit and human skeletal element.

T-226C contained human skeletal remains consisting of an articulated pelvis with no articulating leg elements, located within a pit feature (Feature 13) associated with the culturally-enriched sandy loam A-horizon. The culturally-enriched A-horizon contained both traditional Hawaiian cultural material and post-Contact historic artifacts. The burial pit had been previously truncated by the overlying fill sediment and the burial was disturbed. It was unclear if the upper body was present as the burial extended beyond the limits of the excavation and once the determination of human was made, the burial was not explored further. The size and morphology of the remains suggests an adult or older adolescent individual. Neither sex nor ancestry was determinate; however, based on burial context (location), the burial is more likely native Hawaiian than another ethnicity. Cultural material found within the buried A-horizon included a bone pick, volcanic glass debitage, charcoal, and a minimal amount of marine shell and fish bone. This burial was incorporated into SIHP #50-80-14-2918, originally designated by Yent (1985) to document a buried, culturally-enriched, sand A-horizon containing human skeletal remains located within the former Honolulu Ironworks site.

T-227A contained human infant skeletal remains, believed to represent a complete *in situ* burial. The remains were located within natural Jaucas sand, underlying a buried A-horizon containing both traditional Hawaiian cultural material and post-Contact historic artifacts. The age-at-death of the infant was determined to be between birth and three years based on the size and development of the remains. Neither sex nor ancestry was determinate; however, based on burial context (location), the burial is more likely native Hawaiian than another ethnicity. Cultural material found within the buried A-horizon included: volcanic glass debitage, fire-cracked rock, charcoal, shell midden, fish bone, faunal remains, a basalt fragment, and a brick fragment. This burial was incorporated into SIHP #50-80-14-2918, originally designated by Yent (1985) to document a buried, culturally-enriched, sand A-horizon containing human skeletal remains located within the former Honolulu Ironworks site.

Six of the instances of human skeletal remains documented during the current City Center Section 4 AIS were located in a relatively small area of Kakaʻako, between Punchbowl and Kamakeʻe Streets. The seventh instance of human skeletal remains (from T-096) was located in the Downtown Honolulu (Chinatown Station) area. Within the City Center Section 4 portion of the HHCTCP, human skeletal remains were not found west of River Street or east of Kamakeʻe Street.

Among the seven instances of human skeletal remains, three sets of remains were believed to represent primary in situ burials. The remains from T-142 definitely represent a complete *in situ* burial, while the remains from T-227A are very likely to be a complete in situ burial (although only partially exposed), and the remains from T-226A are not complete, but are articulated, suggesting that they did represent an in situ burial. The remaining four instances of remains represent isolated and previously disturbed remains, although all four cases differ. In T-141, several remains were found in a previously disturbed context dispersed throughout a former cultural layer and its associated features, while in T-150 the human bone had been taken from its original interment location and modified as a potential tool and was located within a discrete feature of a former cultural layer. In T-170 a single isolated cranial bone fragment was within the former cultural layer, and in T-096 the human bone had been disturbed from its original interment location and deposited within historic fill material.

The seven cases of human skeletal remains documented during the current AIS and described above reflect typical instances of human remains documented in the Kakaʻako and Downtown region, and Hawaiʻi in general. Traditional Hawaiian burials were typically (although not always) interred in unmarked locations in sandy sediments, in a flexed or semi-flexed position, close to the former traditional Hawaiian land surface with accompanying cultural material, often lacked grave goods, and did not have coffins. Notably however, grave goods have been found in certain types of burials, and burials are also found within caves, crevices, and sinkholes). In highly urbanized areas, such as the greater Honolulu area, thick fill layers are often present above the former traditional Hawaiian land surface and burials, and have impacted and/or disturbed both. Based on the context and location of the observed human skeletal remains, it is CSH's assessment that all seven instances are most likely Native Hawaiian.

#### *6.7.5.2 Broad Context Human Skeletal Remains Distribution Discussion*

Graphics were created to plot human skeletal remains documented during the current City Center Section 4 AIS as well as during previous archaeological studies within the vicinity of the project corridor. Both sets of findings were plotted on several figures with regards to burial type (traditional Hawaiian, Western, or undetermined), burial condition (*in situ*, previously disturbed, or isolated remains), and geographic location. In the following figures "Archaeological Data" refers to the results of the current City Center Section 4 AIS investigation. The "Prev. Arch. Data" refers to the previously recorded discoveries of human skeletal remains near the City Center Section 4 AIS study area. Specific information for each of these "Prev. Arch. Data" human skeletal remains discoveries is summarized in Section 5.5 of Volume II, "Predictive Model for Human Skeletal Remains."

