Appendix P

Preliminary Engineering Report for
Kaloko Makai
Wilson Okamoto Corporation
July 2013

Preliminary Engineering Report

Kaloko Makai Infrastructure

Kaloko, North Kona, Hawaii
TMK: 7-3-009: 17, 19, 25, 26, 28, 62 and 63

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EXECUTIVE SUMMARY

A preliminary engineering report for the proposed Kaloko Makai development was conducted to: (1) review the site infrastructure and utility systems, (2) determine project demands, (3) identify possible constraints, and (4) conceptualize proposed improvements to sanitary sewer, potable water, storm drainage, parking, roadway, electrical, telephone, cable, and data communications systems to support the development.

Sanitary Sewer System: An average dry weather wastewater flow of 2.34 million gallons per day and a design peak wastewater flow of 11.80 million gallons per day are projected for the development. Since the Kaloko Makai property is undeveloped, a wastewater collection system is not available to service the Project site. Proposed wastewater improvements include an on-site wastewater treatment plant (WWTP). The WWTP would provide treatment for wastewater effluent from the Project site to produce R-1 quality water for reuse as irrigation water. An irrigation storage and distribution system will service parks and open space landscaping within the development. Excess R-1 quality water will be disposed of via injection wells located adjacent to the on-site WWTP.

Potable Water System: An average daily potable water demand of 2.18 million gallons per day and a maximum daily storage volume of 3.28 million gallons are projected for the development. Water service and improvements, in the North Kona area are not available to support any new developments. Proposed improvements include new groundwater source development, desalination plant, transmission, and distribution system.

Drainage System: Existing topography within the Project site is characterized by moderate mauka to makai slopes. Site elevations range from about 80 feet above mean sea level to about 700 feet above mean sea level. Drainage of storm runoff can be accommodated through culverts, drainpipes and catch basins, connected to drywells and/or detention basins. Permanent Best Management Practices will be developed and implemented in coordination with the regulatory agencies.

Roadway and Parking System: Primary access to the Project site is proposed along Hina Lani Street off the Queen Kaahumanu Highway and the new Ane Keohokalole Highway. Street parking will be allowed in residential areas, and off-street parking will be developed for commercial areas.

Electrical, Telephone, Cable, and Data Systems: Electrical, telephone, cable TV service, and data line access to the information system for the Project will be provided by Hawaii Electric Light Company, Hawaiian Telcom and Time Warner Cable.

1. INTRODUCTION

Based on the Conceptual Land Use Plan dated June 2012 prepared by SCD-TSA Kaloko Makai, LLC, this Preliminary Engineering Report presents the preliminary engineering assessment of the Project's infrastructure and utility requirements. The objective of the report is to review the existing infrastructure systems, determine the Project demands, identify possible opportunities and constraints based on the projected demands, and conceptualize the improvements relative to wastewater, irrigation, potable water, drainage, roadway, parking, electrical, telephone, cable, and data communication systems. The proposed improvements will be reviewed and revised based on further development of the Project plans and availability of more detailed information. This report is a general summary of the engineering aspects of the Kaloko Makai Project.

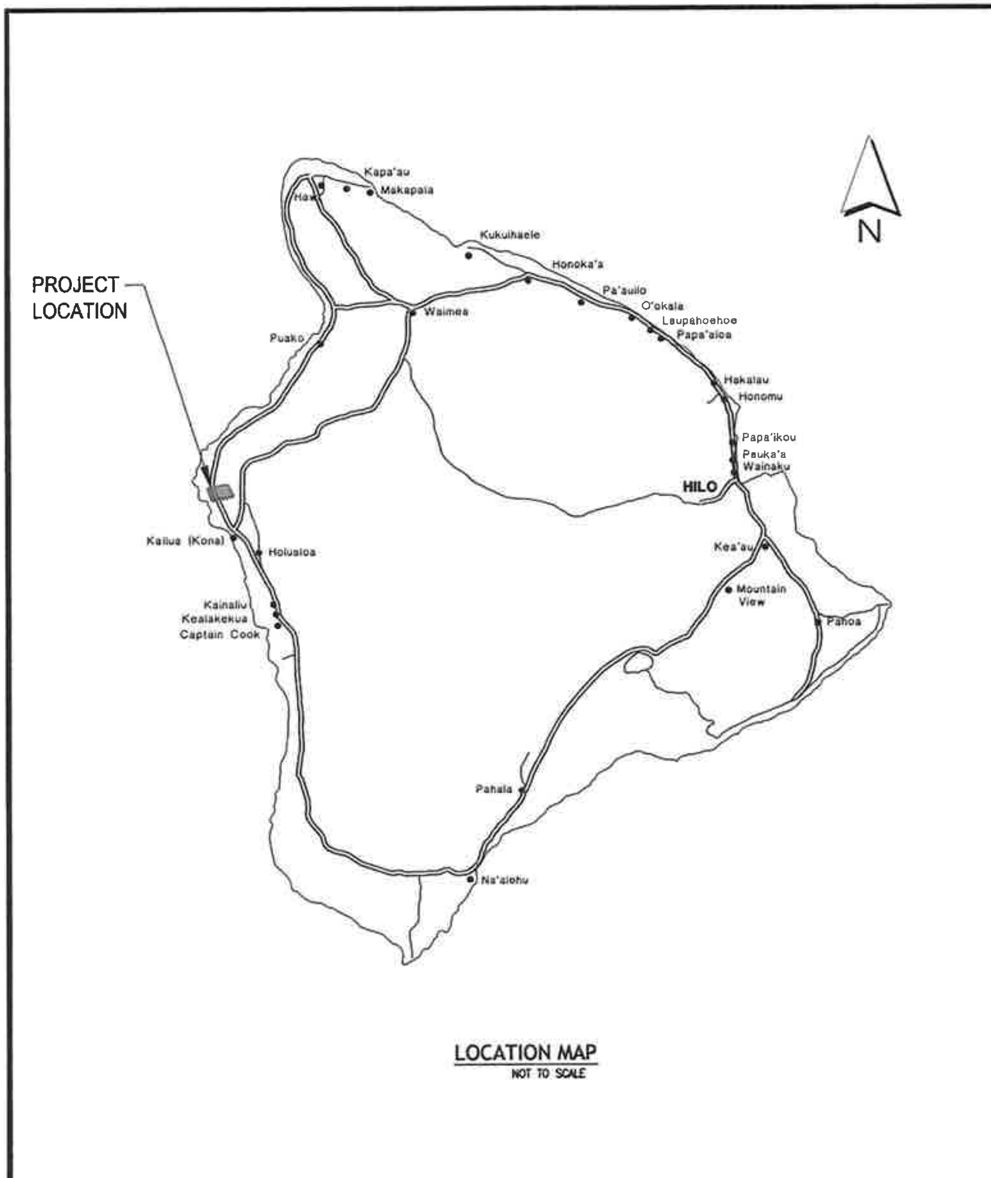
SCD-TSA Kaloko Makai, LLC, plans to develop a 1,100-acre property located within the Kaloko-Honokohau area of North Kona, Island of Hawaii (See Figure 1-1). The Tax Map Keys for the Project site are (3)7-3-009: 17, 25, 26, 28, and 63 (See Figure 1-2). In addition, the Project continues to investigate the potential for a potable water source. The current conceptual land use plan for the Project identifies components of the development as follows (See Figure 1-3):

Natural Zone	Natural Landscape
Sub-Urban Zone	Detached Homes with Landscaped yards
General Urban Zone	Mix Single Family and Small Multi-Family Homes with scattered commercial use
Urban Center Zone	Shops and offices mixed with Town Homes and Large Multi-Family
Industrial Mixed Use	Light Industrial and Mixed Use
School	Elementary (2) and Middle (1) school
Hospital	West Hawaii Hospital
Fire Station	Fire and Emergency Response Unit
Dryland Forest	Wildlife Preserve
Park	Recreational Parks
Open Space/Buffer	Screened Buffer Setback
WWTP	Wastewater Treatment Plant
Kohanaiki Trail	Multi-use pedestrian and bicycle path representing a historical land to sea trail.
Preservation/Buffer Area	Historic sites recommended for preservation

Residential, urban, and mixed-use zones are anticipated to consist of approximately 5,000 residential units, up to 600,000 square feet of retail/commercial space and 42 acres dedicated for school use. Associated amenities include recreational parks and expansion of Ane Keohokalole Highway (also known as Mid Level Road) through the Project. The entire Project will be separated into 3 total phases that are described as followed (See Figure 1-4):

- **Phase 1 –** Phase 1 developments will consist of multi, single, and affordable housing, as well as parks, a school, and a light industrial area. An on-site wastewater treatment plant and electrical substation will also be built during this phase.
- **Phase 2 –** Phase 2 developments will consist of multi, single, senior, and affordable housing. There will also be a school, park, and a light industrial area built during this phase.
- **Phase 3 –** Phase 3 developments will consist of multi, single, affordable and large lot single family units. There will also be a park, school, and industrial area built during this phase, as well as an on-site fire station and desalinization plant.

The Project site is bordered by Queen Kaahumanu Highway to the west and the Kaloko Light Industrial Subdivision to the southwest. The Project site is surrounded by undeveloped lands or other private properties in various stages of developments to the north, south, and east. The curvilinear east-west alignment of Hina Lani Street bisects the Project site. The north-south alignment of the future Ane Keohokalole Highway also bisects the Project site.



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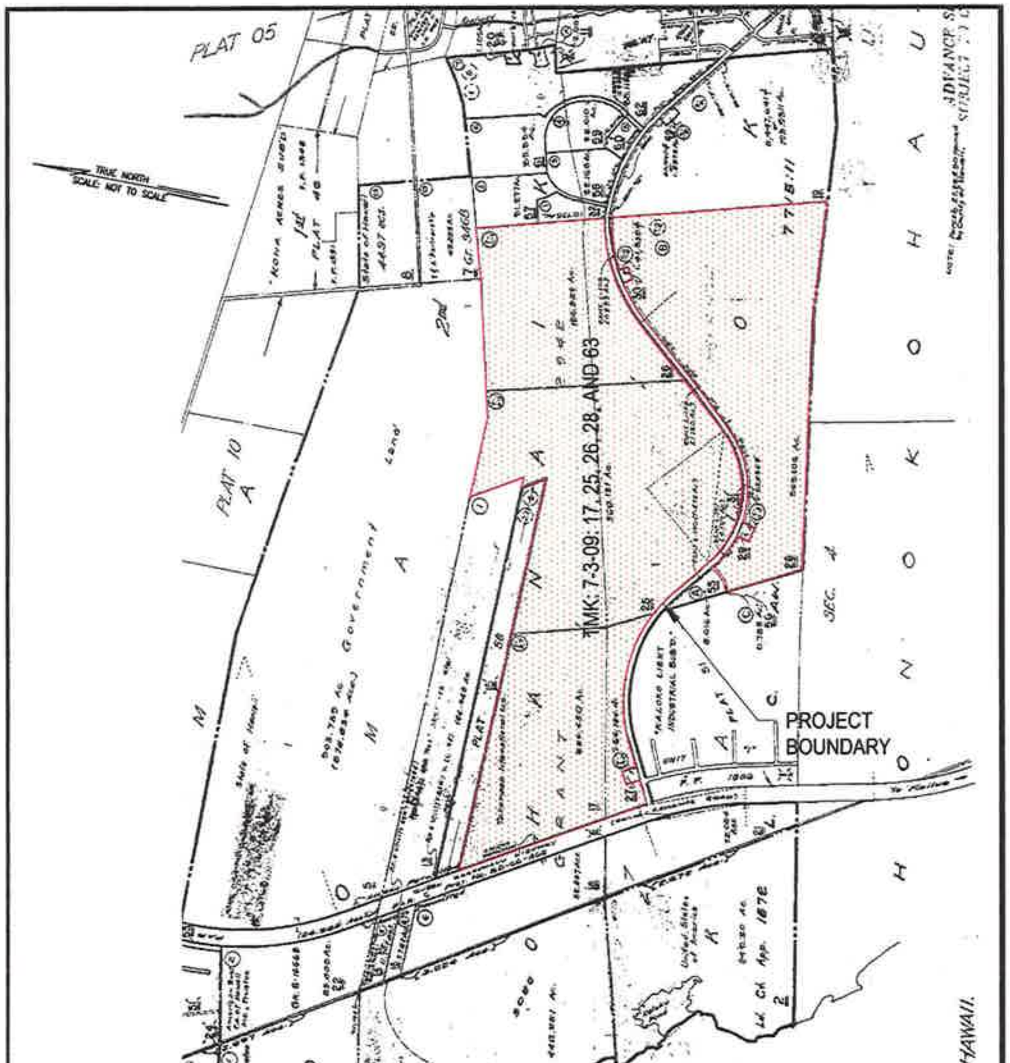
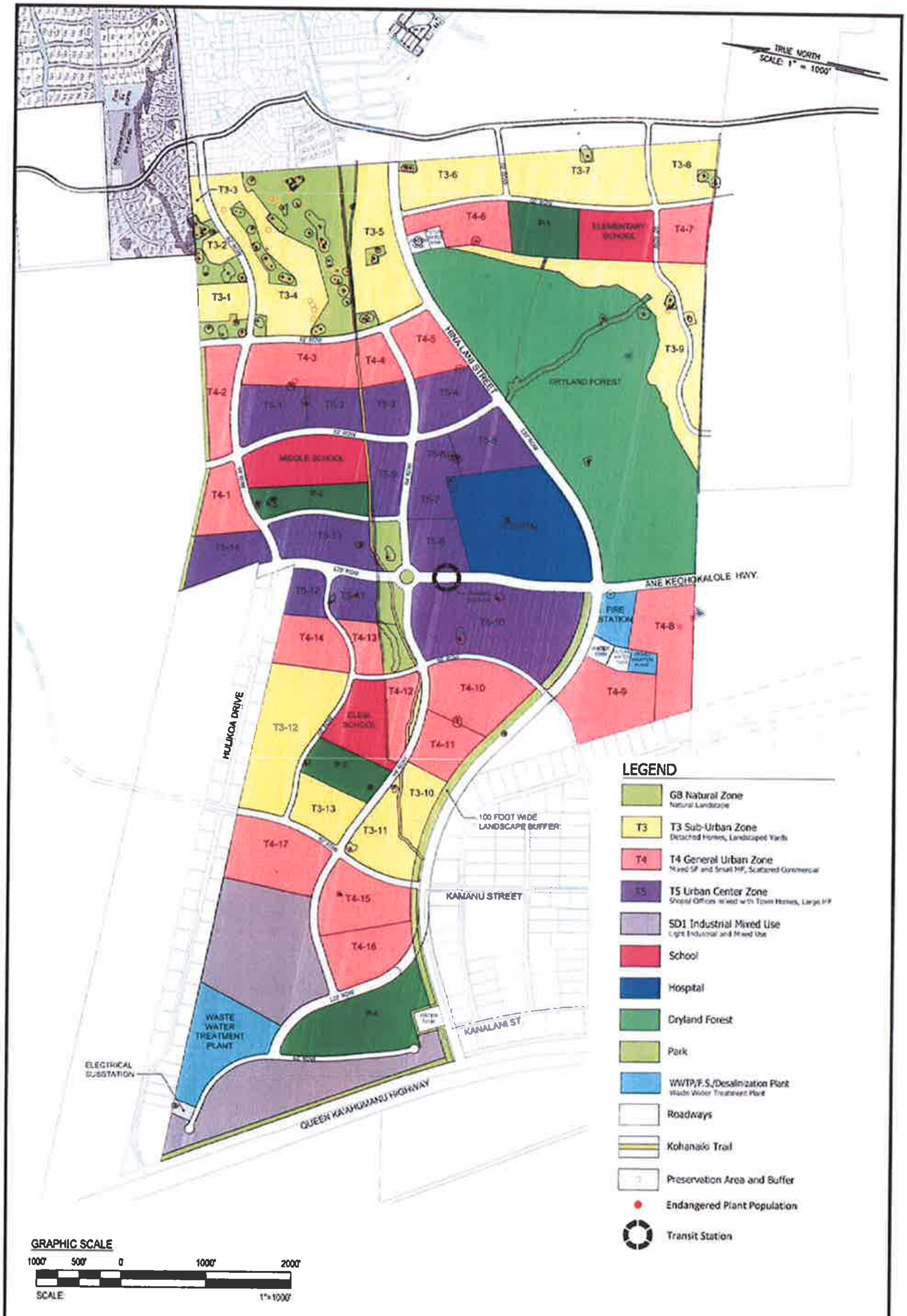
KALOKO MAKAI INFRASTRUCTURE
LOCATION MAP

FIGURE 1 – 1



NOTE: PARCEL 28 HAS BEEN SUBDIVIDED INTO PARCEL 28 AND PARCEL 63. THE TMK MAP DOES NOT REFLECT THE CURRENT CHANGES.

Prepared by: Wilson Okamoto Corporation Engineers • Planners	KALOKO MAKAI INFRASTRUCTURE TAX MAP KEY	FIGURE 1–2



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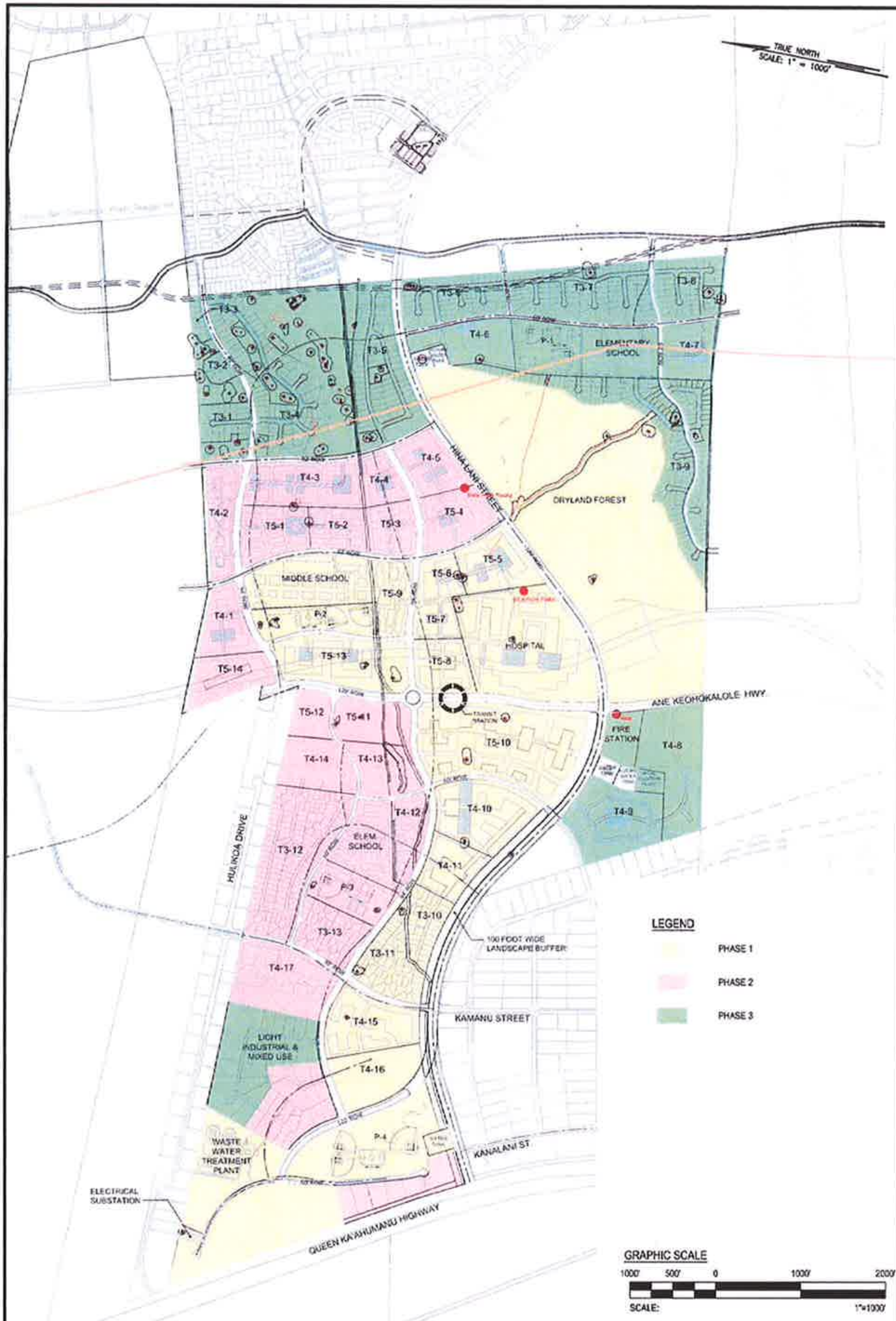
KALOKO MAKAI INFRASTRUCTURE
CONCEPTUAL LAND USE PLAN

FIGURE 1–3



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KALOKO MAKAI INFRASTRUCTURE

PHASE DEVELOPMENT

FIGURE 1-4

2. WASTEWATER SYSTEM

The Kaloko Makai Project used to fall within the boundary of the *North Kona Improvement District Project Sewer Master Plan (2006)* prepared by the Department of Environmental Management (DEM), County of Hawaii. Under an implementation study for the North Kona Improvement District (NKID), the Project site was further evaluated and excluded from the above. The NKID assesses future improvements and additions to the wastewater collection system servicing the Kealakehe Wastewater Treatment Plant (KWWTP) and its north Kona tributary area.

2.1 Existing Conditions

Currently, the Kaloko Makai Project site is undeveloped and there is no county and/or private wastewater collection system servicing the Project area. Properties within the nearby Kaloko Light Industrial Subdivision are serviced by individual wastewater systems consisting of septic tanks with seepage pits, or leach field disposal. Planned developments within Kaloko Light Industrial Subdivision and Lanihau Properties incorporate individual septic systems for short term use and installation of dry sewers for long term build out of NKID. Current development of the Kaloko Heights Project (located mauka of Kaloko Makai) incorporates a private wastewater treatment system.

2.2 Design Wastewater Flows

Wastewater flows for the Project are derived using the Project's program requirements provided by SCD-TSA Kaloko Makai, LLC, and generalized simulation of projected demands for similar developments.

Design peak flows were calculated for each of the Project's parcels using the average wastewater flows, maximum wastewater flows, dry weather infiltration/inflow (I/I), design maximum flows, and wet weather I/I.

The wastewater system for the Project will be designed based on County flow standards. If applicable County standards cannot be established, the City and County of Honolulu standards will be used. The City and County of Honolulu, Department of Wastewater Management Design Standards set forth the criteria to be used to estimate wastewater flows from developments, as shown below:

1. Average Wastewater Flow: The average wastewater flow is the sum of the products of wastewater flow rates multiplied by the number of residential units or areas.

2. Peaking Factor: The peaking factor is determined by using the Babbit equation to determine the maximum hour wastewater flow.

   $$MF = 5 / P^{0.2}$$

   Where: MF = maximum flow peaking factor
   P = population in thousands

3. Maximum Wastewater Flow: The maximum wastewater flow is determined by multiplying the average wastewater flow by a County adopted flow factor. A flow factor was determined using the cumulative total average daily flows for each phase.

4. Dry Weather I/I: Assuming that the sewerlines will be laid above the normal groundwater table, an additional quantity of 5 gallons per capita per day (gpcd) is used to account for water entering the collection system through pipe and manhole joints.

5. Design Maximum Flow: The design maximum flow is the sum of the maximum wastewater flow and dry weather I/I.

6. Wet Weather I/I: Assuming that the sewerlines will be laid above the normal groundwater table, an additional quantity of 1,250 gallons per acre per day (gad) is used to account for water entering the collection system through pipe joints and sewer structures.

7. Design Peak Flow: The design peak flow is the sum of the design maximum flow and wet weather I/I.

The average dry weather wastewater flow was calculated to be 2.34 million gallons per day (MGD) and the peak wet weather is 11.80 MGD. See Appendix A for wastewater demand calculations.

2.3 Proposed Improvements

2.3.1 Treatment System

2.3.1.1 Alternative 1: On-site Wastewater Treatment Plant

If a connection to the Kealakehe WWTP is not available to the Project prior to Hawaii County Council's approval of the Change of Zone (COZ) for the Project, and no connection to a public WWTP is available to Kaloko Makai, a private on-site WWTP will be developed to serve the Project.

The current Kaloko Makai Conceptual Land Use Plan reserves approximately 20 acres for the development of a private WWTP at the western end of the Project site. The WWTP will be designed to accept sewage flows from the Project site and provide treatment to meet R-1 water quality standards set forth by the State of Hawaii, Department of Health (DOH). The R-1 quality water will be stored in reservoirs on-site for distribution and use by Kaloko Makai and public facilities. It may also be made available for use by private commercial or residential developments as landscape irrigation water.

According to DOH *Guidelines for the Treatment and Use of Recycled Water (2002)*, R-1 water means recycled water that is at all times oxidized, then filtered, and then exposed, after the filtration process, to:

a. A disinfection process that, when combined with the filtration process, has been demonstrated to inactivate and/or remove 99.999 percent of the plague-forming units of F-specific bacteriophage MS2, or polio virus in the wastewater. A virus that is at least resistant to disinfection as polio virus may be used for purposes of demonstration; and
b. A disinfection process that limits the concentration of fecal coliform bacteria to the following criteria:
    1) The median density measure in the disinfected effluent does not exceed 2.2 per 100 milliliters utilizing the bacteriological results of the last seven days for which analyses have been completed; and
    2) The density does exceed 23 per 100 milliliters in more than one sample in any 30-day period; and
    3) No sample shall exceed 200 per 100 milliliters.

Kaloko Makai Development – Conceptual Wastewater Management System report was prepared by Brown and Caldwell consultants to master-plan the WWTP. A summary of the report is provided below and the entire report is included in Appendix B.

The initial treatment goal will be readily achievable via conventional secondary treatment, followed by coagulant addition, filtration and disinfection with ultraviolet light. The subsequent goal requires an advanced wastewater treatment process. Components of the treatment process consist of the following:

Influent Pump Station: A pump station will be required to lift raw wastewater from the sewer system to the treatment processes.

Headworks: Headworks will include screening systems to remove debris, grit, or inorganic particles (e.g., sand) from the waste stream. Grit and screenings will be disposed at the West Hawaii Landfill.

Biological Treatment: Organic matter and nutrients will be removed using an activated sludge process. The process will incorporate biological nutrient removal (BNR). BNR incorporates aerobic and anoxic zones within the treatment process and recycle flows to facilitate biological reduction of TN (Total Nitrogen) and TP (Total Phosphorus) to 10 mg/L (milligrams/liter) and 2 mg/L, respectively meeting DOH requirements. Clarifiers will be used to separate the activated sludge from the secondary effluent.

Coagulant Addition/Flocculation: Coagulants (such as aluminum sulfate and/ or polymer) will be added to the secondary effluent downstream of the secondary clarifiers and mixed to combine small particles into larger "flocs" that can be removed in the filtration process.

Filtration: The filtration process will provide two treatment benefits: turbidity reduction to meet R-1 water recycling requirements, and additional nitrogen removal. Denitrification filters are available and accepted by the California Department of Public Health (CDPH) for Title-22 recycled water production and are also capable of reducing TN concentrations to 5 mg/L via denitrification. The DOH allows the use of filtration processes that are accepted by CDPH for R-1 water production. Addition of a carbon source (typically methanol) is required upstream of the filters to facilitate denitrification process. The DOH requires that R-1 water have effluent turbidity of less than 2.0 Nephelometric turbidity units (NTU) at all times.

Disinfection: The effluent will be disinfected with ultraviolet light (UV) to meet R-1 water requirements. The DOH requires that R-1 water have a median density of fecal coliform that does not exceed 2.2 per 100 mL.

Effluent Pump Station: An effluent pump station will deliver R-1 water to the R-1 storage tank for reuse, or to the infiltration basins for disposal.

Aerobic Digester: Waste solids (sludge) from the biological treatment and filtration systems will be pumped to an aerobic digester system for stabilization and thickening via periodic decanting.

Mechanical Dewatering: Aerobically digested sludge will be mechanically dewatered prior to being hauled offsite for disposal or composting at the West Hawaii Landfill.

The Kaloko Makai WWTP will be designed to reduce nitrogen and phosphorous concentrations in the treated effluent to: TN to a concentration of <10 mg/l, and TP to a concentration of <2 mg/l (aerobic nitrification processes combined with anoxic/anaerobic sand filters to perform denitrification, or comparable technology.) Installation of the private WWTP shall be subject to conditions of approval by the DOH, including any lower concentrations of TN and/or TP in the effluent, and Hawaii Administrative Rules (HAR) Chapter 11-62.

2.3.1.2 Alternative 2: Off-site Wastewater Treatment Plant

The DEM is considering development of a decentralized treatment plant. The tributary area considered for the decentralized treatment plant includes the Kaloko Makai property. The decentralized WWTP will likely be located on State land north of Kaloko Makai and next to Queen Kaahumanu Highway. Detailed planning of the decentralized treatment plant with respect to treatment process, flow capacity, and land area requirements have not been determined.

DEM is also considering a new County WWTP to be located in the Kaloko Makai vicinity. This plant will be designed to the extent feasible to utilize a natural treatment system that can double as an open space feature.

A natural wastewater treatment plant or system is also known as a "constructed wetland" or a "constructed ecosystem," and is an alternative to mechanical wastewater treatment systems, which are methods conventionally used to treat and purify wastewater. Constructed wetlands simulate natural wastewater treatment systems, using flow beds to support water-loving plants. The roots of these plants help provide an aerobic environment to aggressively break down contaminants. However, concerns have been raised as to the proposed location of this new wastewater facility, especially its proximity to the Kona International Airport.

If a connection to either the Kealakehe WWTP or a proposed natural wastewater treatment system is available to the Project prior to the change of zone (COZ), Kaloko Makai will develop a system of dry sewer lines within the Project to be used for the connection into the Kealakehe WWTP or natural WWTP.

