NEPA Action EA/EIS
Publication Form

Project Name Joint Intelligence Operations Center Final EA

Island: Oahu
District: Ewa
TMK: (1) 9-9-002:004 (por.)
Permits: National Pollutant Discharge Elimination System Construction General Permit
Applicant or Proposing Agency: U.S. Department of the Navy, Naval Facilities Engineering Systems Command Pacific
258 Makalapa Drive, Suite 100, JBPHH, HI 96860
Attn: EV21 Project Manager, JIOC EA
NFPAC-Receive@navy.mil
Approving Agency: Same as above

Consultant: HHF Planners, Gail Renard, 808-457-3167, comments@hhf.com

Status: FEA-FONSI

Summary (Provide proposed action and purpose/need in less than 200 words. Please keep the summary brief and on this one page)**:**

Joint Base Pearl Harbor-Hickam (JBPHH) proposes to construct an administrative facility to consolidate the United States Indo-Pacific Command Joint Intelligence Operations Center (JIOC) functions from dispersed locations at JBPHH and Camp H.M. Smith. The Preferred Alternative would construct a multi-story, approximately 172,000-square-foot administrative facility within the U.S. Navy's JBPHH Makalapa Compound. The project also includes supporting infrastructure and facilities (e.g., parking, stormwater detention, sanitary sewer lift station, and offsite sewer improvements). Project construction is anticipated to begin in 2026 and be completed in 2030.

The purpose of the Proposed Action is to provide an administrative facility for JIOC that meets current and anticipated facility requirements at JBPHH, improves its ability to carry out its mission, and consolidates geographically dispersed functions and personnel in order to improve integration among JIOC organizations. The Proposed Action is needed to improve the integration and close collaboration required to support operations by collocating JIOC functions and personnel at a new facility with the ability to accommodate new technologies, which would better support national, strategic, and operational theater requirements. The Navy determined that the project would not significantly impact the quality of the human environment.

FINAL

ENVIRONMENTAL ASSESSMENT

For

JOINT INTELLIGENCE OPERATIONS CENTER

At

JOINT BASE PEARL HARBOR-HICKAM

AUGUST 2022

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DEPARTMENT OF DEFENSE
DEPARTMENT OF THE NAVY

FINDING OF NO SIGNIFICANT IMPACT FOR THE PROPOSED JOINT INTELLIGENCE OPERATIONS CENTER AT JOINT BASE PEARL HARBOR-HICKAM (JBPHH), MAKALAPA COMPOUND, OAHU, HAWAII

Pursuant to the Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations [CFR] Parts 1500-1508) implementing the National Environmental Policy Act (NEPA) and Department of the Navy (DON) NEPA regulations (32 CRF Part 775), DON gives notice that an Environmental Assessment (EA) has been prepared and an Environmental Impact Statement (EIS) is not required for the Joint Intelligence Operations Center at Joint Base Pearl Harbor-Hickam (JBPHH), Makalapa Compound, Oahu, Hawaii. This action will be implemented as set out in Alternative 1 (Preferred Alternative).

Proposed Action: JBPHH proposes to construct an administrative facility to consolidate the U.S. Indo-Pacific Command (USINDOPACOM) Joint Intelligence Operations Center (JIOC) at JBPHH Makalapa Compound. The proposed action would include a new operations building along with supporting infrastructure and facilities (e.g., parking, stormwater detention facility, sanitary sewer lift station, and offsite sewer improvements). Project construction is anticipated to begin in 2026, with construction completed in 2030. The JIOC facility would be a multi-story, approximately 172,000-square-foot building.

Purpose and Need: The purpose of the Proposed Action is to provide an administrative facility for JIOC that meets current and anticipated facility requirements at JBPHH, improves its ability to carry out its mission, and consolidates geographically dispersed functions and personnel in order to improve integration among JIOC organizations. The Proposed Action is needed to improve the integration and close collaboration required to support operations by co-locating JIOC functions and personnel at a new facility with the ability to accommodate new technologies, which would better support national, strategic, and operational requirements.

Alternatives Analyzed: Alternatives were developed for analysis based upon the following reasonable alternative screening factors: meets the purpose and need for the Proposed Action, meets physical siting and mission requirements of JIOC, distance from USINDOPACOM and Commander U.S. Pacific Fleet headquarters, availability of site, adequate land area to consolidate dispersed JIOC functions in one facility, availability of utilities and supporting infrastructure, minimization of physical vulnerabilities, and minimization of existing facility/function displacement.

Based on the reasonable alternative screening factors and meeting the purpose and need for the Proposed Action, the No Action Alternative and two action alternatives were carried forward for detailed analysis in the EA.

<u>No Action Alternative:</u> Under the No Action Alternative, the Proposed Action would not occur and a new consolidated JIOC facility would not be constructed. JIOC operations would continue to be conducted in seven separate buildings separated by a distance of several miles. The existing space and technology infrastructure limitations would persist, constraining JIOC's ability to expand, adapt, and integrate new technologies in support of mission requirements. The No Action Alternative would not meet the purpose and need for the Proposed Action; however, as required by NEPA, the No Action Alternative was carried forward in the EA analysis. The No Action Alternative was used to analyze the consequences of not undertaking the Proposed Action, not simply conclude no impact, and serves to establish a comparative baseline for analysis.

<u>Alternative 1 (Preferred Alternative):</u> In this alternative, an approximately 172,000-square-foot (sq ft) facility would be constructed on an approximately 15-acre site located at JBPHH Makalapa Compound as Military Construction Project (MILCON) P-079. The main building would be a three-story structure with concrete structural framing, concrete walls, reinforced concrete floor and roof slabs with membrane roofing, and reinforced concrete combination shallow, deep foundation floor systems and flat roof. The facility would also include single-story

attached wings for a central utility plant, warehouse, and food vendor area. This alternative also includes supporting facilities such as an electrical substation/switching station near the Luapele Gate, sanitary lift station, at-grade stormwater detention facility, an at-grade parking lot for approximately 650 vehicles, and off-site sewer infrastructure improvements in secured Department of Defense-controlled areas or in existing easements within public roadway rights-of-way. This alternative would have fewer impacts to air quality, geological resources, and visual resources than Alternative 2 and is DON's Preferred Alternative.

Alternative 2: The components of Alternative 2 would be of similar size and function as in the Preferred Alternative with differences in location (approximately 700 feet south of the Preferred Alternative site), parking lot configuration, and below-grade construction of the stormwater detention facility. Alternative 2 was evaluated as having a greater Net Present Value cost to construct due to its greater distance from the main road and utility lines, as well as requiring a subsurface stormwater detention facility, which may increase the construction period. It may also have greater impacts on views within Makalapa Crater from historic housing areas than the Preferred Alternative. Because of its greater cost, ground disturbance, and potentially greater cultural impacts, it is not the Navy's Preferred Alternative. This alternative meets project objectives and screening criteria and is considered a reasonable alternative.

Alternatives Considered but Dismissed from Further Consideration: The following alternatives were considered, but not carried forward for detailed analysis in this EA because they do not meet the purpose and need for the project and satisfy the reasonable alternative screening factors:

- Renovation of existing JIOC facilities
- Renovate existing Makalapa Compound facilities and construct new annex
- New construction at alternate sites
- Lease

Environmental Effects: No significant direct, indirect, or cumulative environmental impacts would occur from implementing the Proposed Action. Because their potential impacts were considered negligible or nonexistent, the following resources were not evaluated in detail in this EA: airspace and socioeconomics. Potential environmental impacts on transportation, air quality and greenhouse gases, water resources, geological resources, visual resources, cultural resources, biological resources, land use, noise, infrastructure, public health and safety, hazardous materials and wastes and environmental justice are summarized here.

Transportation: The Proposed Action would result in less than significant impacts to transportation during the construction or operational periods. During the construction period, there may be temporary impacts to traffic volumes on roadways immediately surrounding the Makalapa Compound and offsite sewer project areas as well as roadways leading to the two entrances to Makalapa Compound, as construction vehicles, equipment, and workers access the project area. During the operational period, analyses using conservative assumptions and factors that are currently in flux indicated that project-related traffic volumes could result in over capacity conditions (i.e., from Level of Service D to Level of Service F). Suggested mitigation measures (i.e., traffic signal modifications and lane striping), if needed, would result in less than significant impacts if the conservative volumes are reached; timing and the ultimate need should be re-evaluated closer to project occupancy. Therefore, no mitigation measures are proposed for implementation at this time. Tandem manual processing of driver credentials at Luapele Gate would be considered if gate operations result in extended queues or delays in the future. There would be no operational period traffic impacts at the off-site sewer improvement areas because the infrastructure would not generate additional vehicle trips.

Air Quality and Greenhouse Gases: The Proposed Action would result in insignificant air quality impacts in the construction and operational periods. Additional emissions associated with the Proposed Action were assessed to estimate project impacts and found to continue to be within federal and state standards at the intersections studied. Because the State of Hawaii is in attainment of the National Ambient Air Quality Standards, the Proposed Action is

not subject to the Clean Air Act's General Conformity Rule. Greenhouse gas emissions during the construction and operational periods were estimated to be well below the CEQ's threshold of 25,000 metric tons per year.

Water Resources: The Proposed Action would result in insignificant impacts to water resources. The use of construction best management practices (BMPs) would minimize soil erosion and runoff and avoid adverse impacts to surface water and marine resources. During the operational period, there would be no net increase in off-site runoff. The project's low impact development strategies, such as vegetated bioswales, would manage stormwater in an environmentally friendly manner. The off-site sewer improvements would reduce the risk of failure of the segments of the sewer system that would be replaced or upgraded, and subsequently reduce the risk of spills that could pollute receiving waters or groundwater.

Geological Resources: The Proposed Action would result in insignificant construction period impacts to geological resources with the implementation of BMPs and soil remediation for foundation preparation. Operation of the JIOC facility is not expected to increase soil erosion or stormwater runoff, or have other impacts to geological resources. Operation of the proposed offsite sewer improvements would be via below grade lines and would not have ongoing effects on soil conditions.

Visual Resources: The Proposed Action would have less than significant construction period and operational period impacts as new facility would generally not be visible from offsite locations and would not impede distant views of the Koolau range and Red Hill from important view points within the crater.

Cultural Resources: The Proposed Action would have no impacts to cultural resources during project construction or operation. The DON determined that the Proposed Action would have no effect on historic properties under National Historic Preservation Act. The Proposed Action would not impact traditional Hawaiian (or other ethnic group's) rights related to gathering, access, or other customary activities exercised for subsistence, cultural, and religious purposes. No historic properties would be left unoccupied as a result of the Proposed Action.

Biological Resources: The Proposed Action would result in less than significant construction or operational period impacts to biological resources. The Navy conducted informal consultation with the U.S. Fish and Wildlife Service (USFWS) pursuant to Section 7(a)(2) of the ESA for the Proposed Action and developed a Biological Evaluation to assess the potential impacts to threatened and endangered species. The Navy determined that the Proposed Action may affect, but is not likely to adversely affect ESA-listed species potentially occurring within the project area (e.g., endangered Hawaiian hoary bat, Hawaiian stilt, Hawaiian petrel, Hawaiian DPS of the band-rumped storm petrel, or the threatened Newell's Townsend's shearwater). By letter dated September 22, 2021, the USFWS concurred with the Navy's determination.

Land Use: The Proposed Action would result in less than significant impacts to land use. The Proposed Action is compatible with surrounding land uses and adopted DON development plans and is expected to have insignificant coastal effects. It is considered a de minimis activity under the Coastal Zone Management Act and is not subject to further review by the Hawaii Coastal Zone Management Program (CZMP). The State CZMP office was advised by electronic mail on February 8, 2022 of the Navy's usage of the De Minimis Activity List and the preparation of an EA; it acknowledged receipt of the Navy's notification on the same day.

Noise: The Proposed Action would result in less than significant impacts to the noise environment during the construction or operational periods. Construction of the Proposed Action would generate noise associated with the use of ground clearing and site preparation equipment, and construction vehicles, equipment, and tools. Results of planning level assessment of construction noise impacts estimated the combined sound from the simultaneous operation of the loudest equipment (i.e., pile driving) to be about 53 decibels (dB) at the noise-sensitive locations nearest to the Makalapa Compound project area, which could be perceived as "quiet," similar to sound levels in a busy office. Family housing areas, Hickam Elementary School, and Pearl Harbor Kai Elementary School would be exposed to temporary construction period noise along South Avenue and Center Drive from the offsite sewer improvements. Construction activities would proceed along the relief sewer line routes, therefore reducing the noise

exposure for any one location as the noise source moves along the construction route. Noise control measures such as temporary noise barriers and avoidance of nighttime operations would be considered and implemented—as appropriate—to minimize adverse impacts at the noise sensitive receptors. During the operational period, there would be less than significant noise impacts due to the shifting of vehicle transportation routes from Borchers Gate (via Kamehameha Highway) to Luapele Gate (via Salt Lake Boulevard), with a corresponding shift in noise impacts associated with roadway traffic. The Proposed Action would result in no noise impacts from the offsite sewer improvements because the new infrastructure would operate below grade.

Infrastructure: The Proposed Action would result in less than significant construction or operational period impacts to infrastructure. Construction of the required utility system improvements within Makalapa Crater or the offsite sewer improvement areas would require little to no temporary disruption to existing service during the construction period. During the operational period, proposed improvements to the water distribution system at JBPHH Makalapa Compound would provide adequate flow and pressure to the new JIOC facility, including for fire flow. Incorporation of high efficiency plumbing fixtures would minimize potable water demand and water usage would be subject to smart metering. With implementation of planned sewer improvements associated with the Proposed Action, the Navy's wastewater system would have adequate capacity to accommodate the Preferred Alternative. The surface detention system would provide the required stormwater storage to limit discharge from the site to pre-development levels. Low impact development strategies (e.g., vegetated swales and water quality units) would reduce the quantity and improve the quality of stormwater flows that eventually reach receiving waters. The Proposed Action would not use a substantial proportion of the remaining overall potable water, wastewater, or stormwater system capacity or require development of facilities and sources beyond those currently planned.

Public Health and Safety: The Proposed Action would result in less than significant construction or operational period impacts to public health and safety. Construction Management Plans that include public safety measures would be implemented to ensure the public is not exposed to construction site hazards. Hazards to personnel in or adjacent to construction zones would be avoided or minimized through the use of standard operating procedures and BMPs in accordance with applicable federal and state regulations. Construction sites that are located within the entry-controlled installation boundaries would prevent public access. Access to the offsite sewer improvement construction areas would be controlled and open trenches covered at the end of each work day. Due to the secured premises and administrative nature of the activities that would take place in the new JIOC, the Navy has determined that there are no environmental health and safety risks associated with the Proposed Action that would disproportionately affect children.

Hazardous Materials and Wastes: The Proposed Action would result in less than significant impacts involving hazardous materials and wastes. If hazardous materials or waste are encountered during the construction period, they would be handled, transported, disposed of and/or remediated in accordance with applicable federal and state regulations and procedures. Limited quantities of hazardous materials and wastes typical of operating and maintaining an administrative-type facility would be stored, used, and or generated during the operational period (e.g., diesel fuel for the emergency generator, cleaning products). All operational period hazardous materials, wastes, and special hazards associated with the new facility would be transported, stored, handled, and disposed of in accordance with federal and state regulations.

Environmental Justice: The Proposed Action would result in less than significant construction and operational period impacts to air quality, water resources, noise, transportation, public health and safety, or hazardous materials and wastes. Therefore, implementation of the Proposed Action would not cause disproportionately high and adverse human health or environmental effects on any minority or low-income populations.

Mitigation Measures: The Proposed Action will include the implementation of a range of BMPs and impact avoidance and minimization measures to limit potential impacts to environmental resources (See Tables 2-2 and 3-18 in the EA). Therefore, the Proposed Action will not result in significant impacts to environmental resources and no mitigation measures are proposed.

FINDING OF NO SIGNIFICANT IMPACT FOR THE JOINT INTELLIGENCE OPERATIONS CENTER AT JOINT BASE PEARL HARBOR-HICKAM (JBPHH), MAKALAPA COMPOUND, OAHU, HAWAII

Public Outreach: The DON released the Draft EA for a 21-day public review from July 21, 2022 through August 10, 2022 to inform the public of the Proposed Action and to allow the opportunity for public review and comment A notice of availability of the Draft EA was published in the Honolulu Star Advertiser on July 21, 22, and 24, 2022, and the Draft EA was made available at the Naval Facilities Engineering Systems Command, Pacific webpage, as well as at the State of Hawaii Environmental Review Program webpage. No public comments were received on the Draft EA during the public comment period

Finding:

Based on the analysis presented in the EA, which has been prepared in accordance with the requirements of NEPA and DON policies and procedures (32 CFR Part 775), DON finds that implementation of the proposed action as set out in Alternative 1 (Preferred Alternative) will not significantly impact the quality of the human environment. This analysis fulfills the requirement of NEPA and CEQ regulations; therefore an EIS will not be prepared.

Electronic copies of this EA and Finding of No Significant Impact may be downloaded from the websites identified above.

28DEC22
Date

S.D. Barnett
Stephen D. Barnett
Rear Admiral, U.S. Navy
Commander, Navy Region Hawaii

Abstract

Designation:	Environmental Assessment
Title of Proposed Action:	Joint Intelligence Operations Center
Project Location:	Joint Base Pearl Harbor-Hickam, Makalapa Compound
Lead Agency for the EA:	Department of the Navy
Affected Region:	Honolulu, Hawaii
Action Proponent:	Joint Base Pearl Harbor-Hickam
Point of Contact:	NAVFAC Pacific 258 Makalapa Drive, Suite 100 JBPHH, HI 96860-3134 Attn: EV21 Project Manager JIOC EA
Date:	August 2022

Joint Base Pearl Harbor-Hickam (JBPHH), a Command of the U.S. Navy (hereinafter, jointly referred to as the Navy) has prepared this Environmental Assessment in accordance with the National Environmental Policy Act, as implemented by the Council on Environmental Quality Regulations and Navy regulations for implementing the National Environmental Policy Act. The Proposed Action would construct an administrative facility to consolidate the U.S. Indo-Pacific Command (USINDOPACOM) Joint Intelligence Operations Center (JIOC) at JBPHH Makalapa Compound. The JIOC facility would be a multi-story, approximately 172,000-square-foot building. The Proposed Action would also construct supporting infrastructure and facilities (e.g., parking, stormwater detention facility, sanitary sewer lift station, and offsite sewer improvements). Project construction is anticipated to begin in 2026, with construction completed in 2030. This Environmental Assessment evaluates the potential environmental impacts associated with the two action alternatives, JIOC Facility-North (Preferred Alternative) and JIOC Facility-South, and the No Action Alternative on the following environmental resources or components concern: transportation, air quality, water resources, geological resources, visual resources, cultural resources, biological resources, land use, noise, infrastructure, public health and safety, hazardous materials and waste, and environmental justice.

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EXECUTIVE SUMMARY

ES.1 Proposed Action

Joint Base Pearl Harbor-Hickam (JBPHH) proposes to construct an administrative facility to consolidate the United States Indo-Pacific Command (USINDOPACOM) Joint Intelligence Operations Center (JIOC) at JBPHH Makalapa Compound. The Proposed Action would include a new operations building along with supporting infrastructure and facilities. Project construction is anticipated to begin in 2026 with construction completed in 2030.

ES.2 Purpose of and Need for the Proposed Action

The purpose of the Proposed Action is to provide an administrative facility for USINDOPACOM JIOC that meets current and anticipated facility requirements at JBPHH and improves its ability to carry out its mission. This includes providing adequate space and optimizing internal layouts and organizational functional relationships. The purpose is also to consolidate geographically dispersed functions and personnel in order to improve integration among JIOC organizations and ultimately their support of USINDOPACOM's mission.

The Proposed Action would improve JIOC's ability to expand, adapt and integrate new technologies in support of mission requirements. The Proposed Action is needed to improve the integration and close collaboration required to support operations by collocating JIOC functions and personnel at a new facility. Accommodating new technologies and collocating personnel are needed to more capably support national, strategic, and operational requirements.

ES.3 Alternatives Considered

Alternatives were developed for analysis based upon the following reasonable alternative screening factors: meets the purpose and need for the Proposed Action, meets physical siting and mission requirements of JIOC, distance from USINDOPACOM and PACFLT headquarters, availability of site, adequate land area to consolidate dispersed JIOC functions in one facility, availability of utilities and supporting infrastructure, minimization of physical vulnerabilities, and minimization of existing facility/function displacement. The Navy is considering two action alternatives that meet the purpose of and need for the Proposed Action, as well as a No Action Alternative. Alternative 1 (Preferred Alternative) would construct an approximately 172,000-square-foot facility on an approximately 15-acre site located at JBPHH Makalapa Compound. Alternative 2 is the same as Alternative 1 except that the proposed new JIOC facility and supporting infrastructure would be constructed at a site approximately 700 feet south of the Preferred Alternative site. The components of Alternative 2 would be of similar size and function as in the Preferred Alternative with differences in the parking lot configuration and a below-grade stormwater detention facility. Under the No Action Alternative, a new consolidated JIOC facility would not be constructed and JIOC operations would continue to be conducted in seven separate buildings separated by a distance of several miles.

ES.4 Summary of Environmental Resources Evaluated in the EA

Council on Environmental Quality regulations, National Environmental Policy Act, and Navy instructions for implementing the National Environmental Policy Act specify that an Environmental Assessment (EA)

should address those resources potentially subject to impacts. In addition, the level of analysis should be commensurate with the anticipated level of environmental impact.

The following environmental resources or components have been addressed in this EA: transportation, air quality, land use, cultural resources, biological resources, geological resources, water resources, infrastructure, public health and safety, hazardous materials and wastes, noise, visual resources, and environmental justice.

The following regulated resources (e.g., that require mitigation measures, consultations, and concurrence) were analyzed in this EA: wetlands, threatened and endangered species/habitat, protected migratory birds, historic properties eligible for listing on the National Register of Historic Places, and the coastal zone.

Because potential impacts were considered negligible or nonexistent, the following were not evaluated in this EA: airspace and socioeconomics.

ES.5 Summary of Potential Environmental Consequences of the Action Alternatives and Major Mitigating Actions

Table ES-1 provides a tabular summary of the potential impacts to the resources associated with each of the alternative actions analyzed.

ES.6 Public Involvement

The Department of the Navy has coordinated with the State of Hawaii Department of Transportation and City and County of Honolulu Department of Planning and Permitting and has consulted with the State Historic Preservation Officer and U.S. Fish and Wildlife Service in the preparation of this EA. In addition, notices of the availability of the Draft EA were published in the Honolulu Star Advertiser (a newspaper with statewide circulation) and the State of Hawaii Environmental Review Program's (formerly the Office of Environmental Quality Control [OEQC]) The Environmental Notice. The Draft EA was made available through a Navy webpage and the State Environmental Review Program's webpage for public review.