It is clear from looking at Figure 462 and Figure 463 that the majority of human skeletal remains were originally located in the eastern half of the City Center Section 4 project corridor, east of Nuʻuanu Stream and the Chinatown district of downtown Honolulu, with very few human skeletal remains documented west of Nuʻuanu Stream (only four instances from previous studies). Within the eastern half of the City Center Section 4 corridor, human skeletal remains are clustered in the center of Kakaʻako, at the eastern end of Kakaʻako, and to a lesser extent in the Chinatown District of downtown Honolulu. The locations of human skeletal remains plotted on a 1927 aerial photograph of the Kakaʻako Coast show that many burials were located on the edges of ponds or wetlands, where raised sand berms acted as boundaries (Figure 464). It is not surprising that the majority of documented burials are located within the greater Kakaʻako region; the land surface in large portions of this area was formerly sand, which was a preferred burial matrix.

In most cases, human skeletal remains documented during the current City Center Section 4 AIS were located very close to human skeletal remains identified during previous archaeological studies. Only human skeletal remains from T-170 of the City Center AIS (SIHP #50-80-14-7429) were not located in the vicinity of other previously identified human skeletal remains (see Figure 463). In part this may be due to the isolated nature of the find, which could have been transported from an entirely separate interment location, or due to a lack of previous archaeological studies conducted in the area, which potentially would have located additional human skeletal remains.

Figure 466 and Figure 467 show that both traditional Hawaiian and Western burials/human skeletal remains have been documented in the same vicinity. There are no discrete geographical areas along the City Center Section 4 project corridor where only one type of burial is found. There are, however, some discrete groupings based on burial type, although these groupings are located adjacent to one another.

Figure 468 shows that in many cases, *in situ* burials have been located near previously disturbed burials. This indicates that previous disturbance, largely due to construction activities and development, did not necessarily disturb all human skeletal remains in the general area or even within a discrete grouping. The fact that *in situ* burials have been found at all in the highly urbanized areas along the City Center Section 4 project corridor, particularly within the greater Kakaʻako area, shows that development and construction activities have not disturbed or obliterated all earlier burials that once existed along the southern coast of Oʻahu. Instances of isolated human remains are not found only near previously disturbed remains, but are often located near *in situ* burials or by themselves.