Currently, the DEM is planning to build a portion of NKID in conjunction with the next phase of the Queen Kaahumanu Widening Project. DEM proposes to install a dry gravity force main along Queen Kaahumanu Highway from Hina Lani Street to a future pump station. Prior to becoming active, DEM needs to implement at least two more projects to connect to the Kealakehe WWTP.

2.3.2 Collection System

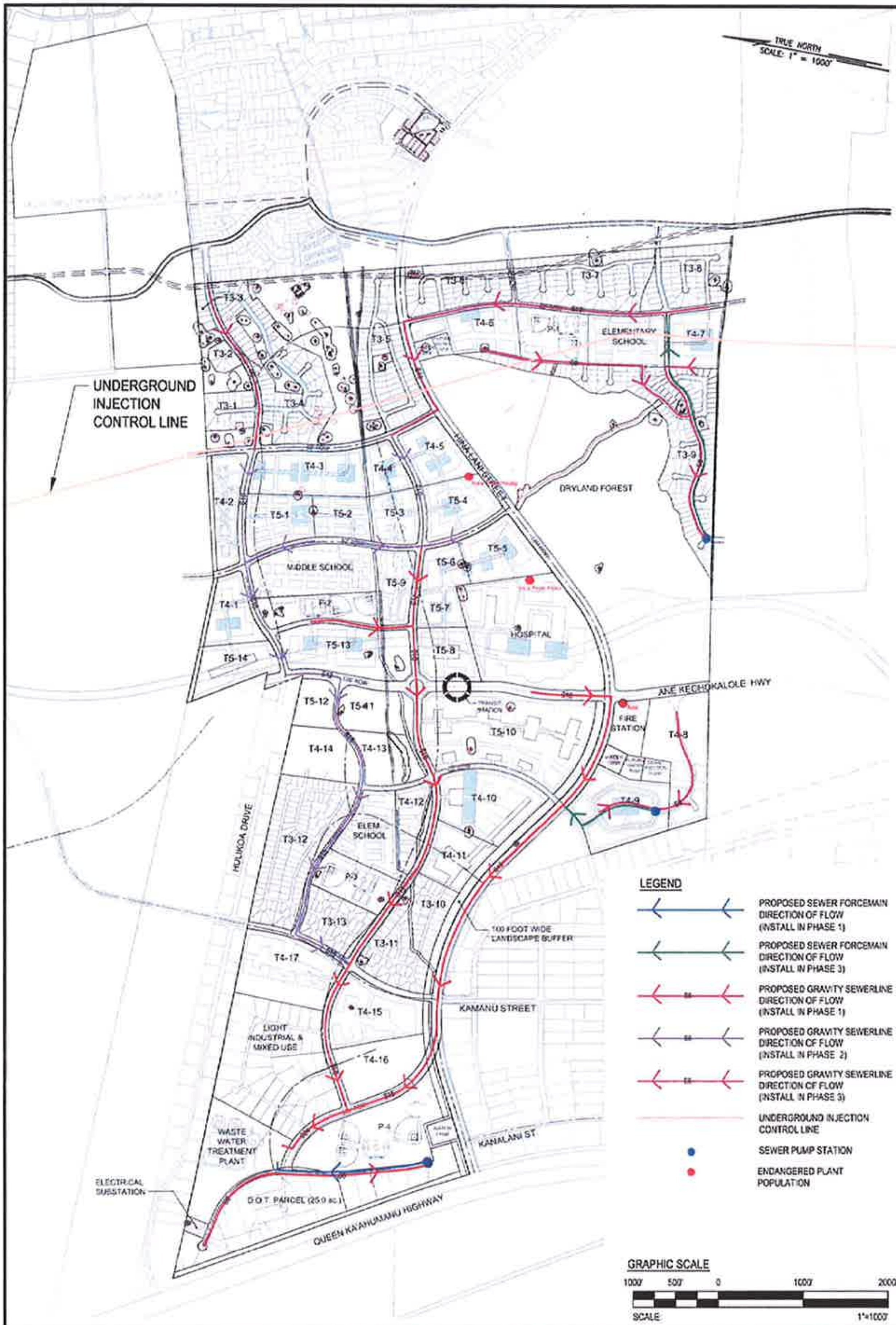
A proposed gravity sewer system will collect wastewater from areas located mauka of the WWTP and within the Kaloko Makai development. For areas located makai of the WWTP, a proposed gravity sewer system and pump station force mains will collect and convey wastewater to the WWTP. Three sewer pump stations are required as shown in Figure 2-1 where topography limits use of a gravity sewer system.

Design of the sewer system will follow DEM guidelines and criteria. Pipe sizes will vary from 8-inch to 24-inch based on the quantity of wastewater flow (see Figure 2-1). Lateral pipe sizes, force main, and pump station requirements will be determined during the design phase of the Project. The development of the sewer system is described as followed:

- **Phase 1** – Phase 1 will have approximately 16,200 LF of sewer lines designed to accommodate a peak flow of approximately 4.42 MGD of wastewater. The sewer lines will be installed along Hina Lani Street, as well as majority of the Spinal Roadway. Phase 1 sewer lines will service a hospital, fire station, offices, single and multi-family homes, as well as the Light Industrial area and parks 2, 3, and 4. There will also be a sewer forcemain and pump station installed below park 4 in the Cul-De-Sac Road. A WWTP will be designed during phase 1 in the makai portion of the Project site which will be able to accommodate a total peak flow of approximately 11.80 MGD of wastewater.

- **Phase 2** – Phase 2 will have approximately 11,000 LF of sewer lines designed to accommodate a peak flow of approximately 4.11 MGD. Phase 2 sewer lines will be installed along Collector Roads 1, 2, 3, and the Spinal Roadway. They will service the Elementary and Middle school, as well as offices, and single and multi-family homes. Phase 2 will tie back into the Kamanu Street extension and Spinal Roadway intersection, as well as in the mauka portion of the Spinal Roadway.

- **Phase 3** – Phase 3 will have approximately 15,000 LF of sewer lines designed to accommodate a peak flow of approximately 3.26 MGD. It will service an Elementary school and a desalinization tank, as well as offices, and single and multi-family homes. There will be 2 sewer forcemains and pump stations installed during phase 3. The first forcemain and pump station is located in the eastern portion of the project site near the elementary school and parcel T3-9. The other forcemain and pump station is located below the desalinization plant. Phase 3 sewer lines will tie back into the 15-inch sewer line along Hina Lani Street, as well as in the mauka portion of the Spinal Roadway.



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KALOKO MAKAI INFRASTRUCTURE
PROPOSED SEWER LAYOUT

FIGURE
2-1

2.4 Wastewater Reuse

The information provided below summarizes Kaloko Makai Development – Conceptual Wastewater Management System, a report prepared by Brown and Caldwell Consultants. The report is an assessment on the recycled water system. The report in its entirety is included in Appendix B.

Based on the report prepared by Brown and Caldwell Consultants, an average R-1 quality water flow rate of 2.37 MGD was estimated. This projection has the potential to provide irrigation water for approximately 273 acres without routine supplemental water addition. The DOH has restrictive requirements for R-1 irrigation on property located above the Underground Injection Control (UIC) line including groundwater or vadose zone monitoring; no excess irrigation for salt flushing below the root zone. Brown and Caldwell recommends R-1 reuse be limited to properties located below the UIC line at approximately 620-foot elevation.

The Kaloko Makai development includes 45 acres of parks and 30 acres of schools located below the UIC Line that will likely be the largest users of the R-1 water. Based on preliminary estimates, approximately 60 acres of the total park and school acreage will ultimately be irrigated using R-1 water. Other users of R-1 water include landscaping for the hospital, light industrial, multi-family and commercial areas.

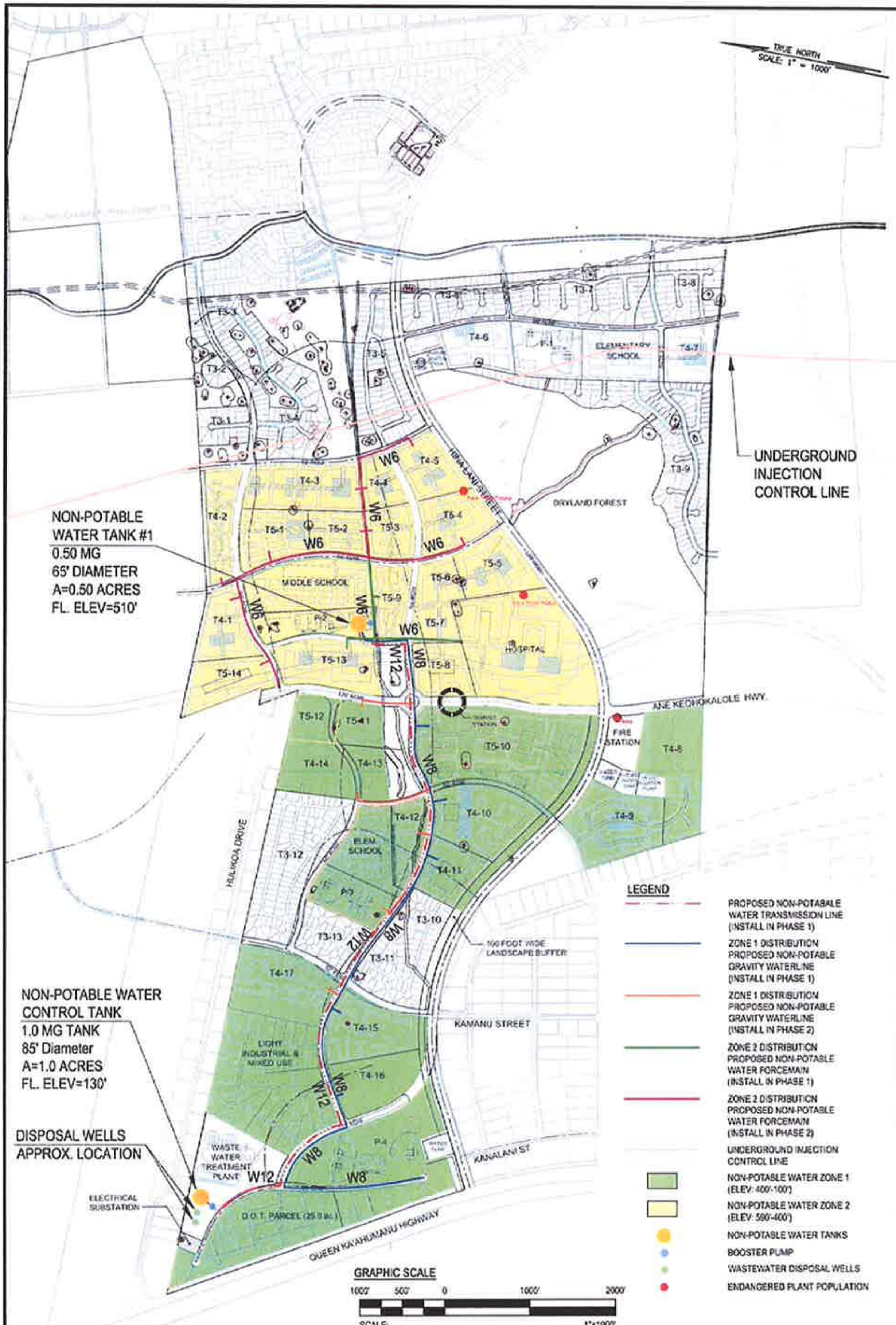
At full build out, the total demand of non-potable R-1 water for the Project site is 0.57 MGD (see Appendix A – Potable/Non-Potable Water Demand) which will be stored in a 1.0 million gallon (MG) tank located adjacent to the WWTP (see Figure 2-2). Phase 1 for the Kaloko Makai Development will require approximately 0.30 MGD of non-potable water, phase 2 will require approximately 0.19 MGD of non-potable water, and phase 3 will require approximately 0.08 MGD of non-potable water. The 1.0-MG tank will provide additional storage when R-1 supply is not sufficient to meet irrigation demands.

The project is divided into 2 pressure zones based off topography (See Figure 2-2). A high pressure 12-inch non-potable transmission water line will be installed during phase 1 to supply R-1 water to a 0.5 MG tank located at Park-2. A pressurized system will provide landscape irrigation for the adjacent middle school, Park-2, and multi-family housing. Landscaping for the parks, elementary school, commercial, hospital, light industrial and multi-family properties will be irrigated by a system of

appropriate pipe sizes and fittings. Other appurtenances will be installed to facilitate the system for irrigation use. Other recycled water users can be added to the system if they are located near the distribution lines that service the largest users.

A gravity system using class 250 pipe and fittings will irrigate properties below the 0.5 MG tank located at Park-2. A reduced pressure backflow preventer will be installed to provide the appropriate pressure needed for irrigation use.

The amounts of wastewater produced by the developments in phase 1 will likely not produce enough R-1 water after treatment to meet parks and schools irrigation requirements. Supplemental water source (potable) will be required to satisfy the irrigation demands. On the other hand, during periods of wet weather, there will be excess R-1 water which will be disposed of via deep injection wells.



Prepared by:
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KALOKO MAKAI INFRASTRUCTURE

CONCEPTUAL NON-POTABLE WATER LAYOUT

FIGURE 2-2

3. POTABLE WATER SYSTEM

3.1 Existing Conditions

Kaloko Makai Project site is undeveloped and not serviced by the County of Hawai'i, Department of Water Supply (DWS),

The DWS operates and maintains potable water supply facilities in the vicinity of the Project. The DWS facilities include three water reservoirs along Hina Lani Street, each with a capacity of 1.0 MG, and each supplying a different pressure zone. The 20-inch transmission main along Hina Lani Street, connects the water reservoirs extending the water system from Queen Kaahumanu Highway to Mamalahoa Highway, and completing the Hina Lani water supply system. The Hina Lani water system provides water to the Kaloko Light Industrial subdivision and the County housing project off of Hina Lani Street.

Of the three existing water reservoirs, the makai reservoir (Control Tank #1) has been abandoned by DWS and will be dedicated to DEM for use as an R-1 water storage reservoir.

DWS currently has three projects planned in the vicinity of Kaloko Makai.

1. DWS is participating with the State of Hawaii, Department of Transportation, Highways Division's (DOT) in the Queen Kaahumanu Highway Widening Project, Phase II to install a new 16" water main in parallel with an existing 12" water main along Queen Kaahumanu Highway.
2. A water tank has been constructed by a private developer at 1200-feet elevation for the Kaloko Heights Project. DWS is still awaiting the transfer of ownership of the water tank.
3. The third project is another water tank along Hina Lani Street, which is the last water tank developed for the Hina Lani water system.

3.2 Projected Potable Water Demands

Potable water demand for the Project is derived using the Project's program requirements provided by SCD-TSA Kaloko Makai, LLC, and generalized simulation of projected demands for similar developments.

Based on demand factors shown in the *Water System Standards 2002*, Department of Water Supply, County of Hawaii, an average daily potable water demand of 2.18 MGD is projected for the Project. The projected maximum daily consumption is approximately 3.28 MGD. The anticipated required storage volume for the entire Project is approximately 3.27 MG. (See Appendix A)

3.3 Proposed Improvements

3.3.1 Alternative Sources for Potable Water

DWS indicated that due to delays in planning and construction of the Ane Keohokalole Highway (Mid-Level Road), water service in the North Kona area is not adequate to support new developments. The Project needs to develop a new water source and provide a new potable water system which includes treatment, storage, transmission and distribution facilities. Currently, the Hina Lani water system has been adequately designed to accommodate the Project and its associated water facilities.

It should be noted that source development, which is subject to Commission on Water Resources Management (CWRM) review, should be a priority. According to DWS, suitable and reliable potable water source is more favorable if located above the 1,700-feet elevation, up-slope of the Project site.

In consultation with Tom Nance Water Resources Engineering (TNWRE) and Hookuleana, LLC, Kaloko Makai is investigating the following four alternatives to meet its potable water needs. TNWRE's report is included in its entirety as Appendix B.

1. On-site wells at 710-foot elevation – Preferred Alternative
2. On-site wells at 710-foot elevation with Reverse Osmosis (RO) Treatment
3. Off-site wells approximately 3-4 miles south of Kaloko Makai
4. Desalinization of On-site Saline Groundwater

In providing sources of potable water for the Project, Kaloko Makai will comply with applicable laws and regulations. As necessary, Kaloko Makai will undertake additional research to assess the potential impacts and appropriate mitigation measures of the selected systems.

3.3.1.1 On-site Wells at 710-foot elevation

A deep exploratory borehole at 710-foot elevation at the eastern end of the Project site will be undertaken to determine if fresh groundwater can be found at depth and to determine the feasibility of its development. If successful, three production wells would be developed in the area. Under this preferred alternative, the possibility of developing potable quality wells at 710-foot elevation is suggested by the discoveries of two deep monitor wells (state Nos. 3858-01 and 3959-01), both of which encountered fresh groundwater under artesian pressure at a depth below the saline groundwater table which is hydrologically disconnected from the basal lens.

The potable source facility developed would be integrated into the DWS system, with two-thirds of their capacity allocated to supply the Project.

The Project will consist of the following elements:

- Three (3) production wells each of 1150 GPM production capacity and driven by a 350 horsepower motor
- Pump control building
- Security fencing
- Access road improvements
- Three (3) 1-2 MG concrete reservoir, as required by DWS
- New 16- to 20-inch transmission lines connecting to an existing 16-inch water main on Māmalahoa Highway

3.3.1.2 On-site wells at 710-foot elevation with Reverse Osmosis Treatment

If artesian groundwater is found below the saline groundwater table and its salinity at the projected draft rates do not meet drinking water standards, the RO treatment process will be considered. In addition to producing drinking quality water this treatment process will produce a wastewater stream, referred to as a concentrate that will be disposed of via injection wells located at the Project's on-site WWTP at the makai end of the Project site. Due to the operating costs of the RO treatment, DWS may not accept the wells and RO treatment plant for dedication. In that case, the capacity of the wells, as feedwater sources for RO treatment, will be sized to provide the Project's maximum day use in a 24-hour pumping day assuming 65%

product recovery in the RO process. As a private system, provision of standby well pumping capacity will be required. At full build-out, the disposal of concentrate will be 1.15 MGD as a year-round average. The cost of construction will be borne by Kaloko Makai.

The Project will consist of the following elements:

- Four (4) production wells of 1,170 GPM capacity each and each well driven by a 350 horsepower motor with standby.
- Pump control building
- Security fencing
- Access road improvements
- Three (3) 1-2 MG concrete reservoir, as required by DWS
- Transmission lines connecting to an existing water main on Hina Lani Street
- Desalinization Treatment Plant
- RO Concentrate disposal wells

An on-site desalination plant will be constructed in the event the water does not meet DOH standards for domestic use (i.e. too saline). The on-site desalination facility will include storage, transmission and a distribution system. The desalination plant will be situated in the vicinity of the mid-level water tank in Kaloko Makai. Feed lines from the wells to the treatment facility will follow along Hina Lani Street. The desalination facility will treat the water through a reverse osmosis (RO) process.

3.3.1.2.1 Reverse Osmosis Treatment Process

Feedwater from the wells are initially pre-treated prior to RO process to remove particles that can negatively affect the RO membranes.. This pre-treatment will reduce damage and wear to RO membranes, which increases the RO process performance and life span of the system.

After pre-treatment, high pressure created by pumps will force the pre-treated water through the RO membranes filtering and reducing total dissolved solids. The water is then conditioned for pH adjustment and disinfection. The water is then used as "potable" drinking water.

The wastewater of the RO process is a concentrated saline brine solution which will be discharged in on-site deep injection wells at depths below the feedwater source and the basal groundwater, in an area with 30 parts per thousand (ppt) salinity. The injection wells will be situated below the Underground Injection Control (UIC) line.

Since the concentrate would have a greater density than the surrounding saline groundwater, the concentrate will flow seaward without rising above the surrounding saline groundwater and will not rise to the basal lens. It will then be discharged into the ocean offshore at a substantial depth and distance from the shoreline.

In addition to potable water and brine concentrate, the desalination process will also produce small amounts of reject water from the pre-treatment process and from membrane cleaning and membrane cleaning solution. These by-products will be properly treated and processed at the on-site wastewater treatment facility or disposed of in the same injection wells used for the concentrated brine solution.

The proposed desalination system is subject to regulation as a public water system and needs to meet conditions of the DOH, including HAR Chapter 11-20, 11-21, and 11-25. The desalination water system will have no impact on potable or brackish groundwater. Likewise, it will not affect nearshore waters. This includes groundwater used by neighboring projects or anchialine pools and fishponds in the area, including nearby Kaloko-Honokōhau National Park.

3.3.1.3 Off-site wells to the south of Kaloko Makai

In the event that neither of the two on-site well alternatives described above is feasible, development of potable wells approximately 3-4 miles to the south will be undertaken. The exact locations of these wells will depend on land acquisition costs and additional costs for DWS infrastructure required to transmit this well supply north to the Project site. In general, however, there are two distinctly different possibilities, wells above Mamalahoa Highway tapping the high level groundwater directly, or wells in the near vicinity of the State's deep monitor well tapping the high level groundwater at depth below saline groundwater.

The Project will consist of the following elements:

- Three (3) production wells with 1,120 GPM or four 840 GPM pumps and appurtenances
- Pump control building
- Improvements to DWS transmission/distribution system
- Security fencing
- Access road improvements
- Three (3) 1-2 MG concrete reservoir, as required by DWS
- Transmission line connecting to existing water main on Hina Lani Street

Cost of construction would be borne by Kaloko Makai. The water tanks may be dedicated to DWS and an agreement negotiated with the DWS for use of the water.

Each mid-level well is anticipated to yield from 1.0-2.0 MGD. This amount is not significant in terms of the remaining sustainable yield of the aquifer. No adverse groundwater effects have been observed from any of the existing wells in the regions, individually or cumulatively.

3.3.1.4 Desalinization of On-site Saline Groundwater

In the event that none of the alternatives previously mentioned are feasible, raw water supply wells and a desalinization plant will be installed near existing Kaloko Water Tank #1 along Hina Lani Drive. The raw water supply wells will draw saline groundwater from beneath the basal lens at depths between 250 and 350-feet below sea level, requiring total well depths at about 710-feet. Water recovery from this saline feedwater supply is approximately 40%.

The Project will consist of the following elements:

- Three (3) treatment trains each of 750 GPM capacity supplied by a 1900 GPM raw water supply well.
- Pump control building
- Security Fencing
- Access road improvements
- Three (3) 1-2 MG concrete reservoir, as required by DWS
- Transmission lines connecting to an existing water main along Hina Lani
- Desalinization treatment plant
- RO Concentrate disposal wells

Pressure transfer devices would be installed to recover energy from the RO's concentrate stream. The concentrate will be hypersaline and amount to 4.9 MGD at full build out. The cost of construction will be borne by Kaloko Makai.

3.4 Storage and Distribution

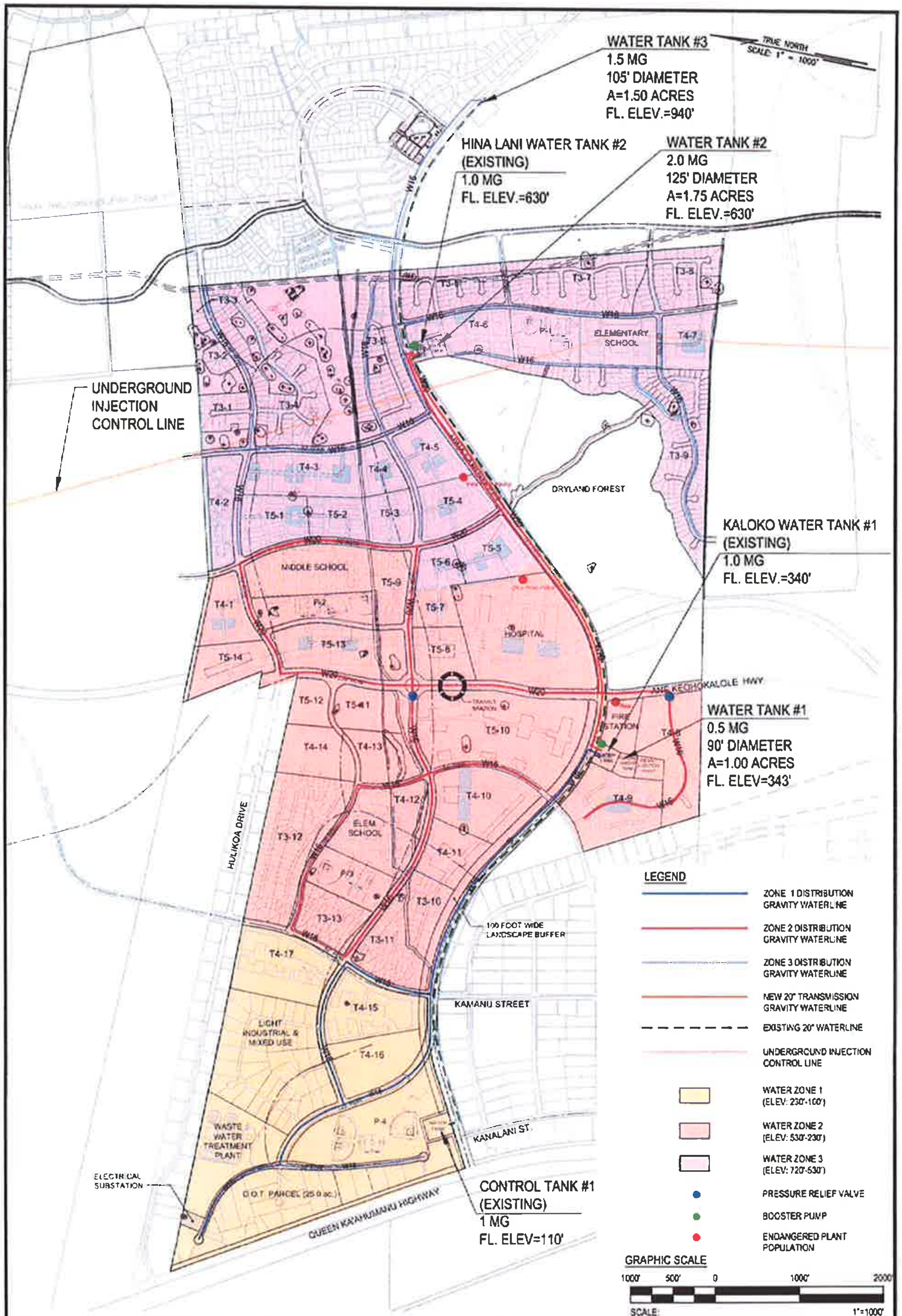
During the preliminary planning stages, water source development and plans for water storage for the Project should be studied, investigated, determined, verified, and confirmed. The transmission lines vary in size from 16-inch to 20-inch based on the demand and will be integrated with the existing DWS water system (See Figure 3-1)

The project site has been divided into 3 different pressure zones based on topography. The desalination plant, reservoir size and locations, booster pumps, and on-site and off-site water system will be determined during the design phase based on these pressure zones and in consultation with TNWRE. The on-site potable water distribution system will be determined once the Project layout and roadway scheme are approved by the County Department of Public Works.

The preferred alternative for the potable water system for the Kaloko Makai development will consist primarily of gravity flow (See Figure 3-1). During phase 1, an on-site well will be drilled at elevation 710 feet, which will supply potable water for proposed Water Tank #2 at elevation 630 feet. A new 20-inch gravity waterline will connect at Water Tank #2 to accommodate a flow of 1161 GPM and to service zone 2. Pressure release valves will be installed below Ane Keohokalole Street to reduce pressures gained due to the drop in elevation. Internal pipe pressures shall follow the *Water System Standards 2002*. There will also be a new 20" transmission line installed during phase 1 to transmit water from Water Tank #2 to Water Tank #1 at elevation 343 feet. A new 16" gravity waterline will connect from Water Tank #1 to accommodate a flow of approximately 343 GPM and to service zone 1. During phase 2, a booster pump will be installed at Water Tank #2 to transmit water to Water Tank #3 at elevation 840 feet through the existing 20-inch water line along Hina Lani Street. A new 16-inch gravity waterline will connect from Water Tank #3 to accommodate a flow of approximately 515 GPM and to service zone 3.

The existing DWS water system includes the required fire flow capacity. Additional fire flow capacity has not been included in sizing of the new water tanks. Fire protection requirements for the Project will be analyzed and will consist of appropriate improvements and/or upgrades and waterline extension to the various parts of the Project site. The need for any additional pressurized system for the Project will be determined by the mechanical or other consultants during the design phase of the Project.

The Fire Department will be consulted during the design phase of the Project to determine the need for on-site roadside fire hydrants and to review fire truck access requirements.



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KALOKO MAKAI INFRASTRUCTURE
PROPOSED POTABLE WATER LAYOUT

FIGURE 3-1

4. DRAINAGE SYSTEM

This section reviews the existing topography and drainage conditions of the Project site. It also describes proposed improvements to meet County Best Management Practice (BMP) requirements. The proposed improvements are subject to change based on the refinement of plans and availability of more detailed information.

4.1 Existing Conditions

There are currently no existing BMP's to filter and treat storm water runoff prior to disposal into drywells. The County of Hawaii currently operates and maintains a series of swales and drywells along Hina Lani Street. Typically, the V-type swales are 6' wide running along roadside shoulders. Drywells are located to intercept runoff collected in the swales and are approximately 5-feet in diameter, 20-feet deep, and capped with a catch basin/grated inlet drywell cover. Drywells allow collected storm water runoff to percolate into the ground to replenish ground water source.

4.1.1 Topography and Soils Condition

The Project site is located along the west coast of the Island of Hawaii, mauka of Queen Kaahumanu Highway. Based on information shown on the USGS maps, existing topography is characterized by moderate mauka to makai slopes. Site elevations range from approximately 80 feet above Mean Sea Level (MSL) along Queen Kaahumanu Highway to approximately 700 feet above MSL along the mauka boundary. (See Figure 4-1).