Table ES-1 Summary of Potential Impacts to Resource Areas

Environmental Resource or Component	*No Action Alternative*	*JIOC Facility-North Alternative (Preferred Alternative)*	*JIOC Facility-South Alternative*
Transportation	No impact	Less than significant temporary construction period impacts on roadways leading to project area. Operational period impacts at Salt Lake Boulevard-Kahuapaani Street intersection due in part to shifting of traffic volumes from Borchers Gate to Luapele Gate. Analyses using conservative assumptions and factors that are currently in flux indicated that project-related traffic volumes could result in over capacity conditions (i.e., from LOS D to LOS F). Suggested mitigation measures (i.e., traffic signal modifications and lane striping), if needed, would result in less than significant impacts if the conservative volumes are reached (timing and ultimate need should be re-evaluated closer to project occupancy). Therefore, no mitigations are proposed for implementation at this time. Tandem manual processing of driver credentials at Luapele Gate would be considered if gate operations result in extended queues or delays in the future.	Same less than significant impacts as in the Preferred Alternative.
Air Quality	No impact	Less than significant impacts during construction due to equipment exhaust, ground disturbance and possible traffic congestion. Less than significant operational period impacts from relocated vehicle trips to JBPHH Makalapa Compound.	Similar less than significant impacts as in the Preferred Alternative (minor additional construction period emissions due to greater ground disturbance needed for below-grade stormwater detention facility).
Water Resources	No impact	Less than significant construction and operational period impacts with implementation of construction BMPs.	Same less than significant impacts as the Preferred Alternative
Geological Resources	No impact	Less than significant temporary construction period impacts with implementation construction BMPs and soil remediation. Less than significant operational period impacts.	Similar less than significant impacts as in the Preferred Alternative (slightly greater ground disturbance due to the below-grade stormwater detention facility)

Environmental Resource or Component	*No Action Alternative*	*JIOC Facility-North Alternative (Preferred Alternative)*	*JIOC Facility-South Alternative*
Visual Resources	No impact	Less than significant construction period and operational period impacts as new facility would generally not be visible from offsite locations and would not impede distant views of the Koolau range and Red Hill from important view points within the crater.	Less than significant construction and operational period impacts similar to Preferred Alternative; however, more visible than Preferred Alternative from Makalapa Navy Housing Historic District.
Cultural Resources	No impact	No impacts, as Preferred Alternative results in no historic properties affected determination and would not impact traditional Hawaiian (or other ethnic group's) rights related to gathering, access, or other customary activities exercised for subsistence, cultural, and religious purposes. No historic properties would be left unoccupied.	No impacts (same as Preferred Alternative).
Biological Resources	No impact	Less than significant construction or operational period impacts as the Preferred Alternative may affect, but is not likely to adversely affect, biological resources (including listed species) with implementation of BMPs and conservation measures.	Less than significant impacts similar to Preferred Alternative; about five percent larger area of vegetation to be removed within Makalapa Crater than in the Preferred Alternative.
Land Use	No impact	Less than significant impacts. Action is compatible with surrounding land uses and adopted DON development plans and is expected to have insignificant coastal effects. It is considered a de minimis activity under the Coastal Zone Management Act and is not subject to further review by the Hawaii Coastal Zone Management program.	Same less than significant impacts as in the Preferred Alternative
Noise	No impact	Less than significant impacts during the construction period with implementation of BMPs. Less than significant operational period impacts.	Same less than significant impacts as in the Preferred Alternative
Infrastructure	No impact	Less than significant impacts during the construction and operational periods. The proposed on- and offsite sewer improvements	Same less than significant impacts as in the Preferred Alternative

Environmental Resource or Component	*No Action Alternative*	*JIOC Facility-North Alternative (Preferred Alternative)*	*JIOC Facility-South Alternative*
		would provide adequate wastewater capacity for Proposed Action.	
Public Health and Safety	No impact	Less than significant construction and operational period impacts. No increased environmental health and safety risks that would disproportionately affect children.	Same less than significant impacts as in the Preferred Alternative
Hazardous Materials and Wastes	No impact	Less than significant construction and operational period impacts.	Same less than significant impacts as in the Preferred Alternative
Environmental Justice	No impact	Less than significant impacts during the construction and operational periods with no disproportionately high and adverse human health or environmental effects on any minority or low-income populations.	Same less than significant impacts as in the Preferred Alternative

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Final Environmental Assessment

JOINT INTELLIGENCE OPERATIONS CENTER

Joint Base Pearl Harbor-Hickam, Hawaii

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Abbreviations and Acronyms

Acronym	Definition
AAQS	ambient air quality standards
ACM	asbestos-containing material
ADP	Area Development Plan
AICUZ	Air Installation Compatible Use Zone
ALISH	Agricultural Lands of Importance in the State of Hawaii
APE	Area of Potential Effect
APZ	Accident Potential Zone
ATFP	Antiterrorism Force Protection
BMP	best management practice
CAA	Clean Air Act
CAFE	corporate average fuel economy
Camp Smith	Camp H.M. Smith
CATV	cable television
CCH	City and County of Honolulu
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CLA	Cultural Landscape Assessment
CLR	Cultural Landscape Report
CO	carbon monoxide
CO_2	carbon dioxide
COPC	contaminants of potential concern
CR	Coral Outcrop
CRB	Coconut Rhinoceros Beetle
CWA	Clean Water Act
CY	calendar year
CZMA	Coastal Zone Management Act
dB	decibel
dBA	A-weighted sound level
DBEDT OP	Department of Business, Economic Development and Tourism Office of Planning
DERP	Defense Environmental Restoration Program
DLNR	Department of Land and Natural Resources
DNL	day-night average sound level
DoD	United States Department of Defense
DON	United States Department of the Navy
EA	Environmental Assessment
ECF	entry control facility
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FHWA	Federal Highways Administration
FPPA	Farmland Protection Policy Act
FY	fiscal year
GHG	greenhouse gas
GSF	gross square feet
H_2S	hydrogen sulfide
HAP	hazardous air pollutant
HAR	Hawaii Administrative Rules

Acronym	Definition
HART	Honolulu Authority for Rapid Transportation
HECO	Hawaiian Electric Company
HCEI	Hawaii Clean Energy Initiative
HDOH	State of Hawaii Department of Health
HDOT	State of Hawaii Department of Transportation
HDOT	State of Hawaii Department of Transportation Airports Division
HRS	Hawaii Revised Statutes
HRTP	Honolulu Rail Transit Project
HUD	U.S. Department of Housing and Urban Development
Hz	Hertz
ICRMP	Integrated Cultural Resources Management Plan
IDP	Installation Development Plan
INRMP	Integrated Natural Resources Management Plan
ISWMP	Integrated Solid Waste Management Plan
JBPHH	Joint Base Pearl Harbor-Hickam
JIOC	Joint Intelligence Operations Center
kV	kilovolt(s)
LBP	lead based paint
LED	light emitting diode
LEED	Leadership in Energy and Environmental Design
Leq	equivalent sound level
Leq(9hr)	9 hour equivalent sound level
Leq(24)	24 hour equivalent sound level
Lmax	maximum A-weighted sound level
LOS	level of service
LSB	Land Study Bureau
LUO	Land Use Ordinance
MBTA	Migratory Bird Treaty Act
MEC	munitions and explosives of concern
mgd	million gallons per day
MILCON	Military Construction Project
MMPA	Marine Mammal Protection Act
MPPEH	material potentially presenting an explosive hazard
MSAT	Mobile Source Air Toxics
MSL	mean sea level
NAAQS	National Ambient Air Quality Standards
NASED	New Aloha Stadium Entertainment District
NAVFAC PAC	Naval Facilities Engineering Command, Pacific
NEPA	National Environmental Policy Act
NGIS	Navy Gateways Inns and Suites
NHPA	National Historic Preservation Act
NHL	National Historic Landmark
NIOSH	National Institute for Occupational Safety and Health
NIPTS	Noise Induced Permanent Threshold Shift
NO_2	nitrogen dioxide

Acronym	Definition
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
Oahu MPO	Oahu Metropolitan Planning Organization
OEQC	Office of Environmental Quality Control
OPNAVINST	Office of the Chief of Naval Operations Instruction
PACFLT	U.S. Pacific Fleet
PAH	polynuclear aromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyl
PDEIS	Programmatic Draft Environmental Impact Statement
PHNC	Pearl Harbor Naval Complex
PHNHL	Pearl Harbor National Historic Landmark
PHNSY & IMF	Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility
PM_{10}	particulate matter less than or equal to 10 microns in diameter
$PM_{2.5}$	particulate matter less than or equal to 2.5 microns in diameter
POV	privately owned vehicle
ppm	parts per million
PUC	Primary Urban Center
PUC DP	Primary Urban Center Development Plan
RAICUZ	Range Air Installation Compatible Use Zone
RCRA	Resource Conservation and Recovery Act
ROI	region of influence
ROICC	Regional Officer In Charge of Construction
ROW	right-of-way
SEL	sound exposure level
sq ft	square foot (feet)
SHPO	State Historic Preservation Officer
SIHP	State Inventory of Historic Places
SIP	State Implementation Plan
SO^2	sulfur dioxide
SMA	Special Management Area
TCP	Traditional Cultural Property
TMDL	Total Maximum Daily Load
TOC	total organic compounds
TOD	transit-oriented development
TSCA	Toxic Substances Control Act
tpy	tons per year
U.S.	United States
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USINDOPACOM	United States Indo-Pacific Command
VMT	vehicle miles traveled

Acronym	Definition	Acronym	Definition
VOC	volatile organic compound		
vph	vehicles per hour		

1 Purpose of and Need for the Proposed Action

1.1 Introduction

Joint Base Pearl Harbor-Hickam (JBPHH), a Command of the United States (U.S.) Navy (hereinafter, jointly referred to as the Navy), proposes to construct an administrative facility to consolidate the United States Indo-Pacific Command (USINDOPACOM) Joint Intelligence Operations Center (JIOC) at JBPHH Makalapa Compound (see Figure 1-1 for Location Map). Construction is anticipated to begin in 2026 and be completed in 2030. Facility occupancy and use would follow in 2032, after installation of furniture, fixtures, and equipment.

The Navy has prepared this Environmental Assessment (EA) in accordance with the National Environmental Policy Act (NEPA), as implemented by the Council on Environmental Quality (CEQ) Regulations and Navy regulations for implementing NEPA.

1.2 Background

Currently operating in seven buildings within JBPHH and Marine Corps Base Hawaii's Camp H.M. Smith (Camp Smith), USINDOPACOM JIOC is faced with space, utility, and infrastructure constraints (see Figure 1-1 for locations of existing JIOC facilities). In 2010, a Basic Facilities Requirements assessment documented a substantial unmet space requirement for USINDOPACOM JIOC. Starting in the 2010 timeframe, the Department of the Navy (DON) investigated alternatives for maximizing efficiencies of internal operations and joint operations with USINDOPACOM staff, component commands, and forward deployed forces. It also evaluated alternatives for providing adequate facility space to meet existing and anticipated future operational requirements. The evaluation effort assessed 16 alternative locations and scenarios on Oahu. Based on facility requirements and screening factors identified during the evaluation process, the analyses recommended new construction at JBPHH Makalapa Compound to meet the requirements of JIOC. (Note: The term "Makalapa Crater" is also used in this document when referring to the physical landform versus the DON installation).

Following the initial analyses, JIOC submitted a Preliminary Site Approval application to construct a new JIOC facility in Makalapa Compound on one of two potential sites identified for future development in the 2013 Makalapa Area Development Plan (ADP) (*Installation Development Plan for Joint Base Pearl Harbor-Hickam,* Volume I*)*. In 2015, the DON evaluated the two potential new construction sites along with expansion of JIOC's existing facilities in Makalapa Compound. The two new construction alternatives included a site at the north end of Makalapa Crater floor and a site approximately 0.25 miles to the south. Expansion of existing Makalapa facilities was concluded to be nonviable due to disruption of operations during project implementation and the likelihood that such expansion would not meet physical siting criteria. The DON concluded that new construction at the north end of the Makalapa Crater floor best met JIOC's operational and facility requirements for upgraded and consolidated facilities. The north Makalapa site is the Navy's preferred alternative and this EA includes analysis of both Makalapa alternative sites.

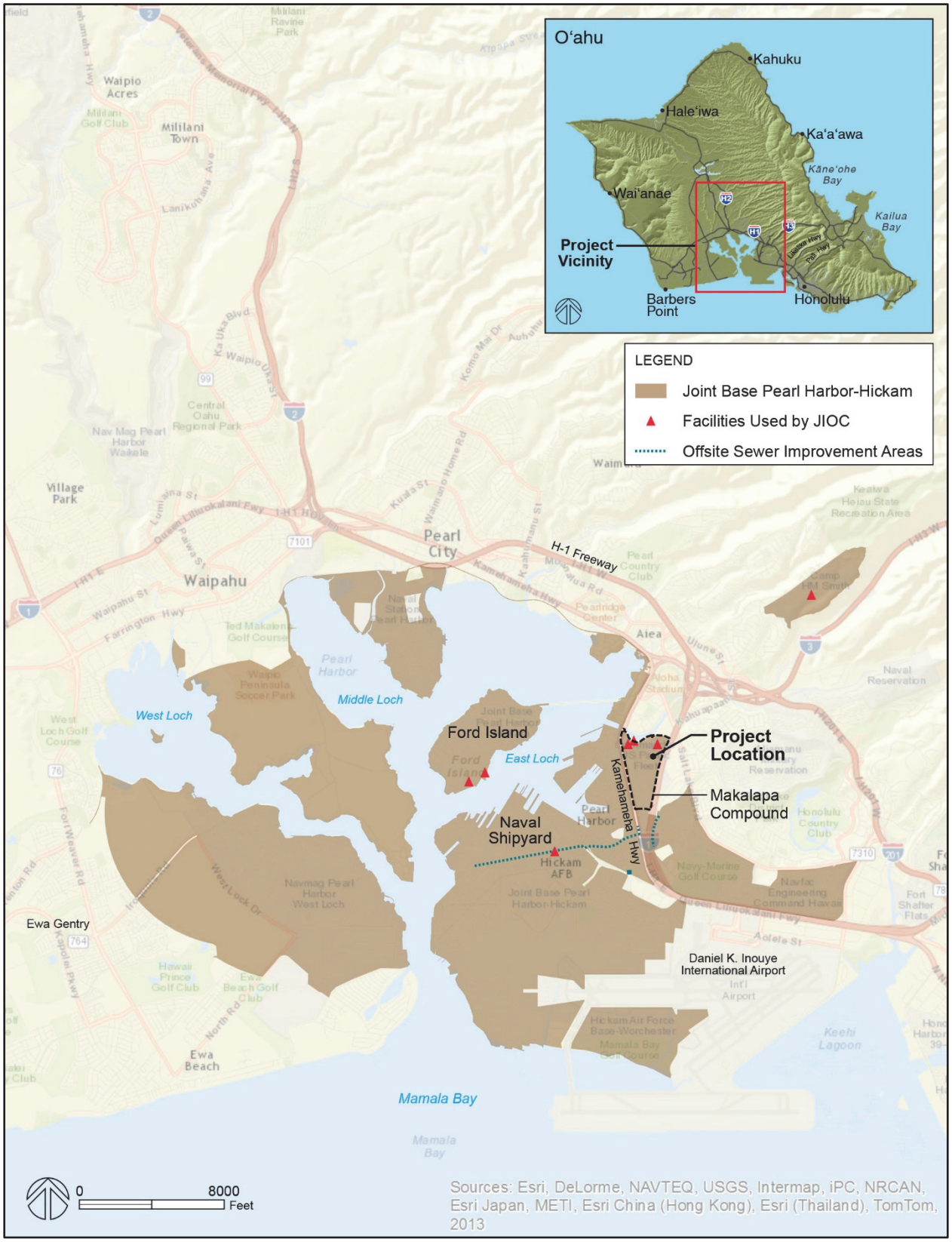

Figure 1-1 Location Map

Several offsite sewer system improvements are required to support operations at the proposed new JIOC facility (see Figure 1-1). The proposed improvements would be made to existing Department of Defense (DoD)-owned infrastructure or within DoD-controlled lands in and around JBPHH.

1.3 Location

Located within the Hawaiian archipelago on the southern, central, and western areas of the island of Oahu, JBPHH encompasses approximately 28,000 acres of land and water, and includes significant land holdings at the main base, West Loch Annex, Pearl City Peninsula, Waipio Peninsula, and other outlying areas (Figure 1-1). In 2010, Naval Station Pearl Harbor joined with Hickam Air Force Base to become JBPHH, combining the two bases into a single joint installation to support both U.S. Air Force (USAF) and DON missions in the Pacific. JBPHH serves as the home base for USAF air wings and DON surface ship and submarine squadrons, and is a regional maintenance center for ships and submarines. The main base is host to Commander U.S. Pacific Fleet (PACFLT) and the Headquarters Pacific Air Forces. In addition, JBPHH hosts over 100 tenant commands that support the DON, USAF, and other missions in Hawaii and the Pacific.

Joint Base Pearl Harbor-Hickam, Makalapa Compound is a triangular district located directly east of and noncontiguous to JBPHH Main Base across Kamehameha Highway (see Figure 1-2). It is bordered by Halawa Stream to the north, H-1 Freeway to the east, and Kamehameha Highway to the west. Its prominent features are the steep slopes along its north, west, and south sides that create a rim around a large, flat inner expanse of about 79 acres.

1.4 Purpose of and Need for the Proposed Action

The purpose of the Proposed Action is to provide an administrative facility for USINDOPACOM JIOC that meets current and anticipated facility requirements at JBPHH and improves its ability to carry out its mission. This includes providing adequate space and optimizing internal layouts and organizational functional relationships. The purpose is also to consolidate geographically dispersed functions and personnel in order to improve integration among JIOC organizations and ultimately their support of USINDOPACOM's mission.

The Proposed Action is needed because JIOC's existing facilities – all shared with other facility users - do not allow the flexibility to accommodate evolving technologies. In addition, due to a planned increase in mission command requirements, JIOC is anticipated to operate at a 40 percent space deficit in its current facilities by 2026. The Proposed Action would improve JIOC's ability to expand, adapt and integrate new technologies in support of mission requirements. Many of JIOC's current work spaces were initially constructed in the 1940s and are not functionally-suited or readily adaptable to a modern, technologically-driven work environment. Furthermore, the facilities and personnel are spread over a four-mile distance. The Proposed Action is needed to improve the integration and close collaboration required to support operations by collocating dispersed JIOC functions and personnel at a new facility. Accommodating new technologies and collocating personnel are needed to more capably support national, strategic, and operational requirements.

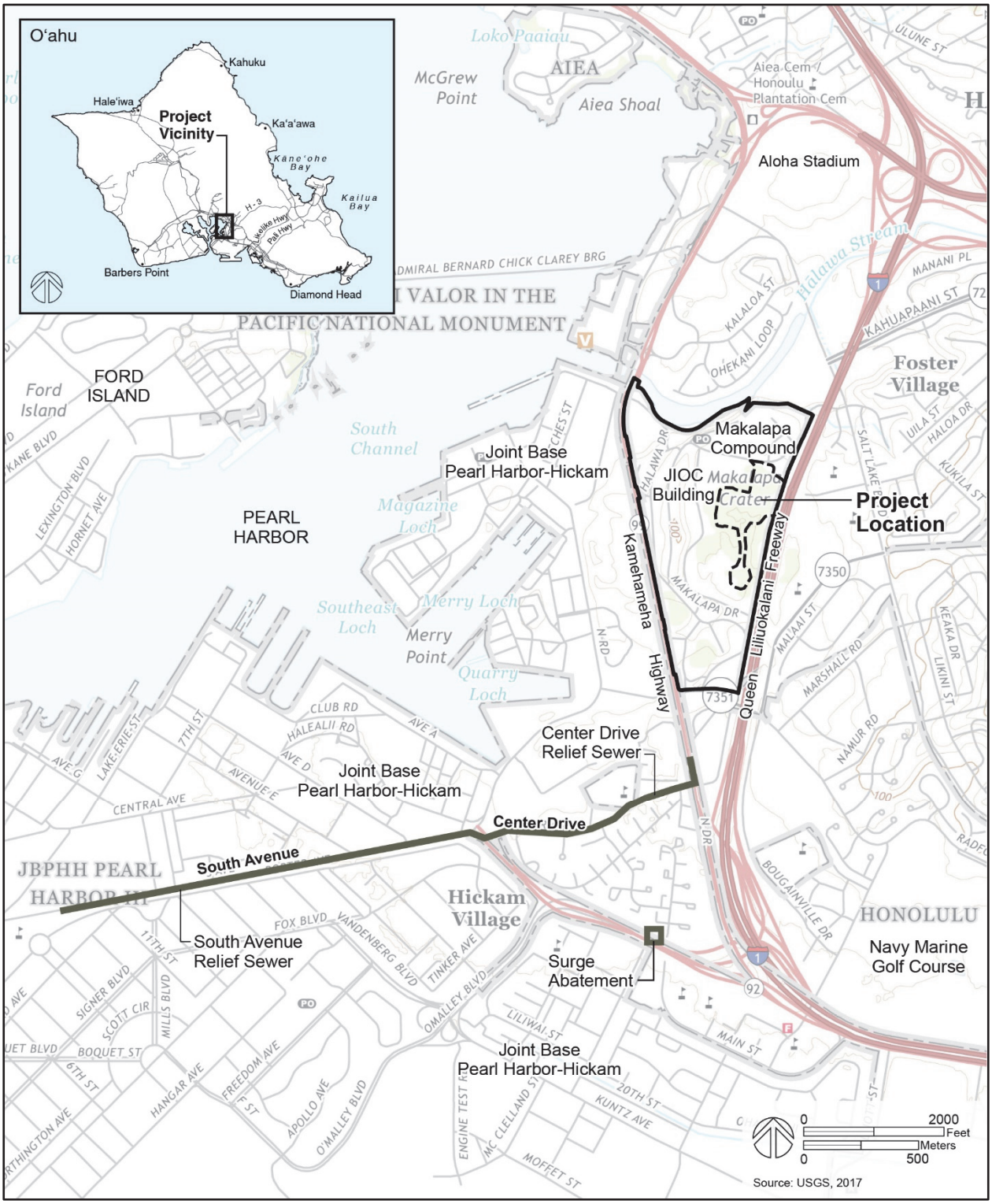

Figure 1-2 Vicinity Map

1.5 Scope of Environmental Analysis

This EA includes an analysis of potential environmental impacts associated with the action alternatives and the No Action Alternative. The environmental resources and concerns analyzed in this EA include: transportation, air quality, water resources, geological resources, visual resources, cultural resources, biological resources, land use, noise, infrastructure, public health and safety, hazardous materials and waste, and environmental justice. The study area for each resource analyzed may differ due to how the Proposed Action interacts with or impacts the resource. For instance, the study area for geological resources may only include the construction footprint of a building whereas a noise study area could expand to include areas that may be impacted by construction, aircraft or firing range noise, as applicable.