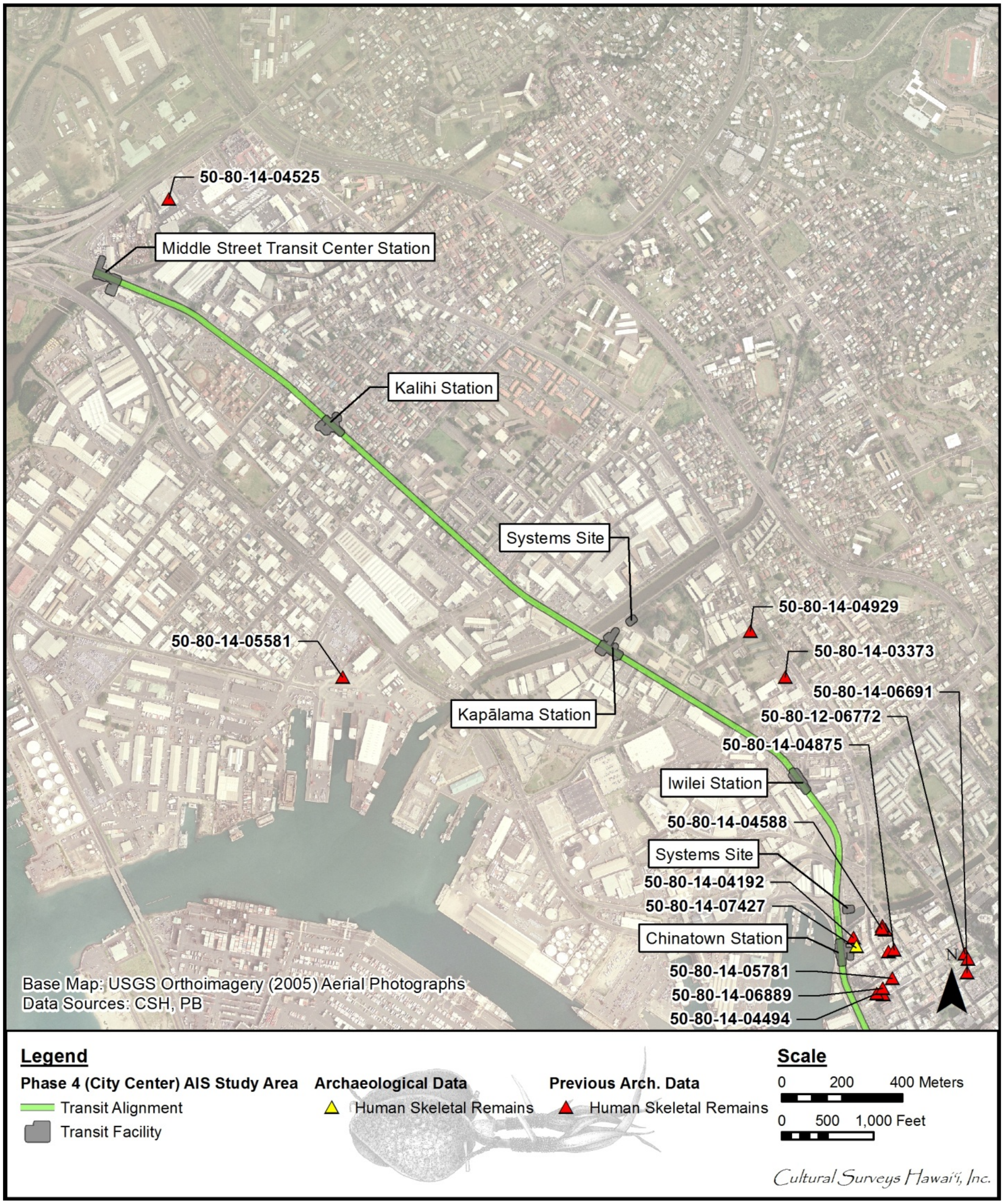



Figure 462. Human skeletal remains documented in the western half of the City Center corridor (base map: U.S.G.S. orthoimagery 2005)

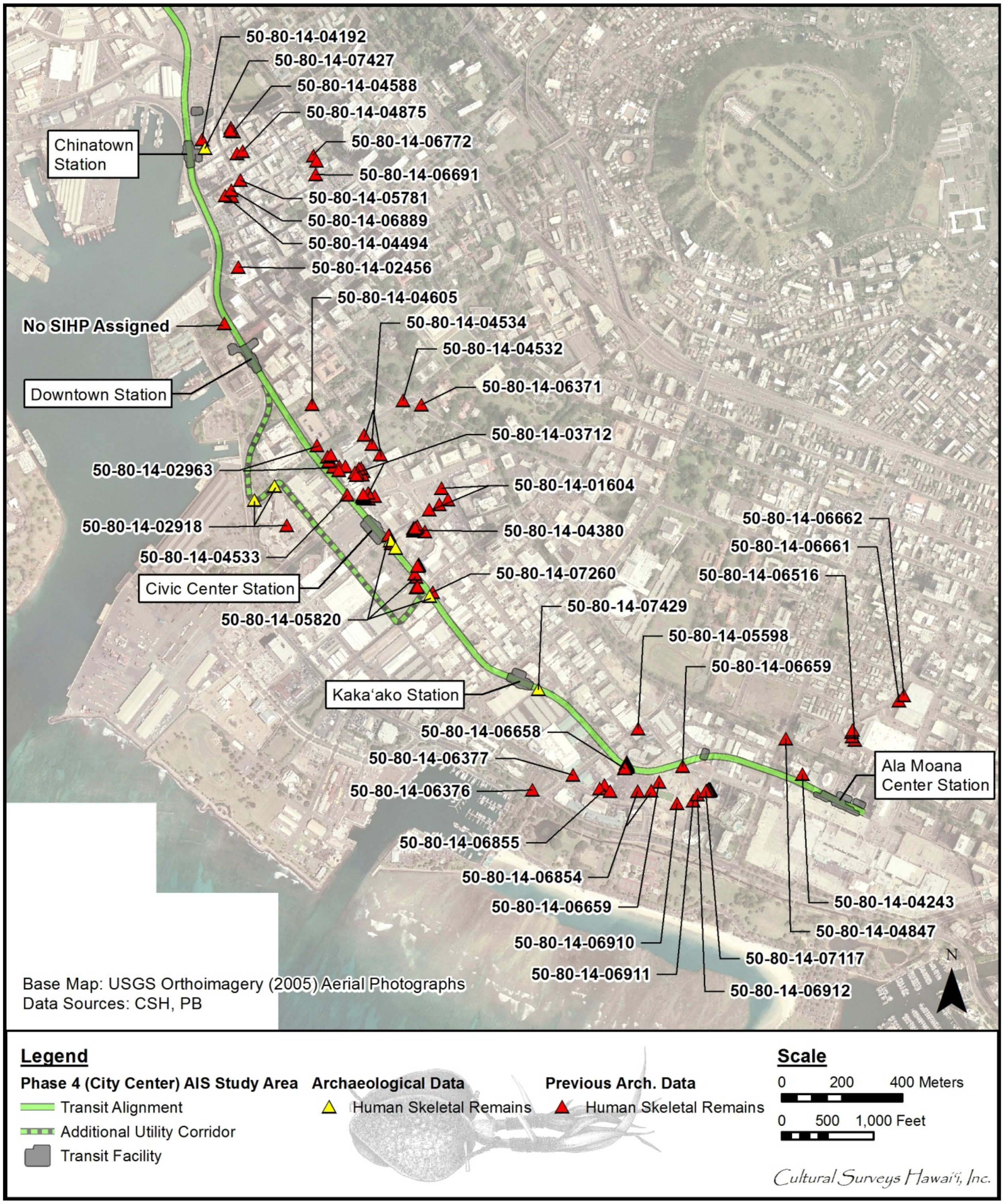



Figure 463. Human skeletal remains documented in the eastern half of the City Center corridor (base map: U.S.G.S. orthoimagery 2005)