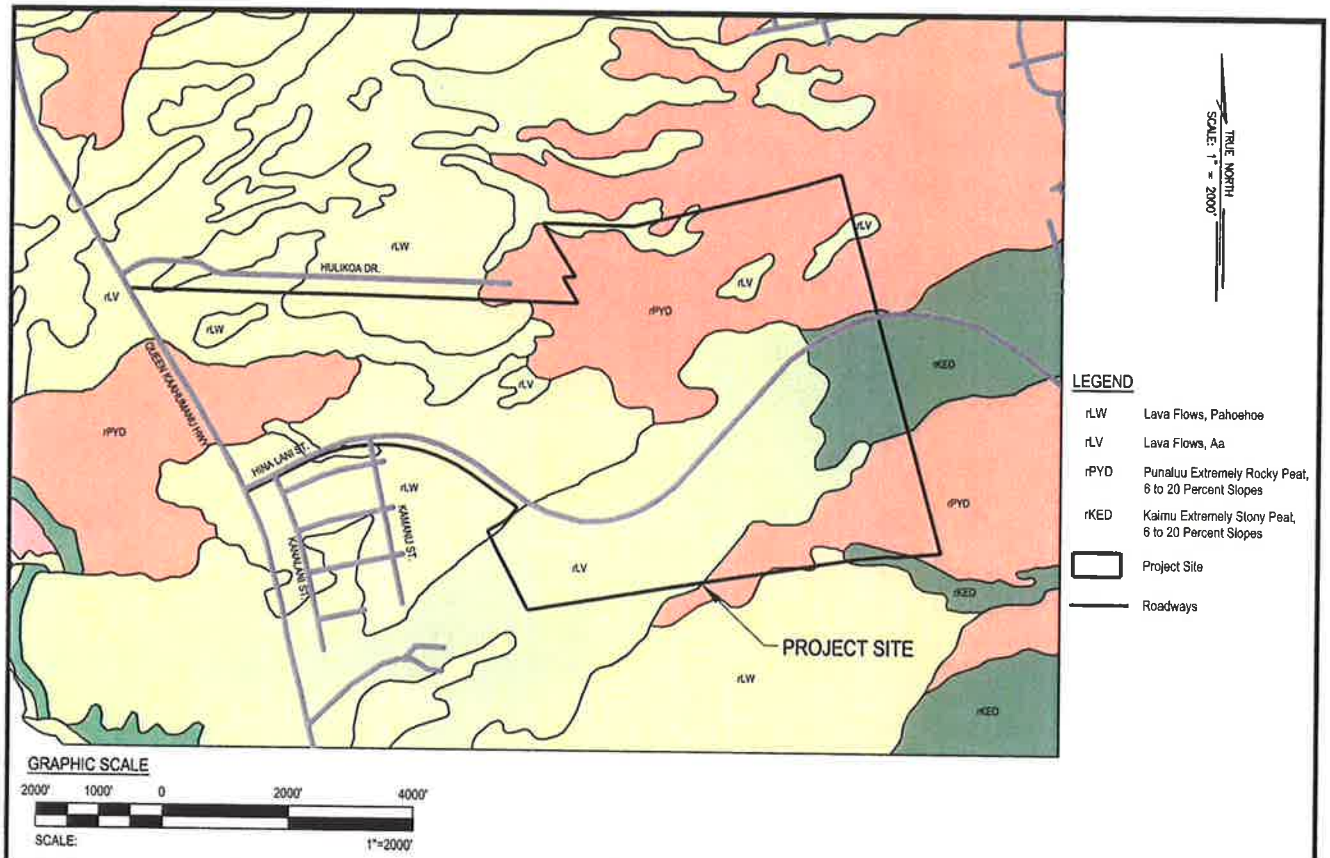
According to the U.S. Natural Resources Conservation Service's (NRCS) *Soil Survey of the Island of Hawaii, State of Hawaii* (1972), the Project site is largely comprised of four soil types designated by the (see Figure 4-2):

- Punaluu Extremely Rocky Peat, *6 to 20 percent slope* **(rPYD)** – This soil is low on the leeward side of Mauna Loa. Rock outcrops occupy 40-50 percent of the surface. In a representative profile the surface layer is black peat about 4 inches thick. It is underlain by pahoehoe lava bedrock. The peat is rapidly permeable. The pahoehoe lava is very slowly permeable, although water moves rapid through the cracks. Runoff is slow, and the erosion hazard is slight. This soil is used for pasture. (Capability subclass VIIs, non-irrigate; pasture group 3)

- Lava Flow, Pahoehoe, **(rLW)** – Pahoehoe lava has been mapped as a miscellaneous land type. This lava has a billowy, glassy surface that is relatively smooth. In some areas however, the surface is rough and broken, and there are hummocks and pressure domes. Pahoehoe lava has no soil covering and is typically bare of vegetation except for mosses and lichens. (Capability subclass VIIIs, non-irrigated)

- Lava Flow, Aa, **(rLV)** – Aa lava has been mapped as a miscellaneous land type. This lava has practically no soil covering and is bare of vegetation, except for mosses, lichens, ferns, and a few small ohia trees. Aa is rough and broken, and is a mass of clinkery, hard, glassy, sharp pieces piled in tumbled heaps. (Capability subclass VIIIs, non-irrigated)

- Kaimu Extremely Stony Peat, *6 to 20 percent slope* **(rKED)** – This soil is at low elevations on Mauna Loa. In a representative profile the surface layer is very dark brown extremely stony peat about 3 inches thick. It is underlain by fragmental Aa lava. Permeability is rapid, runoff is slow, and the erosion hazard is slight. This soil is not suitable for cultivation. Most of it is in native woodland. Small areas are used for pasture, macadamia nuts, papaya, and citrus fruits. (Capability subclass VIIs, non-irrigated; pasture group 5)



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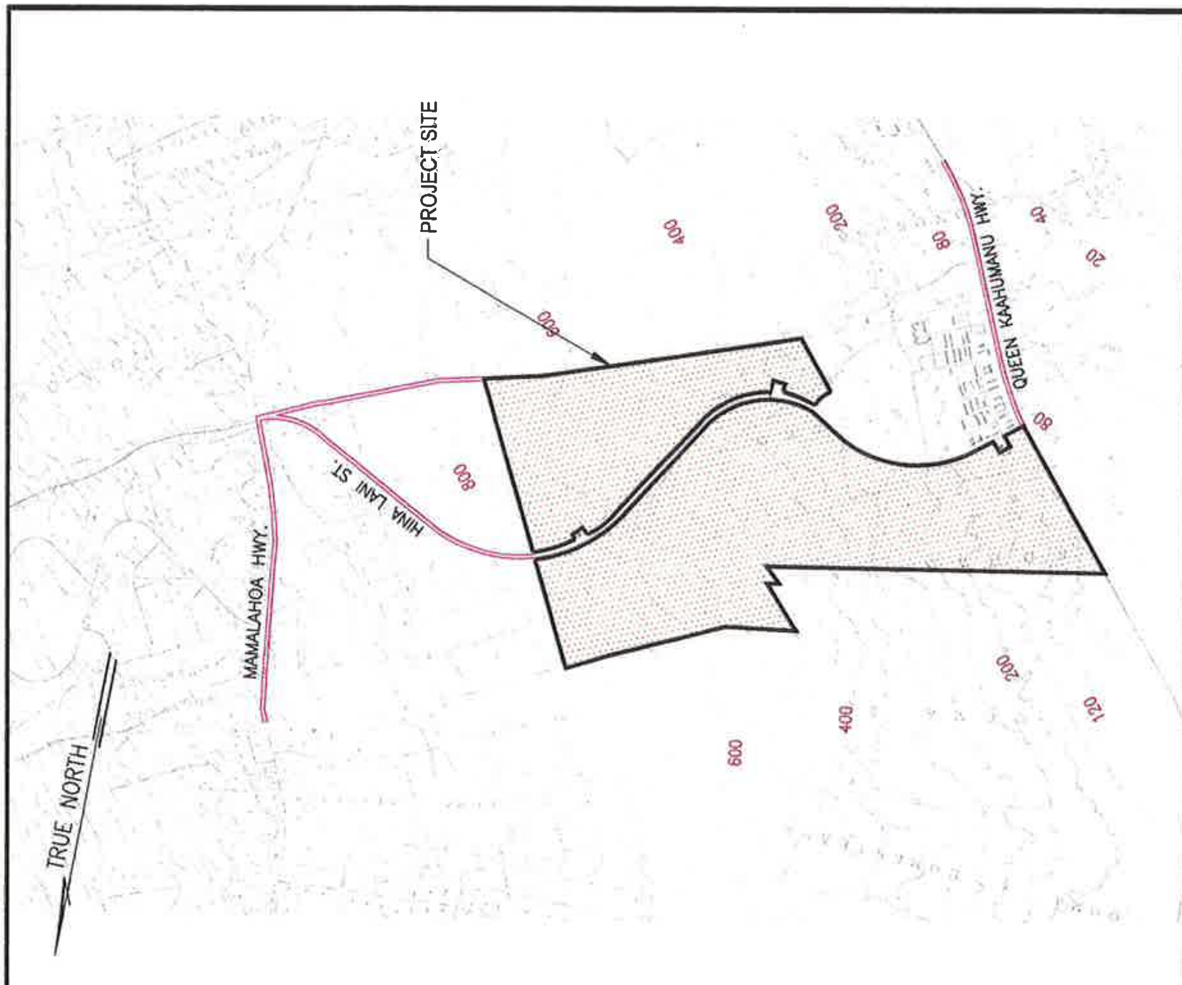
KALOKO MAKAI INFRASTRUCTURE
SOILS MAP

FIGURE 4-2



KALOKO MAKAI INFRASTRUCTURE
TOPOGRAPHIC MAP

FIGURE 4-1

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4.1.2 Existing Hydrology

Surface runoff Mauka of the Project sheet flows toward the Project site and percolates into the ground. The existing Project area consists of about 5,036 acres of off-site and on-site drainage. The existing area can be categorized into eleven (11) distinct drainage basins, based on approximate ridgelines and natural topography (see Figure 4-3). Runoff from the eleven existing drainage basins was calculated for a 100 year – 24 hour storm event (see Table 4-1).

Drainage Basins 1 and 2. Drainage Basins 1 and 2 encompass approximately 156 acres and 880 acres, respectively. These areas are covered with slight to moderate vegetation and lava rock with very few paved areas. Runoff generated in these basins flow in a westerly direction toward the ocean and percolates through the ground. These drainage basins can be considered off-site.

Drainage Basins 3, 4, and 5. Drainage Basins 3, 4, and 5 encompass approximately 152, 64, and 74 acres, respectively and are on-site. These basins contain only slight to moderate vegetation and lava rock with no paved areas. Surface flow travels in a westerly direction toward the ocean and percolates through the ground.

Drainage Basins 6, 7, and 8. Drainage Basins 6, 7, and 8 encompass approximately 1,674, 148, and 13 acres, respectively. These drainage basins contain mostly slight to moderate vegetation and lava rock with Drainage Basin 6 also having some residential paved areas. Runoff generated in these drainage basins flow in a westerly direction toward the ocean and percolates through the ground. Drainage Basin 8 is on-site while Drainage Basin 7 is off-site. Drainage Basin 6 is both on and off-site.

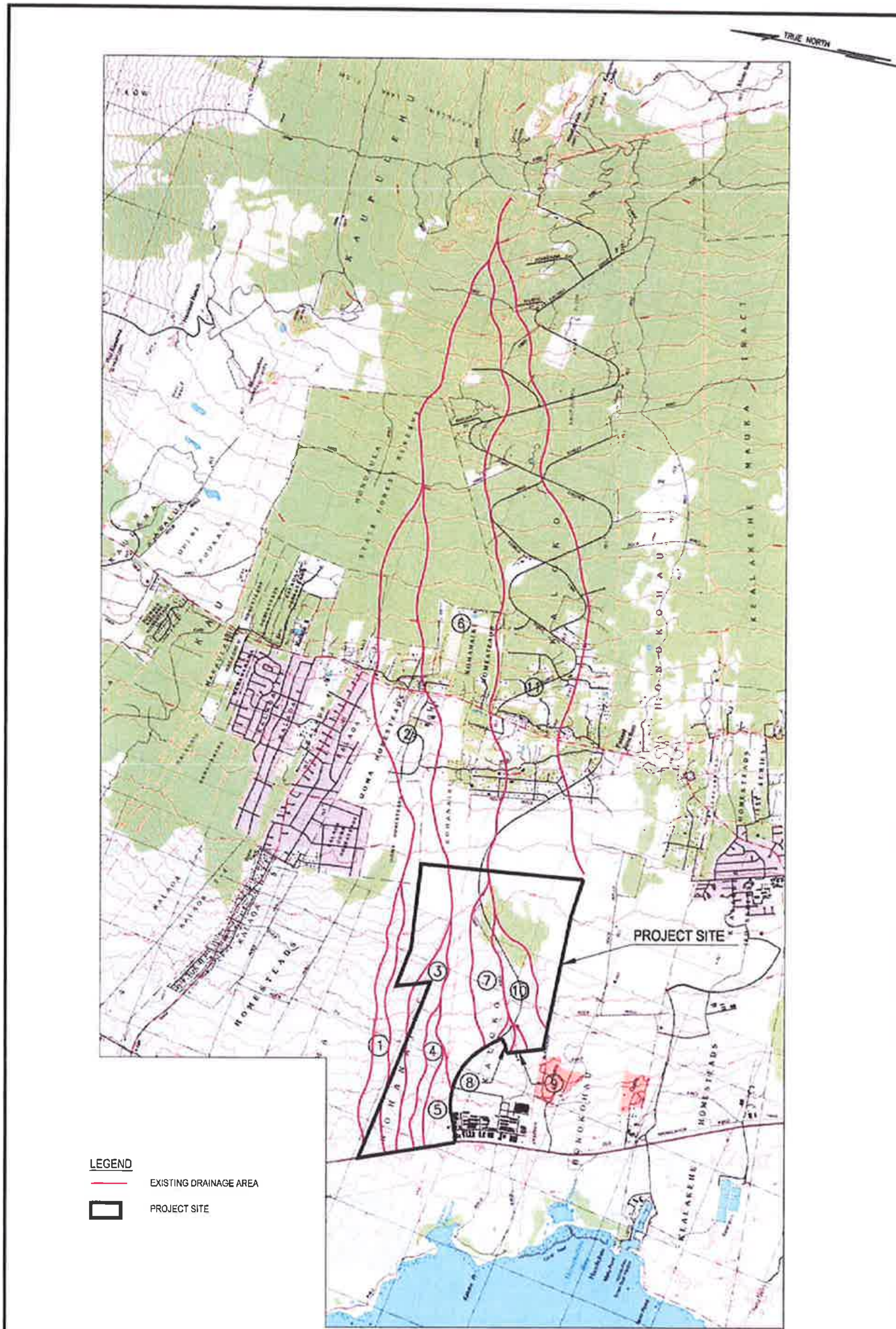
Drainage Basin 9 and 10. Drainage Basins 9 and 10 encompass approximately 11 and 132 acres, respectively and are completely on-site. Both drainage basins consist of slight to moderate vegetation and lava rock. Hina Lani Street is the only pavement crossing the drainage basins. Runoff generated flow toward the ocean in a westerly direction and percolates through the ground.

Drainage Basin 11. Drainage Basin 11 encompasses approximately 1,732 acres and consists of more development (residential uses and Hina Lani Street) than any other drainage basin. This drainage basin also contains slight to moderate vegetation and lava rock. Runoff generated flows in a westerly direction toward the ocean and percolates through the ground.

Table 4-1 Existing Hydrology

Existing Condition

Sub Basin	AREA (acre)	C	LENGTH	HEIGHT	SLOPE	VELOCITY (fps)	T_c (sec)	T_c (min)	i (in.)	Q (ft³/s)
1	155.67	0.21	11025	690.00	0.063	3	3675.00	61.25	8.00	265.26
2	880.39	0.23	27429.5	2760.00	0.101	3	9143.17	152.39	8.00	1637.53
3	151.82	0.20	9530.5	520.00	0.055	3	3176.83	52.95	8.00	242.92
4	64.09	0.20	6020	360.00	0.060	3	2006.67	33.44	7.00	89.72
5	73.79	0.20	3857	240.00	0.062	3	1285.67	21.43	7.00	103.31
6	1674.71	0.27	32375	4300.00	0.133	3	10791.67	179.86	7.50	3328.48
7	148.25	0.23	6531	400.00	0.061	3	2177.00	36.28	8.00	275.75
8	12.94	0.23	1032.5	60.00	0.058	3	344.17	5.74	8.00	24.08
9	10.45	0.23	1022	60.00	0.059	3	340.67	5.68	7.00	17.01
10	132.29	0.23	5498.5	300.00	0.055	3	1832.83	30.55	7.00	215.31
11	1732.03	0.30	32033.43	4480.00	0.140	3	10677.81	177.96	7.00	3606.95
Total	**5036.45**									**9806.32**



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KALOKO MAKAI INFRASTRUCTURE

EXISTING DRAINAGE AREA

FIGURE 4–3

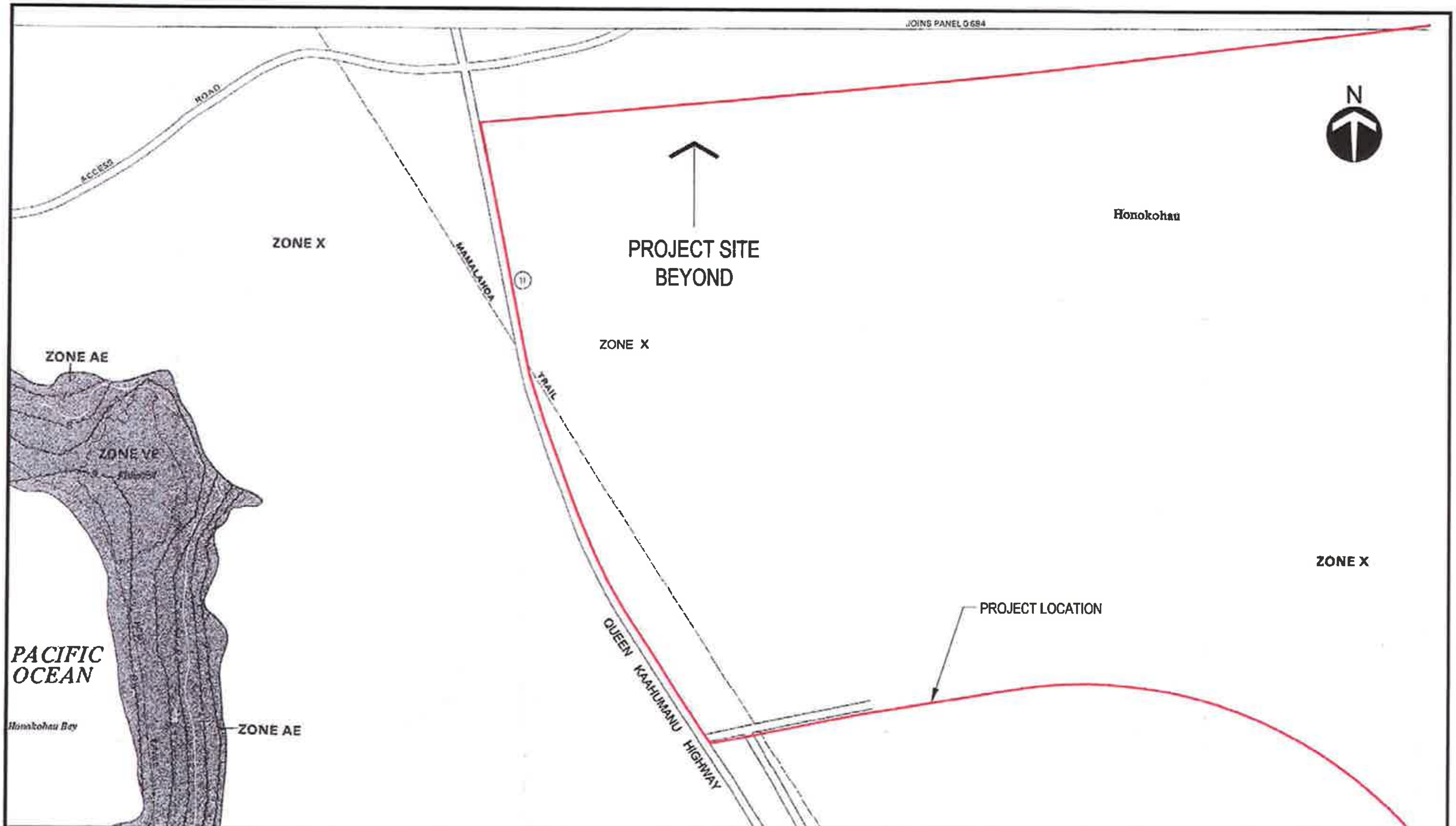
4.1.3 Flood Zone

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM), Community Panel 155166 0692C revised April 02, 2004, the Project site is within Zone "X", "Areas determined to be outside of 500-year flood plain." The other FIRM panel 155166 0684C covering the Project site, is determined to be in Zone X. (See Figure 4-4)

4.2 Peak Runoff Rates

The peak runoff rates for the drainage area were calculated using the Rational Method, with a recurrence interval of 100 year-24 hour storm event in conformance with the County of Hawaii, Department of Public Works Storm Drainage Standard.

Increase in storm water runoff is generally related to the type of development or improvements undertaken to previously undeveloped areas. This increase of storm water runoff is created by changes in a number of factors including soil infiltration characteristics (soil permeability), relief (slope of ground), vegetation cover (percentage of vegetation cover over the drainage area), and development type (industrial, residential, agriculture, others). Of these factors, development type is the most significant characteristic that affects storm water runoff. The rate at which surface runoff flows (measured in cubic feet per second, cfs) will change and the quantity of runoff (measured in acre-feet, ac-ft) will also change resulting from the altered landscape.



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KALOKO MAKAI INFRASTRUCTURE
FLOOD INSURANCE RATE MAP

FIGURE
4–4

4.3 Post Development Improvements

The natural drainage pattern will be modified due to on-site development, including roadways, residential lots, and commercial areas. Runoff from the off-site mauka areas is not expected to increase and will be redirected away from the Project site through drainage channels located on the eastern and northern borders of the Project site. However, the proposed drainage system improvements will maintain or reduce the rate of runoff discharged off the Project site to equal or less than the existing rates, in compliance with County BMP Requirements. The use of detention basins, and natural swales or channels will store and filter the storm runoff, removing pollutants via percolation (see Figure 4-5).

4.3.1 Proposed Hydrology

As the Kaloko Makai Development is built, the runoff pattern defining the existing eleven drainage basins will be modified by the construction of roadways and drainage facilities. To calculate the peak runoff rates for the proposed condition, the existing eleven drainage areas were further divided into 21 drainage areas (see Figure 4-6). Runoff from the proposed Project was calculated for a 100 year – 24 hour storm event (see Table 4-2).

Drainage Basin 1. Drainage Basin 1 encompasses approximately 24 acres and located on the northeast corner of the Project Site. This drainage basin will consist of large single family lots.

Drainage Basin 2. Located on the east side of the Project Site, Drainage Basin 2 is roughly 102 acres and consists of large single family lots.

Drainage Basin 3. Drainage Basin 3 encompasses approximately 126 acres located on the southeast corner of the Project Site. This drainage basin will consist of single family lots, large single family lots, multi family lots, a park, and elementary school.

Drainage Basin 4. Drainage Basin 4 has an area of approximately 15 acres and is located on the north side of the Project Site. This area will consist of mixed single and multi family lots.

Drainage Basin 5. At approximately 60 acres, Drainage Basin 5 is located near the northeast corner of the Project Site and will consist of single family, multi family, and mixed use lots all make up this drainage basin.

Drainage Basin 6. Located near the east side of the Project Site, Drainage Basin 6 is approximately 26 acres. It is planned to be used for both single family and multi family lots.

Drainage Basin 7. Drainage Basin 7 is approximately 228 acres and is located near the southeast corner of the Project Site. Most of this basin consist of the native dryland forest while the rest will be used for a park, elementary school, and single family residential lots.

Drainage Basin 8. Drainage Basin 8 is located on the north side of the Project Site and is roughly 27 acres. This drainage basin will consist of mixed use, affordable housing, and for single and multi family lots.

Drainage Basin 9. This drainage basin encompasses approximately 47 acres. Situated at the northern end of the Project site, Drainage Basin 9 will consist of a middle school, park, and mixed use and multi family lots.

Drainage Basin 10. Drainage Basin 10 is centrally located and encompasses approximately 91 acres. This drainage basin will consist of various uses including medical offices, a transit station, hospital, lodge, and business center.

Drainage Basin 11. This drainage basin is near the north end of the Project Site and approximately 25 acres. It is planned for mixed use lots.

Drainage Basin 12. Located on the north end of the Project Site, Drainage Basin 12 runs parallel to Hulikoa Drive. It is approximately 56 acres and will consist of single and multi family lots as well as affordable housing and live-work lots.

Drainage Basin 13. Drainage Basin 13 is situated near the center of the Project Site and is roughly 54 acres. It will consist of a shopping center, legal offices, multi family lots, a transit station, and a senior Independent living center.

Drainage Basin 14. This drainage basin is located near the center of the Project Site and is about 13 acres. It will consist of single and multi family logs.

Drainage Basin 15. Drainage Basin 15 encompasses approximately 68 acres and will consist of single family, multi family, and live-work lots. It is located along the southern border of the Project Site.

Drainage Basin 16. Approximately 72 acres make up this drainage basin located at the northwest corner of the Project Site. This basin will consist of light industrial and mixed use, multi family residential lots , affordable housing, and live-work .

Drainage Basin 17. Drainage Basin 17 is situated near the southwest corner of the Project Site. It is approximately 39 acres and will include single and multi family lots, affordable housing, and live-work areas.

Drainage Basin 18. Located in the southwest corner of the Project Site, Drainage Basin 18 is about 40 acres. It will contain a park and water tank site.

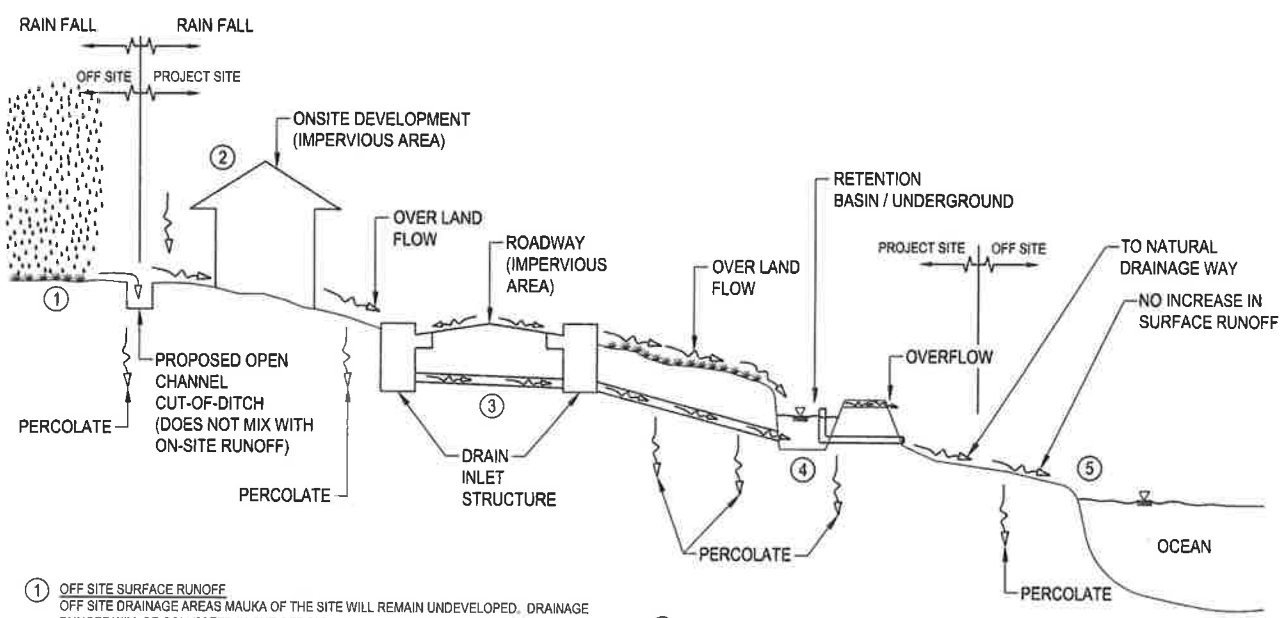
Drainage Basin 19. This drainage basin runs along the western border and northwestern corner of the Project Site and is approximately 74 acres. It includes a waste water treatment plant.

Drainage Basin 20. A fire station, desalination plant, water tank, live-work and mixed use lots, multi family residential areas, and affordable housing will all make up the nearly 60 acres of this drainage basin. It is located on the southern end of the Project Site.

Drainage Basin 21. Situated near the center of the Project Site, this drainage basin is planned to contain single and multi family residential areas, live-work lots, senior housing, a park, and elementary school. It is approximately 62 acres.