1.6 Key Documents

Key documents are sources of information incorporated into this EA. Documents are considered to be key because of similar actions, analyses, or impacts that may apply to this Proposed Action. CEQ guidance encourages incorporating documents by reference. Documents incorporated by reference in part or in whole include:

- Traffic Impact Analysis Report P-079 JIOC Facility, 2022. Evaluates potential traffic impacts on surrounding transportation facilities resulting from Military Construction Project (MILCON) P-079 project and identifies measures potentially needed to mitigate potential adverse impacts.
- Air Quality Study for the Navy Joint Intelligence Operations Center, 2019. Assesses air quality impacts resulting from MILCON P-079 JIOC project.

1.7 Relevant Laws and Regulations

The Navy has prepared this EA based upon federal and state laws, statutes, regulations, and policies pertinent to the implementation of the Proposed Action, including the following:

- National Environmental Policy Act (NEPA) (42 United States Code [U.S.C.] sections 4321–4370h), which requires an environmental analysis for major federal actions that have the potential to significantly impact the quality of the human environment
- Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations parts 1500–1508) (1978, as amended in 1986 and 2005)
- Navy regulations for implementing NEPA (32 Code of Federal Regulations part 775), which provides Navy policy for implementing Council on Environmental Quality regulations and NEPA
- Clean Air Act (42 U.S.C. section 7401 et seq.)
- Clean Water Act (33 U.S.C. section 1251 et seq.)
- Coastal Zone Management Act (16 U.S.C. section 1451 et seq.)
- National Historic Preservation Act (54 U.S.C. section 306108 et seq.)
- Endangered Species Act (16 U.S.C. section 1531 et seq.)
- Migratory Bird Treaty Act (16 U.S.C. section 703–712)
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 U.S.C. section 9601 et seq.)

- Emergency Planning and Community Right-to-Know Act (42 U.S.C. sections 11001–11050)
- Resource Conservation and Recovery Act (42 U.S.C. section 6901 et seq.)
- Toxic Substances Control Act (15 U.S.C. sections 2601–2629)
- Executive Order (EO) 11988, Floodplain Management
- EO 12088, Federal Compliance with Pollution Control Standards
- EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations
- EO 13045, Protection of Children from Environmental Health Risks and Safety Risks
- EO 13990, Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis
- EO 14008, Tackling the Climate Crisis at Home and Abroad
- EO 14057, Catalyzing America's Clean Energy Economy Through Federal Sustainability

A description of the Proposed Action's consistency with relevant laws, policies, and regulations, as well as their status of compliance, is presented in Chapter 5 (Table 5-1).

1.8 Public and Agency Participation and Intergovernmental Coordination

Regulations from the Council on Environmental Quality direct agencies to involve the public in preparing and implementing their NEPA procedures. The DON has coordinated with the State of Hawaii Department of Transportation and City and County of Honolulu Department of Planning and Permitting and has consulted with the State Historic Preservation Officer and the U.S. Fish and Wildlife Service in the preparation of this EA. In addition, notices of the availability of the Draft EA were published in the Honolulu Star Advertiser (a newspaper with statewide circulation) and the State of Hawaii Environmental Review Program's (formerly the Office of Environmental Quality Control [OEQC]) *The Environmental Notice*. The Draft EA was made available for public review through a Navy webpage and the State Environmental Review Program's webpage.

2 Proposed Action and Alternatives

2.1 Proposed Action

Joint Base Pearl Harbor-Hickam proposes to construct an administrative facility to consolidate USINDOPACOM JIOC at JBPHH Makalapa Compound. The Proposed Action would include a new operations building along with supporting infrastructure and facilities. Project implementation is anticipated to begin in 2026 with construction completed in 2030. Facility occupancy and use would follow in 2032 after installation of furniture, fixtures, and equipment.

2.2 Screening Factors

NEPA's implementing regulations provide guidance on the consideration of alternatives to a federally proposed action and require rigorous exploration and objective evaluation of reasonable alternatives. Only those alternatives determined to be reasonable and to meet the purpose and need require detailed analysis.

Potential alternatives were evaluated against the following screening factors:

1. Meets the purpose and need for the Proposed Action
2. Meets physical siting and mission requirements of JIOC
3. Distance from USINDOPACOM and PACFLT headquarters (priority of locations: 1) Camp Smith, 2) Makalapa, 3) JBPHH Main Base)
4. Availability of site (competition with other users/projects)
5. Adequate land area to consolidate multiple JIOC functions in one facility with adequate on-site parking
6. Availability of utilities and supporting infrastructure
7. Minimization of physical vulnerabilities (e.g., physical security)
8. Minimization of displacement of existing facility/function (e.g., displacing an existing parking area)

Various alternatives were evaluated against the screening factors. The alternatives considered include:

- No Action
- New construction at Makalapa Compound
- Renovation of existing facilities
- New construction at alternate sites (including other sites within Makalapa Compound)
- Lease

2.3 Alternatives Carried Forward for Analysis

Because INDOPACOM – JIOC's parent command – is located at Camp Smith, that location would be ideal for a consolidated JIOC facility. However, due to limited site and utility availability, potential traffic concerns, and projected very high development costs, a Camp Smith alternative was not practical. Due to JIOC's command relationship with the U.S. Pacific Fleet at Makalapa Compound, Makalapa was considered the next-best location alternative. Based on the reasonable alternative screening factors and meeting the purpose and need for the Proposed Action, two action alternatives were identified and analyzed within this EA.

2.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur. Under this alternative, a new consolidated JIOC facility would not be constructed and JIOC operations would continue to be conducted in seven separate buildings separated by a distance of several miles. The existing space and technology infrastructure limitations would persist, constraining JIOC's ability to expand, adapt, and integrate new technologies in support of mission requirements. The No Action Alternative would not meet the purpose and need for the Proposed Action; however, as required by NEPA, the No Action Alternative is carried forward for analysis in this EA. The No Action Alternative is used to analyze the consequences of not undertaking the Proposed Action and will serve to establish a comparative baseline for analysis.

2.3.2 JIOC Facility-North (Preferred Alternative)

In this alternative, an approximately 172,000-square-foot (sq ft) facility would be constructed on an approximately 15-acre site located at JBPHH Makalapa Compound as Military Construction Project (MILCON) P-079. The main building would be a three-story, approximately 147,800-sq ft structure with concrete structural framing, concrete walls, reinforced concrete floor and roof slabs with membrane roofing, and reinforced concrete combination shallow, deep foundation floor systems and flat roof. The facility would also include single-story attached wings for a central utility plant, warehouse, and food vendor area. This alternative also includes supporting facilities such as an electrical substation/switching station near the Luapele Gate, sanitary lift station, stormwater detention facility, and an at-grade parking lot for approximately 650 vehicles. A preliminary site plan for the Preferred Alternative is shown in Figure 2-1. See Figure 2-2 for site photos. The various facility components are described in the following sections.

2.3.2.1 Main JIOC Facility

The first floor of the main JIOC building would comprise approximately 51,500 sq ft with the second and third floors encompassing about 48,600 sq ft each (total of about 147,800 sq ft). This structure would house various functions and departments that support USINDOPACOM and JIOC missions.

2.3.2.2 Central Utility Plant

An approximately 16,200-sq ft contiguous single-story central plant wing would be constructed on the west side of the main facility. This wing would house air conditioning and ventilation equipment, electrical power equipment, fire protection equipment, Uninterruptable Power Supply and battery equipment, and emergency generator equipment. A fenced, open-air chiller yard would be located adjacent to the south of the central plant and a loading area would be located adjacent to the north.

2.3.2.3 Warehouse

An approximately 6,400-sq ft contiguous, single-story warehouse wing would be constructed on the west side of the main facility. It would provide spaces for shipping and receiving functions along with the storage of materials.

2.3.2.4 Food Vendor

An approximately 700-sq ft contiguous, single-story food vendor area would be constructed on the east side of the main JIOC facility.

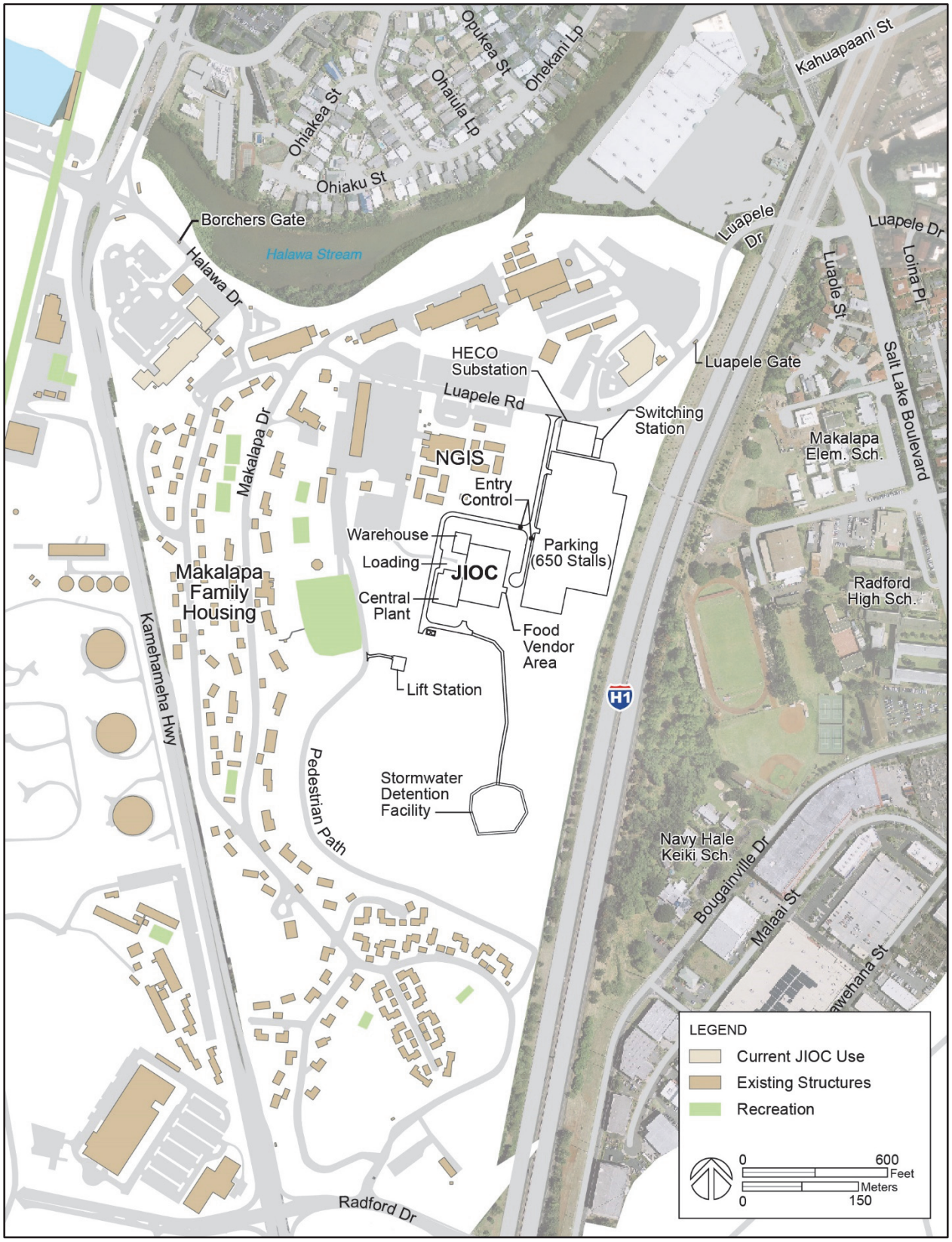

Figure 2-1 Preferred Alternative Site Plan

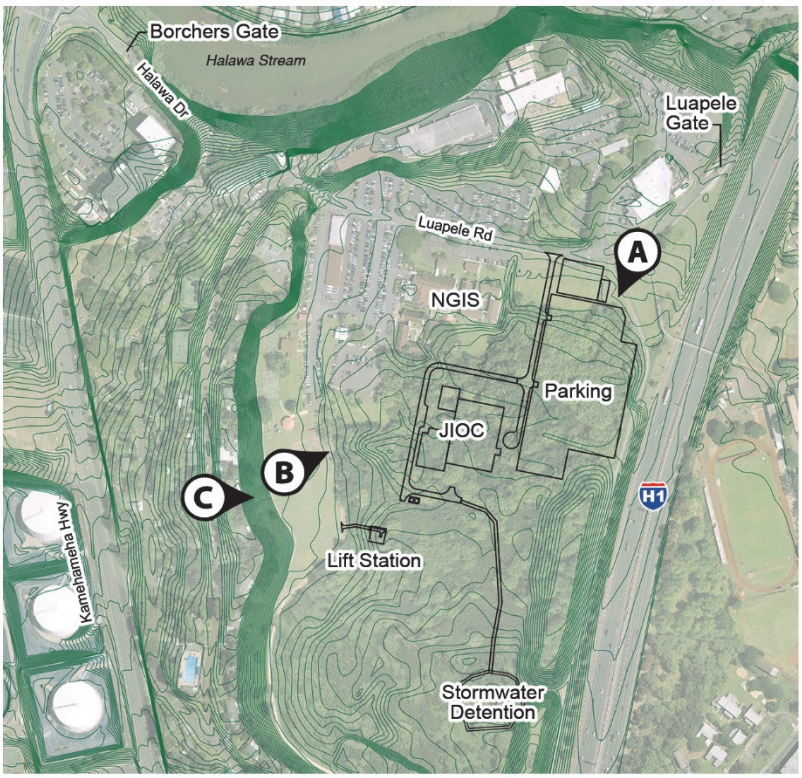

Photo source and date:
HHF Planners, November 2017

Photo A: View to south from proposed parking lot site

Photo B: View towards project area looking northeast

Photo C: View to east from top of slope

Figure 2-2 Site Photos

2.3.2.5 Utilities and Infrastructure

Vehicular Roadways and Parking

A two-lane access road would be constructed from Luapele Road and extending south into the crater. (Note: In this EA, Luapele Road refers to the roadway within JBPHH Makalapa Compound and Luapele Drive refers to the roadway segment outside the base boundary, including its intersection with Salt Lake Boulevard.) The road would provide access to an at-grade parking area and the main building entrance. A secured vehicle entry point would control access for guests arriving at the building's main entrance/porte cochere. A vehicle security gate would also be provided to control access to the utility, warehouse, loading, delivery, shipping, and receiving areas at the rear of the building.

The proposed parking area would accommodate about 650 vehicles (including privately-owned vehicles (POV), organizational vehicles, and replacement parking for stalls that could be displaced by an unrelated project to improve the Luapele Entry Control point. Americans with Disabilities Act-accessible stalls and electric vehicle charging stalls would be provided within the parking area.

A gravel access lane would be constructed from the main entry road to the proposed stormwater detention facility (i.e., pond) for maintenance and inspection.

Potable Water and Fire Protection Water

The Proposed Action includes installation of new water distribution piping to connect to the existing water supply network. The new piping would be sized to meet flow and pressure requirements of the new facility. Plumbing fixtures would be high efficiency water conserving type to meet ASHRAE 189.1 and EPACT 2005 requirements.

A looped water supply system is proposed to improve fire protection at the JIOC site. Fire hydrants would be installed at a spacing of approximately 300 feet at the new building and vehicle parking areas.

Sanitary Sewer

Within Makalapa Crater, a new 8-inch sewer line would be installed to service the new facility and a new sanitary sewer lift station and force main would be constructed southwest of the new JIOC building (see Figure 2-1). The existing JBPHH wastewater collection system has limited capacity in areas downstream of the new JIOC project site (i.e., between the JIOC site and the JBPHH Fort Kamehameha Waste Water Treatment Plant). Several proposed upgrades/adjustments to existing sewer infrastructure are needed to provide adequate sewer capacity and service to the new JIOC facility, and are summarized below. The locations of these improvements are shown in Figure 2-3.

South Avenue Relief Sewer

This improvement would construct a new 42-inch diameter, approximately 6,300-foot long relief sewer line along South Avenue from Nimitz Gate to an existing pump station on South Avenue. The relief sewer line would replace an existing 30-inch line in South Avenue, which would be abandoned in place and jet grouted. An existing 27-inch sewer line on South Avenue would remain active as a relief line if the new 42-inch sewer line reaches capacity.

Center Drive Relief Sewer

This improvement would construct approximately 3,900 feet of 21- to 24-inch sewer line from Kamehameha Highway to Center Drive, where it would connect to the proposed 42-inch South Avenue

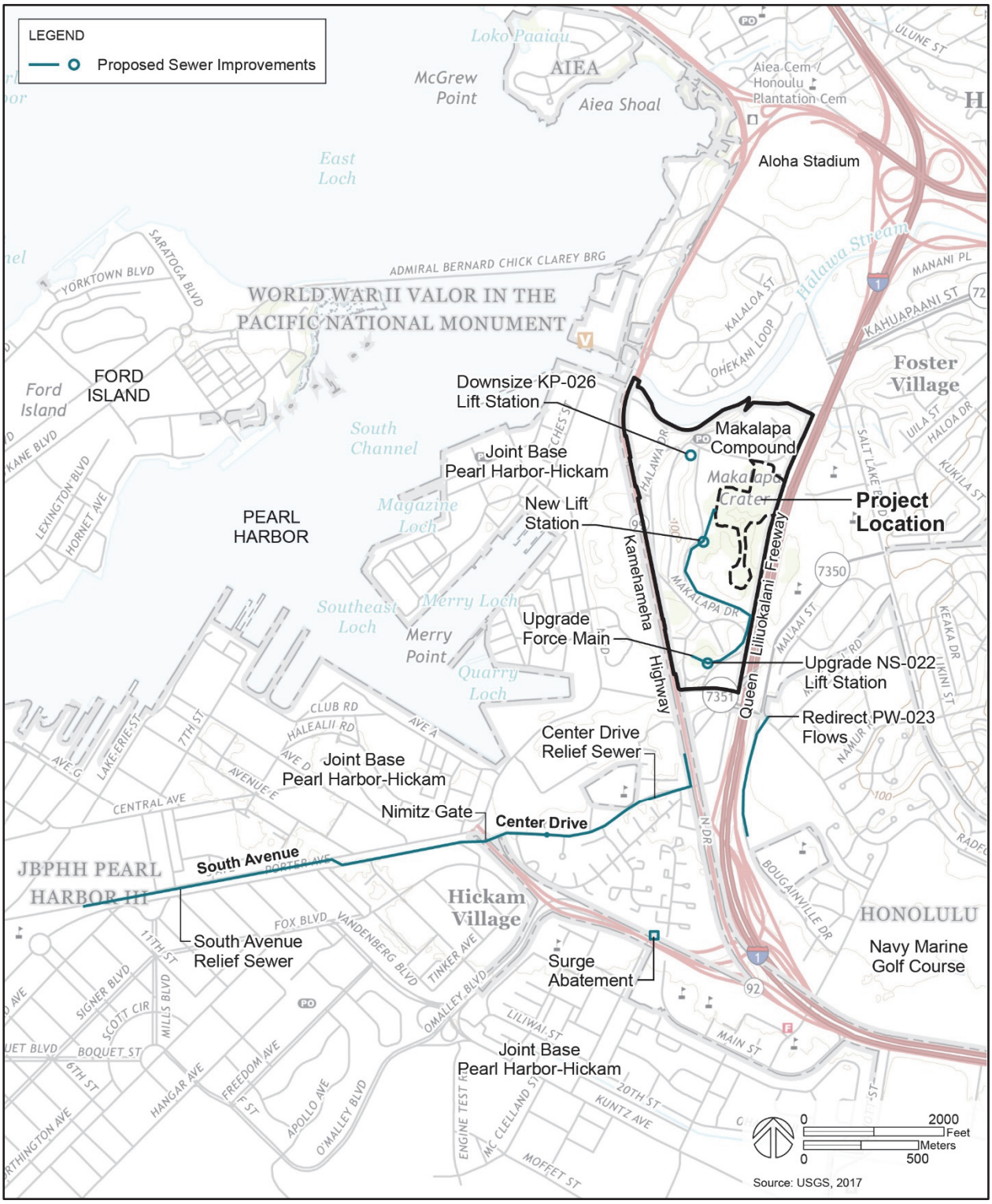

Figure 2-3 Proposed Sewer System Improvements

relief sewer near Nimitz Gate. The new line would replace sewer service for flows generated at Makalapa Crater that are currently handled in sewer lines located in the military family housing area north of Center Drive.

Other Wastewater System Upgrades/Adjustments

Other sewer improvements within Makalapa Crater would:

- Downsize existing KP-026 lift station and force main
- Upgrade existing lift station NS-022, force main, and existing emergency generator

Other offsite sewer infrastructure improvements and adjustments would:

- Redirect capacity from trunk sanitary line PW-023 to the Moanalua/Hokulani branch
- Provide surge mitigation measures at the Nimitz Spur trunk sanitary line to accommodate the increased flow that is redirected from Lift Station PW-023

Stormwater Drainage

An on-site network of inlets, storm drain manholes, and piping would convey stormwater runoff around the new facilities to a surface drainage detention facility/pond. The detention facility is sized to accommodate, at a minimum, the increase in runoff from existing conditions and limit discharge from the site to pre-development levels in accordance with Section 438 of the Energy Independence and Security Act of 2007. The surface detention system would provide the required storage and promote water quality enhancement opportunities. An at-grade, approximately one-acre facility for stormwater detention is proposed as a grass-lined facility with side slopes in the range of 5:1 (horizontal:vertical) with an estimated capacity of about 80,000 cubic feet. A six-foot high perimeter safety fence with a vehicle access gate would surround the facility. Low impact development strategies would be included in the implementation, including vegetated bioswales and water quality units. The stormwater quality units (e.g., to remove sediments and oil products) would treat runoff prior to being discharged into the surface drainage detention system and the base drainage system. A grassed bioswale is proposed to be installed upstream of the stormwater detention facility.

Electrical Utilities, Telecommunications and Lighting

A new electrical substation/switching station is proposed adjacent to the north side of the proposed parking lot that would supply redundant power to the new JIOC building through a looped underground electrical distribution system. Two 46-kilovolt (kV) Hawaiian Electric Company (HECO) circuits from Kamehameha Highway and/or Salt Lake Boulevard would supply the new substation/switching station. Emergency generators located in the central plant would include a primary aboveground, concrete vaulted, double fuel tank equipped with leak detection and level controls. Three diesel powered generators are included in the project. Fuel piping would be double-wall with leak detection on the exterior of the building and threaded black steel on the interior of the building. The generator mechanical support would include a discharge silencer/muffler.

The project includes a lightning protection system consisting of roof-mounted terminals and loop conductors.

Cable connections for fiber optic and telephone service to the new JIOC building would be provided from the existing network in Makalapa Compound. Connection to an existing cable television (CATV)

handhole along Luapele Road would be used for CATV service for the new JIOC building. CATV service would be delivered by the local CATV provider.