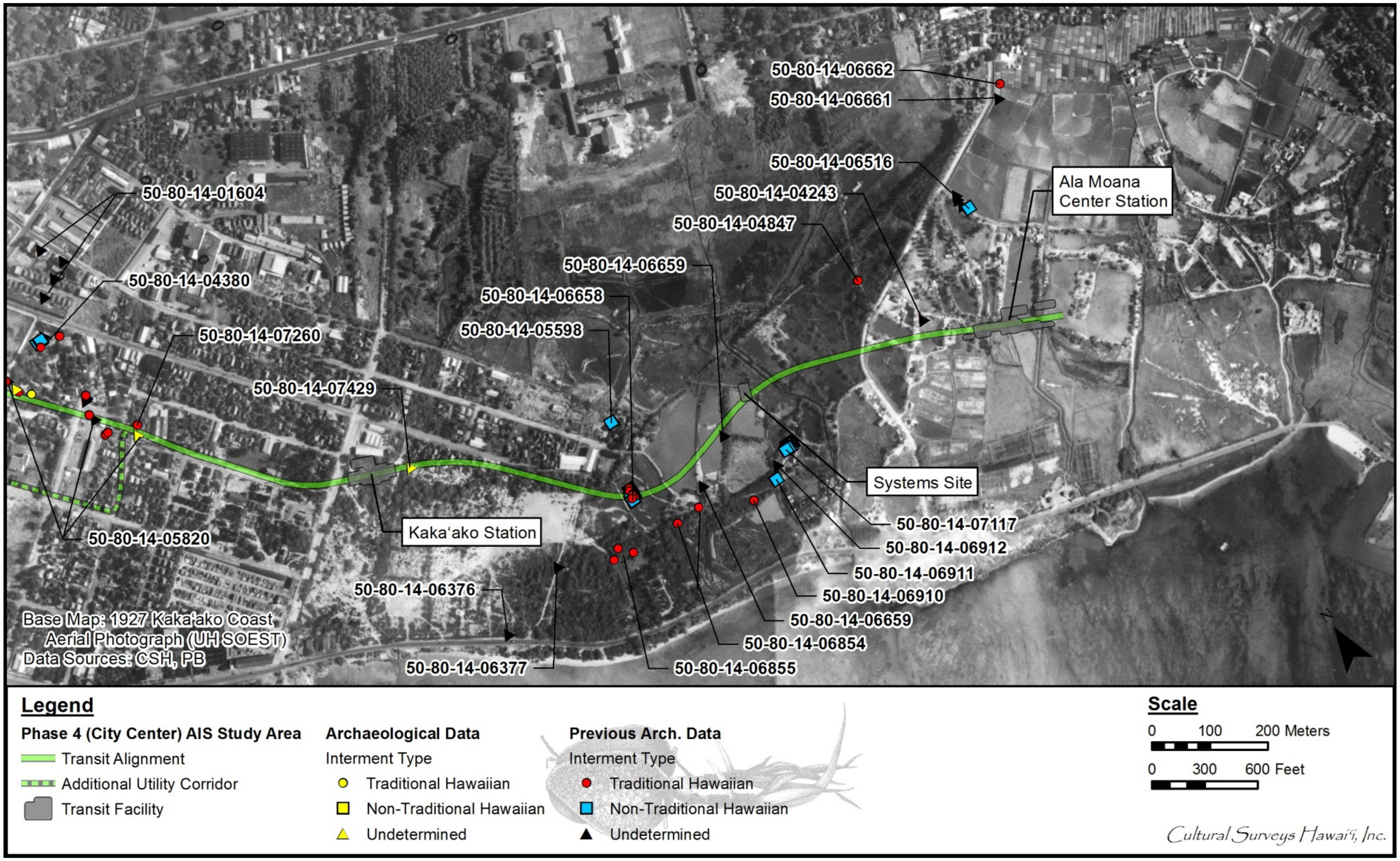



Figure 464. 1927 aerial photograph of the Kaka‘ako Coast showing locations of human skeletal remains in the eastern portion of the City Center corridor (source: U.H. SOEST)