Table 4-2 Proposed Hydrology

Proposed Condition										
Sub Basin	AREA (acre)	C	LENGTH	HEIGHT	SLOPE	VELOCITY (fps)	T_c (sec)	T_c (min)	i (in.)	Q (ft³/s)
Off Site										
A	133.75	0.20	10755.92	680	0.063	3	3585.31	59.76	7.00	187.24
B	680.90	0.20	24516.6	2600	0.106	3	8172.20	136.20	8.00	1089.44
C	20.59	0.27	1983.63	160	0.081	3	661.21	11.02	7.00	38.20
D	1441.19	0.27	24609.37	3680	0.150	3	8203.12	136.72	8.00	3055.33
E	1451.97	0.30	25859.59	4240	0.164	3	8619.86	143.66	8.00	3455.68
Total Off-Site	**3728.40**									**7825.90**
On Site										
1	23.74	0.33	2086	160	0.077	12	173.83	2.90	7.00	54.83
2	101.47	0.33	2443	160.00	0.065	12	203.58	3.39	7.00	234.39
3	125.98	0.40	899.5	80.00	0.089	12	74.96	1.25	7.00	348.34
4	14.75	0.59	1330	100.00	0.075	12	110.83	1.85	7.00	60.92
5	59.54	0.59	1816.5	80.00	0.044	12	151.38	2.52	7.00	245.89
6	26.15	0.59	1456	60.00	0.041	12	121.33	2.02	7.00	108.01
7	228.42	0.33	5292	240.00	0.045	12	441.00	7.35	7.00	527.66
8	27.14	0.66	1309	80.00	0.061	12	109.08	1.82	7.00	124.46
9	46.53	0.53	1715	80.00	0.047	12	142.92	2.38	7.00	170.98
10	90.65	0.59	2796.5	120.00	0.043	12	233.04	3.88	7.00	374.39
11	25.08	0.40	1113	80	0.072	12	92.75	1.55	7.00	69.33
12	55.66	0.40	1344	80.00	0.060	12	112.00	1.87	7.00	153.91
13	54.24	0.59	2086	100.00	0.048	12	173.83	2.90	7.00	223.99
14	12.87	0.40	1277.5	40.00	0.031	12	106.46	1.77	7.00	35.60
15	68.02	0.53	1466.5	60.00	0.041	12	122.21	2.04	7.00	249.97
16	71.90	0.66	2443	120.00	0.049	12	203.58	3.39	7.00	329.66
17	38.94	0.59	1473.5	100.00	0.068	12	122.79	2.05	7.00	160.81
18	40.37	0.27	938	60.00	0.064	12	78.17	1.30	7.00	74.88
19	74.37	0.66	983.5	60.00	0.061	12	81.96	1.37	7.00	341.01
20	59.24	0.59	1641.5	100.00	0.061	12	136.79	2.28	7.00	244.65
21	62.24	0.40	1487.5	100.00	0.067	12	123.96	2.07	7.00	172.09
Total On-Site	**1307.30**									**4305.78**



① OFF SITE SURFACE RUNOFF
OFF SITE DRAINAGE AREAS MAUKA OF THE SITE WILL REMAIN UNDEVELOPED. DRAINAGE RUNOFF WILL BE COLLECTED IN CUT-OFF-DITCH AND TO NATURAL DRAINAGE PATH AND ALLOWED TO PERCOLATE.

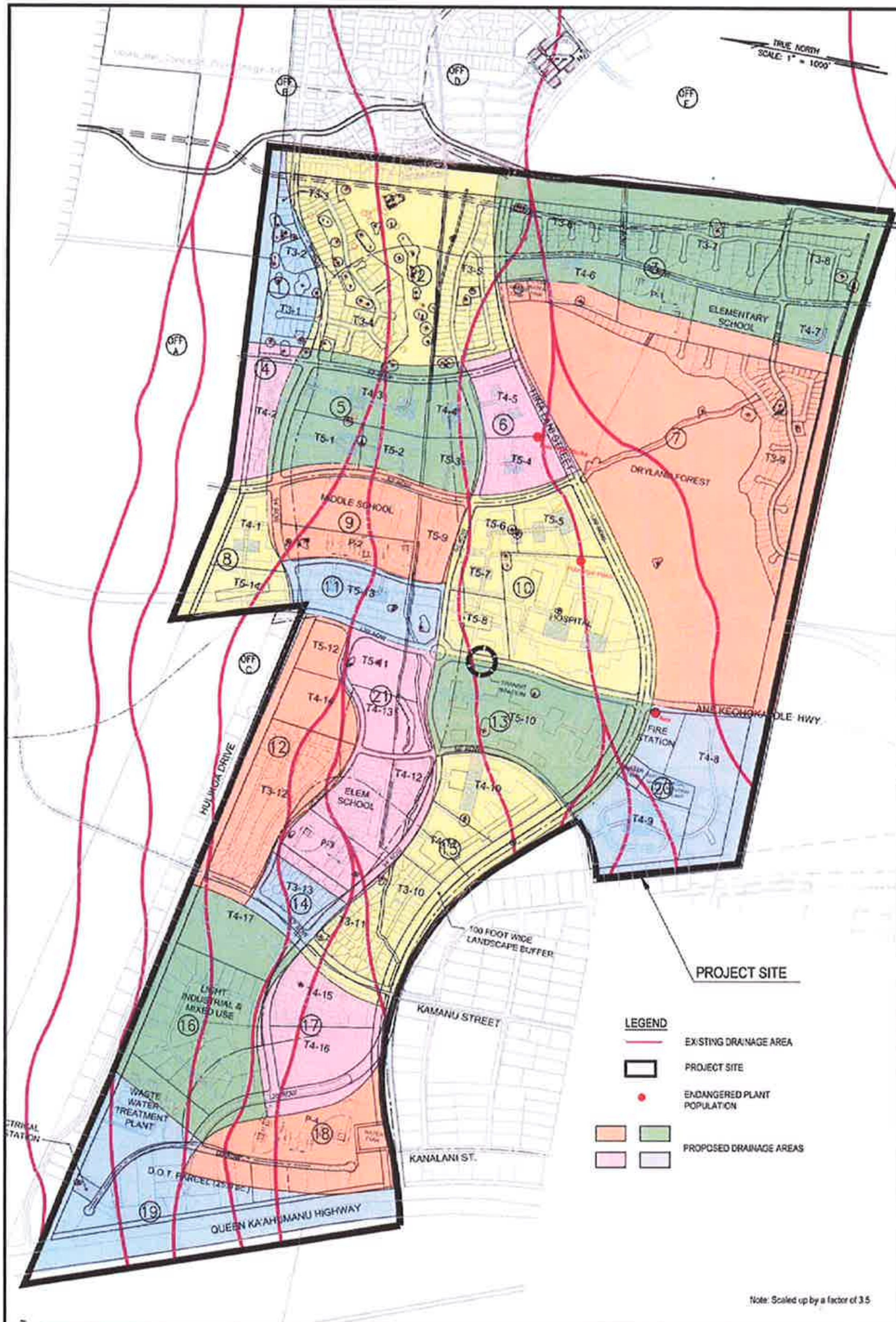
② ON SITE RUNOFF
THE PROPOSED DEVELOPMENT OF THE SITE WILL INCREASE THE STORM WATER RUNOFF VOLUME DUE TO THE ADDITIONAL IMPERVIOUS AREAS.

③ DRAINAGE PIPE SYSTEM
ON SITE RUNOFF WILL BE DIVERTED TO DRAIN INLET STRUCTURES AND PIPED THROUGH A SERIES OF DRAINLINES THROUGHOUT THE PROJECT SITE TO PROPOSED BASINS.

④ RETENTION BASIN / UNDERGROUND RETENTION SYSTEM
BASINS WILL BE PROVIDED TO CAPTURE THE ADDITIONAL RUNOFF VOLUME CREATED BY THE NEW DEVELOPMENT. THE BASINS WILL "RETAIN" THE INCREASED RUNOFF VOLUME AND ALLOW TO PERCOLATE.

⑤ DOWNSTREAM PROPERTIES
THE RUNOFF VOLUME LEAVING THE PROJECTS SITE WILL BE REDUCED, DUE TO THE ON SITE PROPOSED IMPROVEMENTS. THE PROPOSED KALOKO DEVELOPMENT WILL NOT ADVERSELY AFFECT THE EXISTING RUNOFF CONDITIONS AND THE ADJACENT DOWNSTREAM PROPERTIES. THERE WILL BE NO INCREASE IN SURFACE RUNOFF.

Prepared by: Wilson Okamoto Corporation Engineers • Planners	KALOKO MAKAI INFRASTRUCTURE CONCEPTUAL DRAINAGE DIAGRAM	FIGURE 4–5



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Engineers • Planners

KALOKO MAKAI INFRASTRUCTURE
POST DEVELOPMENT AND OFFSITE
DRAINAGE BASINS

FIGURE
4–6

4.3.2 Future Runoff Volume Calculations

In order to accommodate the additional flow, detention basins will be provided to retain the increased drainage runoff volume. The Area-Duration method was used with a 100 year–24 hour storm event to determine the required capacity of each detention basins. This calculation method uses the runoff coefficient (C) of the existing and proposed conditions to determine the increase of storm water runoff volumes. Basin volumes are measured in acre-feet and Table 4-3 illustrates the volumes of the pre development and post-development conditions.

4.4 Proposed Improvements

The natural drainage pattern will be modified due to on site development, including roadways, residential lots, and commercial areas. Runoff from the off site mauka areas is not expected to increase and will be redirected away from the project site through drainage channels located on the eastern and northern borders of the Project site. However, the proposed drainage system improvements will maintain or reduce the rate of runoff discharged off the Project site to equal or less than the existing rates, in compliance with County BMP Requirements.

4.4.1 Temporary Best Management Practice (BMP)

During construction, temporary BMP's will be designed, installed, and maintained by the contractor for each phase to limit the amount of sediments and other pollutants generated from the Project. Some temporary BMP's may include stabilized construction entrance/exist, geotextiles, silt fences, storm drain inlet protection, and temporary swales. NPDES permits will be applied for should storm water discharge into any water under jurisdiction of the United States of America.

4.4.2 Permanent Best Management Practice (BMP)

Permanent BMP's will be designed for each phase of construction and will include ultimate build-out. Drain inlets and catch basin filters may be used to accommodate roadway drainage, as well drainage for school, parks, and other properties. Hydrodynamic devices may be used to separate pollutants such as grease and oils in storm water runoff before discharge. Low impact development structures such as biofilters and bioswales can also be used to treat storm water runoff. All permanent BMP's will meet County BMP standards to filter first flush sediment and other pollutants prior to discharge off-site, into injection wells, or percolation into the ground

4.4.3 Detention Basins

A drainage basin approximately 4-7 feet deep will be placed at each park located throughout the Project site (see Figure 4-7). Approximately 30% of the park is assumed useable as a drainage basin due to the natural topography and usage of the park. Any additional storm water runoff will be stored in an underground retention system located throughout the park. Storm water collected in the drainage basin and underground retention system will percolate through the ground. At each drainage basin, a spillway will be constructed to allow any excess storm water to overflow.

4.4.4 Drainage Pipe System

Depending on the type of development proposed, use of an underground storm drainage system consisting of drainlines, drain inlets, and storm drain manholes will be required to collect and convey storm drainage runoff to the drywells and/or detention basins. The proposed drainage system will be designed to minimize the impacts to near shore coastal waters. The actual number of drywells and size of detention basins will be determined during the design phase of the Project. A geotechnical engineer should be retained during the design and construction phase of the Project to verify percolation results of the drywells to confirm discharge capacities. Drywells will require an underground Injection Well Permit from the State Department of Health.

The storm water utility line sizes, inlet locations, drywell requirements and detention/retention basin sizes will be determined during the design phase of the Project.

4.4.5 Open Channels

An open drainage channel will be constructed along the eastern boundary (mauka) of the Kaloko Makai development to redirect any off-site drainage away from the Project site and into the natural drainage paths flowing through the Project site (see Figure 4-7). A second drainage channel will be constructed along the eastern boundary of the dryland forest to prevent any on-site drainage from entering the dryland forest. A third and fourth drainage channel will be built along the northern boundary of the Kaloko Makai development to capture any redirect generated uphill from flowing into the Project site.

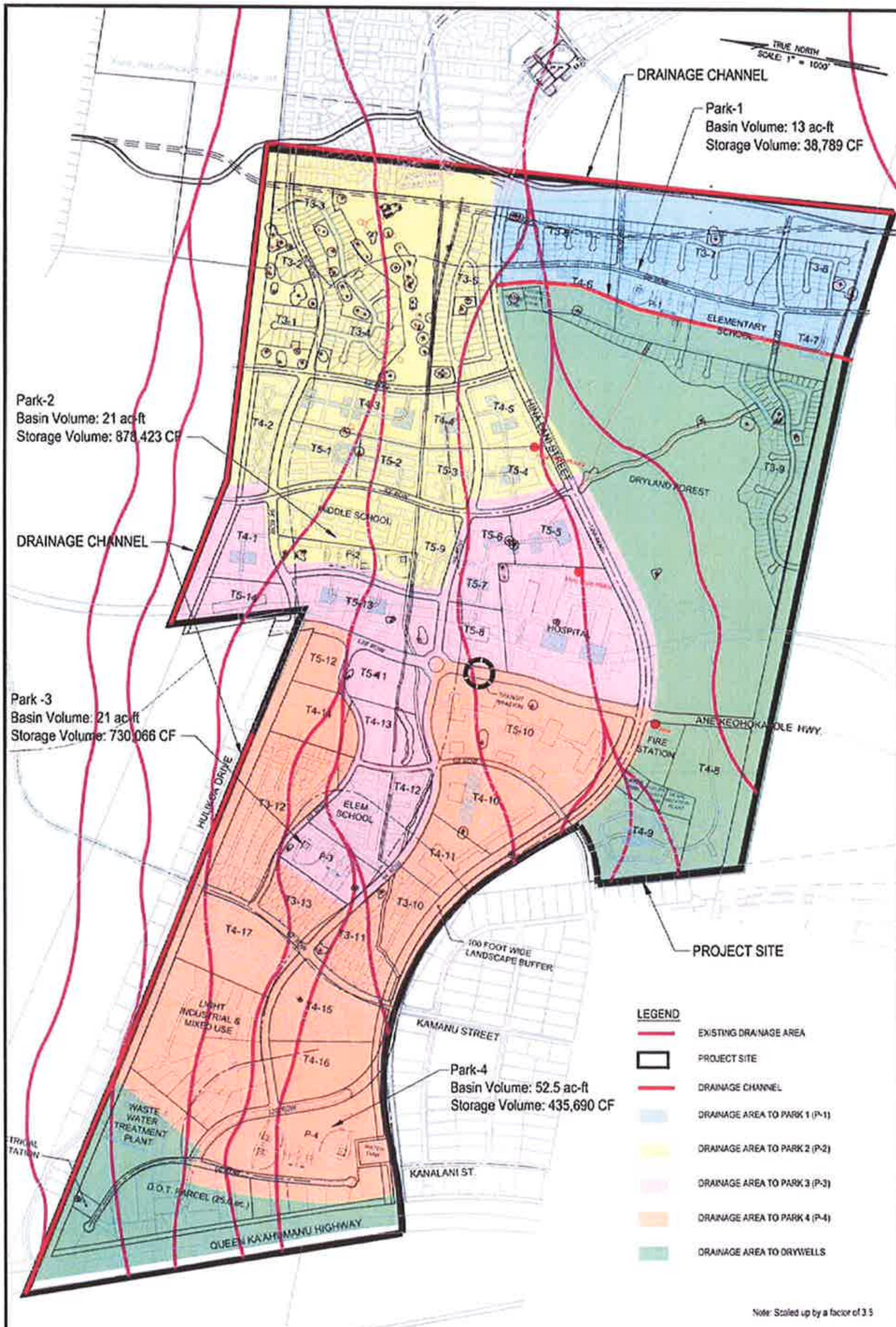
4.4.6 Roadway Culverts

Proposed roadway culverts will be provided throughout the Project Site to divert runoff under roadways, which will prevent excessive flooding on the roadways. Roadway culvert plans and profiles will be finalized during the final design of the Project.

In addition, bioswales, landscape elements designed to remove silt and other pollutants, along roadways may be an option where appropriate.

Table 4-3 On-Site Existing and Proposed Volumes
Area-Duration Method
100 Year - 24 Hour Event

Basin	Analysis Method	Area (Acres)	$I_{100\ year}$ (in.)	Pre C	Post C	Pre V (ac-ft)	Post V (ac-ft)	Net V (ac-ft)
Off-Site								
A	Rational	133.75	7	0.20		15.60		
B	Rational	680.90	7.5	0.20		85.11		
C	Rational	20.59	7	0.27		3.18		
D	Rational	1441.19	8	0.27		254.61		
E	Rational	1451.97	8	0.30		287.97		
On-Site								
1	Rational	23.74	7	0.20	0.33	2.77	4.57	1.80
2	Rational	101.47	7	0.20	0.33	11.84	19.53	7.69
3	Rational	125.98	7	0.20	0.40	14.70	29.03	14.33
4	Rational	14.75	7	0.20	0.59	1.72	5.08	3.36
5	Rational	59.54	7	0.20	0.59	6.95	20.49	13.54
6	Rational	26.15	7	0.20	0.59	3.05	9.00	5.95
7	Rational	228.42	7	0.20	0.33	26.65	43.97	17.32
8	Rational	27.14	7	0.20	0.66	3.17	10.37	7.20
9	Rational	46.53	7	0.20	0.53	5.43	14.25	8.82
10	Rational	90.65	7	0.20	0.59	10.58	31.20	20.62
11	Rational	25.08	7	0.20	0.40	2.93	5.78	2.85
12	Rational	55.66	7	0.20	0.40	6.49	12.83	6.33
13	Rational	54.24	7	0.20	0.59	6.33	18.67	12.34
14	Rational	12.87	7	0.20	0.40	1.50	2.97	1.46
15	Rational	68.02	7	0.20	0.53	7.94	20.83	12.90
16	Rational	71.90	7	0.20	0.66	8.39	27.47	19.08
17	Rational	38.94	7	0.20	0.59	4.54	13.40	8.86
18	Rational	40.37	7	0.20	0.27	4.71	6.24	1.53
19	Rational	74.37	7	0.20	0.66	8.68	28.42	19.74
20	Rational	59.24	7	0.20	0.59	6.91	20.39	13.48
21	Rational	62.24	7	0.20	0.40	7.26	14.34	7.08
	Total On-Site	1307.30				152.52	358.82	206.30



Prepared by:
Wilson Okamoto Corporation
Engineers · Planners

KALOKO MAKAI INFRASTRUCTURE
DETENTION BASIN DRAINAGE AREAS

FIGURE 4-7

5. ROADWAY AND PARKING SYSTEM

The review of the roadway and parking system is based on the review of the Conceptual Land Use Plan prepared by SCD-TSA Kaloko Makai, LLC. This section will concentrate on on-site related roadway and parking system issues.

5.1 Existing Conditions

Access to the Project Site is provided by Queen Kaahumanu Highway and Hina Lani Street. Queen Kaahumanu Highway, located along the western boundary of the Project Site is a two-way, two-lane State highway, currently being widened to a 4-lane divided arterial road.

Hina Lani Street is a two-way, two-lane County roadway with paved shoulders and no curb, gutter, or sidewalk Hina Lani Street bisects the Project Site in an east-west alignment, and connects to Queen Kaahumanu Highway to the west, Mamalahoa Highway to the east, and Ane Keohokalole in the center.

5.2 Projected Demands

On-site parking requirements for the Project will be based on information provided by SCD-TSA Kaloko Makai, LLC. The current site plan allows street parking in residential areas and parking lots in commercial areas.

5.3 Proposed Improvements

The primary access to the Project site will be provided by Queen Kaahumanu Highway and Hina Lani Street. The Ane Keahokalole Highway (Mid-Level road) will provide a secondary access to the Project Site.

The third access point to the Project site will be from Mamalahoa Highway via Hina Lani Street.

Based on the Conceptual Land Use Plan prepared by SCD-TSA Kaloko Makai, LLC, the internal roadway system for the proposed Project will include extending Kamanu Street. The Ane Keohokalole Highway (Mid-Level Road) is a secondary arterial being developed by the County of Hawaii bisecting the Project site in a north-south alignment and will be developed as part of the Project road improvements.

5.4 Roadway Types

There will be five (5) major types of roadways within the Project site as described below (see Figures 5-1 to 5-6). Sidewalks will be provided to meet ADAAG requirements unless it is technically infeasible. Industrial roads will be designed for WB-40 vehicles and all other roadways will be designed for SU vehicles.

1. Primary Arterials – There are three (3) primary arterial roadway sections for the development. The existing mid-level roadway (Ane Keohokalole Highway) alignment bisects the Spinal Roadway.

    a. Spinal Roadway – The Spinal Road bisects the Project site in an east-west alignment. This roadway will consist of a 94-foot right-of-way with four travel lanes (one 14-foot lane and one 12-foot lane), 22-foot curbed median, 2-foot curb and gutter, and 8-foot sidewalk on both sides of the roadway.

    b. Future Ane Keohokalole Highway (Phase 2) – The existing Ane Keohokalole Highway will be extended to the north through the Project Site. This roadway will consist of a 120-foot right-of-way and will initially be built with two 12-foot travel lanes, one 6-foot bike lane, 2-foot curb and gutter, and an 8-foot wide sidewalk on one side of the street. As traffic demand increases the roadway will ultimately be expanded to six travel lanes (one 14-foot lane and two 12-foot lanes), 12-foot curbed median, two 6-foot bike lane, 2-foot curb and gutter, and 8-foot wide sidewalk on both sides of the street.

    c. Hina Lani Street Extension (Phase 1) – Initially this extension will not connect to the existing Hina Lani Street and will only provide access to the industrial area. This roadway will primarily be designed as an industrial roadway to include two 18-foot travel lanes, 2-foot curb and gutter, and 10-foot sidewalk. As the capacity of the roadway increases, the roadway will be widened to six travel lanes and provide access from Hina Lani Street to the future Queen Ka'ahumanu Highway interchange.

2. Secondary Arterial – There are two (2) secondary arterial roadway sections for the development.

   a. Kamanu Street Extension – Kamanu Street is aligned in a north-south direction. The existing Kamanu Street will be extended to the north intersection with Hulikoa Road. This roadway segment will consist of an 82-foot right-of-way with four travel lanes (one 14-foot lane and 12-foot lane), two 6-foot bike lane, 2-foot curb and gutter, and 7-foot sidewalk on both sides of the street.

   b. Secondary Arterial Roadway – This roadway section will consist of an 82-foot right-of-way with a 62-foot travel way, 2-foot curb and gutter, and 8-foot sidewalk on both sides of the street.

3. Collector Roads – There are three (3) collector roadway sections for the development. The Collector Roads connect to Hina Lani Street or bisect Ane Keohokalole Highway.

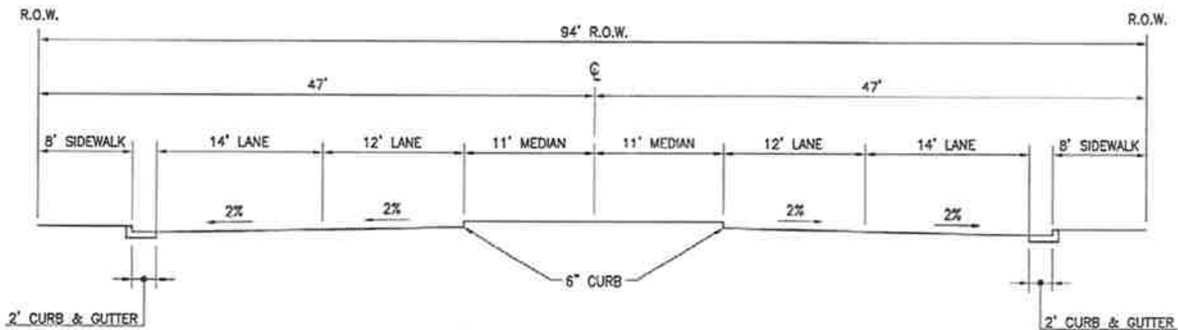
   a. Collector Road 1 –This roadway section will consist of 60-foot right-of-way with two 18-foot travel lanes, 2-foot curb and gutter, and 10-foot sidewalk on both sides of the street.

   b. Collector Road 2 – This roadway section section will consist of a 94-foot right-of-way with two 35-foot travel ways, 2-foot curb and gutter, and 10-foot sidewalk on both sides of the street.

   c. Collector Road 3 – This roadway section will consist of a 82-foot right-of-way with two 29-foot travel lanes, 2-foot curb and gutter, and 10-foot sidewalk on both sides of the street.

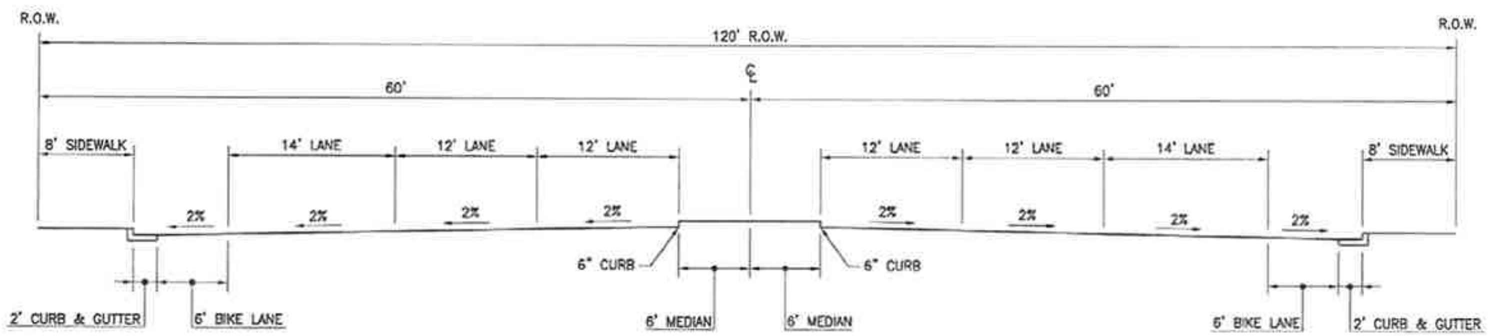
4. Industrial Road – This roadway section will consist of 60-foot right-of-way with two 18-foot travel lanes, 2-foot curb and gutter, and 10-foot sidewalk on both sides of the street.

5. Minor Roads and Cul-De-Sacs – The minor streets for the development will consist of a 50-foot right-of-way with two 16-foot travel lanes, 2-foot curb and gutter, and 7-foot sidewalk on both sides of the street.