Proposed exterior lighting for the parking lots would incorporate photocell/motion control and full cut-off, pole-mounted Light Emitting Diode (LED) luminaires to minimize light trespass pollution and improve energy efficiency. General interior illumination would be provided by Energy Star-qualified luminaires, when available, with LED light sources (with some exceptions where specialty lighting is needed). Luminaires would be controlled with occupancy sensors. Outdoor lighting would be fully shielded so the bulbs can only be seen from below, as allowable by safety, security, and antiterrorism force protection requirements.

2.3.2.6 Site Preparation and Demolition

Site preparation for this alternative would include site clearing and grubbing, removal of any buried construction debris that may be encountered during excavation, and site grading. A CERCLA investigation is being conducted under the Navy's Environmental Restoration program and is scheduled to be completed before project construction. The Record of Decision for the CERCLA investigation would define a specific environmental restoration site boundary and specify cleanup remedies and CERCLA requirements for the site. CERCLA contaminants of potential concern (COPCs) include asbestos, polychlorinated biphenyls (PCBs), metals, polynuclear aromatic hydrocarbons (PAHs), and dioxins/furans. All soil with COPCs above USEPA Regional Screening Levels and State of Hawaii Department of Health (HDOH) Environmental Action Levels would be handled and disposed of as CERCLA waste. Due to the geotechnical conditions anticipated at the site, deep foundations (e.g., pre-cast driven piles and pre-drilling) are expected to be required in project construction. Erosion and sediment controls would be provided to prevent offsite discharge. Slab-on-grade construction is also assumed for the building construction. Site preparation for slab-on-grade construction may include the placement of imported granular structural fill below slabs or aggregate subbase below pavements.

2.3.2.7 Building Construction and Occupancy

Construction is expected to begin in calendar year (CY) 2026, with completion in CY 2030. After construction is completed, the building would be fitted out with furnishings, fixtures, and equipment, a process that would take approximately 18 months. Building occupancy is expected in CY 2032, when approximately 1,000 personnel would relocate from existing JIOC facilities in Makalapa Compound, Naval Shipyard, Camp Smith, and Ford Island to the new facilities. Approximately 100 of these positions are expected to originate from Ford Island and Camp Smith (i.e., personnel new to Makalapa Compound). Of the three facilities in Makalapa Compound where JIOC currently occupies space, such space is shared by or with other commands. This tenant relationship also holds true for space occupied by JIOC in the two facilities located on Ford Island, one in the Naval Shipyard, and in one facility at Camp Smith. That is, JIOC does not occupy 100% of the space available in any facility. JIOC plans to maintain some space and personnel for administrative functions for the foreseeable future at some of its current facilities. All facility space currently occupied by JIOC is expected to eventually be reused by other DoD entities once vacated.

2.3.2.8 Antiterrorism/Force Protection

In October 2006, the DoD issued Instruction number 2000.16, "DoD Antiterrorism Standards," requiring all DoD Components to adopt and adhere to common criteria and minimum construction standards to mitigate antiterrorism vulnerabilities and terrorist threats. (Note: Current applicable reference is Unified

Facilities Criteria (UFC) 4-010-01, Change 1 August 19, 2020.) Because the project would be occupied by DoD personnel, Antiterrorism/Force Protection (ATFP) requirements would be incorporated into the design of the new JIOC building.

2.3.2.9 Sustainable Development

This construction project would incorporate Leadership in Energy and Environmental Design, commonly referred to as LEED, and sustainable development concepts to achieve optimum resource efficiency, sustainability, and energy conservation. Example features include water saving strategies, high efficiency air conditioning equipment, energy saving controls and strategies, and improved ventilation and indoor air quality. The new building would be served by an energy management system and provided with Smart Metering of all utilities including water, electricity, power, and gas.

2.3.3 JIOC Facility-South Alternative

The second action alternative evaluated in this EA involves constructing a new JIOC facility and supporting infrastructure at a site approximately 700 feet south of the Preferred Alternative site (see Figure 2-4). The South Alternative would include all the same components as the Preferred Alternative: 3-story main building; attached 1-story central utility plant, attached 1-story warehouse with chiller yard and loading area, attached 1-story food vendor area, sanitary sewer lift station, 650-stall at-grade parking lot; and stormwater detention facility. See Section 2.3.2 for descriptions of project components. The components would be of similar size and function as in the Preferred Alternative with the following differences:

- Parking lot: Sized for 650 vehicles, but reconfigured to fit the site
- Stormwater detention: Due to site topography, stormwater would be collected and detained beneath the at-grade parking lot (i.e., low point of the site)

Due to the inclusion of a below-grade stormwater detention facility, this alternative is likely to require more ground disturbance and a slightly longer construction period than the Preferred Alternative, which includes an at-grade stormwater detention facility. However, the contractor's means and methods would not be determined until project implementation and construction of the below-grade detention facility may be conducted concurrently with other construction activities and may not result in a longer construction period.

The same utility and infrastructure services would be included in the South Alternative as in the Preferred Alternative, including the offsite sewer improvements shown in Figure 2-3 (see Section 2.3.2.5 for descriptions).

The South Alternative was evaluated as having a greater Net Present Value cost to construct due to its greater distance from the main road and utility lines, as well as requiring a subsurface stormwater detention facility. It may also have greater impacts on views within Makalapa Crater from historic housing areas than the Preferred Alternative. Because of its greater cost and potentially greater cultural impacts, it is not the Navy's Preferred Alternative. This alternative meets project objectives and screening criteria and is considered a reasonable alternative. Therefore, it is carried forward for detailed analysis in this EA.

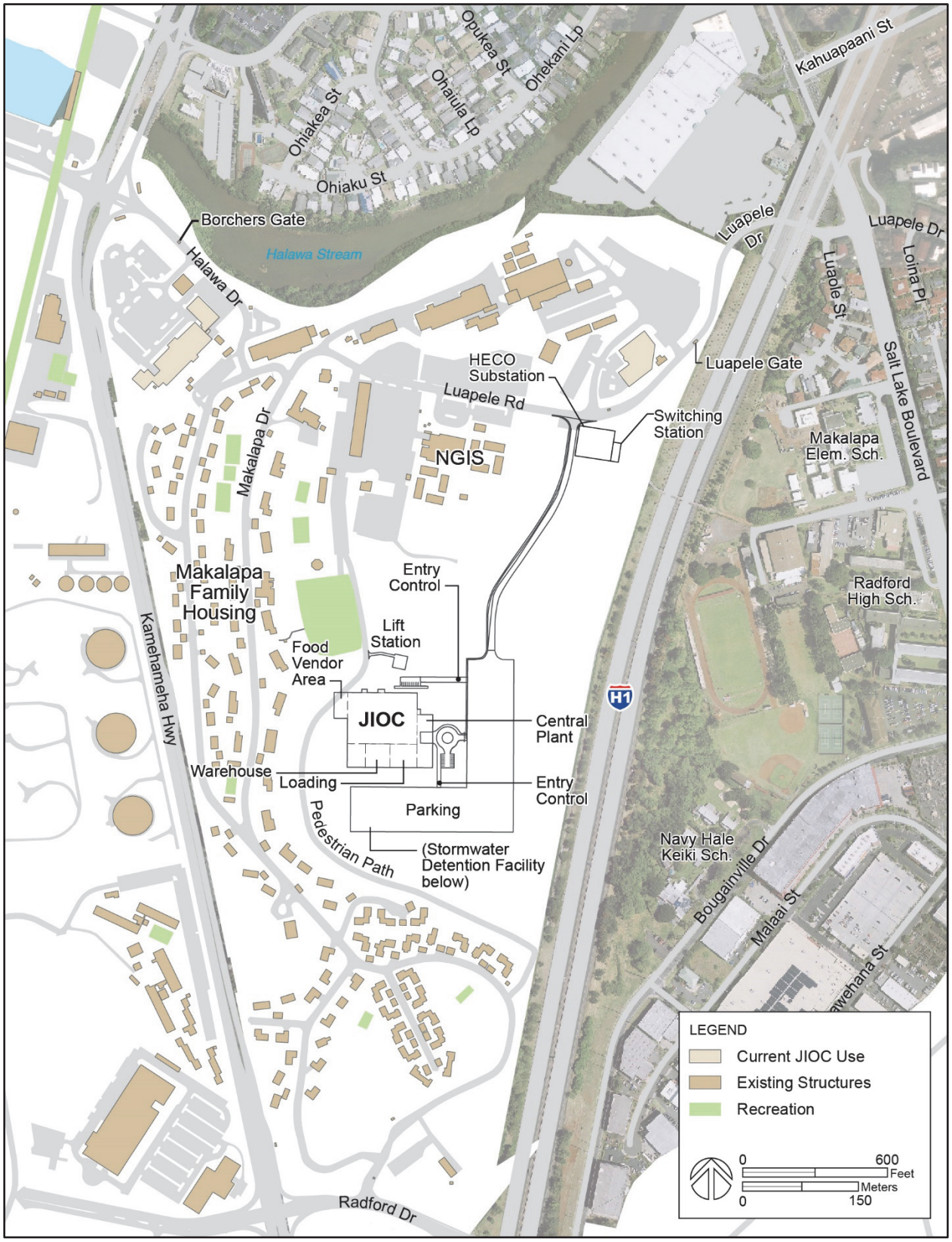

Figure 2-4 JIOC Facility-South Alternative Site Plan

As in the Preferred Alternative, because the project would be occupied by DoD personnel, ATFP requirements would be incorporated into the design of the South Alternative.

As with the Preferred Alternative, the South Alternative would incorporate LEED and sustainable development concepts to achieve optimum resource efficiency, sustainability, and energy conservation.

2.4 Alternatives Considered but not Carried Forward for Detailed Analysis

The Navy initially identified and evaluated a wide range of alternatives to meet the Proposed Action's facility requirements, purpose and need, and screening factors. The Navy's alternatives analysis process identified potential project sites and development scenarios, which resulted in 16 different alternatives. These alternatives included 12 potential project areas in 7 geographical locations island-wide and four consolidation scenarios. The 12 potential project sites were in 3 different installations: JBPHH (9 sites), Camp Smith (2 sites), and JBPHH Wahiawa Annex (1 site). The four scenarios involved new construction, consolidation and partial reuse of existing facilities, and partial consolidation of JIOC operations in existing or new facilities. The full range of alternatives was narrowed to three alternatives that scored the highest in terms of operational efficiencies and locational or siting criteria. Consolidation and new construction in Makalapa Crater was identified as the alternative that would best meet JIOC's mission and physical facility requirements. The following alternatives were considered, but not carried forward for detailed analysis in this EA because they did not meet the purpose and need for the project and satisfy the reasonable alternative screening factors presented in Section 2.2.

2.4.1 Renovation and Modernization of Existing Facilities

2.4.1.1 Renovate Existing Facilities

This alternative involves repairing and modernizing the existing facilities used by JIOC at JBPHH Makalapa Crater, Camp Smith, Ford Island, and Pearl Harbor Naval Shipyard. This alternative was considered but is not being carried forward for detailed analysis in the EA because it would not meet the purpose and need for the action or screening factors (i.e., would not consolidate JIOC functions and staff, optimize functional relationships, or provide necessary levels of utility redundancy due to physical constraints of the existing facilities).

2.4.1.2 Renovate Existing Facilities at Makalapa Compound and Construct New Annex

This alternative involves repairing and modernizing the existing facilities used by JIOC at JBPHH Makalapa Crater and constructing a new five-story, 78,500-sq ft annex and new two-story, 7,500-sq ft utility building adjacent to the two buildings. Under this alternative, JIOC functions and personnel would be consolidated at one location. A new 4.5-level parking structure would also be constructed along the Kamehameha Highway frontage. Under this alternative, JIOC functions would be disrupted during the construction period. The ability to optimize operational functional relationships would be limited by existing internal building configurations. The new utility building may not meet physical siting requirements due to its proximity to the base boundary. This alternative was considered but is not being carried forward for detailed analysis in the EA because it would not meet the purpose and need for the action or screening factors (i.e., optimizing internal layouts and functional relationships, meeting physical siting requirements).

2.4.2 New Construction at Alternate Sites

New construction at 13 alternative sites was considered and is summarized below in Table 2-1, along with the reasons they are not being pursued for implementation or carried forward for detailed analysis in this EA. Expansion and renovation of the existing JIOC complex in JBPHH Makalapa Compound was also considered, and is included in Table 2-1.

Table 2-1 Site Alternatives Not Carried Forward in EA Analysis

Description of Alternative	***Rationale for Elimination / (Applicable Screening Factor)***
JBPHH Main Base – Hickam New Construction	• Distance from USINDOPACOM and PACFLT (*Screening Factor 3*) • No site available to accommodate JIOC facility requirements (*Screening Factors 4 and 5*)
JBPHH Wahiawa Annex New Construction	• Distance from USINDOPACOM and PACFLT headquarters (*Screening Factor 3*) • Major infrastructure upgrades required (*Screening Factor 6*)
Camp Smith New Construction (Camp Hawkins Site [southeast of headquarters building])	• High infrastructure costs (no existing infrastructure) (*Screening Factor 6*)
Camp Smith New Construction (next to INDOPACOM Headquarters) and Makalapa Facility Reuse	• Would not fully consolidate JIOC functions from existing facilities (*Screening Factor 1*) • Site availability is unlikely (*Screening Factor 4*)
JBPHH Makalapa Compound New Construction (Partial Consolidation of functions) – 2 site options	• Would not fully consolidate JIOC functions from existing facilities (*Screening Factor 1*) • 1 site option would displace about 180 existing parking spaces (*Screening Factor 8*)
JBPHH Makalapa Compound Partial New Construction (Partial Consolidation of functions) – 2 site options	• Would not fully consolidate JIOC functions from existing facilities (*Screening Factor 1*) • 1 site option would displace about 140 existing parking spaces (*Screening Factor 8*)
Ford Island Partial New Construction near Pacific Warfighting Center (Partial Consolidation in separate building)	• Would separate JIOC functions rather than consolidate (*Screening Factor 1*) • Site may not be available due to future Public Works Center expansion (*Screening Factor 4*)
Ford Island Partial New Construction in Bldg. 55 (Partial Consolidation of functions in separate building)	• Would separate JIOC functions rather than consolidate (*Screening Factor 1*) • Physical vulnerabilities not reduced (*Screening Factor 7*) • Unlikely to retrofit the historic property to adequately meet JIOC requirements (*Screening Factor 2*)
JBPHH Main Base Partial New Construction (Partial Consolidation of functions in new facilities) – 2 site options at Naval Shipyard	• Would separate JIOC functions rather than consolidate (*Screening Factor 1*) • Site availability is unlikely (*Screening Factor 4*)
JBPHH Makalapa Compound Construct New Annex and Reuse Existing JIOC Buildings	• Would not fully consolidate JIOC functions from existing facilities (*Screening Factor 1*) • Physical vulnerabilities not reduced (*Screening Factor 7*) • Limited flexibility to reconfigure existing JIOC spaces for greater operational effectiveness and efficiency (*Screening Factor 1*)

2.4.3 Lease

This alternative would involve leasing commercial space for JIOC activities and storage. This alternative was considered but is not being carried forward for detailed analysis in the EA because the use of a private-sector facility is precluded by the inherent security and mission requirements of JIOC.

2.5 Best Management Practices Included in Proposed Action

This section presents an overview of the best management practices (BMPs) that are incorporated into the Proposed Action in this document. BMPs are existing policies, practices, and measures that the Navy would adopt to reduce the environmental impacts of designated activities, functions, or processes. Although BMPs mitigate potential impacts by avoiding, minimizing, or reducing/eliminating impacts, BMPs are distinguished from potential mitigation measures because BMPs are (1) existing requirements for the Proposed Action, (2) regularly occurring practices, or (3) not unique to this Proposed Action. In other words, the BMPs identified in this document are inherently part of the Proposed Action and are not potential mitigation measures proposed as a function of the NEPA environmental review process for the Proposed Action. Table 2-2 includes a list of BMPs. Mitigation measures are discussed separately in Chapter 3.

Table 2-2 Best Management Practices

BMP	*Description*	*Impacts Reduced/Avoided*
Implement construction dust control plan	Example BMPs include watering of active work areas, using wind screens, keeping adjacent paved roads clean, covering of open-bodied trucks, limiting the area that is disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Other potential BMPs include paving and landscaping of project areas early in the construction schedule and moving construction equipment and workers to and from the project site during off-peak traffic hours.	Prevents or minimizes fugitive particulate emissions from being transported away from the project area
Erosion control	Compliance with National Pollutant Discharge Elimination System provisions including Storm Water Pollution Prevention Plans; erosion and sediment control measures, such as protection of erodible soils; control of stormwater runoff from the construction site; use of sediment basins; use of vegetation and mulch on soil exposed by grading; use of silt fencing and barriers around excavated and cleared areas; and fugitive dust control measures.	Prevents or minimizes water quality impacts on receiving waters

BMP	*Description*	*Impacts Reduced/Avoided*
Management of Historic Properties	In the event that historic properties are discovered or unanticipated effects are found during the project, the Navy would follow Stipulation XI of the Programmatic Agreement Among the Commander Navy Region Hawaii, The Advisory Council on Historic Preservation and the Hawaii State Historic Preservation Officer Regarding Navy Undertakings in Hawaii.	Protection of historic properties
Tree removal	Trees 15 feet or taller would not be removed or trimmed during the bat pupping season from June 1 through September 15. If any bat pups were to be discovered in the construction zone, outside of this season, vegetation clearing would immediately stop and operations would be moved to a minimum of 300 feet away. Construction would not resume until the bat pups have departed the area on their own accord.	To prevent disturbance to Hawaiian hoary bats
Pre-construction nest surveys of protected bird species	Conduct nest surveys for protected bird species a maximum of seven days before construction. Active nests would be left in place and undisturbed until chicks have fledged, which may take up to eight weeks. A qualified biologist would monitor active nests during construction activities to reduce the chances of nest abandonment by temporarily shutting down construction activities that disrupt the normal daily patterns of the birds.	To prevent adverse impacts to protected avian species.
Shielded lighting	Taking into consideration safety, security, antiterrorism/ force protection requirements, outdoor lighting would be designed in accordance with Unified Facilities Criteria Interior and Exterior Lighting Systems and Control, UFC 3-530-01 as of 1 April 2015, and outdoor lighting would be fully shielded so the bulbs can only be seen from below, as allowable by safety, security, and antiterrorism force protection requirements.	To prevent disorientation, disturbance, and/or injury to protected avian species (e.g., Newell's shearwater, Hawaiian petrel, band-rumped storm petrel)
Nighttime construction	Every effort would be made to avoid nighttime construction during the seabird fledging period, September 15 through December 15.	To prevent disorientation, disturbance, and/or injury to protected avian species (e.g., Newell's shearwater, Hawaiian petrel, band-rumped storm petrel)

BMP	***Description***	***Impacts Reduced/Avoided***
Standing water	No temporary or permanent areas of standing water would be created by the action and the stormwater detention facility would be designed such that there is no exposed standing water or standing water that is accessible to water birds (e.g., within a bioswale).	To prevent disturbance and/or injury to protected avian species (e.g., Hawaiian stilt)
Management of biological resources	Implement habitat management measures outlined in the JBPHH Integrated Natural Resources Management Plan	Protect and benefit threatened and endangered species on JBPHH -controlled lands
Hazardous Waste Management	Handle, transport, dispose of and/or remediate hazardous materials or waste encountered during construction in accordance with applicable federal and state regulations.	Protection of construction workers/community members from any hazardous material encountered during construction.
Compliance with *JBPHH Green Waste Policy*	Keep all green waste generated at the Makalapa Compound project area whole and deliver to the designated green waste collection point on JBPHH within 24 hours. Contain green waste using an approved cover or tarp during the 24-hour period. Cut trees into 3-foot sections, leaving fronds and small branches whole. Notify the Hawaii Department of Agriculture Pest Hotline immediately if any life stage of Coconut Rhinoceros Beetle is suspected in green waste.	Prevent spread of Coconut Rhinoceros Beetle

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3 Affected Environment and Environmental Consequences

This chapter presents a description of the environmental resources and baseline conditions that could be affected by implementing any of the alternatives and an analysis of the potential direct and indirect effects of each alternative.

All potentially relevant environmental resources/components were initially considered for analysis in this EA. In compliance with the National Environmental Policy Act (NEPA), the Council on Environmental Quality (CEQ), and Department of Navy guidelines; the discussion of the affected environment (i.e., existing conditions) focuses only on those resource areas potentially subject to impacts. Additionally, the level of detail used in describing a resource is commensurate with the anticipated level of potential environmental impact.

"Significantly," as used in NEPA, requires considerations of both context and intensity. Consideration of "context" means that the significance of an action must be analyzed under several different circumstances such as society as a whole (e.g., human, national), the affected region, the affected interests, and the locality. Significance varies with the setting of a proposed action. For instance, in the case of a site-specific action, significance would usually depend on the effects in the locale rather than in the world as a whole. Both short- and long-term effects are relevant. Intensity refers to the severity or extent of the potential environmental impact, which can be thought of in terms of the potential amount of the likely change. In general, the more sensitive the context, the less intense a potential impact needs to be in order to be considered significant. Likewise, the less sensitive the context, the more intense a potential impact would need to be in order to be significant.

The potential impacts to the following environmental resources are considered to be negligible or non-existent so they were not analyzed in detail in this EA: Airspace and Socioeconomics. Explanations for their exclusion are provided below.

Airspace: Construction and operation of the Proposed Action would not involve impacts to military or civilian airspace or facilities. The proposed project location is not proximal to military or civilian airfield or airspace. The nearest airport (Daniel K. Inouye International Airport) is located approximately two miles south of the project area. The proposed facility would not extend into any of the airport's approach or departure surfaces. Therefore, it requires no further analysis with respect to airspace impacts.

Socioeconomics: Construction and operation of the Proposed Action would not impact population; employment/industry characteristics; demand for schools, housing, recreational facilities; or demographic, economic, or fiscal conditions of the State of Hawaii or City and County of Honolulu. Economic benefits of construction job creation would be temporary and associated with project construction of both the new JIOC facility and associated sewer infrastructure improvements. The proposed new JIOC facility would collocate existing functions that are currently dispersed in multiple locations. Although the additional square footage of administrative-type space would allow the reuse of existing JIOC spaces, and conservatively may result in an additional 800 personnel employed at JBPHH Makalapa Compound, this would represent less than one percent of the total federal government personnel employed in the state (State of Hawaii, 2017, Table 10.05). Decisions on staffing of existing or future DoD activities on Oahu or in the State would be made based on operational and support requirements and unrelated to the reuse availability of the vacated JIOC facilities. Therefore, project would not result in secondary impacts related to increasing development capacity or population growth.

The sewer system improvements are required to address the new facility's wastewater transmission needs and are part of the overall JBPHH sewer infrastructure plans.

This section includes transportation, air quality, water resources, geological resources, visual resources, cultural resources, biological resources, land use, noise, infrastructure, public health and safety, hazardous materials and wastes, and environmental justice.

3.1 Transportation

This discussion of transportation includes all of the air, land, and sea routes with the means of moving passengers and goods. A transportation system can consist of any or all of the following: roadways, bus routes, railways, subways, bikeways, trails, waterways, airports, and taxis, and can be looked at on a local or regional scale.