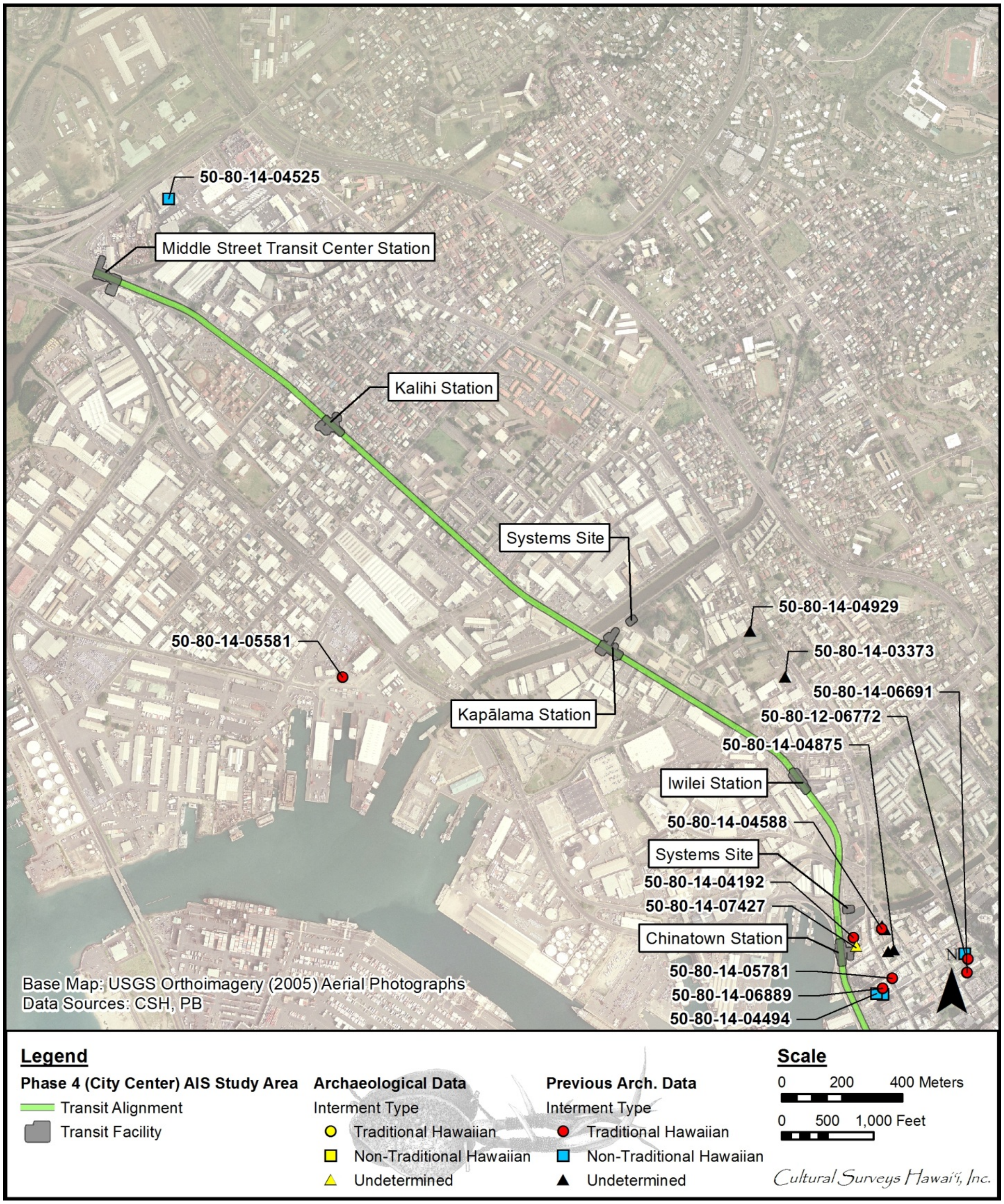



Figure 465. Human skeletal remains documented in the western half of the City Center corridor by interment type (base map: U.S.G.S. orthoimagery 2005)