SPINAL ROADWAY CROSS SECTION

SCALE: 1"=10'



FUTURE HINA LANI & ANE KEOHOKALOLE ROADWAY CROSS SECTION

SCALE: 1"=10'

GRAPHIC SCALE

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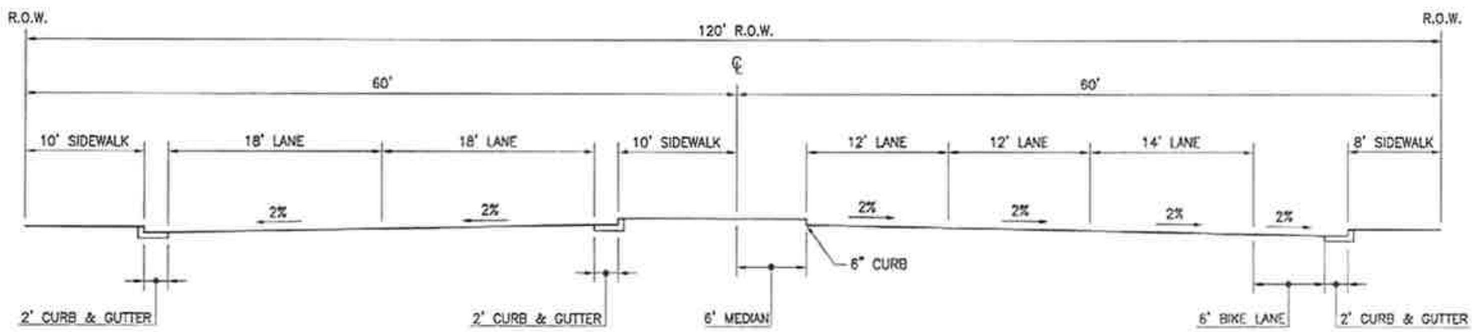
Engineers • Planners

KALOKO MAKAI INFRASTRUCTURE
PRIMARY ARTERIAL ROADWAY SECTIONS 1

FIGURE
5-1



HINA LANI (PHASE 1) CROSS SECTION

SCALE: 1"=10'

GRAPHIC SCALE

10' 5' 0 10' 20'

SCALE 1"=10'

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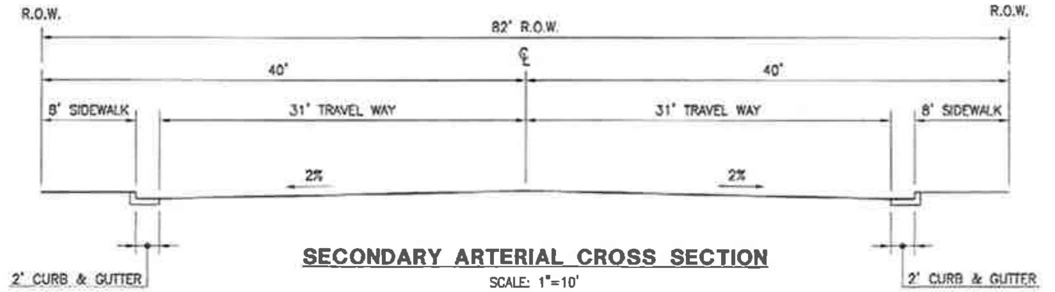
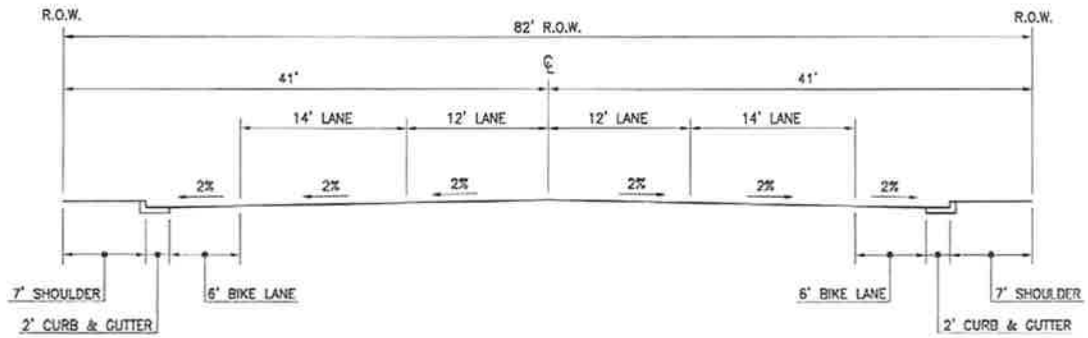
KALOKO MAKAI INFRASTRUCTURE
PRIMARY ARTERIAL ROADWAY SECTIONS 2

FIGURE 5-2



SECONDARY ARTERIAL CROSS SECTION

SCALE: 1"=10'



KAMANU STREET EXTENSION CROSS SECTION

SCALE: 1"=10'

GRAPHIC SCALE

10' 5' 0 10' 20'

SCALE: 1"=10'

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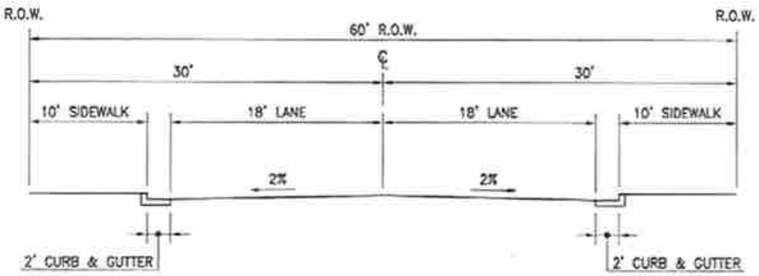
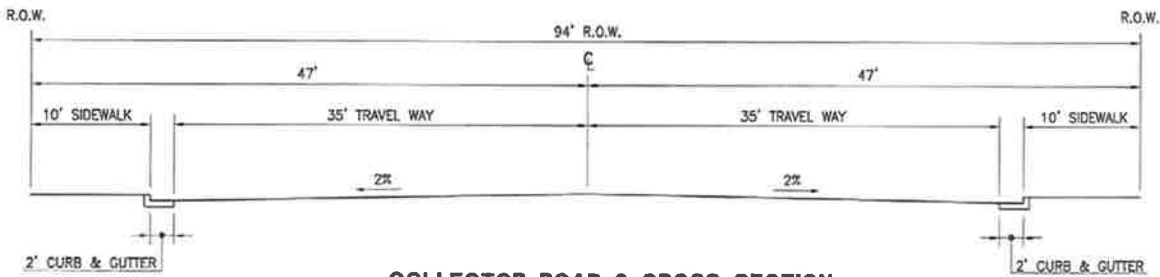
KALOKO MAKAI INFRASTRUCTURE
SECONDARY ARTERIAL SECTIONS

FIGURE 5-3



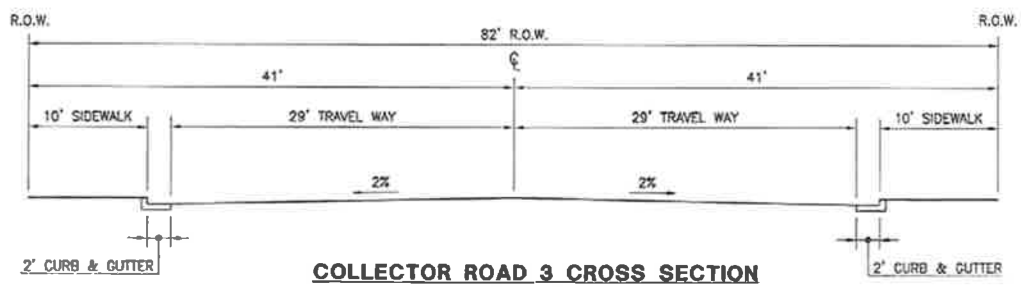
COLLECTOR ROAD 1 CROSS SECTION

SCALE: 1"=10'



COLLECTOR ROAD 2 CROSS SECTION

SCALE: 1"=10'



COLLECTOR ROAD 3 CROSS SECTION

SCALE: 1"=10'

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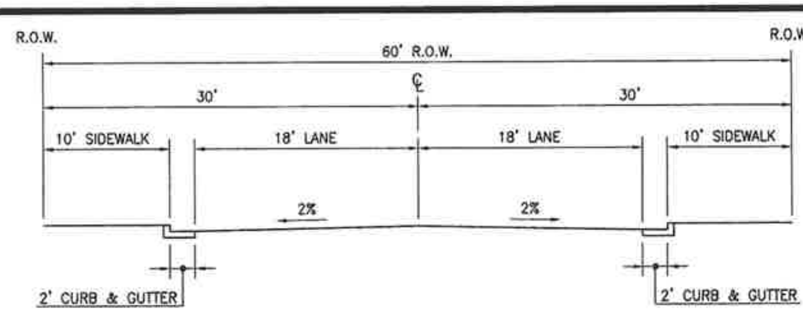
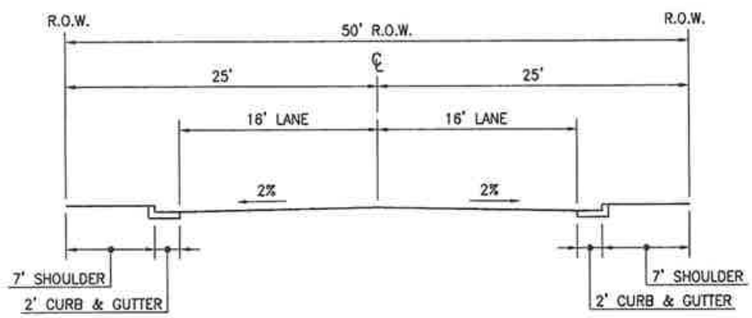
KALOKO MAKAI INFRASTRUCTURE
COLLECTOR ROADWAY SECTIONS

FIGURE
5-4



INDUSTRIAL ROADWAY CROSS SECTION

SCALE: 1"=10'



MINOR STS. & CUL-DE-SAC CROSS SECTION

SCALE: 1"=10'

GRAPHIC SCALE

Prepared by:
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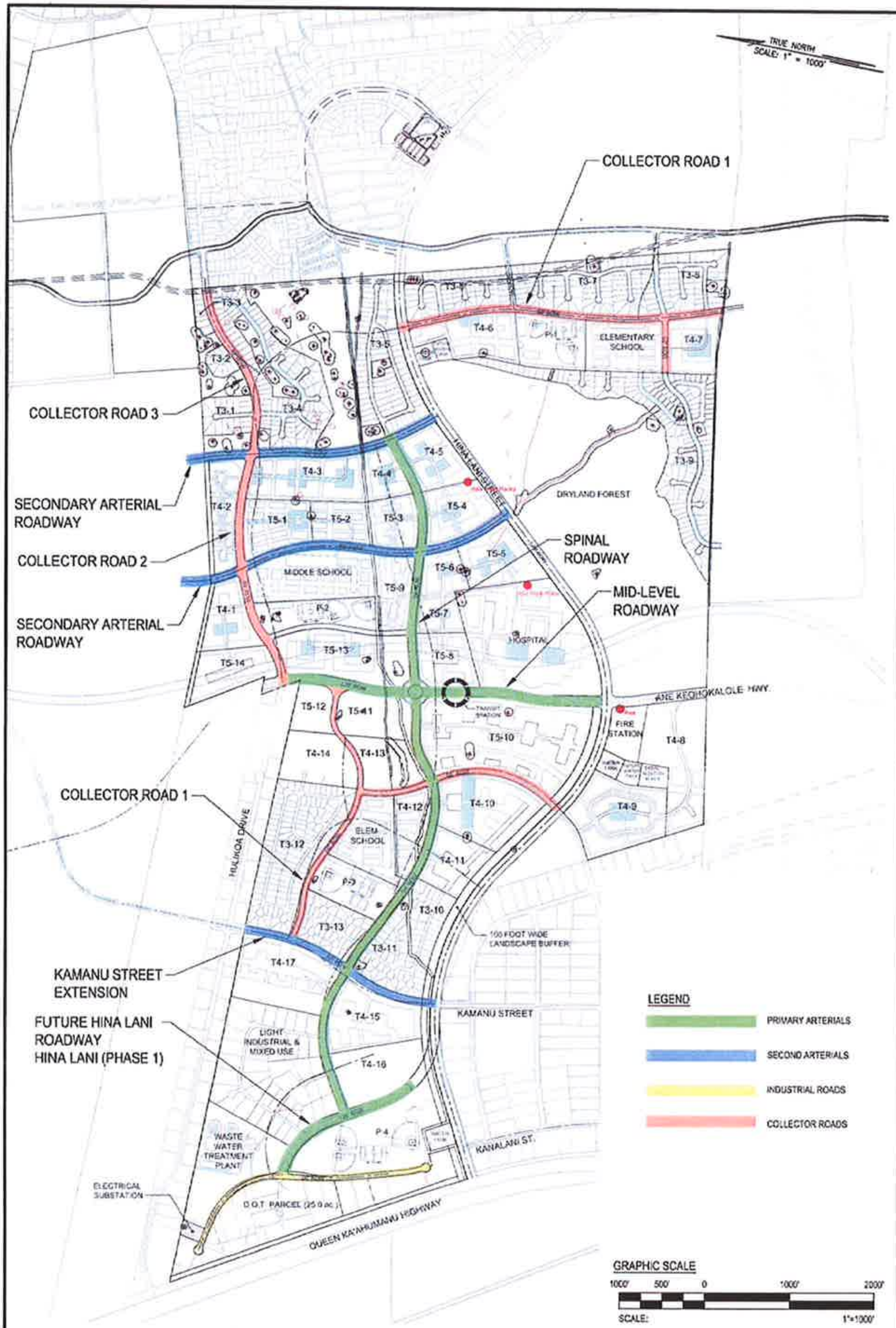
KALOKO MAKAI INFRASTRUCTURE
INDUSTRIAL ROAD, MINOR ROAD, & CUL-DE-SAC SECTIONS

FIGURE 5-5



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KALOKO MAKAI INFRASTRUCTURE

ROADWAY SITE LAYOUT

FIGURE 5-6

6. ELECTRICAL, TELEPHONE, CABLE, AND DATA SYSTEMS

6.1 Background

Electrical, telephone, data line access to the Internet, and cable TV service for the Project will be provided by Hawaii Electric Light Company (HELCO), Hawaiian Telcom and Time Warner Cable.

6.2 Existing Conditions

The existing electrical, telephone, and cable systems in the vicinity of the Project site consists of overhead lines located along Queen Kaahumanu Highway.

6.3 Projected Demands

The Project will need to contact HELCO to confirm the availability of service in the area as well as identify any other constraints or items that may be of concern.

6.4 Proposed Improvements

Electrical, telephone, cable TV service, and data line access to the Internet for the Project, if available, will be provided through Hawaii Electric Light Company, Hawaiian Telcom and Time Warner Cable.

7. OTHER UTILITIES

7.1 Fuel Systems

If propane or diesel fuel service is required, an on-site tank system would be required since no gas or fuel lines exist near the Project site. Sizing and locations of the various fuel tanks will be determined during the design phase of the Project.

8. REFERENCES

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APPENDIX A

- Projected Wastewater Demand Calculations
- Projected Water Demand Calculations

Projected Wastewater Demand Calculations

EQUATIONS			KEY	
R=(D/12)/4	n=	0.015	A	Average Wastewater Flow = Contribution x Capita (GPD)
A=PIxR^2	Q=VxAx0.646317		B	Max Flow Factor
V=(1.486/n)x(R^2/3)x(S^1/2)			C	Max Flow (GPD)
			D	Dry Weather Infiltration/Inflow @ 5 GPCD (GPD)
			E	Design Average Flow (GPD)
			F	Design Max Flow (GPD)
			G	Wet Weather Infiltration/Inflow @ 1250 GPAD (GPD)
			H	Design Peak Flow (GPD)

SEWER LOCATION			TRIB. AREA (Acres)		CPA	#	CPU	#	WASTEWATER FLOW COMPUTATION							
Parcel	Type of Use / Unit	Contribution Gal/Cap/Day	Increment	Total	Cap/Acre	Units[1]	Cap/unit	Capita	A	B	C	D	E	F	G	H
PHASE 1																
[illegible]	Light Industrial	80	25.0	25.0	100.0			2,500	200,000	4.2	832,553	12,500	212,500	845,053	31,250	876,303
WWTP	Industrial	80	20.0	45.0				20	1,600	5.0	8,000	100	1,700	8,100	25,000	33,100
Elec. Sub	ESS	80	1.0	46.0				20	1,600	5.0	8,000	100	1,700	8,100	1,250	9,350
P-4	Park	20	25.0	71.0	40.0			1,000	20,000	5.0	100,000	5,000	25,000	105,000	31,250	136,250
[illegible]	MF, Affordable Housing	80	13.1	84.1		30	2.8	84	6,720	5.0	33,600	420	7,140	34,020	16,375	50,395
	SF	80	13.1	84.1		88	4.0	352	28,160	5.0	140,800	1,760	29,920	142,560	16,375	158,935
[illegible]	Live Work, MF	80	15.4	99.5		35	2.8	98	7,840	5.0	39,200	490	8,330	39,690	19,250	58,940
	SF	80	15.4	99.5		104	4.0	416	33,280	5.0	166,400	2,080	35,360	168,480	19,250	187,730
	Retail/Office Space	40	0.5	100.0	140.0			64	2,571	5.0	12,856	321	2,893	13,177	574	13,751
T3-11	SF	80	11.6	111.6		58	4.0	232	18,560	5.0	92,800	1,160	19,720	93,960	14,500	108,460
T3-10	SF	80	7.4	119.0		37	4.0	148	11,840	5.0	59,200	740	12,580	59,940	9,250	69,190
[illegible]	MF	80	9.4	128.4		22	2.8	62	4,928	5.0	24,640	308	5,236	24,948	11,750	36,698
	SF	80	9.4	128.4		63	4.0	252	20,160	5.0	100,800	1,260	21,420	102,060	11,750	113,810
[illegible]	Live Work, MF	40	18.0	146.4		41	2.8	115	4,592	5.0	22,960	574	5,166	23,534	22,500	46,034
	SF	80	18.0	146.4		121	4.0	484	38,720	5.0	193,600	2,420	41,140	196,020	22,500	218,520
	Retail/Office Space	40	0.3	146.7	140.0			48	1,928	5.0	9,642	241	2,169	9,883	430	10,313
T5-10	MF	80	39.1	185.8		423	2.8	1,184	94,752	4.8	457,993	5,922	100,674	463,915	48,875	512,790
	Retail/Office Space	40	3.6	189.4	140.0			498	19,927	5.0	99,633	2,491	22,417	102,124	4,448	106,571
T5-13	MF, Mixed Use, Aff. Housing	80	14.3	203.7		215	2.8	602	48,160	5.0	240,800	3,010	51,170	243,810	17,875	261,685
	Retail/Office Space	40	1.4	205.0	140.0			193	7,713	5.0	38,567	964	8,678	39,532	1,722	41,253
P-3	Park	20	10.0	215.0	40.0			400	8,000	5.0	40,000	2,000	10,000	42,000	0	42,000
School	School	25	18.0	233.0				750	18,750	5.0	93,750	3,750	22,500	97,500	22,500	120,000
T5-9	MF	80	7.7	240.7		116	2.8	325	25,984	5.0	129,920	1,624	27,608	131,544	9,625	141,169
	Mixed Use	40	0.5	241.2	140.0			64	2,571	5.0	12,856	321	2,893	13,177	574	13,751
T5-5	MF	80	11.9	253.1		179	2.8	501	40,096	5.0	200,480	2,506	42,602	202,986	14,875	217,861
	Long Term Care, Medical Offices	40	0.7	253.8	140.0			96	3,857	5.0	19,284	482	4,339	19,766	861	20,627
T5-6	MF	80	5.5	259.3		83	2.8	232	18,592	5.0	92,960	1,162	19,754	94,122	6,875	100,997
	Long Term Care	40	0.7	260.0	140.0			96	3,857	5.0	19,284	482	4,339	19,766	861	20,627
T5-7	Lodge	80	5.3	265.3		0	4.0	0	0	5.0	0	0	0	0	6,625	6,625
	Business Center, Medical Offices	40	0.9	266.2	140.0			129	5,142	5.0	25,712	643	5,785	26,354	1,148	27,502
T5-8	MF	80	9.1	274.4		137	2.8	384	30,688	5.0	153,440	1,918	32,606	155,358	11,375	166,733
	Transit Station, TOD Square, Medical Offices, Senior	40	1.4	275.8	140.0			193	7,713	5.0	38,567	964	8,678	39,532	1,722	41,253
Hospital	Medical	400	40.0	315.8				200	80,000	5.0	400,000	1,000	81,000	401,000	50,000	451,000
Greenbelt	Park	0	0.0	71.0	0.0			0	0	5.0	0	0	0	0	0	0

		GPD
Average Wastewater Daily Discharge	=	818,302
Total Design Average Flow	=	877,016
Total Design Maximum Flow	=	3,967,010
Total Design Peak Flow	=	4,420,225

Projected Wastewater Demand Calculations

SEWER LOCATION			TRIB. AREA (Acres)		CPA	#	CPU	#	WASTEWATER FLOW COMPUTATION							
Parcel	Type of Use / Unit	Contribution Gal/Cap/Day	Increment	Total	Cap/Acre	Units[1]	Cap/unit	Capita	A	B	C	D	E	F	G	H
PHASE 2																
Industrial	Light Industrial	80	25.0	25.0	100.0			2,500	200,000	4.2	832,553	12,500	212,500	845,053	31,250	876,303
[illegible]	MF	80	18.8	43.8		43	2.8	120	9,632	5.0	48,160	602	10,234	48,762	23,500	72,262
	SF	80	18.8	43.8		127	4.0	508	40,640	5.0	203,200	2,540	43,180	205,740	23,500	229,240
	Retail/Office Space	40	0.3	44.1	140.0			48	1,928	5.0	9,642	241	2,169	9,883	430	10,313
T3-12	SF	80	28.5	72.6		171	4.0	684	54,720	5.0	273,600	3,420	58,140	277,020	35,625	312,645
T3-13	SF	80	9.9	82.5		60	4.0	240	19,200	5.0	96,000	1,200	20,400	97,200	12,375	109,575
P-3	Park	20	10.0	92.5	40.0			400	8,000	5.0	40,000	2,000	10,000	42,000	0	42,000
School	School	25	12.0	104.5				1000	25,000	5.0	125,000	5,000	30,000	130,000	15,000	145,000
[illegible]	MF	80	6.5	111.0		13	2.8	36	2,912	5.0	14,560	182	3,094	14,742	8,125	22,867
	SF	80	6.5	111.0		39	4.0	156	12,480	5.0	62,400	780	13,260	63,180	8,125	71,305
[illegible]	MF	80	5.0	116.0		11	2.8	31	2,464	5.0	12,320	154	2,618	12,474	6,250	18,724
	SF	80	5.0	116.0		32	4.0	128	10,240	5.0	51,200	640	10,880	51,840	6,250	58,090
	Retail/Office Space	40	0.1	116.2	140.0			16	643	5.0	3,214	80	723	3,294	143	3,438
[illegible]	MF	80	11.0	127.2		24	2.8	67	5,376	5.0	26,880	336	5,712	27,216	13,750	40,966
	SF	80	11.0	127.2		70	4.0	280	22,400	5.0	112,000	1,400	23,800	113,400	13,750	127,150
	Retail/Office Space	40	0.2	127.4	140.0			32	1,286	5.0	6,428	161	1,446	6,589	287	6,876
T5-11	MF	80	6.3	122.5		90	2.8	252	20,160	5.0	100,800	1,260	21,420	102,060	7,875	109,935
	Senior, Live Work	40	0.3	122.8	140.0			48	1,928	5.0	9,642	241	2,169	9,883	430	10,313
T5-12	MF	80	5.5	128.3		101	2.8	283	22,624	5.0	113,120	1,414	24,038	114,534	6,875	121,409
	Mixed Use	40	0.5	178.8	140.0			64	2,571	5.0	12,856	321	2,893	13,177	574	13,751
T5-14	MF	80	10.6	139.4		155	2.8	434	34,720	5.0	173,600	2,170	36,890	175,770	13,250	189,020
	Retail/Office Space	40	0.5	139.8	140.0			64	2,571	5.0	12,856	321	2,893	13,177	574	13,751
[illegible]	MF	40	12.7	152.5		26	2.8	73	2,912	5.0	14,560	364	3,276	14,924	15,875	30,799
	SF	80	12.7	152.5		76	4.0	304	24,320	5.0	121,600	1,520	25,840	123,120	15,875	138,995
[illegible]	MF	80	10.7	163.2		22	2.8	62	4,928	5.0	24,640	308	5,236	24,948	13,375	38,323
	SF	80	10.7	163.2		64	4.0	256	20,480	5.0	102,400	1,280	21,760	103,680	13,375	117,055
[illegible]	MF	80	15.4	178.6		31	2.8	87	6,944	5.0	34,720	434	7,378	35,154	19,250	54,404
	SF	80	15.4	178.6		93	4.0	372	29,760	5.0	148,800	1,860	31,620	150,660	19,250	169,910
[illegible]	MF	80	5.6	184.2		12	2.8	34	2,688	5.0	13,440	168	2,856	13,608	7,000	20,608
	SF	80	5.6	184.2		33	4.0	132	10,560	5.0	52,800	660	11,220	53,460	7,000	60,460
[illegible]	MF	80	9.6	193.8		22	2.8	62	4,928	5.0	24,640	308	5,236	24,948	12,000	36,948
	SF	80	9.6	193.8		64	4.0	256	20,480	5.0	102,400	1,280	21,760	103,680	12,000	115,680
	Retail Space	40	0.5	194.3	140.0			64	2,571	5.0	12,856	321	2,893	13,177	574	13,751
T5-1	MF	80	10.7	205.0		161	2.8	451	36,064	5.0	180,320	2,254	38,318	182,574	13,375	195,949
T5-2	MF	80	7.2	212.2		116	2.8	325	25,984	5.0	129,920	1,624	27,608	131,544	9,000	140,544
T5-3	MF	80	7.4	219.6		119	2.8	333	26,656	5.0	133,280	1,666	28,322	134,946	9,250	144,196
T5-4	MF	80	10.9	230.5		175	2.8	490	39,200	5.0	196,000	2,450	41,650	198,450	13,625	212,075
	Retail Space	40	0.6	231.1	140.0			80	3,214	5.0	16,070	402	3,616	16,472	717	17,189

		GPD
Average Wastewater Daily Discharge	=	763,185
Total Design Average Flow	=	817,048
Total Design Maximum Flow	=	3,702,339
Total Design Peak Flow	=	4,111,820

Projected Wastewater Demand Calculations

SEWER LOCATION			TRIB. AREA		CPA	#	CPU	#	WASTEWATER FLOW COMPUTATION							
Parcel	Type of Use / Unit	Contribution Gal/Cap/Day	(Acres) Increment	Total	Cap/Acre	Units[1]	Cap/unit	Capita	A	B	C	D	E	F	G	H
PHASE 3																
Industrial	Light Industrial	80	25.0	25.0	100.0			2,500	200,000	4.2	832,553	12,500	212,500	845,053	31,250	876,303
T3-1	SF	80	5.7	30.7		17	4.0	68	5,440	5.0	27,200	340	5,780	27,540	7,125	34,665
T3-2	SF	80	2.2	32.9		6	4.0	24	1,920	5.0	9,600	120	2,040	9,720	2,750	12,470
T3-3	SF	80	1.7	34.6		5	4.0	20	1,600	5.0	8,000	100	1,700	8,100	2,125	10,225
T3-4	SF	80	25.6	60.2		76	4.0	304	24,320	5.0	121,600	1,520	25,840	123,120	32,000	155,120
T3-5	SF	80	21.9	82.1		112	4.0	448	35,840	5.0	179,200	2,240	38,080	181,440	27,375	208,815
T3-6	SF	80	13.5	95.6		71	4.0	284	22,720	5.0	113,600	1,420	24,140	115,020	16,875	131,895
T3-7	SF	80	23.2	118.8		117	4.0	468	37,440	5.0	187,200	2,340	39,780	189,540	29,000	218,540
T3-8	SF	80	11.5	130.3		63	4.0	252	20,160	5.0	100,800	1,260	21,420	102,060	14,375	116,435
[illegible]	SF	80	11.8	142.1		83	4.0	332	26,560	5.0	132,800	1,660	28,220	134,460	14,750	149,210
	MF	80	11.8	153.9		35	2.8	98	7,840	5.0	39,200	490	8,330	39,690	14,750	54,440
	Retail Space	40	0.3	154.2	140.0			48	1,928	5.0	9,642	241	2,169	9,883	430	10,313
P-1	Park	20	11.2	165.4	40.0			448	8,960	5.0	44,800	2,240	11,200	47,040	0	47,040
School	School	25	12.0	177.4				750	18,750	5.0	93,750	3,750	22,500	97,500	15,000	112,500
[illegible]	SF	80	9.1	186.5		54	4.0	216	17,280	5.0	86,400	1,080	18,360	87,480	11,375	98,855
	MF	80	9.1	195.6		37	2.8	104	8,288	5.0	41,440	518	8,806	41,958	11,375	53,333
T3-9	MF	80	38.3	233.9		193	2.8	540	43,232	5.0	216,160	2,702	45,934	218,862	47,875	266,737
[illegible]	SF	80	20.3	254.2		134	4.0	536	42,880	5.0	214,400	2,680	45,560	217,080	25,375	242,455
	MF	80	20.3	274.5		90	2.8	252	20,160	5.0	100,800	1,260	21,420	102,060	25,375	127,435
[illegible]	MF	40	18.6	293.1		82	2.8	230	9,184	5.0	45,920	1,148	10,332	47,068	23,250	70,318
	SF	80	18.6	311.7		123	4.0	492	39,360	5.0	196,800	2,460	41,820	199,260	23,250	222,510
	Mixed Use	40	0.6		140.0			80	3,214	5.0	16,070	402	3,616	16,472	717	17,189
Fire Station	Fire Station	80	5.5	298.6				20	1,600	5.0	8,000	100	1,700	8,100	6,875	14,975
Desal. Plant	Desalination Plant	80	1.7	313.4				20	1,600	5.0	8,000	100	1,700	8,100	2,125	10,225
Dryland Forest	Park	0	150.0	463.4	0.0			0	0	5.0	0	0	0	0	0	0
Greenbelt	Park	0	40.3	503.7	0.0			0	0	5.0	0	0	0	0	0	0

		GPD
Average Wastewater Daily Discharge	=	600,276
Total Design Average Flow	=	642,947
Total Design Maximum Flow	=	2,876,606
Total Design Peak Flow	=	3,262,004

OVERALL TOTALS

		GPD
Average Wastewater Daily Discharge	=	2,181,763
Total Design Average Flow	=	2,337,011
Total Design Maximum Flow	=	10,545,955
Total Design Peak Flow	=	11,794,048

Assumptions:

4 persons per Single Family Dwelling Units and Hotel/Lodge Units
2.8 persons per Multi-Family Dwelling/Mixed Use Unit
40 cpa for Park area; 140 cpa for office/retail space; 100 cpa for industrial area
80 gal/cap/day (gpcd) for SF/MF; 40 gpcd for Office/Retail/Commercial; 20 gpcd for Park
Schools - Used maximum extreme enrollment numbers; 750 for elementaries and 1000 for middle schools. Assume schools will be at or near capacity.
[1] # Units taken from *Kaloko Makai Land Use Summary (6-7-12) Computed SF-MF Land Areas per Pod* Spreadsheet
[2] 200 units assumed for the lodge and hospital
Areas used in calculations (infiltration/inflow, etc.) were taken from the "Parcel Size" column in the *Kaloko Makai Land Use Summary (6-7-12) Computed SF-MF Land Areas per Pod Spreadsheet*
Dry and Wet weather Infiltration/Inflow is assumed above the groundwater table

Reference:

Based on Kaloko Makai - Business Plan Use-Density Spreadsheet, as of 5/11
Design Standards fo the Department of Wastewater Management, Volume I, July 1993, Department of Wastewater Management, City and County of Honolulu