Traffic is commonly measured through average daily traffic and design capacity. These two measures are used to assign a roadway with a corresponding level of service (LOS). The LOS designation is a professional industry standard used to describe the operating conditions of a roadway segment or intersection. The LOS is defined on a scale of A to F that describes the range of operating conditions on a particular type of roadway facility. LOS A through LOS B indicates free flow travel. LOS C indicates stable traffic flow. LOS D indicates the beginning of traffic congestion. LOS E indicates the nearing of traffic breakdown conditions. LOS F indicates stop-and-go traffic conditions and represents unacceptable congestion and delay. Table 3-1 describes the delays associated with each Level of Service. Level of Service F also describes conditions when traffic volume exceeds capacity.

Table 3-1 Level of Service Categories

Average Delay (seconds per vehicle)	***General Description of Delay***	***Level of Service (LOS)***
≤ 10	Little or no delay	A
> 10 and ≤ 25	Short traffic delays	B
> 25 and ≤ 35	Average traffic delays	C
> 35 and ≤ 55	Long traffic delays	D
> 55 and ≤ 80	Very long traffic delays	E
> 80	Very long traffic delays	F
Source: *Highway Capacity Manual*, 2010 in Julian Ng Inc., 2022		

3.1.1 Regulatory Setting

The *Highway Capacity Manual* is a publication by the Transportation Research Board, a division of the National Academies of Sciences, Engineering, and Medicine that provides research-based solutions to improve transportation. The *Highway Capacity Manual* is a nationally-accepted reference for concepts, performance measures, and analysis techniques for evaluating the multimodal operation of streets, highways, freeways, and off-street pathways. It provides an integrated multimodal approach to the analysis and evaluation of urban streets from the points of view of automobile drivers, transit passengers, bicyclists, and pedestrians. It includes methodologies for evaluating the capacity and quality of service provided to road users traveling through roadway facilities, including signalized intersections.

3.1.2 Affected Environment

JBPHH Makalapa Compound is bounded by Kamehameha Highway on the west, Radford Drive on the south, the H-1 Freeway on the east, and a shopping center and Halawa Stream on the north. Roadways within the compound are interconnected, and two vehicular gates provide access from off-base roadways: to the west, Borchers Gate is located on Makalapa Drive near its intersection with Kamehameha Highway, and to the east, Luapele Gate is located along Luapele Drive near its intersection with Salt Lake Boulevard. Pedestrian access is also available through a locked gate that connects to a footpath leading to a pedestrian overpass of the H-1 Freeway from the vicinity of Radford High School. The area is also served by the City's municipal bus service and would be served by its future rail transit system.

The proposed offsite South Avenue and Center Drive relief sewer lines would be located within the rights-of-way (ROW) of South Avenue , Nimitz Highway, Center Drive, and Kamehameha Highway. The surge abatement improvement would be located in the Nimitz Highway ROW (see Figure 2-3).

3.1.2.1 Roadways

A traffic impact analysis report was prepared by Julian Ng Inc. for the Proposed Action and is included as Appendix A (initial fieldwork/data collection was conducted in late 2017, with the traffic analysis based upon that data. The results of the earlier analysis were re-evaluated and Appendix A updated in 2022). Three signalized intersections near Makalapa Compound were identified in an earlier traffic study as locations where significant peak hour traffic volume increases (i.e., greater than 100 vehicles per hour) could occur—Kamehameha Highway and Halawa Drive, Salt Lake Boulevard and Luapele Drive, and Salt Lake Boulevard and Kahuapaani Street (see Figure 3-1). The offsite sewer improvement areas are not expected to affect peak hour traffic volumes or vehicle trip generation and were not included in the traffic analysis. The segments of Kamehameha Highway, Salt Lake Boulevard, and Kahuapaani Street analyzed in the traffic report are under Hawaii Department of Transportation jurisdiction. Luapele Drive from Salt Lake Boulevard to Luapele Gate is under the jurisdiction of the Navy (with the Navy having a perpetual easement from HDOT for a short segment between Salt Lake Boulevard and Navy-owned property at Makalapa Crater).

Turning movement counts were taken at the three intersections studied during weekday morning and afternoon peak periods in October 2017. Overall intersection levels of service were calculated for the AM and PM peak hours based on peak hour volumes. (See Appendix A for details of traffic impact analysis report methodology and intersection operations and signal phasing.)

As noted earlier, Levels of Service (LOS) are based on the average delay per vehicle; peak hour LOS D or better for the overall average delay is considered adequate (Julian Ng Inc., 2022).

Peak hour volumes are shown in Figures 3-2 and 3-3 along with the overall levels of service for each intersection studied.

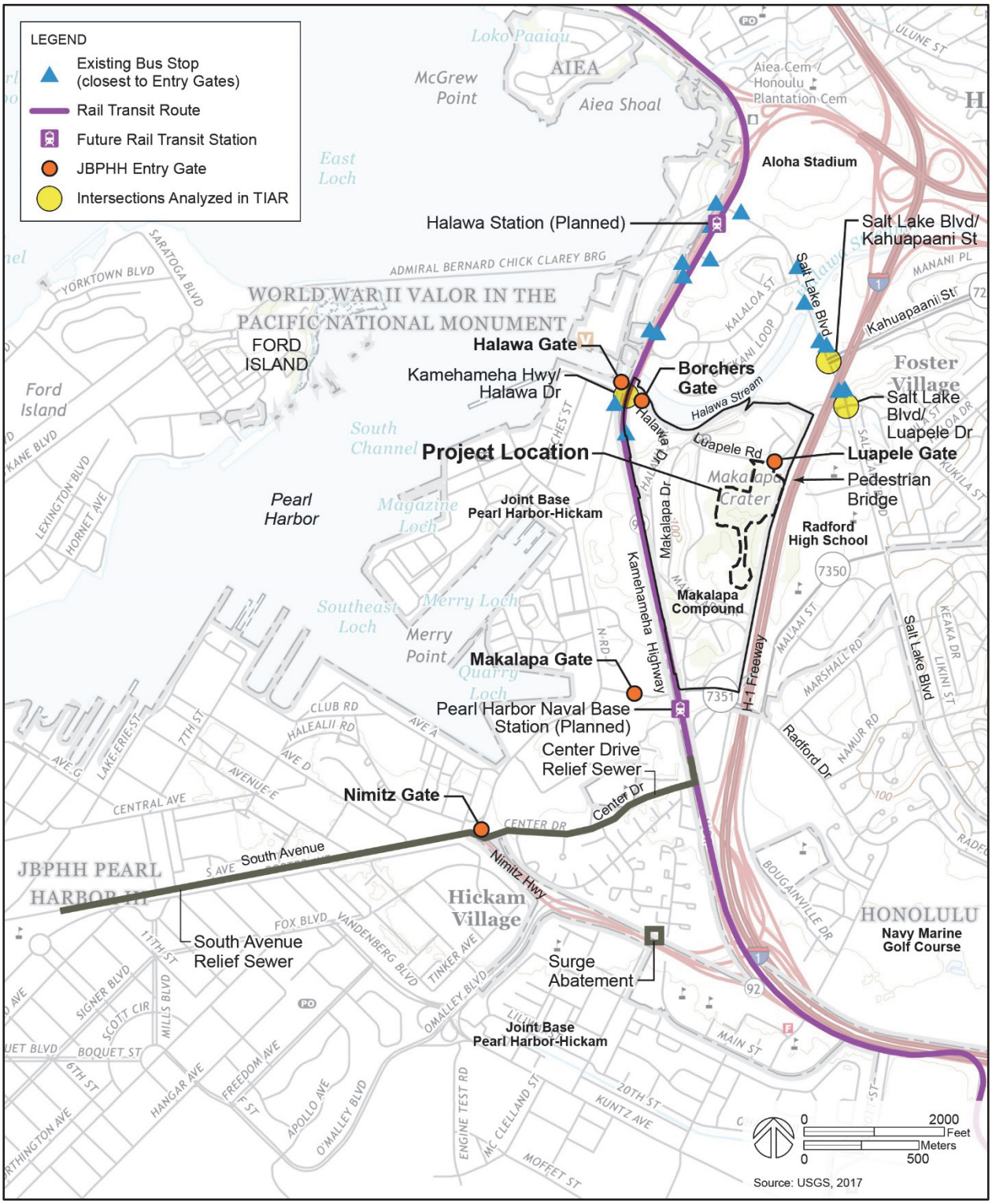
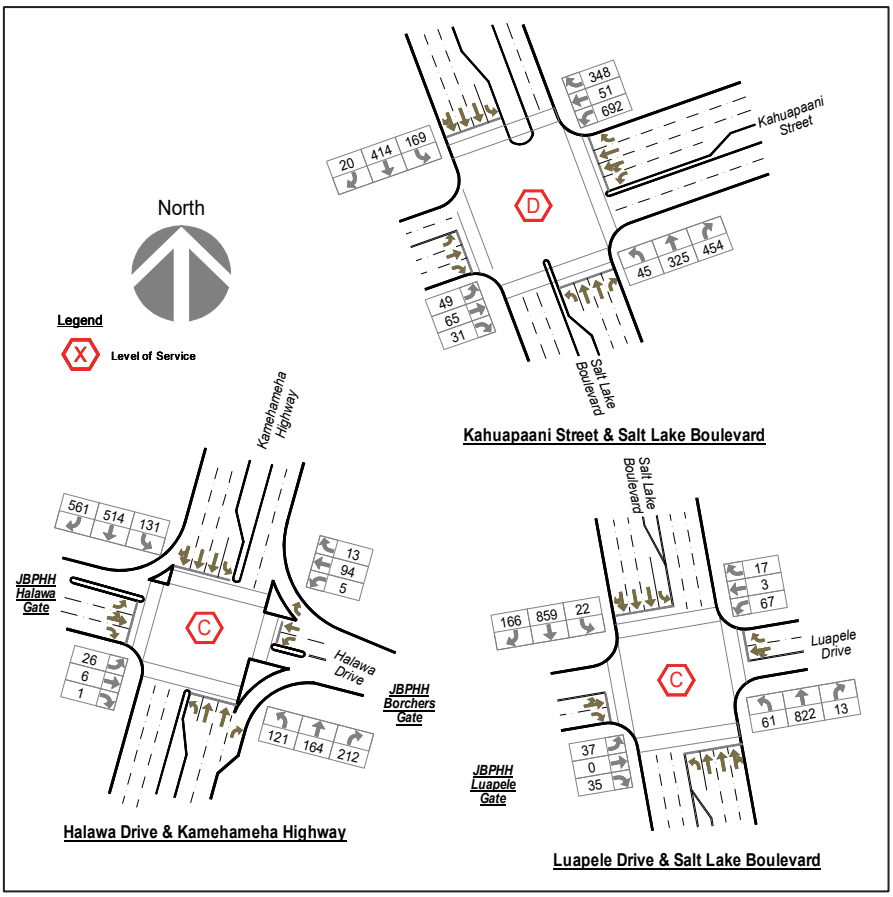
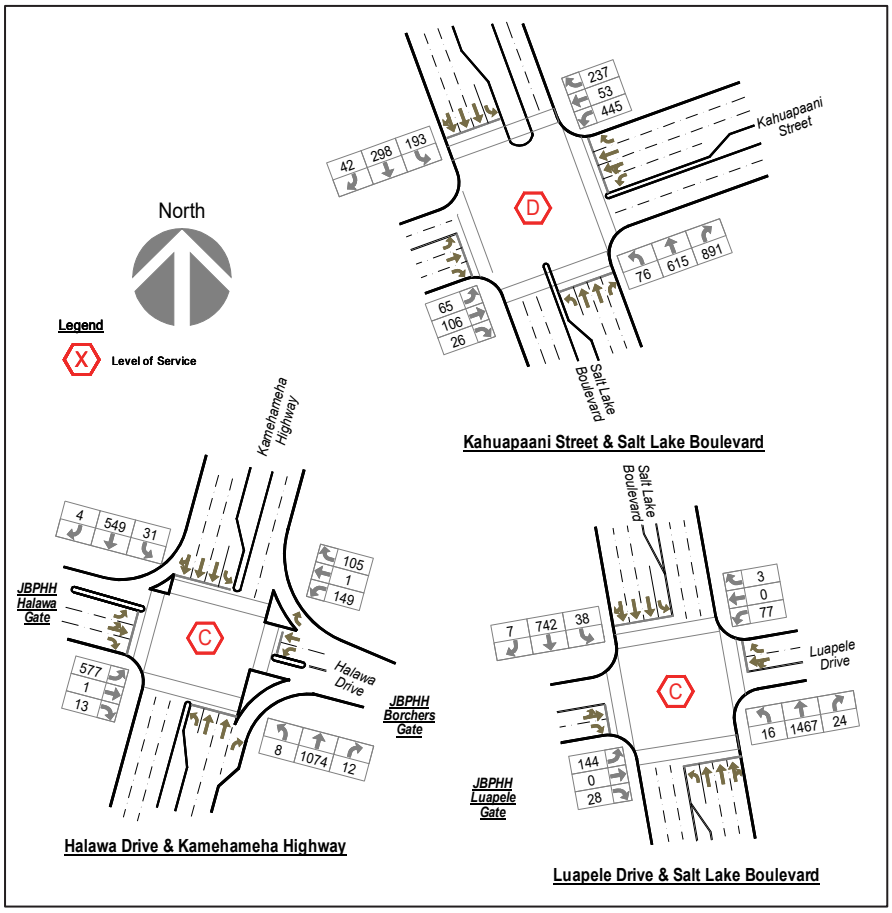


Figure 3-1 Transportation Facilities



Julian Ng Inc., 2022

Figure 3-2 Existing AM Peak Hour Traffic Volumes



Julian Ng Inc., 2022

Figure 3-3 Existing PM Peak Hour Traffic Volumes

Table 3-2 provides a summary of the existing peak hour conditions at the intersections studied, which shows that all intersections are operating at acceptable levels of service.

Table 3-2 Existing Conditions at Intersections Studied

Kamehameha Highway & Halawa Drive						
	AM Peak Hour			***PM Peak Hour***		
	X	***Delay***	***LOS***	***X***	***Delay***	***LOS***
Overall Intersection	0.49	28.4	C	0.70	29.1	C
Salt Lake Boulevard & Luapele Drive						
	AM Peak Hour			***PM Peak Hour***		
	X	***Delay***	***LOS***	***X***	***Delay***	***LOS***
Overall Intersection	0.39	16.4	C	0.45	17.7	C
Salt Lake Boulevard & Kahuapaani Street						
Note: Peak hour volumes from October 2017 manual counts	***AM Peak Hour***			***PM Peak Hour***		
	X	***Delay***	***LOS***	***X***	***Delay***	***LOS***
Overall Intersection	0.71	47.8	D	0.94	50.6	D

Note: Peak hour volumes from October 2017 manual counts
X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service Source: Julian Ng Inc., 2022

Kamehameha Highway-Halawa Drive Intersection

According to the project's traffic impact analysis report (Julian Ng Inc., 2022), the flow of traffic through the intersection was affected by delays at both Halawa Gate and Borchers Gate during the AM Peak Hour and at other times during the morning peak period. Queues of entering vehicles often backed onto the through lanes on the highway, but this blockage did not significantly affect the through traffic due to the low utilization of the through lanes. Afternoon conditions during and beyond the PM Peak Hour were affected by the signal phasing and the relative timing offset of the traffic signal at the intersection of Kamehameha Highway and Arizona Memorial Drive (located 700 feet north); northbound through traffic on the highway and turns onto the northbound lanes at times could not move even during the appropriate green phase. However, there is sufficient capacity at the Halawa Drive intersection that these delays were not excessive. As shown in Table 3-2, this intersection operates at LOS C during both the morning and afternoon peak periods.

Salt Lake Boulevard-Luapele Drive Intersection

Some congestion was observed on Salt Lake Boulevard to the south of this intersection during the morning just prior to the start of the school day (7:40 AM to 7:55 AM) as queues from the driveways into nearby schools backed onto the street. This congestion did not affect movements at the Salt Lake Boulevard intersection with Luapele Drive.

In the afternoon, some queuing from the northbound right turn lane to Kahuapaani Street occurred, affecting left turn movements from Luapele Drive onto Salt Lake Boulevard. While most drivers who wanted to enter that lane waited for the end of the queue to move up, others turned into the adjacent lane and merged into the desired lane between the two intersections. This occurrence was intermittent, due to the varying lengths of the northbound queue that resulted from the different cycle lengths of the signals at the two intersections. As seen in Table 3-2, the level of service for the overall intersection is LOS C during both the morning and afternoon peak hours. At this intersection, eastbound Luapele Drive is striped as a single lane; however, it is wide enough and is used as if it were striped for two lanes: a left turn/through lane and a right turn lane.

Salt Lake Boulevard-Kahuapaani Street Intersection

At the intersection of Kahuapaani Street and Salt Lake Boulevard, the signal operated in six phases. Separate phases are provided for the westbound Kahuapaani Street approach and the opposing eastbound approach from the shopping center parking lot ("split-phase" operation). Pedestrian crossing of Salt Lake Boulevard (when actuated) is served during the phase in which there is no conflict with left turn traffic. Leading left turn phases are provided for the turns from Salt Lake Boulevard–northbound into the shopping center and southbound to Kahuapaani Street. The opposing through movements on Salt Lake Boulevard follow the demand-actuated left turn phases. Observed cycle lengths during the peak periods varied from 140 seconds to more than 200 seconds. As shown in Table 3-2, the intersection has an overall LOS of D during both the morning and afternoon peak hours.

3.1.2.2 Bus Routes

TheBus is the City and County of Honolulu's public bus transportation service. It includes a fleet of 542 fixed route buses serving approximately 101 fixed routes throughout the island.

Currently, the project area is served by the following TheBus routes: A, 20, 32, 40, 42, 51, 74, 88A, PH1, PH2, PH3, PH4, PH5, PH6, and PH7. Routes 32 (Kalihi Transit Center) and 74 (Halawa Heights) run along

Salt Lake Boulevard. The bus stops closest to Luapele Gate are on either side of Salt Lake Boulevard, approximately 200 feet north of its intersection with Luapele Drive.

Routes A (City Express Waipahu), 20 (Waikiki Beach and Hotels), 40 (Honolulu-Ala Moana Center), 42 (Waikiki Beach and Hotels), 51 (Alapai Transit Center), 88A (North Shore Express) run on Kamehameha Highway. Routes PH1 (Kapolei-Makaha Express), PH2 (Express Mililani), PH3 (Wahiawa Heights Express), PH4 (Kaneohe-Kahaluu Express), PH5 (Kailua Express), PH6 (Hawaii Kai Express), and PH7 (Ewa Beach Express) provide express bus service to and from JBPHH Main Base (i.e., across Kamehameha Highway from Makalapa Compound), with the express bus stop closest to Borchers Gate located at Halawa Gate. The non-express bus stops closest to Borchers Gate are located at the southwest corner of the Kamehameha Highway-Halawa Drive intersection, and on Kamehameha Highway (one each approximately 400 feet to the north and south of the Kamehameha Highway-Halawa Drive intersection). See Figure 3-1 for bus stop locations nearest the Makalapa Compound gates.

A new bus transit center will be located at the planned Halawa (Aloha Stadium) rail transit station and bus routes will also serve the planned Pearl Harbor Naval Base rail transit station (described below). TheHandi-Van is a public, paratransit service, generally available islandwide, for disabled persons who are unable to use the City's bus service.

Aside from periodic maintenance and repair activities, the offsite sewer improvement areas (below grade or within fixed facilities) are not generally accessed by JPBHH or other personnel. In those situations, access is generally by vehicle rather than by public transit modes.

3.1.2.3 Railways

There is currently no railway or fixed rail transit service serving the project area. Currently under construction, the Honolulu Rail Transit Project will provide high-capacity rapid transit in the corridor between Kapolei and urban Honolulu. It includes construction and operation of a 20-mile elevated fixed guideway rail system ultimately planned to serve 21 stations. It is intended to provide corridor mobility, transit reliability, and service equity, and improve access to Honolulu's "second city" of Kapolei in West Oahu. The first phase of the system from East Kapolei to Aloha Stadium is essentially complete and the entire system is expected to be constructed by 2031, with the first phase (Kapolei to Aloha Stadium) estimated to open in 2022. Due to rising costs, the route may initially be shortened by two stations (1.25 miles) and end at South Street in Downtown Honolulu. The Halawa Station (near Aloha Stadium) and the Pearl Harbor Naval Base Station will both be located on Kamehameha Highway, approximately 0.5 mile north and 0.8 mile south of the Kamehameha Highway-Halawa Drive intersection, respectively (see station locations and guideway route in Figure 3-1). The first phase of the project will undergo a trial run test period. After successful completion of the trial run period, the first phase of the rail system will be turned over to the City's Department of Transportation Services, which will determine the opening of service.

The Halawa Station will feature bicycle parking and a 600-stall park and ride facility and be connected to TheBus Transit Center, from which there will be circulator bus services to Halawa, Pearl Harbor, Foster Village, and Salt Lake. The Pearl Harbor Naval Base Station will include bicycle parking and provide connections to TheBus circulator services to Hickam Field and Bougainville Drive, along with local service along Kamehameha Highway. Americans with Disabilities Act access and locations for TheHandi-Van pick-up and drop-off will also be provided at both stations.

Construction of the Kamehameha Highway segment of the elevated guideway (from Waiawa [Pearl Highlands] to Halawa) is completed through the Halawa Station and construction on the next segment (Halawa to Middle Street Transit Center) is continuing. The projected date for completion of this guideway segment is 2022. Construction of the Halawa Station is continuing. Construction of the Pearl Harbor Naval Base Station is projected for completion in 2022 (HART, 2022).

3.1.2.4 Bicycle and Pedestrian Transportation

Bikeway facilities include three major types of facilities: paths, lanes, and routes. A bike path is a completely separated right of way for the exclusive use of bicycles (and pedestrians if it is a shared use path). A bike lane provides a striped lane for one-way bike travel on a street or highway. A bike route provides for shared use with motor vehicle traffic, typically on lower volume roadways. The State of Hawaii has a State Bike Plan (2003), and the City and County of Honolulu has an Oahu Bike Plan (2019 update). Both feature bicycle paths, lanes, or routes in the Pearl Harbor vicinity, with some State or City-and-County proposed long-term bike path/lane connections located on Navy and non-Navy property.

Striped crosswalks and pedestrian signals are provided at the intersection of Kamehameha Highway and Halawa Drive. All corners have concrete sidewalks with the exception of the southwest corner, where the crosswalks terminate at a paved asphalt shoulder.

A striped bicycle lane is provided adjacent to the right shoulder of the northbound Kamehameha Highway lanes in this area and a striped shoulder (minimum 5-foot width) is adjacent to the southbound right lane of Kamehameha Highway. (Note: These bikeway facilities may currently be affected by the ongoing rail construction project.)