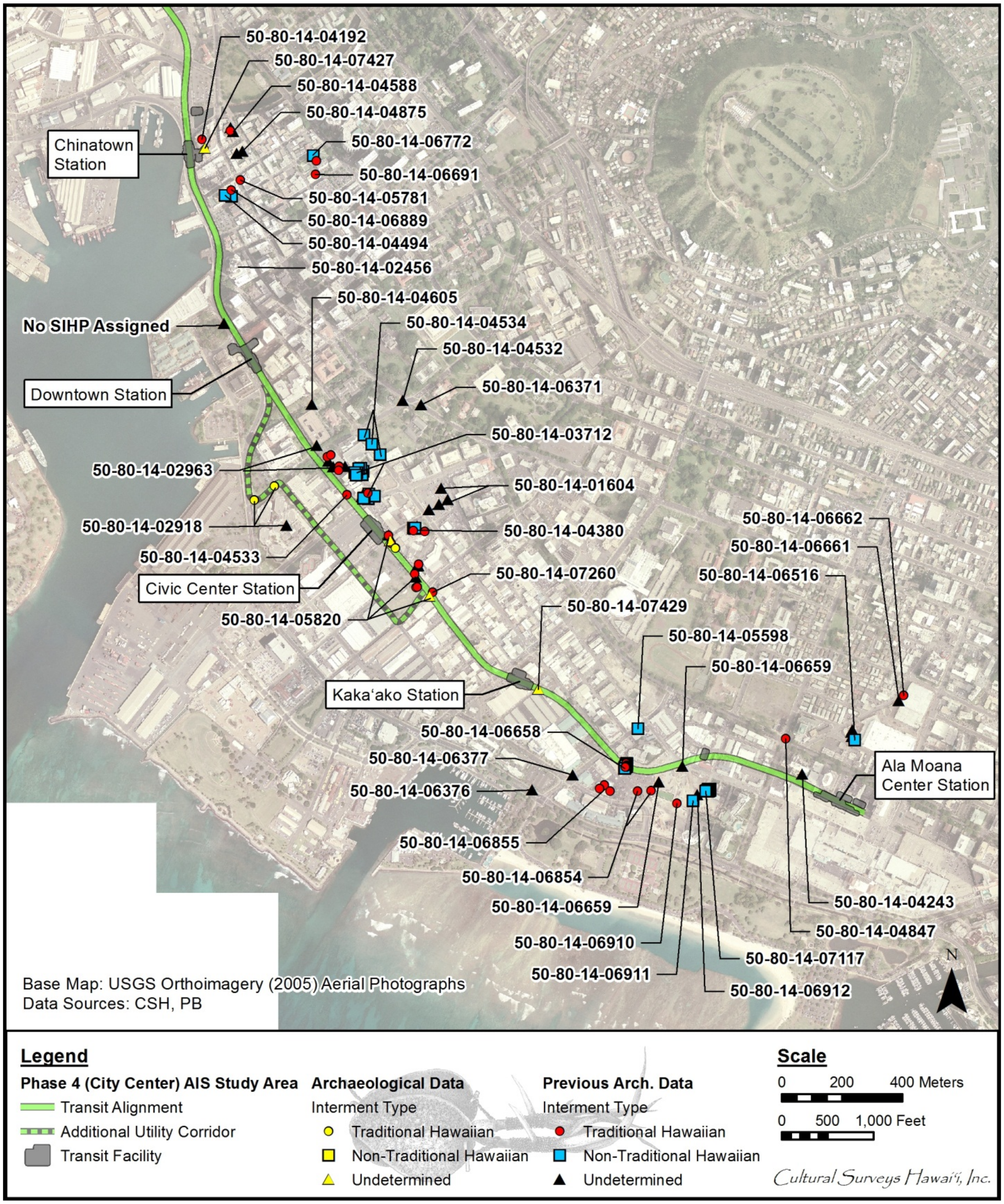



Figure 466. Human skeletal remains documented in the eastern half of the City Center corridor by interment type (base map: U.S.G.S. orthoimagery 2005)