Projected Water Demand Calculations

Parcel I.D.	Land Use	Land Use Description	Parcel Size (Acres)	Landscaped Areas Defined (Acres)	Density of Parcel (D.U./Acre)	Maximum Density (D.U./Acre)	Landscape Density (D.U./Acre)	# of Units	SF Units	MF Units	Retail Space	Office Space	Water Usage: Split (Units) <Potable / Non-Potable> (Rate)	Water Usage: Potable (MGD)	Water Usage: Non-Potable (MGD)
PHASE 1															
INDUSTRIAL	Industrial	Light Industrial	25.0	5.00									<2000/2000> / acre	0.050	0.010
WWTP	WWTP	Waste Water Treatment Plant	20.0	2.00									Arbitrary	0.002	-
ELEC. SUB	ESS	Electrical Substation	1.0	0.10									Arbitrary	0.002	-
P-4	Park	District Sized Park &Drainage Retention	25.0	18.75									<600/3400> / acre	0.015	0.064
T4-16	Res./MU	MF, Affordable Housing	13.1	3.93	9.0	12	2.25	118	88	30			88 SF <400/0> 30 MF <276/124>	0.043	0.004
T4-15	Res./MU	Live-Work, MF, & SF	15.4	4.62	9.0	12	2.25	139	104	35	10,000	10,000	104 SF <400/0> 35 MF <276/124> 20 Commercial ft^2 <83/37>	0.053	0.005
T3-11	SF	Single Family	11.6	4.64	5.0	6		58	58	0			58 SF <400/0>	0.023	0.000
T3-10	SF	Single Family	7.4	2.96	5.0	6		37	37	0			37 SF <400/0>	0.015	0.000
T4-11	Res./MU	Mixed SF and MF	9.4	2.82	9.0	12	2.25	85	63	22			63 SF <400/0> 22 MF <276/124>	0.031	0.003
T4-10	Res./MU	Live-Work, MF, & SF	18.0	5.40	9.0	12	2.25	162	121	41	7,500	7,500	121 SF <400/0> 41 MF <276/124> 15 Commercial ft^2 <83/37>	0.061	0.006
[illegible]	Res./MU	Shopping Center, Legal Offices, MF, Transit Station, Senior Independent Living	39.1	11.73	10.8	30		423	0	423	75,000	80,000	423 MF <276/124> 155 Commercial ft^2 <83/37>	0.130	0.058
[illegible]	Res./MU	Mixed Use, Aff. Housing, Retail, Office,	14.3	4.29	15.0	30		215	0	215	45,000	15,000	215 MF <276/124> 60 Commercial ft^2 <83/37>	0.064	0.029
P-2	Park		10.0	7.50				0	0	0			<600/3400> / acre	0.006	0.026
SCHOOL	School		18.0	9.00				0	0	0			<2400/1600> / acre	0.043	0.014
[illegible]	Res./MU	Mixed Use, MF	7.7	2.31	15.0	30		116	0	116	20,000		116 MF <276/124> 20 Commercial ft^2 <83/37>	0.034	0.015
[illegible]	Res.	Long Term Care, Medical Offices	11.9	3.57	15.0	30		179	0	179	15,000	15,000	179 MF <276/124> 30 Commercial ft^2 <83/37>	0.052	0.023
[illegible]	Res.	Long Term Care	5.5	1.65	15.0	30		83	0	83	15,000	15,000	83 MF <276/124> 30 Commercial ft^2 <83/37>	0.025	0.011
[illegible]	Res./MU	Lodge, Business Center, Medical Offices	5.3	1.59	0.0	30		0	0	0	10,000	30,000	200 units <400/0> 40 Commercial ft^2 <83/37>	0.003	0.001
[illegible]	Res./MU	Transit Station, TOD Square, Medical Offices, MF, Senior	9.1	2.73	15.0	30		137	0	137	20,000	40,000	137 MF <276/124> 60 Commercial ft^2 <83/37>	0.043	0.019
[illegible]	Medical		40.0	10.00				200					200 units <400/0> <0/1600> / acre	0.080	0.016
TOTAL PHASE 1 UNITS			306.8					1752	471	1281	217,500	212,500		0.856	0.304

Projected Water Demand Calculations

													Water Usage		
Parcel I.D.	Land Use	Land Use Description	Parcel Size (Acres)	Landscaped Areas Defined (Acres)	Density of Parcel (D.U./Acre)	Maximum Density (D.U./Acre)	Landscape Density (D.U./Acre)	# of Units	SF Units	MF Units	Retail Space	Office Space	Split (Units) <Potable / Non-Potable> (Rate)	Potable (MGD)	Non-Potable (MGD)
PHASE 2															
INDUSTRIAL	Industrial	Light Industrial	25.0	5.00									<2000/2000> / acre	0.050	0.010
T4-17	Res./MU	MF, Live-Work, Affordable	18.8	5.64	9.0	12	2.25	170	127	43	7,500	7,500	127 SF <400/0> 43 MF <276/124> 15 Commercial ft² <83/37>	0.064	0.006
T3-12	SF	Single Family	28.5	11.40	6.0	6		171	171	0			171 SF <400/0>	0.068	0.000
T3-13	SF	Single Family	9.9	3.96	6.0	6		60	60	0			60 SF <400/0>	0.024	0.000
P-3	Park		10.0	7.50				0					<600/3400> / acre	0.006	0.026
SCHOOL	School		12.0	6.00				0					<2400/1600> / acre	0.029	0.010
T4-12	Res.	Multi Family & Single Family	6.5	1.95	8.0	12	2	52	39	13			39 SF <400/0> 13 MF <276/124>	0.019	0.002
T4-13	Res.	Multi Family & Single Family	5.0	5.13	8.0	12	2	43	32	11	2,500	2,500	102 SF <400/0> 11 MF <276/124> 15 Commercial ft² <83/37>	0.016	0.002
T4-14	Res.	Multi Family & Single Family	11.0	5.64	9.0	12	2.25	94	70	24	5,000	5,000	102 SF <400/0> 24 MF <276/124> 15 Commercial ft² <83/37>	0.035	0.003
[illegible]	Res./MU	MF, Senior, Live-Work	6.3	1.80	15.0	30		90	0	90	7,500	7,500	90 MF <276/124> 15 Commercial ft² <83/37>	0.026	0.012
[illegible]	Res./MU	Mixed Use	5.5	2.01	15.0	30		101	0	101	10,000	10,000	101 MF <276/124> 20 Commercial ft² <83/37>	0.030	0.013
[illegible]	Res./MU	Mixed Use, Affordable Housing	10.6	3.18	14.6	30		155	0	155	10,000	10,000	155 MF <276/124> 20 Commercial ft² <83/37>	0.044	0.020
T4-1	Res./MU	Mixed SF and MF	12.7	3.81	8.0	12	2	102	76	26			76 SF <400/0> 26 MF <276/124>	0.038	0.003
T4-2	Res./MU	Mixed SF and MF	10.7	3.21	8.0	12	2	86	64	22			64 SF <400/0> 22 MF <276/124>	0.032	0.003
T4-3	Res./MU	Mixed SF and MF	15.4	4.62	8.0	12	2	124	93	31			93 SF <400/0> 31 MF <276/124>	0.046	0.004
T4-4	Res./MU	Mixed SF and MF	5.6	1.68	8.0	12	2	45	33	12			33 SF <400/0> 12 MF <276/124>	0.017	0.001
T4-5	Res./MU	Mixed SF and MF	9.6	2.85	9.0	12	2.25	86	64	22	20,000		64 SF <400/0> 22 MF <276/124> 20 Commercial ft² <83/37>	0.033	0.003
[illegible]	Res./MU	Mixed Use	10.7	3.21	15.0	30		161	0	161			161 MF <276/124>	0.044	0.020
[illegible]	Res./MU	Mixed Use	7.2	2.16	16.0	30		116	0	116			116 MF <276/124>	0.032	0.014
[illegible]	Res./MU	MF, Senior	7.4	2.22	16.0	30		119	0	119			119 MF <276/124>	0.033	0.015
[illegible]	Res./MU	Multi Family	10.9	3.27	16.0	30		175	0	175	25,000		175 MF <276/124> 25 Commercial ft² <83/37>	0.050	0.023
TOTAL PHASE 2 UNITS			239.3					1950	829	1121	87,500	42,500		0.737	0.189

Projected Water Demand Calculations

Parcel I.D.	Land Use	Land Use Description	Parcel Size (Acres)	Landscaped Areas Defined (Acres)	Density of Parcel (D.U./Acre)	Maximum Density (D.U./Acre)	Landscape Density (D.U./Acre)	# of Units	SF Units	MF Units	Retail Space	Office Space	Water Usage: Split (Units) <Potable / Non-Potable> (Rate)	Water Usage: Potable (MGD)	Water Usage: Non-Potable (MGD)
PHASE 3															
INDUSTRIAL	Industrial	Light Industrial	25.0	5.00									<2000/2000> / acre	0.050	0.010
T3-1	SF	Large Lot Single Family	5.7	2.20	3.0	6		17	17	0			17 SF <400/0>	0.007	-
T3-2	SF	Large Lot Single Family	2.2	0.72	3.0	6		6	6	0			6 SF <400/0>	0.002	-
T3-3	SF	Large Lot Single Family	1.7	0.58	3.0	6		5	5	0			5 SF <400/0>	0.002	-
T3-4	SF	Large Lot Single Family	25.6	10.04	3.0	6		76	76	0			76 SF <400/0>	0.030	-
T3-5	SF	Single Family	21.9	8.92	5.0	6		112	112	0			112 SF <400/0>	0.045	-
T3-6	SF	Single Family	13.5	5.64	5.0	6		71	71	0			71 SF <400/0>	0.028	-
T3-7	SF	Single Family	23.2	9.36	5.0	6		117	117	0			117 SF <400/0>	0.047	-
T3-8	SF	Single Family	11.5	5.04	5.0	6		63	63	0			63 SF <400/0>	0.025	-
T4-6	Res./MU	Mixed SF and MF	11.8	1.18	10.0	12	3	118	83	35	15,000		83 SF <400/0> 35 MF <276/124> 15 Commercial ft^2 <83/37>	0.044	0.005
P-1	Park		11.2	8.40				0					<600/3400> / acre	0.007	0.029
SCHOOL	School		12.0	6.00				0					<2400/1600> / acre	0.029	0.010
T4-7	Res./MU	Mixed SF and MF	9.1	0.91	10.0	12	4	91	54	37			54 SF <400/0> 37 MF <276/124>	0.032	0.005
T3-9	SF	Single Family	38.3	3.85	5.0	6		193	193	0			193 SF <400/0>	0.077	-
T4-8	Res./MU	Mixed Use, MF, Affordable	20.3	2.03	11.0	12	4.4	224	134	90			134 SF <400/0> 90 MF <276/124>	0.078	0.011
T4-9	Res./MU	Live-Work & Affordable	18.6	1.86	11.0	12	4.4	205	123	82	15,000	10,000	123 SF <400/0> 82 MF <276/124> 25 Commercial ft^2 <83/37>	0.074	0.011
FIRE STATION	Fire	Fire Station	5.5	0.55									<1800/1200> / acre	0.010	0.001
DESAL. PLANT	Desa Facility	Desalinization Plant	1.7	0.17									Arbitrary	0.002	
TOTAL PHASE 3 UNITS			233.8					1298	1054	244	30,000	10,000		0.590	0.081
DRY FOREST	OS	Dryland Forest	150.0												
OPEN SPACE	OS	Open Space	72.2												
ROADWAYS	Roads	Roadways & Buffers	107.7												
TOTAL ALL 3 PHASES			1109.8					5000	2354	2646	335,000	265,000			
COMMERCIAL COMPONENT TOTAL											600,000				

Project Total (Average Demand MGD)	2.182	0.574
Max Day Demand (MGD) (Average Demand x 1.5)	3.273	
Peak Hour Demand (MGD) (Average Demand x 5)	10.911	

APPENDIX B

- Meeting Notes (Department of Water Supply)
  Date: July 20, 2007

7469-04
July 20, 2007

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FAX: (808) 946-2253

MEETING INFORMATION MEMO

SUBJECT: Kaloko Makai Infrastructure

PERSONS PRESENT: Dora Beck
Denis Shiu
Brian Lock

MEETING DATE: July 20, 2007

MEETING LOCATION: County of Hawaii
Department of Environment Management
Wastewater Division, Hilo, Hawaii

INFORMATION ITEMS:

1. Presented the Kaloko Makai, Draft Conceptual Land Use Plan, Dated June 22, 2007. Discussed the TSA/Stanford Carr Development partnership and mentioned that full project is anticipated to continue for approximately 20-30 years.
2. Discussed the status of the North Kona Improvement District (NKID). The study has been put on hold and will remain at draft status. DEM is pursuing Improvement District (ID) funding to finalize the study and construct the project. DEM is also looking into the possibility of incorporating NKID with the North Kona Community Development Plan (CDP) and utilizing Community Facilities District (CFD) funding. Both ID and CFD support a government-private owner cost sharing model, however, CFD also considers project phasing and the immediate benefit to adjacent properties at each phase. To date, DEM has not been able to appropriate funds to construct NKID.
3. DEM currently has only one construction project for North Kona. DEM is proposing work as part of the Department of Transportation, Highways Division's (DOT) Queen Kaahumanu Highway Widening Project, Phase II. The proposed scope of work includes installing a gravity sewer line along Queen Kaahumanu Highway from the future sewer pump station to Hina Lani Street. The project also proposes to install ER-1 piping from the vicinity of the sewer pump station to the vicinity of the Kohanaiki Development. The Queen Kaahumanu Highway Widening Project, Phase II is scheduled to be bid in August 2007 and awarded in November 2007. Both the sewer line and the ER-1 line will be 'dry' lines. Prior to the sewer and ER-1 lines becoming active, DEM needs to construct two more projects. One project, scheduled for construction in FY09-10, will connect

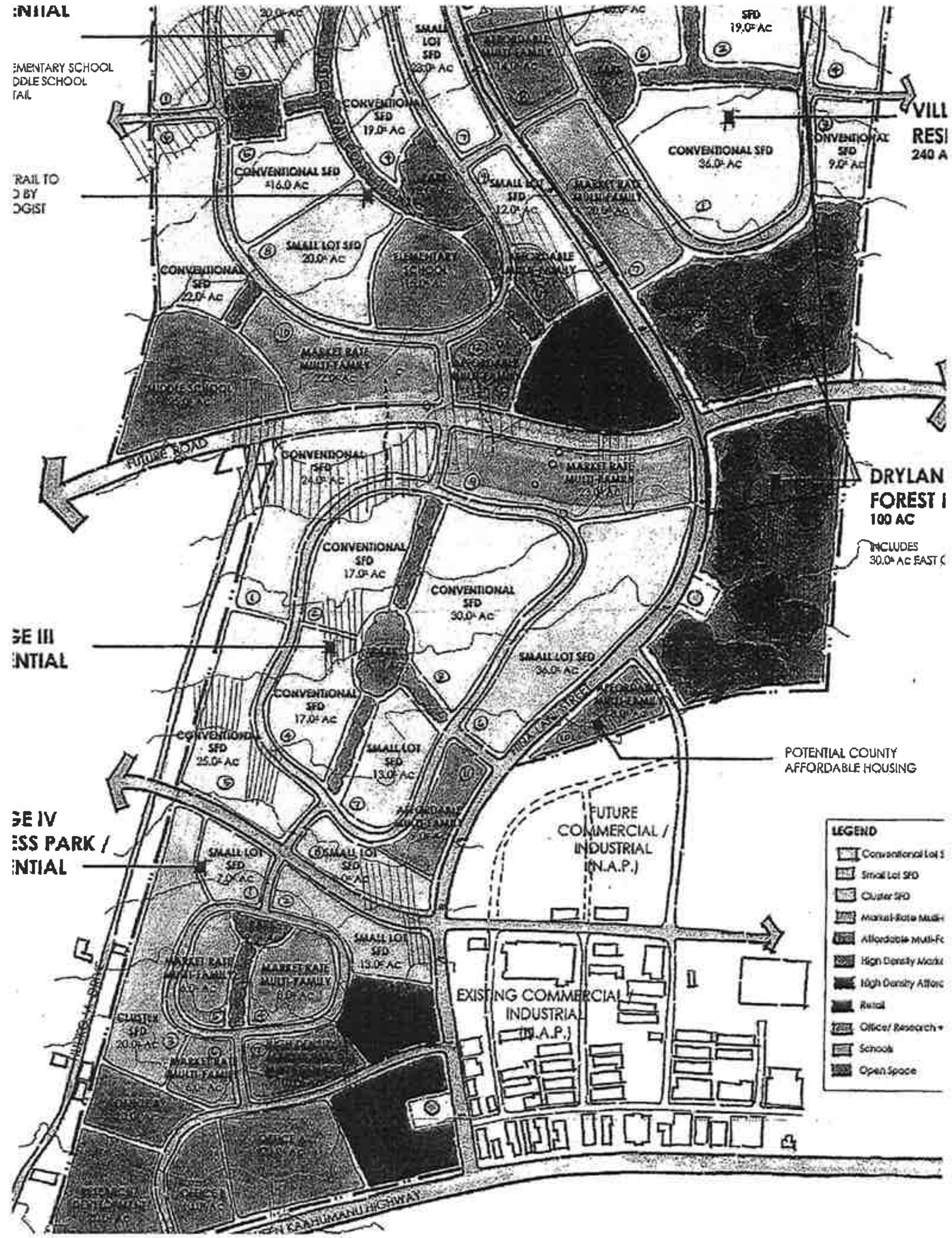
the sewer and ER-1 from the highway to the Kealakehe Wastewater Treatment Plant (KWWTP). The second project, scheduled for FY10-FY11 will expand the KWWTP to produce ER-1 Water. DEM has funds to construct their portion (non-par) of the highway widening project. DEM is pursuing additional funds as needed for the highway project. Funding for the future phases has not been identified.

4. DEM also mentioned that the County is committed to developing decentralized treatment. DEM has identified an area that includes the entire Kaloko Makai property as an 'ideal' area for possible development of decentralized treatment. Funding for decentralized treatment has not been identified.
5. DEM would like to be advised of project phasing and number of units as the information becomes available.

Brian A. Lock

cc: DS, AS, TF

Enclosure: Kaloko Makai: Conceptual Land Use Plan, 06-22-2007



APPENDIX C

- Kaloko Makai Development – Conceptual Wastewater Management System, Brown and Caldwell

1955 Main Street, Suite 200
Wailuku, HI 96793
Tel: 808-244-7005
Fax: 808-244-9026
www.brownandcaldwell.com

July 25, 2011

Brown AND Caldwell

Mr. Peter Phillips
Stanford Carr Development
1100 Alakea Street, Suite 2700
Honolulu, HI 96813

1055/137060

Subject: Kaloko Makai Development – Conceptual Wastewater Management System

Dear Mr. Phillips,

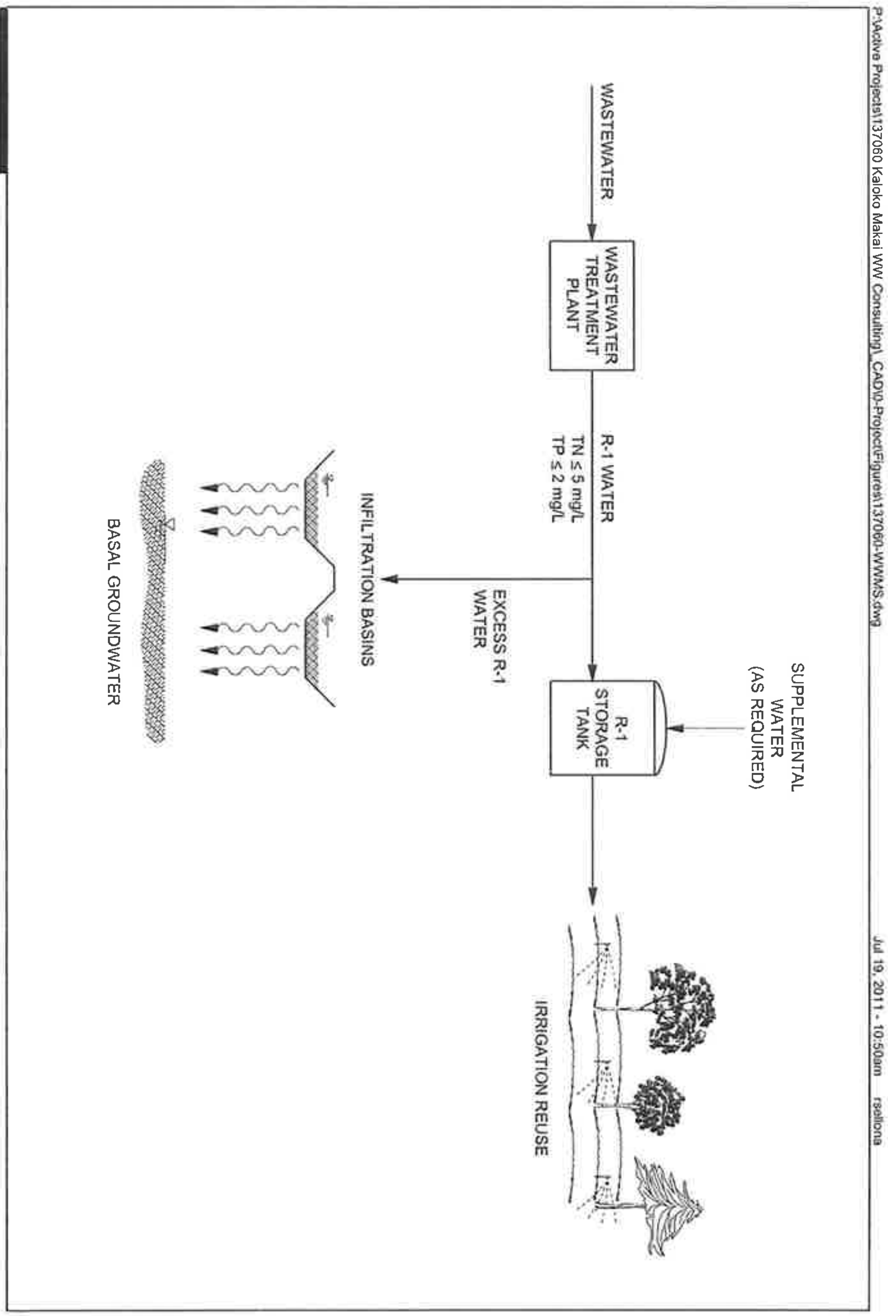
Stanford Carr Development is proposing to develop the 1040 acre Kaloko Makai project (project) north of Kailua-Kona on the Big Island. The land uses will include residential, retail, commercial, office, light industrial, a hospital, schools, parks, and open space. The project is located outside of the service area for the County of Hawaii's Kealakehe Wastewater Treatment Plant; therefore a wastewater management system must be developed. We have developed a wastewater management system concept for the development, based on information forwarded by Wilson Okamoto Corporation.

Estimated Wastewater Flow

The State of Hawaii Department of Health (DOH) requires that wastewater systems be designed based on county flow standards, and if applicable county standards are not established the City and County of Honolulu standards are to be used. The County of Hawaii (County) has not yet established wastewater flow standards. Based on City and County of Honolulu flow standards, the average dry weather flow from the development at buildout is 2.37 million gallons per day (mgd).

Wastewater Management System Concept

Figure 1 is a schematic diagram of the conceptual wastewater management system. Wastewater from the development would be delivered to a wastewater treatment plant (WWTP) that will be located within the project boundaries. The WWTP will be designed to produce R-1 recycled water suitable for irrigation reuse within the project boundaries. The WWTP will also be designed to reduce nitrogen and phosphorus concentrations in the treated effluent to address concerns over nutrient impacts to the adjacent Kaloko-Honokohau National Historical Park and the near shore reef environment. The treated effluent will be pumped to an R-1 storage tank and will be used to irrigate parks, school fields, streetscape, and other allowed used for R-1 recycled water. Supplemental groundwater will be added to the R-1 storage tank as needed to ensure that the irrigation demands of the users can be met at all times. Excess recycled water will be disposed via infiltration basins.



Brown AND Caldwell

FIGURE 1
KALOKO MAKAI

Each element of the wastewater management system is described in more detail below.

Wastewater Treatment System

The WWTP will be designed to achieve two simultaneous goals:

1. Produce R-1 recycled water in accordance with DOH regulations;
2. Reduce nutrient concentrations in the effluent to address potential impacts to the adjacent National Historical Park and near shore reef environments.

The first treatment goal is readily achievable via conventional secondary treatment, followed by coagulant addition, filtration, and disinfection with ultraviolet light. The second goal requires an advanced wastewater treatment process. The nearby Ooma project successfully negotiated with the National Park Service (NPS) to reach an agreement for effluent limits of 5 milligrams per liter (mg/L) of total nitrogen (TN) and 2 mg/L of total phosphorus (TP). The description that follows assumes that the NPS agrees that similar nutrient removal objectives are appropriate for the Kaloko Makai project.

Figure 2 is a schematic diagram of the wastewater treatment concept. The wastewater treatment plant would include the following processes:

Influent Pump Station: A pump station will be required to lift raw wastewater from the sewer system to the treatment processes.

Headworks: The headworks would include screening systems to remove debris and grit removal to remove inorganic particles (e.g., sand) from the waste stream. Grit and screenings will be disposed at the West Hawaii Landfill.

Biological Treatment: Organic matter and nutrients will be removed using an activated sludge process. The process will incorporate biological nutrient removal (BNR). BNR incorporates aerobic, anaerobic and anoxic zones within the treatment process and recycle flows to facilitate biological reduction of TN and TP to 10 mg/L and 2 mg/L, respectively. Clarifiers will be used to separate the activated sludge from the secondary effluent.

Coagulant Addition/Flocculation: Coagulants (such as aluminum sulfate and/or polymer) will be added to the secondary effluent downstream of the secondary clarifiers and mixed to combine small particles into larger "flocs" that can be removed in the filtration process.

Filtration: The filtration process will provide two treatment benefits: turbidity reduction to meet R-1 water recycling requirements, and additional nitrogen removal. Denitrification filters are available that are accepted by the California Department of Public Health (CDPH) for Title-22 recycled water production and are also capable of reducing TN concentrations to 5 mg/L via denitrification. The DOH allows the use of filtration processes that are accepted by CDPH for R-1 recycled water production. Addition of a carbon source (typically methanol) is required upstream of the filters to facilitate the denitrification process. The DOH

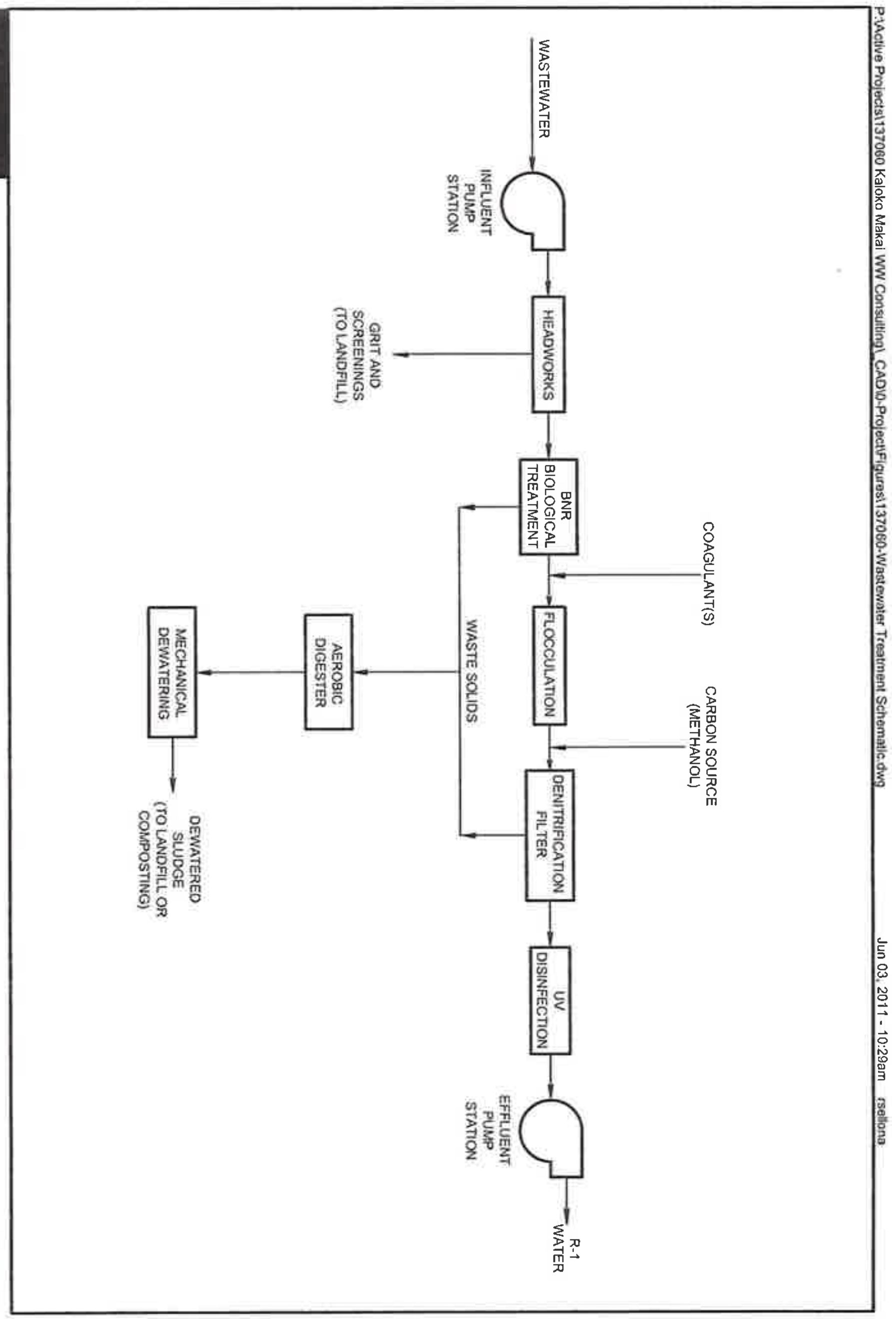


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FIGURE 2
KALOKO MAKAI

requires that R-1 recycled water have effluent turbidity of less than 2.0 Nephelometric turbidity units (NTU) at all times.

Disinfection: The effluent will be disinfected with ultraviolent light (UV) to meet R-1 recycled water requirements. The DOH requires that R-1 recycled water have a median density of fecal coliform that does not exceed 2.2 per 100 mL.

Effluent Pump Station: An effluent pump station will deliver recycled water to the R-1 storage tank for reuse, or to the infiltration basins for disposal.

Aerobic Digester: Waste solids (sludge) from the biological treatment and filtration systems will be pumped to an aerobic digester system for stabilization and thickening via periodic decanting.

Mechanical Dewatering: Aerobically digested sludge will be mechanically dewatered prior being hauled offsite for disposal at the West Hawaii Landfill.

Water Recycling System

Potential acceptable uses for R-1 recycled water in the Project are listed in Table 1. Note that irrigation of single family residential parcels is not allowed by DOH.

Table 1. Potential R-1 Recycled Water Uses at Kaloko Makai

Landscape Irrigation	Industrial	Other
• Parks • School yards • Athletic fields • Road sides and medians • Commercial property (if managed by an irrigation supervisor) • Multi-family residential property (if managed by an irrigation supervisor)	• Commercial and public laundries • Industrial cooling • Industrial process water	• Toilet and urinal flushing in buildings with dual water systems • Decorative fountains • Street sweeping • Dust control

The DOH has restrictive requirements for R-1 irrigation on property located above of the Underground Injection Control (UIC) line (e.g., groundwater or vadose zone monitoring, no excess irrigation to flush salts below the root zone allowed), and therefore we recommend that R-1 reuse be limited to properties located below the UIC line. It appears that most of the development is located below the UIC line; however park P-1 and the upper elementary school may be located above the UIC line and should be irrigated with other water sources.