Striped crosswalks and pedestrian-actuated signals are present at all approaches of the Salt Lake Boulevard and Luapele Drive intersection and there are concrete sidewalks on all corners. There are no separate bicycle lanes designated on either Salt Lake Boulevard or Luapele Drive; bicycles use either the sidewalk or the vehicle lane closest to the curb (approximately 15 feet wide on Salt Lake Boulevard).

There are striped crosswalks and pedestrian-actuated signals on all approaches of the Salt Lake Boulevard and Kahuapaani Street intersection. There are concrete sidewalks on all corners of this intersection, though the sidewalk at the south side of the vehicle entrance to the shopping center directly across Kahuapaani Street terminates and does not extend into the center. There are no designated bicycle lanes on either Salt Lake Boulevard or Kahuapaani Street; bicycles use either the sidewalk or the vehicle lane next to the curb.

There are new bicycle facilities proposed near the Makalapa Compound project area, summarized in Table 3-3.

Table 3-3 Planned Bikeway Facilities

Location	*Planned Bikeway Facility/Description*	*Jurisdiction*
Kamehameha Highway (East Loch)	Lane from Waihona Street to Center Drive	State
Salt Lake Boulevard	Lane from Kamehameha Highway to Puuloa Road	County

Source: City and County of Honolulu, 2019

Pedestrian and bicycle movements were recorded at the three study intersection as part of the October 2017 manual traffic counts. Table 3-4 summarizes the total pedestrian and bicycle movements at the three intersections during four-hour periods in the morning and afternoon.

Table 3-4 Pedestrian and Bicycle Use (2017)

	0500 to 0900 hours		*1400 to 1800 hours*	
	pedestrians	*bicycles*	*pedestrians*	*bicycles*
Kamehameha Highway & Halawa Drive Intersection	26	2	23	7
Salt Lake Boulevard & Luapele Drive Intersection	21	0	61	0
Salt Lake Boulevard & Kahuapaani Street Intersection	22	3	48	6

Source: Julian Ng Inc., 2022

The highest hourly volumes of pedestrians at the intersection of Kamehameha Highway and Halawa Drive were recorded between 7:15 AM and 8:15 AM (10 pedestrians crossing Kamehameha Highway) and between 3:00 PM and 4:00 PM (17 pedestrians; 9 crossing Halawa Drive and 8 crossing Kamehameha Highway).

The highest hourly volumes of pedestrians at the intersection of Salt Lake Boulevard and Kahuapaani Street were recorded between 7:15 AM and 8:15 AM (10 pedestrians crossing the shopping center driveway) and between 2:45 PM and 3:45 PM (9 pedestrians crossing the shopping center driveway). The highest hourly pedestrian use of the crosswalk across Kahuapaani Street was 8 pedestrians between 3:45 PM and 4:45 PM.

The proposed offsite sewer improvement areas (below grade or within fixed facilities) are not generally accessed by JBPHH or other personnel except when maintenance or repair activities are required. In those situations, access is generally by vehicle rather than by pedestrian or bicycle modes.

3.1.3 Environmental Consequences

Impacts to ground traffic and transportation are analyzed by considering the possible changes to existing traffic conditions and the capacity of area roadways from proposed increases in commuter and construction traffic. The traffic impact analysis report prepared for the Proposed Action evaluated future conditions for three scenarios: (1) without the project, (2) with the project in the near-term (i.e., new JIOC facility and no reuse of existing JIOC facilities at Makalapa Compound), and (3) with the project in the long-term (i.e., new JIOC facility and reuse/backfill of existing JIOC facilities at Makalapa Compound). The near-term scenario horizon is after facility occupancy in 2032. The long-term scenario horizon is defined as 2037, or 20 years after the traffic impact analysis report baseline scenario. (Note: Although replacement occupants have not yet been identified for existing JIOC space that may be vacated at Makalapa, Ford Island, Naval Shipyard, or Camp Smith, given the demand for facility space at JBPHH, the Navy anticipates that vacated facility space would be occupied within approximately five years after the current JIOC occupants have relocated to the new facility. Hence, 2037 was identified as the long-term horizon year in the project's traffic impact analysis report. Because of the long horizon and uncertainty of reuse, the long-term scenario is considered under Cumulative Impacts in Chapter 4.)

3.1.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to transportation. Without the project in the near-term and long-term, delays would increase at all three intersections studied due to regional background traffic growth. Table 3-5 summarizes the near-term, without project conditions at the intersections studied, which assumes occupancy would occur within 10-15 years after the existing conditions baseline year (2017). The future baseline condition at the Salt Lake Boulevard intersection with Kahuapaani Street would approach capacity even without the project, but the overall conditions would be acceptable at all three intersections. Therefore, no impacts would occur under the No Action Alternative.

Table 3-5 Future (near-term) Baseline Conditions at Intersections Studied (without project)

Kamehameha Highway & Halawa Drive						
	AM Peak Hour			***PM Peak Hour***		
	X	***Delay***	***LOS***	***X***	***Delay***	***LOS***
Overall Intersection	0.52	29.7	C	0.73	30.9	C
Salt Lake Boulevard & Luapele Drive						
	AM Peak Hour			***PM Peak Hour***		
	X	***Delay***	***LOS***	***X***	***Delay***	***LOS***
Overall Intersection	0.41	16.6	C	0.47	18.0	C
Salt Lake Boulevard & Kahuapaani Street						
	AM Peak Hour			***PM Peak Hour***		
	X	***Delay***	***LOS***	***X***	***Delay***	***LOS***
Overall Intersection	0.75	49.1	D	0.98	54.7	D

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3.1.3.2 JIOC Facility-North Alternative (Preferred Alternative) Potential Impacts

The study area for the Preferred Alternative comprises the Kamehameha Highway and Salt Lake Boulevard roadway segments in the vicinity of the entry gates and the Kamehameha Highway-Halawa Drive, Salt Lake Boulevard-Luapele Drive, and Salt Lake Boulevard-Kahuapaani Street intersections. The study area also includes the offsite sewer improvement construction areas on South Avenue, Center Drive, Kamehameha Highway near Center Drive, and Nimitz Highway near Nimitz Gate.

Roadways

Construction Period Impacts

During the construction period, there may be temporary impacts to traffic volumes on roadways immediately surrounding the Makalapa Compound project area as well as roadways leading to the two entrances to Makalapa Compound, as construction vehicles, equipment, and workers access the project area. Due to its proximity to the project area, it is likely that most of the construction-related traffic would use Luapele Gate, if allowed.

Construction for the relief sewer lines and surge abatement infrastructure on South Avenue, Center Drive, Nimitz Highway, and Kamehameha Highway would involve temporary lane closures and possible re-routing of traffic in the affected areas.

While contractor employees would commute daily to and from the project area, construction vehicles and equipment would likely be moved on a less frequent basis. Construction materials and equipment would be transferred to and from the project sites generally during off-peak traffic hours (8:30 a.m. to 3:30 p.m.) to minimize disruption to traffic on local streets and to minimize contractor costs and delays; this could vary depending on specific construction requirements. The contractor would submit traffic control plans to relevant jurisdictional agencies, as appropriate. A street usage permit would be obtained from the CCH Department of Transportation Services if construction-related work requires temporary closure of any traffic lane on a City street. A Use and Occupancy Agreement would be obtained from the State of Hawaii Department of Transportation (HDOT) if required for work in any roadway under its jurisdiction. If oversize or overweight vehicles are used during construction, the applicable permits would be obtained from the State of Hawaii Department of Transportation. During implementation of the recommended signalization modification and lane striping at the Salt Lake Boulevard-Kahuapaani Street (if necessary) and Salt Lake Boulevard-Luapele Drive intersections (described in the Operational Period Impacts: With-Project Scenario section below), there may be temporary lane closures or detours around immediate work areas. The anticipated construction period impacts would be less than significant because the contractor would comply with measures described in its traffic control plan to mitigate impacts to vehicle traffic patterns resulting from the project.

Operational Period Impacts

As described earlier, the traffic impact analysis report evaluated future traffic conditions with the project at two future periods: (1) a “near-term” scenario, which assumes project construction and operation, but prior to renovation and reuse of vacated JIOC facilities at Makalapa (to be vacated as current JIOC occupants relocate to the new facility) and (2) a “long-term” scenario in which vacated JIOC facilities are renovated and re-occupied. The long-term scenario is addressed in Chapter 4 Cumulative Impacts because the timing and specific reuse of vacated JIOC facilities are unknown.

Offsite sewer improvement areas are not expected to have any operational period impacts to roadway traffic because the infrastructure improvements would be located below grade or in secured areas and would not generate additional vehicle trips, except for repair or maintenance activities. The replacement or upgrading of the sewer infrastructure may have a beneficial impacts on roadway traffic by reducing the risk of sewer line failure in the existing system components that would require repair activities in roadway ROWs.

With-Project Scenario. In the near-term, peak hour traffic patterns of vehicles entering and exiting Makalapa Compound is expected to change as traffic shifts from Borchers Gate to Luapele Gate. This traffic shift is expected because most JIOC personnel are expected to access the new facility site via Luapele Gate, which is in closer proximity than Borchers Gate to the proposed JIOC facility. This is likely to result in a decrease in traffic volumes and improve conditions at the Kamehameha Highway-Halawa Drive intersection, as JIOC personnel vacating existing facilities at Makalapa would occupy the new facility, leaving their former buildings available for re-occupancy in the future. Table 3-6 summarizes the future near-term/with-project conditions.

Table 3-6 Future With-Project Conditions at Intersections Studied (near-term)

Kamehameha Highway & Halawa Drive (near-term)						
	AM Peak Hour			*PM Peak Hour*		
	X	*Delay*	*LOS*	*X*	*Delay*	*LOS*
Overall Intersection	0.51	28.2	C	0.72	29.5	C
Salt Lake Boulevard & Luapele Drive (near-term)						
	AM Peak Hour			*PM Peak Hour*		
	X	*Delay*	*LOS*	*X*	*Delay*	*LOS*
Overall Intersection	0.49	20.1	C	0.56	20.4	C
Salt Lake Boulevard & Kahuapaani Street (near-term)						
	AM Peak Hour			*PM Peak Hour*		
	X	*Delay*	*LOS*	*X*	*Delay*	*LOS*
Overall Intersection	0.75	49.6	D	1.04	64.0	F*
Salt Lake Boulevard & Kahuapaani Street (near-term, with mitigation)						
	AM Peak Hour			*PM Peak Hour*		
	X	*Delay*	*LOS*	*X*	*Delay*	*LOS*
Overall Intersection	0.75	49.6	D	0.90	49.8	D

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service
*LOS F is based on 2017 traffic counts (conservative) and does not take into account current/projected reductions in traffic volume due to COVID-19 pandemic, future transit use, and other factors.

The capacity of Luapele Gate to process vehicles entering and exiting JBPHH Makalapa Compound is affected by inspection procedures at the gate, which can change according to threat level and other factors. Tandem manual gate operation (i.e., simultaneous inspection by two sentries who review driver credentials) provides greater capacity to process entering vehicles compared to automated gate operation or single sentry inspection procedures. Tandem manual gate operation should be considered if and when Luapele Gate operations result in extended queues or delays.

The traffic impact analysis report concluded that there would be a slight increase in delays at the intersection of Salt Lake Boulevard and Luapele Drive; however the overall intersection would continue to operate at LOS C. With or without the project, striping of the eastbound Luapele Drive approach for two lanes (a left turn/through option lane and a right turn-only lane) is recommended to formalize the existing two-lane use of the single, wide lane.

The added traffic volume in the PM Peak Hour at the Kahuapaani Street and Salt Lake Boulevard intersection could increase delays in both peak hours and cause over-capacity conditions in the PM Peak Hour, as shown in Tables 3-5 and 3-6 (i.e., PM peak hour decrease from LOS D to LOS F). This over-capacity condition is due to the high volume of right turns projected with the project from northbound Salt Lake Boulevard to eastbound Kahuapaani Street (1,024 vehicles in the PM Peak Hour, of which at most 308, or 30%, could be attributable to Luapele Gate). The analysis conservatively excludes potential reductions in background traffic volume growth due to telework practices accelerated by the COVID-19 pandemic, future rail transit use, or other factors described below (following Figure 3-4).

Should future traffic conditions reach over-capacity at the Kahuapaani Street-Salt Lake Boulevard intersection, a possible mitigation measure that involves modification of the existing traffic signal

phasing could provide adequate capacities and acceptable level of service during the PM peak period by allowing for additional overlap of non-conflicting vehicular and pedestrian movements. These improvements would not require any right-of-way acquisition, changes in the roadway layout, or designation of lane use, but would require modifications to existing signal heads (or additional signal heads), additional regulatory signage, and possibly an upgrade to the existing signal controller. See Figure 3-4 for location of these improvements. More details on this phasing modification are in Appendix A: Traffic Impact Analysis Report (see Appendix D within the traffic impact report). As shown in Table 3-6, this would provide acceptable level of service during the PM peak hour (i.e., improves LOS from F to D with mitigation). If needed, these improvements would be implemented by the entities having jurisdiction (i.e., Navy and HDOT) and are not part of the Proposed Action.

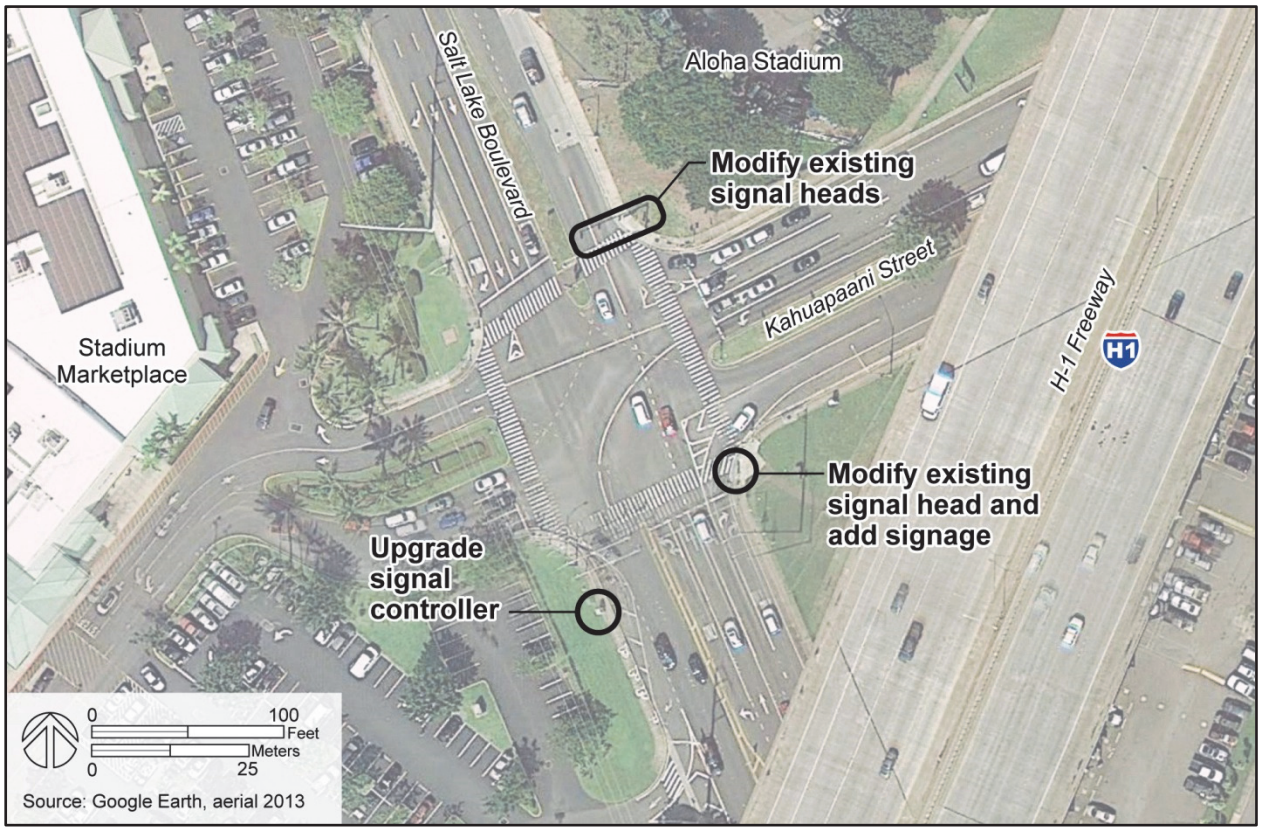


Figure 3-4 Proposed Traffic Modification Measures

There are several factors that would be expected to reduce future traffic volumes or the project's projected impact to traffic conditions to levels where the proposed mitigation is not warranted in the near term:

- Telework practices in both DoD and civilian personnel on Oahu were accelerated by the COVID-19 pandemic. Although a large portion of the workforce has returned to in-person work as COVID-19 cases subside, full- or part-time teleworking is likely to be continue permanently into the future for a consequential percentage of the commuting workforce.
- The traffic estimates used in the analyses were based on an earlier plan that would have relocated 216 personnel from other locations to the new building in Makalapa Crater. Current plans would reduce the number of relocated personnel by more than one-half (i.e., about 100 JIOC personnel

would relocate to Makalapa Crater from Ford Island or Camp Smith). Also, some personnel may be able to telework from home. These conditions, along with changes in travel patterns of non-project traffic, would be expected to result in peak hour traffic volumes that are less than those used in the analyses.

- Lower employment-related trip generation due to a shift from privately owned vehicles to alternative modes of transportation by younger military personnel (e.g., rail transit, bicycle, bus)
- Implementation of policies or physical improvements that support rail transit use (e.g., easier access to JBPHH Makalapa Compound from the Pearl Harbor Naval Base Station via pedestrian gate changes; bike sharing facilities)
- Peak commute times of JIOC personnel non-coincident with peak hours used in the impact analyses (i.e., JIOC-related traffic volumes do not coincide with existing peak entry or exit times)
- Vehicle flow constriction through the JBPHH Makalapa Compound entry gates (e.g., if queuing occurs for vehicles exiting via Luapele Gate during the PM Peak Hour, drivers may choose to depart via Borchers Gate, thereby reducing the impacts at the Salt Lake Boulevard-Kahuapaani Street intersection)
- The fixed-rail transit system currently under construction would provide an alternative mode to automobile travel, which may slow down the increase in area traffic volumes. Due to the unavailability of consistent specific information from the transit agency on their expected effects on traffic, its effects on non-project traffic volumes were not considered in the analyses.

Because there are currently no specific plans or commitments by federal or state agencies in place that support quantitative reductions in the assumptions specific to the project's traffic study, these factors were not taken into account in the analyses of future conditions. By not considering these potential reductions, potential project-related impacts considered conservative and necessary mitigation could be identified. Because with- or without-project traffic volumes may not reach the conservatively projected levels due to factors that could not be quantified in the analyses, the timing and ultimate need for the identified mitigation measures are unclear at this time and should be re-evaluated closer to project occupancy.

Bus Routes

Construction Period Impacts

During the JIOC facility construction period, the project is unlikely to cause disruptions to bus or para-transit operations, routes, or stops because construction activities would primarily occur within Makalapa Compound. Construction of offsite sewer improvements would require temporary lane closures on the affected roadways (e.g., Kamehameha Highway near Center Drive, Nimitz Highway near Nimitz Gate) that may cause temporary delays in the flow of traffic in the area. Impacts to public roadways would be minimized by the implementation of project-specific traffic control plans. Implementation of the recommended signal modifications and striping changes at the Salt Lake Boulevard-Kahuapaani Street and Salt Lake Boulevard-Luapele Drive intersections would temporarily affect local traffic movements and potentially cause short-term delays during the on-site work. However, these minor delays would not affect bus routes or significantly impact service due to their limited geographic and temporal scope.

Operational Period Impacts

In the long-term, project-related changes in traffic volumes in the affected roadways are not expected to affect bus routes or service. Changes to bus routes and stops would be driven more by the implementation of rail transit service rather than by the Proposed Action.

Railways

Construction Period Impacts

Construction of the Preferred Alternative (estimated to commence in CY 2026) is anticipated to begin after construction of the City's high capacity rail guideway in the vicinity of the project area, and the associated Halawa and Pearl Harbor Naval Base Stations are generally completed. Therefore, no construction conflicts between the two projects are expected.

JIOC facility project construction staff are unlikely to use rail transit for their commute to work because of the distance from the nearest rail transit station. A ½-mile radius to a rail station would be considered being within the area served by transit. The proposed project site is approximately ¾ mile from the nearest rail transit station (Halawa Station). Accessing the project site from Halawa Station requires entering JBPHH Makalapa Compound via Luapele or Borchers Gate, for a total one-way distance of about one mile in either case. In addition, construction crews usually carry their personal tools to and from the job site, making the walk (or bike ride) from the rail station even less convenient or appealing.

Construction of the Preferred Alternative would have temporary impacts to local traffic movements in the immediate vicinity of the areas recommended for signal modifications and roadway striping (i.e., Salt Lake Boulevard at Kahuapaani Street, Luapele Drive at Salt Lake Boulevard) and the offsite sewer improvement areas. However, this would not affect operation of or access to the future rail transit system because of the limited geographic areas affected and their distances from the nearest train station (about 2,900 feet and 3,500 feet, respectively from the Halawa Station to Salt Lake Boulevard/Kahuapaani Street and Luapele Drive/Salt Lake Boulevard, and 1,200 feet from Center Drive relief sewer line to the Pearl Harbor Naval Base station). Project construction impacts to pedestrian and bicycle access to the train station, described below, would be temporary and not expected to be significant.

Operational Period Impacts

In the near- and long-term, the Preferred Alternative (including the offsite sewer improvements) would not impact access to or operation of the future rail transit system. If with- or without-project traffic volumes do not reach the conservatively projected levels due to telework practices accelerated by the COVID 19 pandemic, future rail transit use, or other currently unforeseen factors, the identified signal phasing modification may not be needed. If determined to be warranted by future conditions, implementation of the recommended mitigation measures at the Salt Lake Boulevard-Kahuapaani Street intersection would allow the three intersections that would experience the greatest traffic impacts of the Preferred Alternative to operate at acceptable levels. Project operational impacts to pedestrian and bicycle access to the train station, described below, are not expected to be significant. Similar to what is discussed above under Construction Period Impacts, completion of the rail transit project is not expected to substantially affect vehicles accessing the JIOC facility site in the Operational Period. The proposed JIOC facility is outside the radius of what is typically considered the service area of the nearest rail transit station (i.e., ½-mile radius). Although some JIOC employees may utilize rail transit for commuting to work instead of their privately owned vehicles, they are likely to represent a small

percentage of JIOC commuters. JBPHH policies and programs supporting utilization of rail transit by JBPHH employees (including at Makalapa Compound) may increase ridership and reduce vehicle trips. Because no specific plans or commitments have yet been identified, ridership among JIOC commuters was not factored into the quantitative analysis of vehicle traffic impacts. It should be noted that the future traffic volume estimates conservatively did not include scenarios with lower background growth that could be experienced due to utilization of rail transit by area commuters other than JIOC employees.