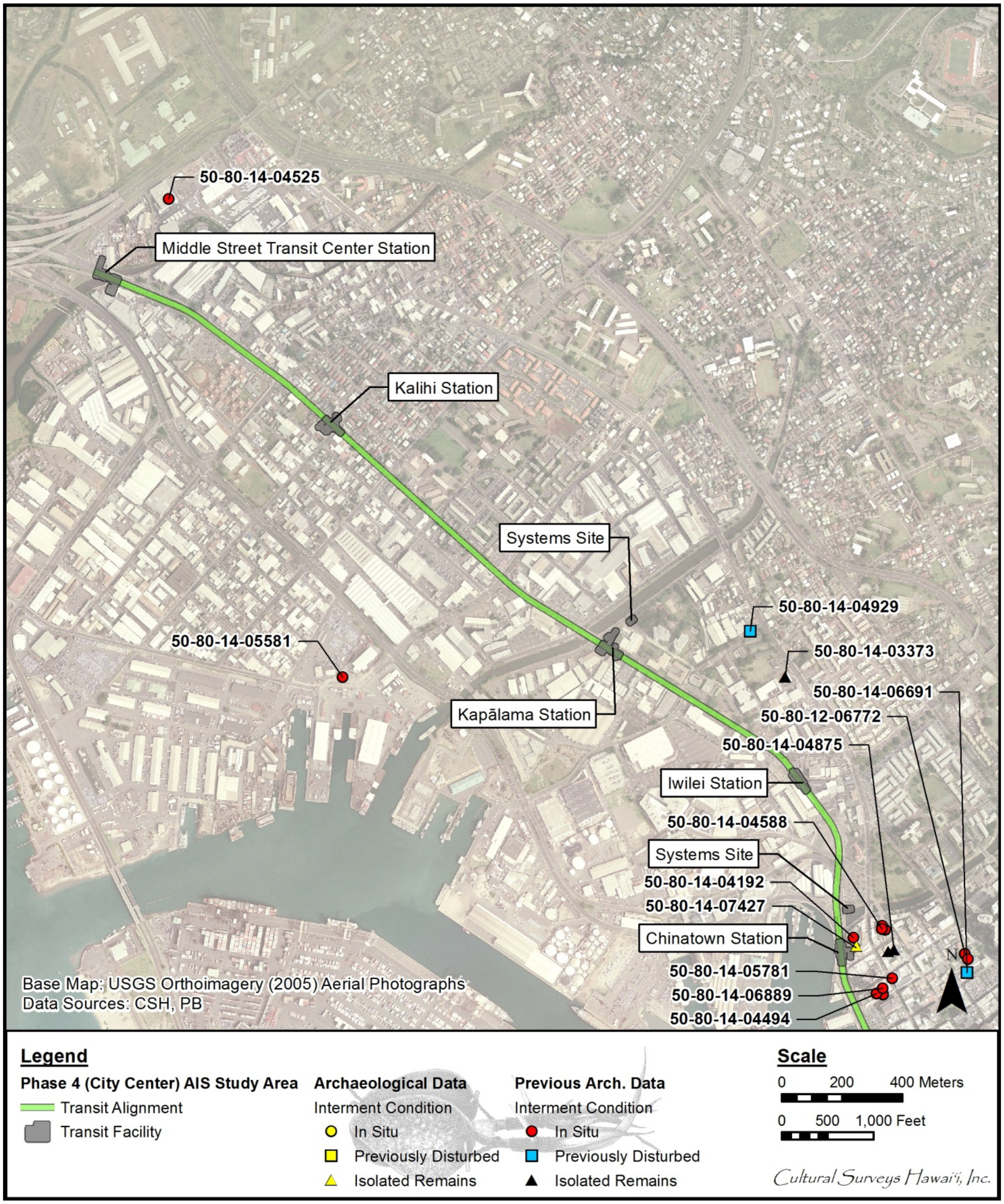



Figure 467. Human skeletal remains documented in the western half of the City Center corridor by burial condition (base map: U.S.G.S. orthoimagery 2005)