Based on other Kona-area evaluations, an average R-1 recycled water flow rate of 2.37 mgd has the potential to provide irrigation water for up to approximately 273 acres without routine supplemental water addition. The Kaloko Makai development concept includes 50 acres of parks and 30 acres of schools located below the UIC line that will likely be the largest users of recycled water. Only a portion of the park and school acreage will be irrigated; our preliminary estimate is that approximately 60 acres of the total park and school acreage will ultimately be irrigated. Additional recycled water users (e.g., streetscape, multi-family residential, etc.) can be added to the system if they are located near the distribution lines that carry the water to the largest users.

The required R-1 storage tank size will be based on the peak day demand of the recycled water uses.

Supplemental Water

There may be times when R-1 supplies are not sufficient to meet the irrigation demands of the parcels that are connected to the R-1 distribution system. For example, in the first development phase there will likely be not enough R-1 water to irrigate the parks and schools that are slated for construction. Therefore, addition of supplemental water (potable or non-potable) to the R-1 storage tank will be required to ensure the irrigation demands can be met.

Disposal System

There will be times when there is more R-1 water available than the irrigation users require; for example, during periods of extended wet weather. The DOH requires that a disposal system be provided for when recycled water supply exceeds the demand. The United States Department of Agriculture Natural Resources Conservation Service Soil Survey indicates that Aa lava is present at the proposed wastewater treatment plant location. Aa lava is typically extremely porous, and significant volumes of water can be disposed in a relatively small area via percolation basins. Percolation basins are currently used at the Kealakehe Wastewater Treatment Plant and at the Waikoloa Resort Wastewater Treatment Plant for disposal purposes.

Please call me at (808) 442-3301 if you have any questions.

Very truly yours,

Brown and Caldwell

Craig C. Lekven, PE (Hawaii License No. 13003, Expires 4/30/12)
Supervising Engineer

CCL:ic

cc: Mr. Earl Matsukawa, Wilson Okamoto Corporation

APPENDIX D

- An Assessment of the Potential Impact of the Proposed Kaloko Makai Project on Water Resources, Tom Nance

An Assessment of the Potential Impact of the Proposed Kaloko Makai Project on Water Resources

Prepared for:

SCD-TSA Koloko Makai, LLC
1100 Alakea Street - Suite 2700
Honolulu, Hawaii 96813

Prepared by:

Tom Nance Water Resource Engineering
560 N. Nimitz Hwy. - Suite 213
Honolulu, Hawaii 96817

December 2012

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INTRODUCTION

This report provides an assessment of the potential impact of the proposed Kaloko Makai project on water resources. It has been prepared to support the project's Supplemental EIS being prepared by others.

DESCRIPTION OF THE PROJECT

Project Site and Proposed Development

Location of the 1113-acre project site is shown on Figure 1. The site is on both sides of Hina Lani Drive and extends from Queen Kaahumanu Highway on its makai end to about 760-foot elevation at its highest point. The project is to be developed in three phases and would be comprised of a mix of residential, commercial, industrial, and public uses, the latter including a 150-acre dry land forest (Figure 2).

Projected Water Supply Requirements

Separate potable and non-potable systems are proposed to supply the project's water requirements. Projected supply requirements have been prepared by Wilson Okamoto Corporation (2012) and are summarized on Table 1. At full build out, projected average potable use would be 2.18 MGD. The average non-potable use would be 0.58 MGD.

Alternative Sources of Supply for the Potable System

The potable system's well pumping capacity must provide the maximum day use (defined as 1.5 times the average use) in a 24-hour pumping day. If the wells are dedicated to and incorporated into the County Department of Water Supply (DWS) system, one-third of the well capacity would be allocated to DWS and two-thirds would be allocated to the developer. Four alternative sources for potable supply are being considered: onsite wells at about 710-foot elevation at the upper end of the project; 710-foot onsite wells with desalinization; wells several miles to the south tapping the high level groundwater body; and desalinization using onsite saline groundwater as the feedwater supply. These are described in the paragraphs following.

<u>Onsite Wells at 750-Foot Elevation Within the Project Site.</u> The possibility of developing potable quality wells onsite at 710-foot elevation is suggested by the discoveries of two deep monitor wells (State Nos. 3858-01 and 3959-01), both of which encountered fresh groundwater under artesian pressure at depth below saline groundwater and far below and hydrologically disconnected from the basal lens. The phenomenon is discussed in detail later in this report. A deep exploratory borehole at 710-foot elevation at the upper end of the project site will be undertaken to determine if fresh groundwater can be found at depth and to determine the feasibility of its development. If successful, three production wells would be developed, each of 1150 GPM capacity and driven by 300 horsepower motors. These wells would be integrated into the DWS system, with two-thirds of their capacity allocated to supply the Kaloko Makai project.

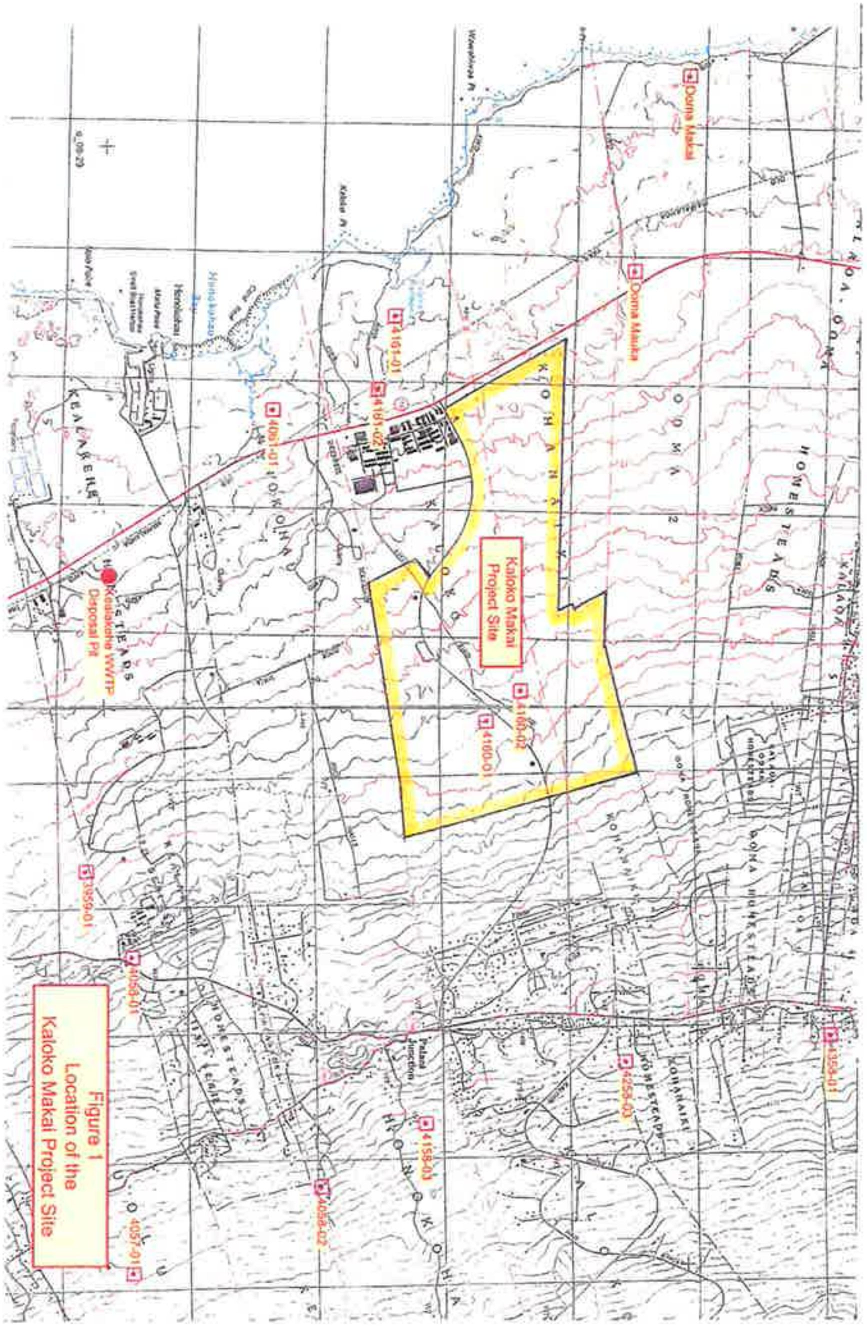


Figure 1
Location of the
Kaloko Makai Project Site

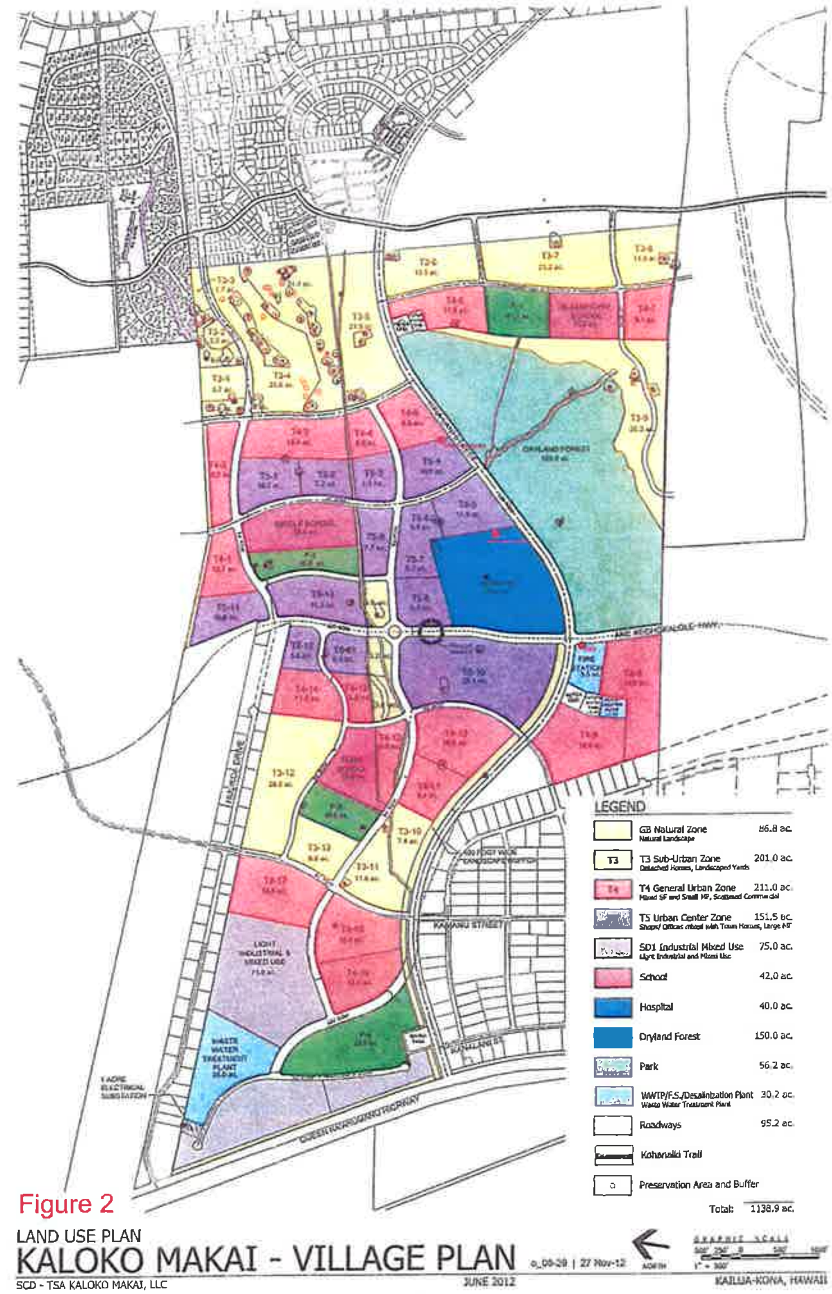


Figure 2

Table 1

Modification of the Water Supply Projections With
Multi-Family Parcels Irrigated by the Non-Potable System

Development Phase	Projected Supply Requirements		Wastewater Generator for Potential Reuse (MGD)	
	Potable (MGD)	Non-Potable (MGD)	Design Amounts by Wilson Okamoto	Expected Actual Generation by TNWRE
1	0.8558	0.3044	0.8183	0.5273
2	0.7382	0.1938	0.7635	0.5288
3	0.5897	0.0856	0.6003	0.4173
Total	2.1837	0.5838	2.1821	1.4734

Note: 400 GPD/Unit water use for multi-family parcels distributed 276 GPD for potable and 124 GPD for non-potable based on Honolulu BWS Guidelines.

710-Foot Onsite Wells With Reverse Osmosis (RO) Treatment. In the event that artesian groundwater is found below saline groundwater but its salinity at projected draft rates would not meet drinking water standards, the alternative of RO treatment of this water would be considered. This treatment process would produce a wastewater stream, referred to as a concentrate, that would be disposed of injection wells located at the project's wastewater treatment plant (WWTP) at the makai end of the project site. Due to the operating costs of the RO treatment, DWS may not accept the wells and RO treatment plant for dedication. In that case, the capacity of the wells, as feedwater sources for RO treatment, would be sized to provide the project's maximum day use in a 24-hour pumping day assuming 65 percent product recovery in the RO process. As a private system, provision of standby well pumping capacity would be required. These criteria translate to four 1170 GPM well pumps, one as standby. At full build out, the disposal of concentrate would be 1.15 MGD as a year-round average.

Wells to the South of the Project Site. In the event that neither of the two onsite well alternatives described above are feasible, development of potable wells several miles to the south, would be pursued. The exact locations of these wells will depend on land acquisition costs and the costs of additions to DWS' infrastructure required to transmit this well supply north to the project site. In general, however, there are two distinctly different possibilities, wells above Mamalahoa Highway tapping the high level groundwater directly or wells in the near vicinity of the State's deep monitor well tapping the high level groundwater at depth below saline groundwater. In either case, these wells would be incorporated into DWS' system. Depending on their location, three 1120 GPM or four 840 GPM wells would be required. Improvements to DWS' transmission/distribution system would also be required for this alternative.

Desalinization of Onsite Saline Groundwater. In the event that none of the three alternatives described above are feasible, desalinization of onsite saline groundwater would be undertaken. The raw water supply wells and desalinization plant would be located next to or below DWS' existing 363-foot tank along Hina Lani Drive. The raw water supply wells would draw saline groundwater from beneath the basal lens. Tentatively, the depth from which this supply would be withdrawn would be between 250 and 350 feet below sea level, requiring total well depths on the order of 710 feet. The expectable product recovery from this saline feedwater supply is 40 percent, meaning that 2.5 gallons of saline groundwater would be required for every gallon of fresh product water produced. As a private system with redundant capacity, this would translate to four 750 GPM treatment trains with each treatment train supplied by a 1900 GPM raw water supply well.

To reduce the RO power requirements, pressure transfer devices would be installed to recover energy from the RO's concentrate stream. The concentrate itself would be hypersaline [salinity on the order of 50 parts per thousand (PPT) compared to seawater at 35 PPT]. Its disposal, amounting to 4.9 MGD at full build out, would be in three deep wells located at the project's WWTP.

Wastewater Generation, Treatment, and Reuse or Disposal

A 20-acre site for the project's WWTP would be located at the makai end of the project site (refer to Figure 2). The WWTP would produce R-1 quality effluent which would be the source of supply for the project's non-potable system. The last two columns of Table 1 list wastewater generation amounts, both as design amounts compiled by Wilson Okamoto Corporation and as expectable average amounts compiled for this report. The expected wastewater amount substantially exceeds potential irrigation reuse in the project's non-potable system. The excess would be disposed of in injection wells at the WWTP if other uses for this water can not be found.

Rainfall-Runoff Generation and Disposal

According to the 2011 Rainfall Atlas of Hawaii (Giambelluca and Others, 2011), average annual rainfall across the project site varies from 15 to 25 inches a year. The land surface of the project site consists of unweathered and very permeable lavas with sparse deposits of ash soils and no defined drainageways. Essentially no rainfall runoff leaves the site in its present condition, even during intense storm events. It is either lost to evaporation or percolates to the underlying groundwater.

Development of the project will create impervious surfaces which will locally create surface runoff. All of this runoff would be directed into seepage pits and drywells such that no runoff will leave the site after it is developed.

DESCRIPTION OF THE HYDROGEOLOGIC ENVIRONMENT IN THE VICINITY OF THE KALOKO MAKAI PROJECT SITE

General Overview

The Kaloko Makai project site and the land upslope from it are comprised of unweathered lava flows with little or no soil cover and extraordinarily high permeability. Except where the natural ground has been converted to impervious surfaces by development, continuous flow of surface runoff during storm rainfalls does not occur. The rainfall percolates downward rather than flowing over the ground surface for any significant distance downslope. Because of this, the description of the hydrogeologic environment within and around the Kaloko Makai project site focuses exclusively on groundwater. Surface water resources are non-existent.

Groundwater in North Kona area occurs into two different modes. Along the coastline and for several miles inland, groundwater occurs as a brackish basal lens floating on saline groundwater beneath it and in hydraulic contact with seawater at the coastline. High level groundwater, the other mode of groundwater occurrence in North Kona, was first discovered in 1990 with a well drilled in Keauhou at 1620-foot elevation above Mamalahoa Highway. Since then, more than 20 high level wells have been developed from Kalaoa on the north and Kealakekua to the south. With only a few exceptions, all of these wells have been located above Mamalahoa Highway. Nine of the wells are currently in use, eight of which are owned and operated by the Hawaii County Department of Water Supply (DWS). DWS is about to put one more high level well (State No. 4158-03) into production in the near future.

Basal Groundwater Occurrence

Basal Water Levels. In the Keahole to Kailua area of north Kona which includes the Kaloko Makai site, basal groundwater levels near the shoreline are about one foot above sea level and slowly increase moving inland to between two and three feet above sea level at the mauka end of the project site. These water levels move up and down in response to the semi-diurnal tide with the tidal response

increasingly lagged and damped with distance inland. At the three monitor wells in the Kaloko Honokohau National Park (KAHO), which are 1500 to 3500 feet in from the shoreline, the tidal variation is about 50 percent of the ocean's tidal amplitude and is lagged by less than one hour. Further inland and within the Kaloko Makai project site at Well 4160-02, the tidal amplitude is about 15 percent and the lag is a little more than three hours (TNWRE 2002, page 10).

Figure 3 is a salinity and temperature profile through the water column of onsite Well 4160-02. It illustrates two relatively anomalous characteristics of the underlying basal groundwater, given the areal extent of the potentially contributing upland watershed. First, the 65.8° F. temperature in this top portion of the basal lens is four to six degrees colder than in upgradient wells which tap the high level groundwater. Second, the salinity is substantially higher than would otherwise be expected. These two characteristics are found in all basal wells from Keahole Point to at least as far south as the old Kona Airport. The subsurface geology which appears to be responsible for this occurrence is discussed in detail in subsequent sections.

Flowrate Through the Basal Aquifer. The most recent, sophisticated, and therefore most reliable computations of groundwater recharge for Hawaii Island are presented in Engott, 2011. The area within and around the Kaloko Makai project site is a part of the 167-square mile area delineated by the State Commission on Water Resource Management (CWRM) as the Keauhou Aquifer System. Its computed recharge in Engott, 2011 is 152 MGD. Reducing this by 14 MGD, the current groundwater pumpage from the aquifer system, leaves an average groundwater flowrate of about nine MGD per coastal mile across the aquifer's shoreline width. If all the rainfall-recharge into the high level aquifer were to discharge into the downgradient basal lens, this flowrate would create a robust basal groundwater body which could be developed for irrigation use and possibly even for potable supply.

This is decidedly not the case for the basal groundwater in the area from the Old Kona Airport to Keahole Point. Indications are that the actual basal flowrate is less than one-third of what might be expected if all of the discharge from the high level groundwater was into the inland margin of the basal lens. As noted above, the substantially lesser actual flowrate through the basal lens is reflected in water levels that are lower than otherwise expected, salinities which are too high for irrigation use, and anomalously cold temperatures.

Deep Monitor Well Results. Results of two deep monitor wells provide insight into the possible geologic feature creating the high level groundwater occurrence tapped by wells above Mamalahoa Highway and the resulting anomalous flowrate, salinity, and temperature in the basal lens. These two wells are the State's Keopu Monitor Well (No. 3858-01) and the Kamakana Monitor Well (No. 3959-01). Both were drilled through the basal lens, continued through the underlying saline groundwater, and then encountered fresh and confined groundwater at depth. Results of Well 3858-01 are described in Water Resources Associates, 2007. Since encountering fresh water at depth was unexpected at this location, the exact depth that it occurred in the borehole during drilling is not known and has not been determined with video logs and other measurements. During drilling of the Kamakana Monitor Well, salinity and temperature of the water in the borehole were closely monitored, enabling the different groundwater regimes penetrated by the borehole to be accurately documented. These are described below and illustrated on Figure 4.

Figure 3. Salinity and Temperature Profile through the Water Column of Well 4160-02 (September 14, 2012)

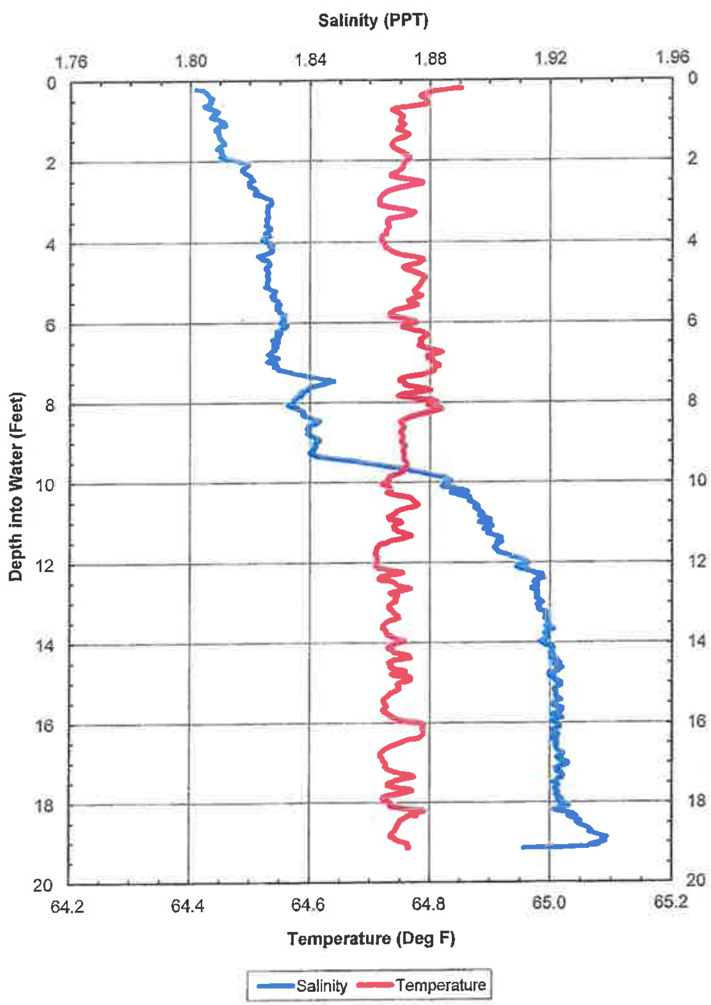
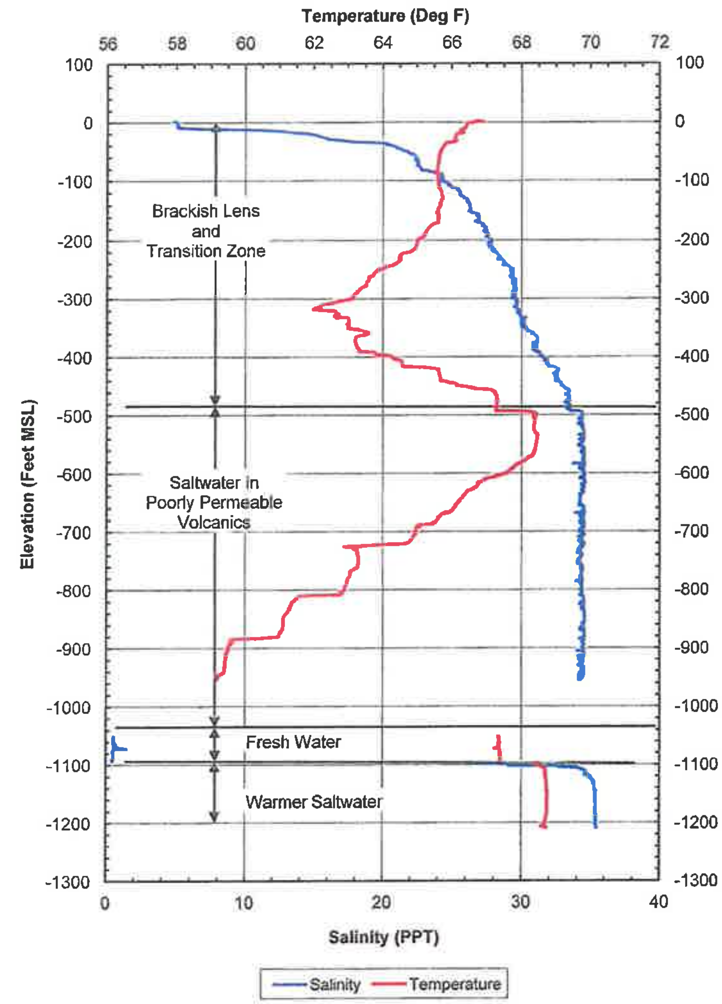


Figure 4. Composite Profile through the Water Column of the Kamakana Borehole (Profiles of 4/12/10, 5/12/10, and 8/18/10)



- Initially, a thin, relatively saline (5 PPT) and cool (66° F.) basal lens was encountered. The water level was typically about 2.5 feet (MSL) according to the available surveyed elevation. However, the mid-point of the transition zone of this basal lens is between 35 and 40 feet into water, suggesting that the actual water level relative to sea level may actually be less than two feet.

- Below the brackish basal lens is a thick transition zone which extends to a depth of 490 feet below sea level. In this transition zone, the water temperature steadily declines to 62° F. at 320 feet below sea level and then the temperature trend reverses, increasing to 67° F. at 490 feet below sea level.

- Below this thick transition zone, extending from 490 to more than 1020 feet below sea level, the salinity is essentially that of seawater and the temperature steadily declines with depth to about 59° F.

- At 1060 feet below sea level, fresh water was encountered. It was about eight degrees warmer than the saline groundwater immediately above it and had a piezometric head subsequently determined to be about 32 feet above sea level. The fresh water rushed up the borehole, mixing with the saltwater above for the first 150 feet, moving up the borehole for the next 720 feet with little or no mixing, and then mixing into the transition zone above that (Figure 5).

- The freshwater zone turned out to be less than 40 feet thick. At 1100 feet below sea level, warmer (70° F.) and slightly hypersaline (35.4 PPT) groundwater was encountered. Drilling was continued for another 120 feet with no salinity or temperature change.

Using inflatable packers to isolate the fresh water zone from the saline groundwater above and below it, short term air lift pumping was done to see if this narrow stratum containing fresh water could provide a developable supply. At low rates of pumping (120 GPM), however, the salinity of the pumped water became brackish and did not stabilize. Somewhat surprisingly, the freshwater zone had a substantial response to ocean tidal variations (Figures 6 and 7), significantly greater than the tidal response in the basal lens directly above. Comparative tidal lags and amplitudes for the respective periods of recording were as tabulated below.