Bicycle and Pedestrian Transportation

Construction Period Impacts

During the construction of the new JIOC facility, there would be temporary increases in traffic volumes on roadways leading to the Makalapa Compound entry gates. These increases are not likely to affect pedestrian or bicycle movements on the surrounding roadways, as traffic control measures would be implemented to maintain safe pedestrian and bicycle circulation around the construction areas. During construction of the recommended signal phasing modifications and lane striping improvements at the Salt Lake Boulevard-Kahuapaani Street and Salt Lake Boulevard-Luapele Drive intersections and construction of the offsite sewer improvement areas, there would be temporary lane closures or detours around immediate work areas. However, the contractor would be required to submit and adhere to a traffic control plan to maintain bicycle and pedestrian circulation and safety around the work areas. Therefore, pedestrian and bicycle access to and from nearby rail transit stations should not be significantly affected by project construction.

Operational Period Impacts

In the near-term and long-term, the change in peak hour traffic patterns of vehicles entering and existing Makalapa Compound (from Borchers Gate to Luapele Gate) and increase in delays at the intersections studied are not expected to significantly affect bicycle and pedestrian facilities or volumes in the area, including to or from the future rail transit station. As seen in Table 3-4 (Pedestrian and Bicycle Use [2017]), there was a total of 48 pedestrian movements at this intersection's four crosswalks during the 4-hour period between 2:00 PM and 6:00 PM. It should be noted that the 2017 pedestrian count indicated the highest hourly pedestrian use of the crosswalk across Kahuapaani Street was eight pedestrians between 3:45 PM and 4:45 PM. This indicates that fairly low use of this crosswalk during the PM Peak Hour. The implementation of rail transit service and additional bicycle facilities in the area are likely to increase pedestrian and bicycle activity in the area. The planned bikeway facilities have not yet been designed, but are proposed as marked bicycle lanes, which would clearly define areas of the roadway designated for bicycle travel.

If determined to be needed upon analyses using post-pandemic and post-rail transit data, potential signal phasing modification at the Salt Lake Boulevard-Kahuapaani Street intersection would result in enhanced pedestrian crossings and safety by providing needed crossing times during each signal phase and reducing potential pedestrian conflicts with vehicular movements. Details of the proposed mitigation are described in Appendix A of the Traffic Impact Analysis Report (see Appendix D within the report).

Because the offsite sewer improvements would not generate additional pedestrian or bicycle trips and would generally be located below ground or in secured areas outside transportation routes, they are not expected to impact pedestrian or bicycle facilities or their usage.

With adherence to construction period traffic control plans, conditions would be acceptable and impacts to transportation facilities and operations minimized. If determined to be warranted upon confirmation closer to project occupancy, implementation of the recommended mitigation measure at the Salt Lake Boulevard-Kahuapaani Street intersection would result in acceptable conditions to transportation facilities. Therefore, implementation of the Preferred Alternative would not result in significant impacts to transportation.

3.1.3.3 JIOC Facility-South Alternative Potential Impacts

The study area for the South Alternative is the same as for the Preferred Alternative. The alternative JIOC site is also in Makalapa Compound and would be of similar scope as the Preferred Alternative, including the proposed offsite sewer improvements. Minor differences include building location and orientation within Makalapa Crater and the stormwater detention facility location and design (see description of specific differences in Section 2.3.3); however, these differences would not affect traffic generation to or from the new facility. Because of this, the South Alternative would generate the same levels of construction and operational period vehicle trips as the Preferred Alternative, and these trips would be distributed between Borchers Gate and Luapele Gate in the same proportions. Because they are the same in both alternatives, the sewer improvements associated with this alternative would have the same impacts on transportation facilities as the Preferred Alternative.

The same mitigation measure (modified traffic signal phasing) is also recommended for the South Alternative—if warranted—in order to reduce the potential over-capacity conditions to an acceptable level of service at this intersection. This alternative would also include striping of the eastbound Luapele Drive approach for two lanes (a left turn/through option lane and a right turn-only lane) to formalize the existing two-lane use of the single, wide lane.

The South Alternative is anticipated to have the same insignificant impacts as the Preferred Alternative to roadways, bus routes, railways, and bicycle and pedestrian transportation in both the construction and operational periods. As with the Preferred Alternative, if determined to be necessary based upon analysis using post-pandemic and in-operation rail data, the proposed modified signal phasing improvements would also enhance pedestrian crossings and safety in the South Alternative.

3.2 Air Quality and Greenhouse Gases

This discussion of air quality includes criteria pollutants, standards, sources, permitting, and greenhouse gases. Air quality in a given location is defined by the concentration of various pollutants in the atmosphere. A region's air quality is influenced by many factors, including the type and amount of pollutants emitted into the atmosphere, the size and topography of the air basin, and the local meteorological conditions.

Most air pollutants originate from human-made sources, including mobile sources (e.g., cars, trucks, buses) and stationary sources (e.g., factories, refineries, power plants), as well as indoor sources (e.g., some building materials and cleaning solvents). Air pollutants are also released from natural sources such as volcanic eruptions and forest fires.

3.2.1 Regulatory Setting

3.2.1.1 Criteria Pollutants and National Ambient Air Quality Standards

The principal pollutants defining the air quality, called "criteria pollutants," include carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone, suspended particulate matter less than or equal to 10 microns in diameter (PM_{10}), fine particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$), and lead (Pb). CO, SO_2, Pb, NO_2, and some particulates are emitted directly into the atmosphere from emissions sources. Ozone, NO_2, and some particulates are formed through atmospheric chemical reactions that are influenced by weather, ultraviolet light, and other atmospheric processes. The State of Hawaii regulates ambient air quality standards (AAQS) defined in Chapter 11-59 of the Hawaii Administrative Rules. State standards have been established for particulate matter, SO_2, NO_2, CO, ozone and Pb. The state has also set a standard for hydrogen sulfide (H_2S). The Hawaii AAQS are given in terms of a single standard that is designed "to protect the public health and welfare and to prevent the significant deterioration of air quality."

Under the Clean Air Act (CAA), the U.S. Environmental Protection Agency (USEPA) has established National Ambient Air Quality Standards (NAAQS) (40 Code of Federal Regulations [CFR] part 50) for these pollutants. NAAQS are classified as primary or secondary. Primary standards protect against adverse health effects; secondary standards protect against welfare effects, such as damage to farm crops and vegetation and damage to buildings. Some pollutants have long-term and short-term standards. Short-term standards are designed to protect against acute, or short-term, health effects, while long-term standards were established to protect against chronic health effects.

Areas that are and have historically been in compliance with the NAAQS are designated as attainment areas. Areas that violate a federal air quality standard are designated as nonattainment areas. Areas that have transitioned from nonattainment to attainment are designated as maintenance areas and are required to adhere to maintenance plans to ensure continued attainment.

The CAA requires states to develop a general plan to attain and maintain the NAAQS in all areas of the country and a specific plan to attain the standards for each area designated nonattainment for a NAAQS. These plans, known as State Implementation Plans (SIPs), are developed by state and local air quality management agencies and submitted to USEPA for approval.

3.2.1.2 Hazardous Air Pollutants

Hazardous air pollutants (HAPs) emitted from mobile sources are called Mobile Source Air Toxics (MSAT). MSAT are compounds emitted from motor vehicles that are known or suspected to cause cancer or other serious health and environmental effects. In 2001, USEPA issued its first MSAT Rule, which identified 201 compounds as being HAPs that require regulation. A subset of six of the MSAT compounds was identified as having the greatest influence on health and included benzene, butadiene, formaldehyde, acrolein, acetaldehyde, and diesel particulate matter. More recently, USEPA issued a second MSAT Rule in February 2007, which generally supported the findings in the first rule and provided additional recommendations of compounds having the greatest impact on health. The rule also identified several engine emission certification standards that must be implemented (40 CFR parts 59, 80, 85, and 86; Federal Register Volume 72, No. 37, pp. 8427–8570, 2007). Unlike the criteria pollutants, there are no NAAQS for benzene and other HAPs. The primary control methodologies for these pollutants for mobile sources involves reducing their content in fuel and altering the engine operating characteristics to reduce the volume of pollutant generated during combustion.

National emission standards exist for HAPs, which are regulated under Section 112(b) of the 1990 CAA Amendments. The *National Emission Standards for Hazardous Air Pollutants* regulate HAP emissions from stationary sources (40 CFR part 61).

3.2.1.3 General Conformity

The USEPA General Conformity Rule applies to federal actions occurring in nonattainment or maintenance areas when the total direct and indirect emissions of nonattainment pollutants (or their precursors) exceed specified thresholds. The USEPA promulgated the General Conformity Rule to ensure federal activities occurring in nonattainment areas do not cause or contribute to new violations of National Ambient Air Quality Standards (NAAQS); actions do not worsen existing violations of the NAAQS; and attainment of the NAAQS is not delayed.

3.2.1.4 Permitting

Title V (Operating Permit)

The Title V Operating Permit Program consolidates all CAA requirements applicable to the operation of a source, including requirements from the State Implementation Plan (SIP), preconstruction permits, and the air toxics program. It applies to stationary sources of air pollution that exceed the major source emission thresholds, as well as other non-major sources specified in a particular regulation. Navy installations subject to Title V permitting shall comply with the requirements of the Title V Operating Permit Program, which are detailed in 40 CFR Part 70 and all specific requirements contained in their individual permits.

3.2.1.5 Greenhouse Gases

Greenhouse gases (GHGs) are gas emissions that trap heat in the atmosphere. These emissions occur from natural processes and human activities. Scientific evidence indicates a trend of increasing global temperature over the past century due to an increase in GHG emissions from human activities. The climate change associated with this global warming is predicted to produce negative economic and social consequences across the globe.

USEPA issued the Final *Mandatory Reporting of Greenhouse Gases Rule* on September 22, 2009. GHGs covered under the Final *Mandatory Reporting of Greenhouse Gases Rule* are carbon dioxide (CO_2), methane, nitrogen oxide (NO_x), hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and other fluorinated gases including nitrogen trifluoride and hydrofluorinated ethers. Each GHG is assigned a global warming potential. The global warming potential is the ability of a gas or aerosol to trap heat in the atmosphere. The global warming potential rating system is standardized to CO_2, which has a value of one. The equivalent CO_2 rate is calculated by multiplying the emissions of each GHG by its global warming potential and adding the results together to produce a single, combined emissions rate representing all GHGs. Under the rule, suppliers of fossil fuels or industrial GHGs, manufacturers of mobile sources and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions as carbon dioxide equivalent (CO2e) are required to submit annual reports to USEPA.

In an effort to reduce energy consumption, reduce GHGs, reduce dependence on petroleum, and increase the use of renewable energy resources the Navy has implemented a number of renewable energy projects. The Navy has established Fiscal Year (FY) 2020 GHG emissions reduction targets of 34 percent from a FY 2008 baseline for direct GHG emissions and 13.5 percent for indirect emissions. Examples of Navy-wide GHG reduction projects include energy efficient construction, thermal and

photovoltaic solar systems, geothermal power plants, and the generation of electricity with wind energy. The Navy continues to promote and install new renewable energy projects.

3.2.2 Affected Environment

The USEPA characterizes air quality by comparing concentrations of criteria pollutants to established NAAQS. The Hawaii Department of Health has established ambient air quality standards similar to the NAAQS. Criteria pollutants at the national level include carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matter, ozone, and lead. Based on ambient air monitoring data, USEPA has classified the State of Hawaii as being in attainment of the Federal standards. Consequently, the General Conformity rule is not applicable for this project. In addition, pollutant concentrations within the state comply with State standards, which are equal to or more stringent than NAAQS (e.g., sulfur dioxide). The State of Hawaii has also established a state ambient air standard for hydrogen sulfide (H_2S), which occurs naturally during the decomposition of organic matter, near geothermal sources, and produced during some industrial processes such as wastewater treatment. A summary of annual air quality monitoring data for monitoring stations on Oahu in comparison with state and federal air quality standards is presented in Table 3-7.

Table 3-7 Comparison of 2020 Oahu Monitoring Station Air Quality Data with State and Federal Air Quality Standards

Pollutant (monitoring station)	*Averaging Time*	*Standards*			*2020 Air Quality Data*
		*National Primary**	*National Secondary***	*State of Hawaii*	
PM_{10} (Honolulu)	Annual 24 Hours	- 150 μg/m³ (a)	- 150 μg/m³ (a)	50 μg/m³ 150 μg/m³ (b)	10.8 μg/m³ 22 μg/m³
$PM_{2.5}$ (Honolulu)	Annual 24 Hours	12 μg/m³ (c) 35 μg/m³ (d)	15 μg/m³ (c) 35 μg/m³ (d)	- -	3.3 μg/m³ 6.8 μg/m³
SO_2 (Honolulu)	Annual 24 Hours 3 Hours 1 Hour	- - - 0.075 ppm (e)	- - 0.5 ppm (b) -	80 μg/m³ 365 μg/m³ (b) 1300 μg/m³ (b) -	0.000 ppm 0.000 ppm 0.001 ppm 0.003 ppm
NO_2 (Kapolei)	Annual 1 Hour	0.053 ppm 0.100 ppm (f)	0.053 ppm -	70 μg/m³ -	0.003 ppm 0.027 ppm
Carbon Monoxide (Honolulu)	8 Hours 1 Hour	9 ppm (b) 35 ppm (b)	- -	5 mg/m³ (b) 10 mg/m³ (b)	0.6 ppm 0.9 ppm
Ozone (Sand Island)	8 Hours	0.070 ppm (g)	0.070 ppm (g)	157 μg/m³ (b)	0.048 ppm
Lead (Kapolei)	3 Months Quarter	0.15 μg/m³ (h) -	0.15 μg/m³ (h) -	- 1.5 μg/m³	0.001 μg/m³(i) -
H_2S (not monitored on Oahu)	1 Hour	-	-	35 μg/m³ (b)	-

Sources: HDOH, 2021a and NAVFAC PAC Air Environmental Engineer, 2022

* **Primary Standards** set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.

** **Secondary Standards** set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

(a) Not to be exceeded more than once per year on average over a 3-year period.

(b) Not to be exceeded more than once per year.

(c) Three-year average of the weighted annual arithmetic mean.
(d) 98th percentile value of the 24-hour concentrations averaged over three years.
(e) Three-year average of annual 99th percentile daily 1-hour maximum.
(f) 98th percentile value of the daily 1-hour maximum averaged over three years.
(g) Three-year average of annual fourth-highest daily 8-hour maximum.
(h) Maximum arithmetic 3-month mean concentration for a 3-year period.
(i) 2018 data; no data on lead available for 2020 (lead monitoring ended on 12/31/18 with USEPA approval).

The most recent emissions inventory for the Honolulu County is shown in Table 3-8. Volatile organic compound (VOC) and nitrogen oxides (NO_x) emissions are used to represent ozone generation because they are precursors of ozone.

Table 3-8 Honolulu County Air Emissions Inventory (2017)

Category	*NO_x (tpy)*	*VOC (tpy)*	*CO (tpy)*	*SO_2 (tpy)*	*PM_{10} (tpy)*	*$PM_{2.5}$ (tpy)*
Fire	32	412	1,737	16	184	156
Mobile	11,227	7,484	81,028	273	2,847	865
Stationary	14,416	30,539	9,221	12,875	11,967	3,403
Totals	25,675	38,435	91,986	13,164	14,998	4,424

Source: USEPA, 2021
Key: tpy = tons per year.

JBPHH operates under four Title V permits issued by the Hawaii Department of Health for several types of air emissions units:

- Permit 0209-01-C: fuel loading facilities
- Permit 0105a-01-C: shipbuilding and ship repair operations
- Permit 0105b-01-C: shipbuilding and ship repair operations
- Permit 0105e-01-C: combustion turbines, industrial waste treatment complex

Recent annual criteria pollutant emissions for JBPHH as reported by the DON are shown in Table 3-9.

Table 3-9 JBPHH Stationary Sources Air Emissions Inventory

Year	*NOx (tpy)*	*VOC (tpy)*	*CO (tpy)*	*SO_2 (tpy)*	*PM_{10} (tpy)*	*$PM_{2.5}$ (tpy)*	*HAP (tpy)*
2019	0.1	11.7	0.0	0.0	0.0	0.0	11.1

Source: Table 3.5-5 in DON, 2022
Key: tpy = tons per year.

HDOH operates a network of air quality monitoring stations at various locations on Oahu. Each station, however, typically does not monitor the full complement of air quality parameters. During calendar year 2020, sulfur dioxide, particulates, and carbon monoxide were monitored by HDOH at an air quality station located in downtown Honolulu. Nitrogen dioxide was monitored at Kapolei and ozone was monitored at Sand Island. The concentrations reported were consistently low compared to the standards for all parameters except for ozone. Maximum 8-hour ozone concentrations reached up to about 70% of the standard over the 2016-2020 reporting period. Ozone concentrations tend to be high in Hawaii due to the abundant sunshine and the island setting.

Much of the particulate emissions on Oahu originate from area sources, such as the mineral products industry and agriculture. Sulfur oxides are emitted almost exclusively by point sources, such as power plants, refineries, and other industrial sources. Nitrogen oxides emissions emanate predominantly from industrial point sources, although area sources (mostly motor vehicle traffic) also contribute a substantial share. The majority of carbon monoxide emissions occur from area sources (motor vehicle traffic), while hydrocarbons are emitted mainly from point sources.

Natural sources of air pollution emissions that could affect the project area at times but cannot be quantified very accurately include plants (aero-allergens), wind-blown dust, and to a lesser extent, volcanoes on the island of Hawaii. Manmade sources in the project area region include construction related to the future rapid transit guideway and stations, homeported and transient ships at JBPHH, and aircraft operating at Daniel K. Inouye International Airport and JBPHH.

Federal air pollution control regulations require that new motor vehicles be equipped with emission control devices that reduce emissions significantly compared to even a few years ago. Federal actions over the past several decades have significantly increased vehicle mileage through the corporate average fuel economy (CAFE) standards, originally passed by the U.S. Congress in 1975 to improve the average fuel economy of cars and light trucks. In 1990, President George H.W. Bush signed into law the Clean Air Act Amendments of 1990. This legislation required further emission reductions, which were phased in since 1994. Additional restrictions were signed into law during the Clinton administration, and began to take effect during the following decade. The increase in mileage and restrictions on emissions from new motor vehicles have helped to lower average emissions even as an increasing number of vehicles are on the roadways. CAFE standards issued in 2012 under the Obama Administration addressed fuel economy standards for new cars and light trucks model years 2017-2025, which would nearly double the fuel efficiency of new cars and light trucks over that of similar vehicles that were currently on the road. In 2022, the Biden Administration established new CAFE standards that will require an industry-wide fleet average of approximately 49 miles per gallon for passenger cars and light trucks in model year 2026. The new standards will increase fuel efficiency by 8% annually for model years 2024-2025 and 10% annually for model year 2026. They will also increase the estimated fleetwide average by nearly 10 miles per gallon for model year 2026, relative to model year 2021.

On January 20, 2021, President Joseph R. Biden, Jr. issued E.O. 13990 Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. The EO ordered an immediate review of agency actions taken during the Trump Administration to ensure compliance with the new administration's environmental policies, including revisiting fuel efficiency standards as well as rules governing emissions from airplanes and appliance and building energy efficiency standards. President Biden is also making electric vehicles a priority and supports tax credits for electric vehicle purchases and retrofitting factories for their production (Reuters, 2021).

Actions by the State of Hawaii are also focused on reducing vehicle emissions. The Hawaii Clean Energy Initiative (HCEI), established by the Hawaii legislature in 2015, sets a 100 percent clean energy goal by 2045, making Hawaii the first state in the nation to set a legally required deadline for obtaining 100 percent of its electricity from sustainable renewable resources (USEIA, 2017). Another major goal of the HCEI is to displace 70 percent of petroleum-based ground transportation fuels by 2030 (ibid). Hawaii has instituted incentives for electric vehicles, including discounted electricity rates, and is second in the nation in the number of electric vehicles per capita. Other HCEI goals include reducing the use of petroleum based fuels in the transportation sector and reducing electricity consumption by 4,300 gigawatt-hours by 2030 (HCEI, 2017).

3.2.2.1 Quantitative Emissions and Dispersion Modeling

An air quality study (B.D. Neal & Associates, 2019) was conducted to analyze baseline conditions, projected future conditions, and the effects associated with the Proposed Action (Appendix B-1).

Air quality analysis for baseline conditions were modeled to estimate ambient carbon monoxide concentrations at the three intersections analyzed in the project's traffic study (see Section 3.1 for discussion of traffic impacts). Roadway intersections in the project area are generally the primary concern because of traffic congestion and the increase in vehicular emissions associated with traffic queuing. Therefore, these intersections were identified as critical receptor areas for analysis:

- Halawa Drive at Kamehameha Highway
- Luapele Drive at Salt Lake Boulevard
- Kahuapaani Street at Salt Lake Boulevard

(Note: Because operation of the offsite sewer improvements would not result in additional traffic volumes or congestion at those sites, they were not included in the quantitative emissions and dispersion modeling.)

Intersection conditions were modeled using USEPA's Motor Vehicle Emission Simulator (MOVES2014a) software to estimate motor vehicle emissions and atmospheric dispersion modeling was done with the CAL3QHC dispersion model, which uses the MOVES emissions estimates as input. (Note: The initial air quality analysis for this project was conducted prior to the release of a subsequent version of the MOVES software [MOVES2014b]. According to USEPA, the software changes relate primarily to non-road equipment emissions and do not significantly change the on-road criteria emission estimates. Because the analysis for this project only evaluated carbon monoxide emissions for on-road vehicles, there would be little to no difference between MOVES2014a and MOVES2014b.) CAL3QHC was developed for the USEPA to simulate vehicular movement, vehicle queuing and atmospheric dispersion of vehicular emissions near roadway intersections. Five scenarios were studied, including: baseline, 2027 with and without the project, and 2037 with and without the project. Modeling focused on maximum 1-hour average carbon monoxide concentrations because it is both the most stable and the most abundant of the pollutants generated by motor vehicles. To evaluate the significance of the estimated concentrations, a comparison of the predicted values for each scenario was made. Comparison of the estimated values to the national and state AAQS was also used to provide another measure of significance. Maximum carbon monoxide concentrations typically coincide with peak traffic periods. The traffic impact assessment report evaluated both morning and afternoon peak-traffic periods. Typically, afternoon peak-hour traffic volumes are higher, but atmospheric dispersion conditions are generally worse during the morning. Thus, the air quality study evaluated both morning and afternoon peak-traffic periods.

Input meteorological conditions for this study were defined to provide "worst-case" or highest estimated results. One of the key meteorological inputs is atmospheric stability category, classified on a scale of one to six, with one being the most turbulent and six the least. For these analyses, atmospheric stability category 5 was assumed for the morning cases, while atmospheric stability category 4 was assumed for the afternoon cases. These are the most conservative stability categories that are generally used for estimating worst-case pollutant dispersion within urban areas for these periods (B.D. Neal & Associates, 2019). Worst-case wind conditions were defined as a wind speed of 2 miles per hour (abnormally slow given Hawaii average wind speeds are in the 12-mile per hour range, and mostly vary

between 6- and 17-miles per hour) with a wind direction resulting in the highest predicted concentration. Concentration estimates were calculated at wind directions of every 5 degrees.