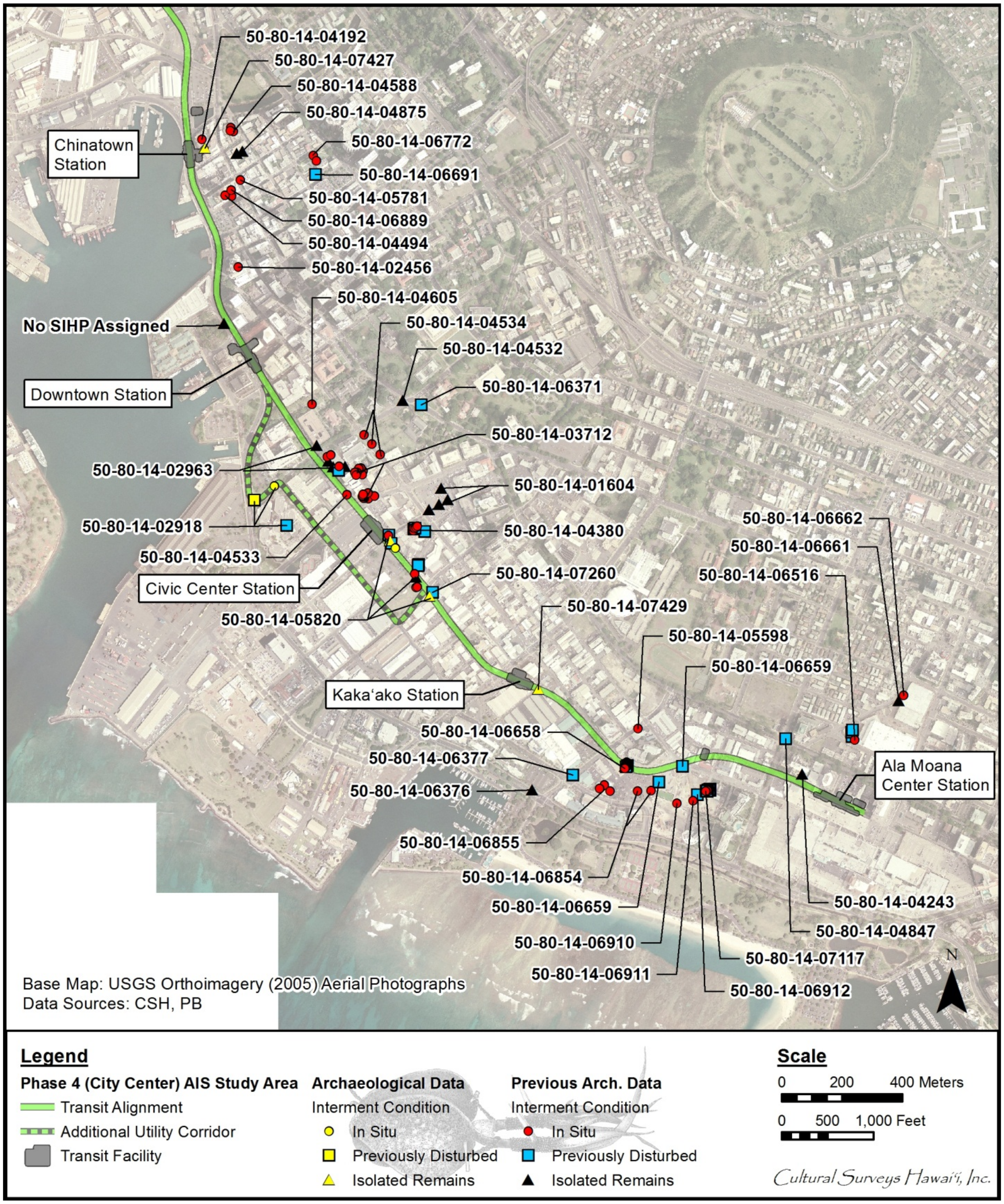



Figure 468. Human skeletal remains documented in the eastern half of the City Center corridor by burial condition (base map: U.S.G.S. orthoimagery 2005)

## 6.8 Cultural Consultation Effort

Following the project's PA requirements (Stipulation III.B and III.C) and the AIS requirements of HAR § 13-276, cultural consultation was an important component of this AIS preparation. During the City Center AIS fieldwork, and subsequently during the preparation of this AIS report (throughout late 2012 and early 2013), CSH and HART consulted frequently with the OIBC and the SHPD regarding the progress and results of the AIS investigation. Presentations to the OIBC at their monthly August, September, October, November, and December 2012, and January and February 2013 meetings included updates on the City Center AIS results and the status of AIS report preparation. During this same time period (later 2012 and early 2013), CSH met twice monthly with the SHPD to discuss the progress and results of the AIS investigations for the City Center.

Feedback from the SHPD was an important factor guiding modifications of the AIS investigation and project design: for example, the reconfiguration of the rail design in the area of Test Excavations 141 and 142 in order to avoid impacting *iwi kūpuna* finds and the sand deposits in the *mauka* portion of Halekauwila Street, and also the decision, made on-site by the SHPD during excavations of T-226C, to excavate an adjacent Test Excavation 226D to provide an alternative utility relocation corridor.

During these SHPD discussions in early 2013, and in follow up emails, the significance of identified archaeological cultural resources was discussed, along with project effect and mitigation measure recommendations for the City Center AIS report. On February 20, 2013, CSH and the HART met with the Office of Hawaiian Affairs (OHA) and updated their archaeological and cultural staff on the City Center AIS results. During this OHA consultation meeting, CSH staff described the archaeological cultural resources documented, along with their significance and proposed mitigation measures.

Additionally, public outreach was a vital component of the AIS consultation effort. Neighborhood meetings providing project updates and the opportunity for comment and questions were held in five neighborhoods in May 2012. Weekly consultation updates on excavation results and finds were provided on the project's website, via e-blast, and via direct mailings, and consultation with concerned individuals was conducted via phone, email, and meetings. Updates of the City Center AIS investigation and *iwi kūpuna* finds were provided at several public meetings (November 8 and 27, 20012 and December 17, 2012). In addition, burial treatment consultation was initiated within a public forum on February 7, 2013 and March 11, 2013 in order to consult with, and seek treatment preferences from, potential lineal or cultural descendants to the human skeletal remains identified in the City Center AIS. The consultation effort also included the implementation of a Cultural Monitoring Program, begun on October 16, 2012, in which cultural monitors worked on site with project archaeologists.

The applicable information provided by cultural consultants was used in the interpretation and consideration of significance for identified archaeological cultural resources, as well as in recommendations of project effect and mitigation.

## 6.9 Completion of AIS Objectives

The City Center AIS was successfully carried out, and its primary objectives are documented in this AIS report. The AIS documentation identified archaeological cultural resources in the City Center archaeological APE. They were documented sufficiently to evaluate their Hawai‘i and National Register eligibility, to determine project effect, and to make specific mitigation recommendations to alleviate the project’s potential adverse effect on Hawai‘i and National Register-eligible archaeological cultural resources. The discussions of significance, project effect and mitigation follow in the next sections.