Groundwater Zone	Tidal Lag (Hours)	Tidal Amplitude (% of Ocean Tide)
Fresh Water Zone	1.0	48
Brackish Basal Lens	3.0	25

Results of the two deep monitor wells provide insight on the relationship between high level and basal groundwater and the anomalies in the basal water body, at least in the near vicinity of these two monitor wells. These conclusions are:

Figure 5. Profile through the Water Column of the Kamakana Borehole After Fresh Water was Encountered (May 12, 2010)

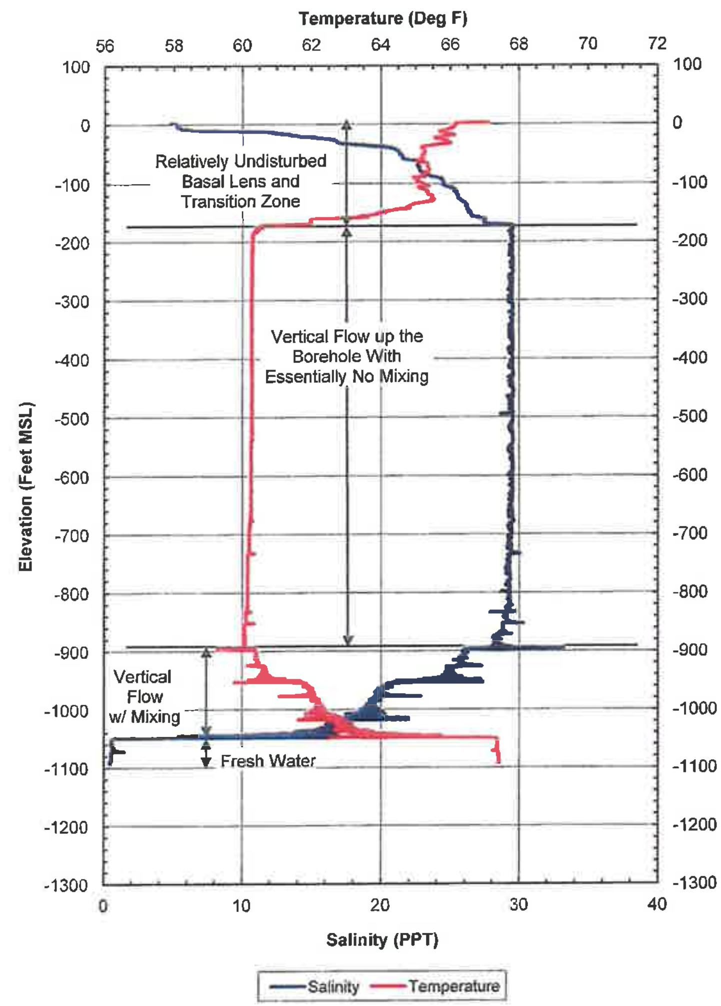


Figure 7. Tidal Variation in the Fresh Water Zone of the Kamakana Monitor Well in January 4 to 5, 2011

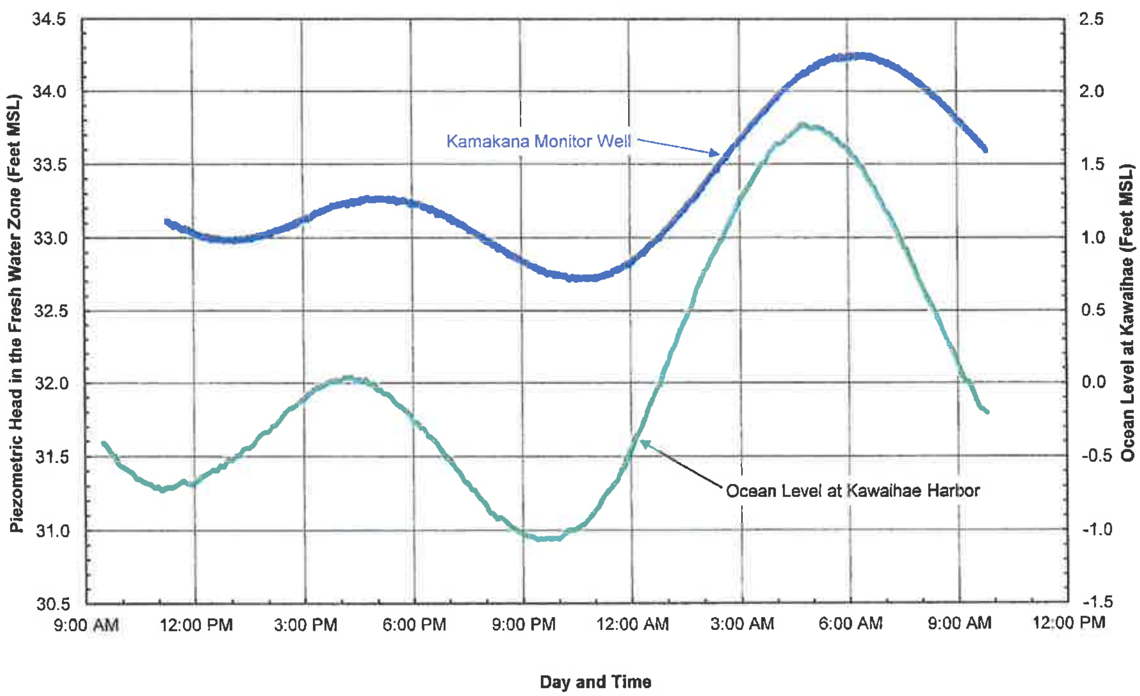
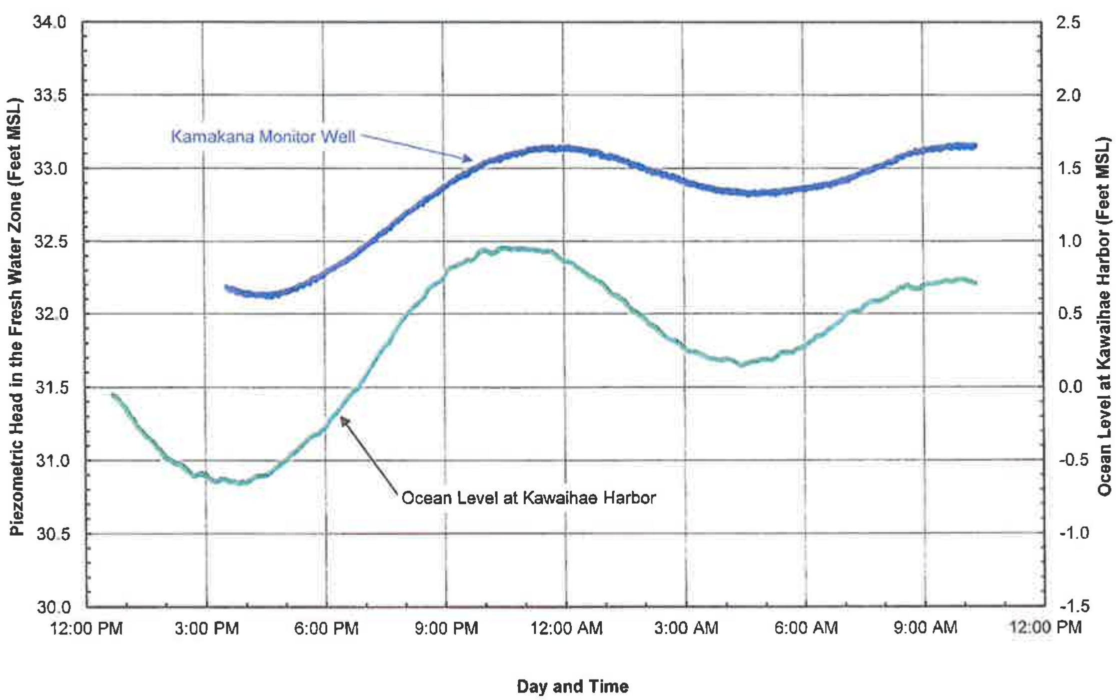


Figure 6. Tidal Variation in the Fresh Water Zone of the Kamakana Monitor Well in December 27 to 28, 2010



- The feature confining the fresh water at depth is a thick sequence of poorly permeable lava flows, in the aggregate hundreds of feet thick (the zone of vertical flow in the Kamakana borehole with essentially no mixing identified on Figure 5).
- That poorly permeable lava flows are the mechanism creating the high level groundwater in Kona is also supported by the results of two high level wells located above Mamalahoa Highway (Hualalai, State No. 4258-03 and Keopu, State No. 3957-05). During the construction and testing of both wells, water levels rose and yields were increased by drilling deeper.
- The confined fresh groundwater at depth, with an apparent hydraulic connection to seawater at depth offshore, suggests that at least some of the inland high level groundwater may discharge at depth offshore rather than flow into the basal lens at its inland margin.
- With limited amounts of warmer, high level groundwater flowing into the inland margin of the basal lens, the source of the colder temperatures in the basal lens is seawater at depth moving inland in a saltwater circulation pattern beneath the basal lens. Figure 8 compares the temperature profile through the water column of the Kamakana borehole with the ocean water directly offshore. Temperatures in the Kamakana borehole to a depth of 320 feet below sea level reflect the movement of saline groundwater below the basal lens which originated as seawater from more than 600-foot depth offshore. Deeper than 500 feet below sea level in the Kamakana borehole, the zone of poorly permeable lava with little groundwater movement on Figure 4, the temperature appear to be simply the result of cooling by the ocean water at similar depths offshore.

Groundwater Quality

Water quality analyses of samples from wells, anchialine ponds, and other locations within and near to the Kaloko Makai mauka-makai corridor are compiled in Table 2. Samples from high level groundwater wells, with very low salinity levels and nutrient concentrations reflecting only natural, rather than man-made input, are at the top of the table. Below that are samples from basal wells with significantly higher salinities and widely varying nutrient concentrations. Toward the bottom of the table are samples from the upper end of Honokohau Harbor and the discharge of the R-2 quality wastewater effluent from the Kealakehe Wastewater Treatment Plant (WWTP). The effluent discharge occurs into an excavated pit which is located on the mauka side of Queen Kaahumanu Highway and about 3700 feet nominally upgradient of Honokohau Harbor (its location is shown on Figure 1). Nutrient removal from the WWTP effluent as it moves to and discharges into upper end of Honokohau Harbor is quantified in section following.

Nutrient Removal by Natural Processes in the Groundwater Environment

The ongoing discharge of 1.3 to 1.7 MGD Kealakehe WWTP effluent into a pit which is nominally upgradient of Honokohau Harbor and the groundwater discharged into the back end of Honokohau Harbor provide an opportunity to quantify natural nutrient removal in the groundwater environment. The inland excavation of the harbor acts as a point sink for groundwater discharge, including the addition of the WWTP effluent into the groundwater. Travel from the pit disposal to the upper end of the harbor

Figure 8. Temperature Profile Comparison, Kamakana Borehole and the Ocean Offshore (Profiles of April 3, 2010 and December 9, 2011, Respectively)

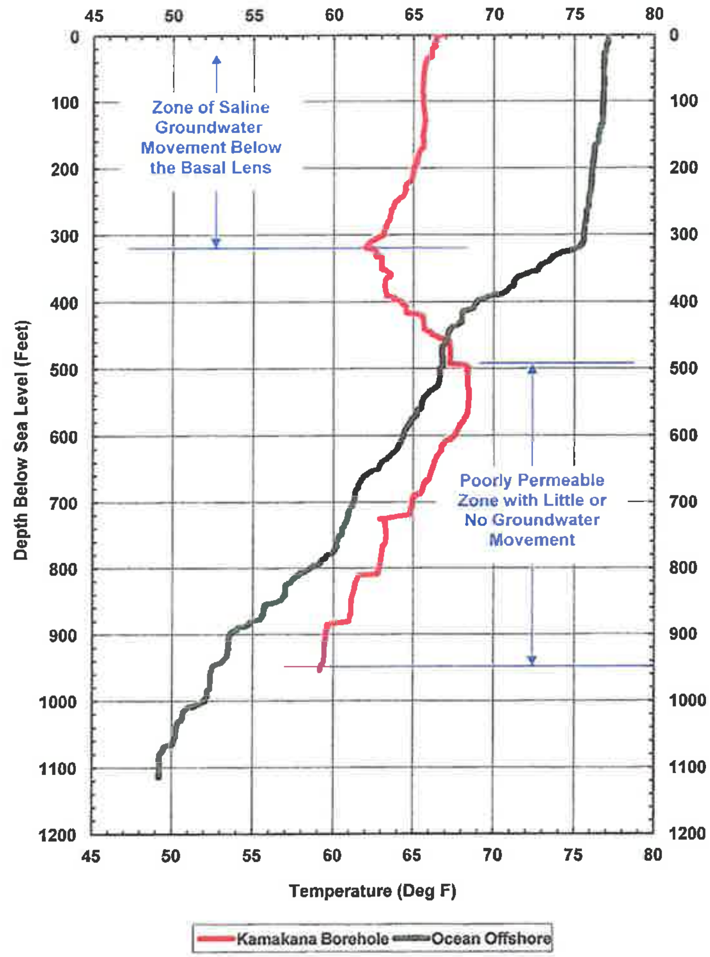


Table 2

Groundwater Quality Within and Near to the Kaloko Makai Corridor

Sampling Site	Date Sampled	Salinity (PPT)	Silica (µM)	Forms of Nitrogen (µM)				Forms of Phosphorus (µM)		
				NO_3	NH_4	TON	Total N	PO_4	TOP	Total P
High Level Potable Quality Wells										
3857-04 DWS Waiaha	11-02-11	0.129	752	74.1	1.5	20.6	96.2	4.24	0.24	4.48
	11-09-11	0.105	749	78.9	1.5	12.6	93.0	4.32	0.88	5.20
	11-25-11	0.119	750	75.9	0.9	13.1	89.9	4.30	0.60	4.90
4057-01 DWS QLT	5-26-00	0.109	801	86.0	0.0	14.7	100.7	3.76	0.08	3.84
	7-20-01	0.079	776	85.1	0.0	35.1	120.2	3.83	3.16	6.99
	11-02-11	0.116	776	87.1	1.1	22.1	110.3	4.00	0.24	4.24
	11-09-11	0.113	771	93.2	1.2	7.7	102.1	4.08	0.80	4.88
	11-25-11	0.130	746	85.4	1.1	11.7	98.2	4.00	0.50	4.50
4158-03 DWS Honokohau	5-26-00	0.144	844	80.1	0.0	14.5	94.6	3.64	0.20	3.84
	11-02-11	0.159	819	79.7	1.0	20.8	101.5	3.84	0.32	4.16
	11-09-11	0.152	804	85.0	2.6	16.6	104.2	4.24	0.80	5.04
	11-25-11	0.158	796	76.8	0.7	2.5	80.0	4.20	0.60	4.80
Basal Wells										
3959-01 Kamakana	11-02-11	5.390	578	160.4	0.7	9.7	170.8	3.84	0.88	4.72
	11-25-11	4.916	598	141.8	1.0	3.6	146.4	3.80	0.40	4.20
3960-01 QLT	10-23-94	25.543	318	28.1	0.3	4.9	33.3	1.49	0.02	1.15
	6-02-00	25.698	356	30.5	1.6	22.5	54.6	1.40	0.70	2.10
4061-01 KAHO 1	5-26-00	9.464	334	55.0	0.3	24.8	80.2	1.84	0.20	2.04
	6-10-00	9.463	304	56.2	3.5	32.1	91.8	1.44	2.96	4.40
	12-19-01	8.657	40	38.4	5.7	20.4	64.5	0.20	0.45	0.65
	11-14-07	10.015	301	67.1	2.7	33.2	103.0	1.65	0.60	2.25
	1-24-12	9.497	482	78.4	2.2	33.6	114.2	4.52	1.56	6.08
	10-29-12	9.317	518	86.3	8.6	68.0	162.9	2.00	0.90	2.90
4161-01 KAHO 3	5-26-00	6.259	672	75.0	0.2	14.8	90.0	4.36	0.04	4.40
	6-10-00	6.325	701	76.9	1.6	43.2	121.7	4.64	2.64	7.28
	12-19-01	6.305	652	79.4	4.2	0.1	83.7	4.35	0.07	4.42
	11-14-07	6.854	666	76.7	1.4	27.2	105.3	3.70	0.50	4.20
	1-24-12	6.387	589	81.4	1.2	11.9	94.5	4.32	0.16	4.48
	10-29-12	6.243	637	81.8	1.3	24.3	107.4	4.50	0.10	4.60
4161-02 KAHO 2	5-26-00	5.399	653	87.2	0.5	22.8	110.4	4.08	0.56	4.64
	6-10-00	5.361	691	104.3	5.1	42.2	151.6	9.04	2.88	11.92
	12-19-01	5.401	616	86.5	1.9	2.0	90.4	4.30	0.05	4.35
	11-14-07	5.382	651	100.4	1.9	31.6	133.9	3.20	1.15	4.35
	1-24-12	5.043	589	95.8	1.4	14.5	111.7	4.52	0.24	4.76
	10-29-12	5.009	653	107.7	2.7	32.9	143.3	5.20	0.00	5.20
4160-02 Kaloko Irrig.	5-15-94	1.734	670	68.6	0.3	2.9	71.8	5.89	0.03	5.92
	3-22-96	1.773	671	78.1	0.3	8.2	86.6	4.42	0.70	5.12
	9-14-12	1.837	633	70.0	1.1	14.4	85.5	4.70	0.60	5.30
	9-14-12	1.917	642	68.2	0.8	14.4	83.4	4.60	0.60	5.20
Ooma Mauka Monitor Well	3-15-96	7.962	661	81.8	0.2	15.8	97.8	3.08	0.16	3.24
	6-02-00	7.783	672	89.7	1.5	26.6	117.8	5.30	0.75	6.05
	6-10-00	7.850	741	91.4	1.0	35.8	128.2	3.60	0.72	4.32
	11-03-06	7.293	640	81.2	3.5	24.8	109.5	2.32	1.28	3.60
	10-29-12	7.067	644	89.5	1.8	9.6	100.9	4.00	0.20	4.20
Ooma Makai Monitor Well	11-03-06	9.945	577	67.0	2.5	22.8	99.2	2.64	1.04	3.68
	10-29-12	10.208	600	94.7	2.2	30.6	127.5	3.70	0.40	4.10
Groundwater Discharge into Honokohau Harbor										
Honokohau Harbor	6-03-00	20.987	373	39.7	0.0	4.2	43.9	2.30	0.07	2.37
	7-20-01	20.431	380	40.4	0.3	10.7	51.4	2.31	2.25	4.56
	9-03-01	20.362	341	38.1	0.3	2.7	41.1	2.05	0.27	2.32
	11-09-11	20.750	305	48.1	0.3	0.2	48.6	2.51	0.17	2.68
	11-09-11	23.216	278	38.0	0.5	1.5	40.0	2.05	0.19	2.24
	11-21-11	19.556	314	51.8	0.1	5.3	57.2	2.93	0.13	3.06
	11-21-11	21.074	318	42.8	0.1	3.6	46.5	2.71	0.09	2.80
Kealakehe WWTP Effluent										
	11-09-11	1.816	450	1037.4	26.2	1.90	1065.5	166.88	7.84	174.72
	12-09-11	1.869	762	1480.6	25.0	35.4	1541.0	193.00	4.80	197.80

Note: All samples collected by Tom Nance Water Resource Engineering (Tom Nance) and/or Marine Research Consultants (Steve Dollar) and analyzed by Marine Analytical Specialists.

consists of a 60-foot drop through the vadose zone and 3700 feet of travel with groundwater to the upper end of the harbor. Samples collected from two visually obvious groundwater discharge locations at the upper end of the harbor are a mix of: (1) the WWTP treated effluent that has undergone natural nutrient removal to the harbor; (2) the ambient groundwater; and (3) seawater. The amount of nutrient removal from the effluent can be approximated in the following steps:

- Assume a ratio of ambient groundwater to treated effluent in the discharge into the harbor;
- Using a salinity balance, solve for the amount of seawater in the mix; and then
- With the ratios of the three sources in the samples collected at the upper end of the harbor, solve for the remaining nitrogen and phosphorus that was originally in the WWTP effluent dumped into the pit.

If the groundwater to WWTP effluent ratio is selected to cover the plausible extremes of this mix, the ensuing nutrient balance calculations would bracket the probable nutrient removal rates from the WWTP effluent. In the resulting removal tabulations below, calculations were done as if only effluent is discharged into the upper end of the harbor and for a 4:1, groundwater to effluent mix. For this plausible range of effluent mixed with groundwater discharging into the upper end of Honokohau Harbor, rates of removal of nitrogen are 89 to 92 percent. For phosphorus, the removal rates are 93 to 98 percent. Several other aspects of the calculation results are worth noting:

- The calculations used the November 9, 2011 sample of the Kealakehe WWTP effluent being discharged into the pit. Had the second, December 9, 2011 sample been used instead, its higher nutrient levels would have resulted in even greater calculated removal rates.
- If it is argued that the WWTP effluent discharges to the shoreline south of Honokohau Harbor rather than into the upper end of the harbor, the nutrients in Kealakehe shoreline samples in Nance (2002) and the Keahuolu shoreline samples (TNWRE data not yet published) could be used for a similar set of calculations. Using these data results in similar, very high natural nutrient removal rates (Table 3).

ESTIMATES OF THE PROJECT'S POTENTIAL IMPACT ON BASAL GROUNDWATER

Assumptions Incorporated Into the Calculations

Relationship of Basal to High Level Groundwater. For the calculations herein, it is assumed that no high level groundwater leaks into the basal lens beneath the project site, meaning that the flow in the basal lens is entirely due to local recharge on the area between Mamalahoa Highway and the shoreline. That flowrate is estimated to be 1.7 MGD per coastal mile. Across the 1.2-mile width of the project site, the basal flowrate is estimated to be 2.0 MGD. It should be pointed out that if some or most of the high level groundwater is flowing into the basal lens, the project's relative impact on this greater basal flowrate would be less than calculated herein.

Table 3

Computed Removal Rates of Nitrogen and Phosphorus From Kealakekua WWTP Effluent Arriving at the Upper End of Honokohau Harbor

Sample Station in Honokohau Harbor	Sample Date	Computed Nutrient Removal Rates (%)			
		All WWTP Effluent		4:1, Groundwater:Effluent	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus
Station 1	11-09-11	90.2	96.8	91.8	93.4
	11-21-11	89.2	96.6	87.7	97.8
Station 2	11-09-11	90.6	96.9	93.4	93.4
	11-21-11	90.5	96.6	93.0	93.1

Notes:
1. Salinity, nitrogen, and phosphorus values for Kealakehe WWTP effluent from the November 9, 2011 sample (bottom of Table 1).
2. Ambient groundwater salinity of nutrient concentrations based on Well 4061-01 in Table 1.
3. Seawater mixed in the sample assumed to be 35.0 PPT salinity; total nitrogen of 7.0 μM, and total phosphorus of 0.50 μM.
4. Discharge into the upper end of Honokohau Harbor based samples of Stations 1 and 2 in Table 2.

Ambient Quality of the Underlying Basal Groundwater. The salinity and nutrient levels in samples taken from onsite Well 4160-02 (Table 2) are assumed to represent the ambient quality of the underlying basal groundwater. These averages are: salinity of 1.75 PPT; total nitrogen of 80 μM or 1.12 mg/l; and total phosphorus of 5.5 μM or 0.17 mg/l.

Potable Supply Alternatives. Two of the four potable supply alternatives would drill wells at the inland end of the project site. If successful, wells for these two alternatives would tap fresh artesian groundwater which exists at depth below the basal lens and saline groundwater. One or the other of these options would only be pursued if it can be demonstrated, initially by testing in the exploratory borehole and subsequently by testing in the finished production wells, that pumping this water will have no impact on the basal lens above. Rather, it would simply be tapping groundwater than flows beneath the basal lens and does not leak into it.

The third potable alternative being considered would tap the high level groundwater at locations several miles or more to the south of the project site. For the purposes of this assessment, it is assumed that these offsite locations would either be to the north and south of DWS' existing Waiaha well (State No. 3857-04) or just north of the State's Keopu deep monitor well (State No. 3858-01). These locations are four and three miles to the south of the Kaloko Makai project site, respectively.

The fourth alternative, desalinization of saline groundwater, would utilize onsite wells designed to draw water from a substantial distance below the basal lens where the salinity may be on the order of 30 PPT. Extensive testing would be undertaken in the development of these wells to affirmatively demonstrate that such pumping can be done without adversely impacting the overlying basal lens.

A key requirement of all four of the supply alternatives being considered is that none would utilize water from the brackish basal lens flowing beneath the project site. Of the three alternatives that would draw from the high level groundwater body, none would impact basal groundwater in the project's mauka-to-makai corridor or elsewhere in North Kona. However, all three of these alternatives would result in a 1:1 reduction of fresh groundwater ultimately discharged into the marine environment offshore.

Landscape Irrigation Return Flow. Landscape irrigation will be supplied by both the potable and non-potable systems, the former occurring primarily in single family residential areas which will not be supplied by the non-potable system. The use of potable water for this purpose at full build out is estimated to be 0.46 MGD, calculated as an average of 4000 GPD/acre on 115 acres throughout the project site. Irrigation using R-1 effluent as the source of supply is estimated to be 0.58 MGD (Table 1). That means the excess of R-1 for disposal in injection wells at the project's WWTP site would be about 0.90 MGD as a year-round average at full build out. For the calculations herein regarding the percolation of excess applied irrigation water to the underlying basal lens, three assumptions are made. First, 12 percent of the water applied for irrigation will be in excess of crop requirements and percolate to the basal groundwater below. Second, total nitrogen and total phosphorus in the R-1 effluent are assumed to be 1500 and 200 μM, respectively, based on levels of these nutrients in the effluent from the County's Kealakehe WWTP (Table 2). Third, fertilizer levels where landscape irrigation is supplied by R-1 effluent will be far less than where the supply is the potable system. Assumed fertilizer applications are:

- In areas irrigated with potable water, nitrogen and phosphorus in fertilizers will be applied at 3.0 and 0.5 pounds/year/1000 ft^2, respectively.

- In areas irrigated where R-1 effluent, nitrogen and phosphorus in fertilizers would be applied at 10 percent of the rate applied in areas with potable water irrigation.

- Ten (10) percent of the applied nitrogen and two (2) percent of the applied phosphorus will be carried in the excess applied irrigation water below the plant root zone.

Onsite Rainfall-Recharge. As an approximation, it is assumed that 60 percent of the project site's 20 inches of average annual rainfall percolates to and becomes groundwater recharge. Over the 1113-acre site, this amounts to an average of 1.0 MGD. Drainage features of the development will capture surface runoff and direct it to seepage basins and drywells, resulting, as a first order approximation, in no change in the amount of onsite rainfall ultimately becoming groundwater recharge. However, it is also assumed that nutrient levels in the post-development rainfall percolating to groundwater will be increased by 20 μM and 2 μM for nitrogen and phosphorus, respectively.

Natural Removal of Nutrients Originating From the Project Site. Earlier in this report, computed nitrogen and phosphorus removal from Kealakehe WWTP effluent disposed of in a pit 3700 feet nominally upgradient of Honokohau Harbor were given. Selecting values slightly lower values than these computed rates, removal rates of 88 and 92 percent of nitrogen and phosphorus are assumed for the calculations herein.

Calculated Changes to Basal Groundwater Flowing Beneath the Kaloko Makai Project Site

Table 4 incorporates all of the foregoing assumptions to approximate possible changes to the brackish basal lens flowing beneath the project site as a result of its proposed development. The resulting approximations are: a 6.2 percent increase in the flowrate; a 5.1 percent reduction in salinity; and nitrogen and phosphorus increases of 5.2 and 2.1 percent, respectively.

OTHER CHANGES TO THE GROUNDWATER DISCHARGE INTO THE MARINE ENVIRONMENT

All of the foregoing calculations were for estimated changes to the brackish basal groundwater flowing directly beneath the project site. Three other aspects of the project's development, although not having an impact on this basal lens, will affect the ultimate discharge of groundwater into the marine environment. Each of these is described and quantified below.

Consumptive Use of Potable Quality Groundwater

Three of the project's four potable supply alternatives under consideration would draw water from what is referred to as the high level groundwater, either as it exists at depth below the basal lens at the inland end of the project site or at a location to the south where it can be accessed directly. The project's ultimate potable water use would be 2.18 MGD as a year-round average. Wells developed for such use would actually draw 3.23 MGD, one-third of which would be used by DWS to serve other customers in its service area. If RO treatment is necessary (Alternative 2), the draft would be slightly greater at about 3.3 MGD.

Table 4

Approximated Changes to the Brackish Basal Groundwater Flowing Beneath the Kaloko Makai Project Site

I t e m	Flowrate (MGD)	Salinity (PPT)	Nitrogen (lbs / day)	Phosphorus (lbs / day)
Present Groundwater Flow	2.0	1.75	18.66	2.83
Excess Applied Irrigation				
• As Potable Water + Fertilizer	0.055	0.15	0.502	0.011
• As R-1 Treated Wastewater + Fertilizer	0.070	0.30	0.210	0.007
Change in Local Rainfall-Recharge	No Change	No Change	0.280	0.041
Post-Development Totals : Amount	2.125	1.661	19.652	2.889
: % Change	+ 6.2	- 5.1	+ 5.2	+ 2.1

Notes: 1. The area irrigated with potable water is 115 acres. The amount of water used for this purpose is 0.46 MGD.

2. The area irrigated with R-1 effluent is 165 acres. The amount of R-1 used for this purpose is 0.58 MGD.

Based on the Keauhou Aquifer recharge calculations in Engott (2011), this total draft for the project and DWS would represent a two to three percent reduction of the total groundwater discharge into the marine environment offshore of the aquifer. Essentially all of this change would be occurring at substantial depth and distance offshore with no significant impact.

Disposal of Excess R-1 Treated Effluent in Onsite Injection Wells

As a long-term average, it appears that the amount of R-1 treated wastewater effluent will exceed its onsite irrigation reuse by about 0.90 MGD. If other uses can not be found for this water, this excess would be disposed of in injection wells located at the project's WWTP. That excess could amount to about half the present disposal by the County's Kealakehe WWTP into a pit inland of Honokohau Harbor. The disposal wells would be designed to deliver the excess effluent at depth below the basal lens so as not to impact the lens itself. To accomplish this, disposal would be at and below where the receiving groundwater salinity is 30 PPT or greater and below poorly permeable lava flows identified in the process of drilling. This may require the injection wells to deliver the water at depths of 300 feet or more below sea level. However, the extraordinary disposal depth is warranted to avoid having a significant impact on basal groundwater moving through the Kaloko-Honokohau National Historical Park or to the Park's nearshore waters. The effluent disposed of would be significantly less dense than the receiving basal groundwater. The tendency for the disposed of effluent to rise up due to its lesser density would be offset by several factors: (1) disposal beneath one or more poorly permeable lava flows; (2) the substantial vertical to horizontal anisotropy in the lava flows; and (3) progressive mixing of the effluent into the receiving groundwater, causing its density to increase. Wastewater disposal in this manner is being done at the Mauna Lani Resort without adverse impact.

Potential Disposal of RO Concentrate

Two of the four drinking water supply alternatives being considered would involve desalinization. An inevitable part of this process is the production of a wastewater stream, referred to as the concentrate. For the desalinization alternative using slightly brackish water extracted at depth below the basal lens, the expected concentrate amount assuming 65 percent product recovery would be 1.17 MGD. If it is assumed that the salinity of the feedwater supply is between 2.0 and 3.0 PPT, the salinity of the concentrate would be in the range of 5.3 to 8.2 PPT. This would be too salty for irrigation reuse and would require disposal in wells located on the project's WWTP site. The disposal wells would be designed to deliver the concentrate to below the midpoint of the transition zone between brackish basal water above and saline groundwater below in order to avoid impacting the overlying basal lens.

For the desalinization alternative using onsite saline groundwater as the feedwater source, the hypersaline (50 PPT) concentrate would amount to an average of 3.27 MGD at the project's full development. Disposal will be at the project's WWTP site and utilize the wells also used for excess R-1 disposal. Mixing the hypersaline concentrate with the excess R-1 will assist in ensuring that the less dense R-1 does not rise up into the overlying basal lens.

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