HDOH monitoring stations for locations on Oahu report average carbon monoxide concentrations of less than one part per million (ppm). Background contributions of carbon monoxide from sources or roadways not directly considered in the analysis were conservatively accounted for by adding a background concentration of 1 ppm to all predicted concentrations for 2017.

The highest estimated 1-hour carbon monoxide concentration for the baseline (2017) case of the intersections studied was 2.1 ppm (see Table 3-10). This was projected to occur during the afternoon peak traffic hour at the intersection of Salt Lake Boulevard and Kahuapaani Street. The next highest concentration was 1.8 ppm at the Salt Lake Boulevard-Luapele Drive intersection during the PM peak hour. These concentrations are well within both the national AAQS of 35 ppm and the state standard of 9 ppm.

The highest estimated 8-hour baseline (2017) concentrations ranged from 0.8 to 1.0 ppm (highest at the Salt Lake Boulevard-Kahuapaani Street intersection), also well within both the state standard of 4.4 ppm and the national limit of 9 ppm (see Table 3-11).

There are no significant stationary air emission sources at JBPHH Makalapa Compound. Mobile sources of air emissions include personal and utility vehicles for personnel and dependents that work and reside at JBPHH Makalapa Compound. As noted in the air quality study, except for periodic impacts from volcanic emissions (vog) and possibly occasional localized impacts from traffic congestion, the present air quality of the project area appears to be reasonably good based on nearby air quality monitoring data. Air quality data from the nearest monitoring stations operated by the HDOH suggest that all national air quality standards are currently being met, and most of the pollutant concentrations reported were consistently low compared to the state and national standards.

3.2.3 Environmental Consequences

Effects on air quality are based on estimated direct and indirect emissions associated with the action alternatives. The region of influence (ROI) for assessing air quality impacts is the air basin in which the project is located (including the offsite sewer improvement areas), the project area in JBPHH Makalapa Compound as well as roadway intersections affected by changes to traffic patterns resulting from the Proposed Action (i.e., Kamehameha Highway-Halawa Drive, Salt Lake Boulevard-Luapele Drive, and Salt Lake Boulevard-Kahuapaani Street intersections).

Estimated emissions from a proposed federal action are considered to assess the potential for increases in pollutant concentrations.

3.2.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline air quality. Therefore, no impacts to air quality or air resources would occur under the No Action Alternative.

3.2.3.2 JIOC Facility-North (Preferred Alternative) Potential Impacts

In the Preferred Alternative, a new three-story, 172,000-sq ft building would be constructed in Makalapa Compound, with associated infrastructure such as an electrical substation/switching station, at-grade

parking lot, stormwater detention facility, and a sanitary lift station. Potential mitigation at two nearby roadway intersections include striping and signalization changes (see description in Section 3.1).

The Preferred Alternative would not introduce any new major air emissions sources. New stationary air emissions sources include five diesel-fueled emergency generators. In the event of a power outage, three generators would be temporarily operated to meet the new JIOC facility's electrical requirements; two generators would serve as backups.

Construction Period

The Preferred Alternative would generate short-term, temporary direct air emissions (e.g., fugitive dust, exhaust emissions from construction equipment and vehicles) and indirect emissions (e.g., transportation of equipment to project area, increase in local traffic from construction crew) during the construction period. BMPs would be employed to minimize particulate emissions during the construction period. The construction contractor would prepare and adhere to a dust control plan to avoid or minimize offsite impacts from fugitive dust emissions. The specific dust control measures used would depend, in part, on the amount and nature of earthwork that is needed, soil type, wind and precipitation conditions, and proximity to other activities. Examples of BMPs include watering of active work areas, using wind screens, keeping adjacent paved roads clean, and by covering of open-bodied trucks. Other dust control measures to consider include limiting the area that is disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Paving and landscaping of project areas early in the construction schedule would also reduce dust emissions. Exhaust emissions can be mitigated by moving construction equipment and workers to and from the project site during off-peak traffic hours.

Operational Period

Although increased traffic is expected to occur within the project area within the next few years with or without the project, background carbon monoxide concentrations may not change significantly since individual emissions from motor vehicles are forecast to decrease with time due to the probable retirement of older vehicles that emit more air pollution. Hence, a background value of 1 ppm was assumed to persist for the future scenarios studied.

After construction is completed, use of the proposed facilities would result in increased motor vehicle traffic in the study area, which has the potential to cause long-term impacts on ambient air quality. However, because most of the vehicle traffic would relocate from using Borchers Gate (along Kamehameha Highway) to Luapele Gate (from Salt Lake Boulevard), a corresponding reduction in traffic-related air pollutant emissions may occur at the Salt Lake Boulevard-Halawa Drive intersection. Modeling of present and future conditions (without and with implementation of P-079) indicated that operational period impacts on air quality in the primary project area due to emissions from project-related motor vehicle traffic are anticipated to be negligible.

As shown in Table 3-10, for the future "near-term" case (2027) without the proposed project, the highest worst-case 1-hour carbon monoxide concentration in the study area was estimated to decrease to 1.5 ppm, lower than the estimated highest worst-case existing concentration (2.1 ppm). This was predicted to occur during the afternoon peak traffic hour at the Salt Lake Boulevard-Kahuapaani Street intersection. Carbon monoxide concentrations at the other intersections studied are projected to decrease as well, with the next highest concentration (1.4 ppm) at the Salt Lake Boulevard-Luapele Drive intersection. The near-term with-project scenario indicated no change in the estimated carbon

monoxide concentrations from without-project conditions upon project build-out and operations (i.e., in 2027). The analysis of near-term with-project conditions estimated the same levels of carbon monoxide emissions with or without implementation of the recommended intersection improvements. These concentrations are well within state and national standards and suggest that emissions from higher traffic volumes and increased traffic congestion in the next several years will likely be more than offset by the retirement of older, more-polluting vehicles over time.

Table 3-10 Estimated Highest 1-Hour Carbon Monoxide Concentrations Along Roadways Near JIOC Facility Project (ppm)

Roadway Intersection	*Baseline (2017)*		*Near-Term (2027) Without Project*		*Near-Term (2027) With Project*	
	AM	*PM*	*AM*	*PM*	*AM*	*PM*
Halawa Drive at Kamehameha Highway	1.4	1.7	1.1	1.3	1.1	1.3
Luapele Drive at Salt Lake Boulevard	1.5	1.8	1.3	1.4	1.3	1.4
Kahuapaani Street at Salt Lake Boulevard	1.7	2.1	1.3	1.5	1.3	1.5

Hawaii State AAQS: 9 ppm National AAQS: 35 ppm

Highest estimated 8-hour future (2027 with and without P-079) carbon monoxide concentrations ranged from 0.6 to 0.8 ppm (highest again at the Salt Lake Boulevard-Kahuapaani Street intersection) (see Table 3-11). Implementation of the recommended improvements at the Salt Lake Boulevard-Kahuapaani Street would not affect these concentration levels. These concentrations are also well within both the state standard of 4.4 ppm and the national limit of 9 ppm. (Note: After the emissions and dispersion modeling was conducted, the potential traffic mitigation at the Salt Lake Boulevard-Kahuapaani Street intersection was revised to address potential vehicle-pedestrian conflicts. The intersection level-of-service resulting from the revised mitigation measure did not change from the earlier traffic study; in fact, the intersection utilization [i.e., volume-to-capacity ratio] and delays improved slightly in the updated traffic study. The highest estimated 1-hour CO concentration impacts at the intersection under the with-project scenario [i.e., 1.5 ppm] would be about 17 percent of the state AAQS and 4 percent of the NAAQS even without the potential mitigation. Because of this, additional quantitative modeling would likely show no change or a slight improvement in air quality impacts and it was determined that no additional modeling was necessary.)

Table 3-11 Estimated Highest 8-Hour Carbon Monoxide Concentrations Along Roadways Near JIOC Facility Project (ppm)

Roadway Intersection	*Baseline (2017)*	*Near-Term (2027) Without Project*	*Near-Term (2027) With Project*
Halawa Drive at Kamehameha Highway	0.8	0.6	0.6
Luapele Drive at Salt Lake Boulevard	0.9	0.7	0.7

Kahuapaani Street at Salt Lake Boulevard	1.0	0.8	0.8

Hawaii State AAQS: 4.4 ppm National AAQS: 9 ppm

The diesel generators to be included in the new facility would provide emergency power, with operation expected to occur only a few hours per year during power outages and scheduled testing. The primary air pollutants in the exhaust would include NOx, sulfur oxides, total organic compounds (TOC), CO, and particulates. There may also be some evaporative losses of TOC but these should be insignificant due to the low volatility of diesel fuel. According to the project's air quality study (B.D. Neal & Associates, 2019), the estimated annual emissions from the emergency generators (estimated in Table 3-12) would be minimal compared to area-wide emissions. These emergency generators should have negligible impacts on air quality.

Table 3-12 Estimated Air Pollution Emissions from Emergency Diesel Generators

Air Pollutant	*Emission Rate (tons/year)*
Particulate	0.6
Sulfur Oxides	0.6
Carbon Monoxide	1.8
Total Organic Compounds	0.7
Nitrogen Oxides	8.2

Source: B.D. Neal & Associates, 2019
Note: Emissions are based on USEPA emission factors for uncontrolled gasoline and diesel industrial engines. Assumes two 1-MW diesel generators and one 1.5-MW diesel generators each operating 100 hours per year. Because the generators would only be operated on an emergency basis during temporary power outages, 100 hours per year was deemed a reasonable proxy to account for routine testing as well as irregular emergency use.

Under this alternative, the Navy must notify HDOH of any changes in emissions sources in compliance with its Title V permits, such as adding emergency generators. However, emergency generators would be considered "insignificant activities" under Hawaii Administrative Rules (HAR) 11-60.1-82(f)(5) and generally exempted from the Title V permit system.

General Conformity

Because the State of Hawaii is in attainment of the NAAQS, the Proposed Action is not subject to the Clean Air Act's General Conformity Rule.

Mobile Source Air Toxics

It should be noted that, even with the project, localized emissions would likely be lower than present MSAT levels during the operational period as a result of USEPA's national control programs that are projected to reduce annual MSAT emissions by over 90 percent between 2010 and 2050 (FHWA, 2016). Local conditions may differ from these national projections in terms of fleet mix and turnover, vehicle miles traveled (VMT) growth rates, and local control measures. However, the magnitude of the USEPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the study area are likely to be lower in the future in nearly all cases.

From a regional perspective, the Preferred Alternative would not have regional impacts on MSAT levels because the Proposed Action would not meaningfully increase overall VMT on the island or state. This is because the new JIOC facility is expected to be staffed by personnel who would already be employed on-island.

Greenhouse Gases

Implementation of the Preferred Alternative would contribute directly to emissions of GHGs from the combustion of fossil fuels. A rough estimate of GHG generated during the construction period was derived using the Green Footstep calculator (URL: www.greenfootstep.org; Rocky Mountain Institute, 2009) assuming a new 210,000-sq ft building constructed on an undeveloped site of about 400,000 sq ft on Oahu, with a total building lifetime of 50 years. The calculation indicated GHG emissions of 22,500 tons CO_2e over the 2-1/2 year construction period—an annual average of 9,000 tons (8,165 metric tons CO_2e per year from demolition, construction, and clearing activities (see Appendix B-2). After the facility is operational, routine activities would generate approximately 3,188 tons (2,892 metric tons CO_2e) of CO_2e each year. These estimated annual GHG emissions fall below the threshold of 25,000 metric tons CO_2e tons of CO_2e at or above which USEPA requires suppliers of fossil fuels or industrial GHGs, manufacturers of mobile sources and engines, and other facilities emitting GHGs to provide annual reporting. This limited amount of emissions would not likely contribute to global warming to any discernible extent. (Note: The current facility design is about 38,000 sq ft smaller than the building analyzed in the GHG calculator. The expected construction period is also about six months longer than what was used in the GHG calculator. Based on the new design and construction duration, the calculated annual GHG emissions reported above may represent a conservative estimate.)

Therefore, implementation of the Preferred Alternative would not result in significant impacts to air quality.

3.2.3.3 JIOC Facility-South Alternative Potential Impacts

This alternative involves constructing a new JIOC facility in JBPHH Makalapa Compound, about 700 feet south of the Preferred Alternative location, as well as offsite sewer improvements. The facility would have similar scope, function, and supporting infrastructure as the Preferred Alternative (including the same location and scope of offsite sewer improvements). Minor differences include building location and orientation within Makalapa Crater and the stormwater detention facility location and design (see description of specific differences in Section 2.3.3), which would not affect traffic volumes to or from the new facility or their associated air emissions. This alternative is assumed to have the same recommended off-site traffic mitigation as in the Preferred Alternative (if determined needed by future conditions).

Because of its comparable scope, project location, and recommended mitigation, the JIOC Facility-South Alternative would result in similar insignificant air quality impacts as the Preferred Alternative. Because the stormwater detention facility would be constructed below grade (i.e., under the at-grade parking lot), this alternative would involve greater ground disturbance and may require a longer construction period, resulting in negligible slightly higher construction period emissions. In this alternative, BMPs would also be employed to avoid or minimize fugitive dust during the construction period. During the operational period, it would have the same insignificant impacts on air emissions as the Preferred Alternative from increased traffic volumes and the generation of GHG.

Because the estimated VMT under the action alternatives would be nearly the same under both action alternatives, it is expected there would be no appreciable difference in overall MSAT emissions between the action alternatives. Similar to the Preferred Alternative, this alternative would also require the Navy to notify HDOH of changes in emissions sources (e.g., adding emergency generators), although they would generally be exempted from the Title V permit system.

Therefore, implementation of this action alternative would not result in significant impacts to air quality.

3.3 Water Resources

This discussion of water resources includes groundwater, surface water, marine waters, wetlands, floodplains, and shorelines. This section also discusses the physical characteristics of marine waters, wetlands, etc.; wildlife and vegetation are addressed in Section 3.7, Biological Resources.

Groundwater is water that flows or seeps downward and saturates soil or rock, supplying springs and wells. Groundwater is used for water consumption, agricultural irrigation, and industrial applications. Groundwater properties are often described in terms of depth to aquifer, aquifer or well capacity, water quality, and surrounding geologic composition. Sole source aquifer designation provides limited protection of groundwater resources which serve as drinking water supplies.

Surface water resources generally consist of wetlands, lakes, rivers, and streams. Surface water is important for its contributions to the economic, ecological, recreational, and human health of a community or locale. A Total Maximum Daily Load (TMDL) is the maximum amount of a substance that can be assimilated by a water body without causing impairment. A water body can be deemed impaired if water quality analyses conclude that exceedances of water quality standards occur.

Marine waters would typically include estuaries, waters seaward of the historic height of tidal influence, and offshore high salinity waters. Marine water quality would be described as the chemical and physical composition of the water as affected by natural conditions and human activities. Additionally, marine waters may include an area within a National Marine Sanctuary requiring an action proponent to avoid adverse water quality impacts in order to prevent damage to resources within the sanctuary.

Wetlands are jointly defined by USEPA and U.S. Army Corps of Engineers (USACE) as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” Wetlands generally include “swamps, marshes, bogs and similar areas.”

Floodplains are areas of low-level ground present along rivers, stream channels, large wetlands, or coastal waters. Floodplain ecosystem functions include natural moderation of floods, flood storage and conveyance, groundwater recharge, and nutrient cycling. Floodplains also help to maintain water quality and are often home to a diverse array of plants and animals. In their natural vegetated state, floodplains slow the rate at which the incoming overland flow reaches the main water body. Floodplain boundaries are most often defined in terms of frequency of inundation, that is, the 100-year and 500-year flood. Floodplain delineation maps are produced by the Federal Emergency Management Agency and provide a basis for comparing the locale of the Proposed Action to the floodplains.

Shorelines can be located along marine (oceans), brackish (estuaries), or fresh (lakes) bodies of water. Physical dynamics of shorelines include tidal influences, channel movement and hydrological systems, flooding or storm surge areas, erosion and sedimentation, water quality and temperature, presence of nutrients and pathogens, and sites with potential for protection or restoration. Shoreline ecosystems

are vital habitat for multiple life states of many fish, birds, reptiles, amphibians, and invertebrates. Different shore zones provide different kinds and levels of habitat, and when aggregated, can significantly influence life. Organic matter that is washed onto the shore, or "wrack," is an important component of shoreline ecosystems, providing habitat for invertebrates, soil and organic matter, and nutrients to both the upland terrestrial communities and aquatic ecosystems.

3.3.1 Regulatory Setting

The Safe Drinking Water Act is the federal law that protects public drinking water supplies throughout the nation. Under the Safe Drinking Water Act, The USEPA sets standards for drinking water quality. Groundwater quality and quantity are regulated under several statutes and regulations, including the Safe Drinking Water Act.

The Clean Water Act (CWA) (33 U.S.C. section 1251 et seq.) establishes federal limits, through the National Pollutant Discharge Elimination System (NPDES) program, on the amounts of specific pollutants that can be discharged into surface waters to restore and maintain the chemical, physical, and biological integrity of the water. The NPDES program regulates the discharge of point (i.e., end of pipe) and nonpoint sources (i.e., stormwater) of water pollution.

The State of Hawaii Department of Health NPDES stormwater program requires construction site operators engaged in clearing, grading, and excavating activities that disturb one acre or more to obtain coverage under an NPDES Construction General Permit for stormwater discharges. Construction or demolition that necessitates an individual permit also requires preparation of a Notice of Intent to discharge stormwater and a Stormwater Pollution Prevention Plan that is implemented during construction. As part of the 2010 Final Rule for the CWA, titled *Effluent Limitations Guidelines and Standards for the Construction and Development Point Source Category*, activities covered by this permit must implement non-numeric erosion and sediment controls and pollution prevention measures.

Wetlands are currently regulated by the USACE under Section 404 of the CWA as a subset of all "Waters of the United States." Waters of the United States are defined as (1) traditional navigable waters, (2) wetlands adjacent to navigable waters, (3) non-navigable tributaries of traditional navigable waters that are relatively permanent where the tributaries typically flow perennially or have continuous flow at least seasonally (e.g., typically 3 months), and (4) wetlands that directly abut such tributaries under Section 404 of the CWA, as amended, and are regulated by USEPA and the USACE. The CWA requires that the HDOH establish a Section 303(d) list to identify impaired waters and establish TMDLs for the sources causing the impairment.

Section 404 of the CWA authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue permits for the discharge of dredge or fill into wetlands and other Waters of the United States. Any discharge of dredge or fill into Waters of the United States requires a permit from the USACE.

Section 438 of the Energy Independence and Security Act establishes stormwater design requirements for development and redevelopment projects. Under these requirements, federal facility projects larger than 5,000 sq ft must "maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow."

Section 10 of the Rivers and Harbors Act provides for USACE permit requirements for any in-water construction. USACE and some states require a permit for any in-water construction. Permits are required for construction of piers, wharfs, bulkheads, pilings, marinas, docks, ramps, floats, moorings,

and like structures; construction of wires and cables over the water, and pipes, cables, or tunnels under the water; dredging and excavation; any obstruction or alteration of navigable waters; depositing fill and dredged material; filling of wetlands adjacent or contiguous to waters of the U.S.; construction of riprap, revetments, groins, breakwaters, and levees; and transportation of dredged material for dumping into ocean waters.

The National Wild and Scenic Rivers System was created by Congress in 1968 to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is notable for safeguarding the special character of these rivers, while also recognizing the potential for their appropriate use and development. It encourages river management that crosses political boundaries and promotes public participation in developing goals for river protection.

The Coastal Zone Management Act of 1972 (CZMA) provides assistance to states, in cooperation with federal and local agencies, for developing land and water use programs in coastal zones. Actions occurring within the coastal zone commonly have several resource areas that may be relevant to the CZMA. The CZMA regulatory setting discussion is discussed in Section 3.8.1.

Executive Order 11990, *Protection of Wetlands,* requires that federal agencies adopt a policy to avoid, to the extent possible, long- and short-term adverse impacts associated with destruction and modification of wetlands and to avoid the direct and indirect support of new construction in wetlands whenever there is a practicable alternative.

Executive Order 11988, *Floodplain Management*, requires federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development unless it is the only practicable alternative. Flood potential of a site is usually determined by the 100-year floodplain, which is defined as the area that has a one percent chance of inundation by a flood event in a given year.

3.3.2 Affected Environment

The following discussions provide a description of the existing conditions for each of the categories under water quality resources at JBPHH Makalapa Compound and the offsite sewer improvement areas that involve ground disturbance.

3.3.2.1 Groundwater

On Oahu, groundwater occurs chiefly as either basal water, a lens of fresh to brackish water that floats on seawater, or high-level water, freshwater that does not rest on sea water. The Pearl Harbor aquifer is the most important aquifer on the island of Oahu and currently supplies about 100 million gallons per day of fresh groundwater mainly for public supply. Most of the surface above the Pearl Harbor aquifer is developed as either residential or urban areas, and most of the water pumped from the aquifer is for domestic and commercial use.

Makalapa Crater is situated in the Waimalu system of the Pearl Harbor aquifer. Shallow groundwater, the upper (“caprock”) groundwater body, occurs in the volcanic tuff. A deep “basal” aquifer occurs within fractured basalts that underlie the caprock formation. Groundwater observations conducted as part of a 2016 Remedial Investigation (RI) of Makalapa Crater Geographic Study area indicated that groundwater in Makalapa Crater is located at depths ranging from approximately 24 to 49 feet below ground surface. Makalapa Crater is located inland of the underground injection control line. However, a

groundwater utility evaluation performed as part of the 2016 RI concluded that groundwater in Makalapa Crater is not suitable for use as a drinking water source (DON, 2016).

The offsite sewer improvement areas are also generally located in the Waimalu system of the Pearl Harbor aquifer; however, the underlying aquifer areas on the seaward side of Kamehameha Highway and Nimitz Highway are not considered sources of drinking water.

3.3.2.2 Surface Water

Pearl Harbor Watershed

The Pearl Harbor watershed encompasses 110 square miles and is subdivided into nine distinct subwatersheds, from east to west: (1) Halawa; (2) Aiea; (3) Kalauao; (4) Waimalu (Waimalu and Waimano Streams); (5) Waiawa; (6) Kapakahi; (7) Waikele; and (8) Honouliuli. These watersheds contain the headwaters of nine streams that drain into Pearl Harbor. Makalapa Crater and the offsite sewer improvement areas are located within the easternmost of these, the Halawa Stream subwatershed.

The Pearl Harbor Watershed is characterized by a very steep precipitation gradient from the harbor to the crest of the Koolau Range. Although the Pearl Harbor area is relatively dry with a mean annual rainfall of 25.5 inches, the crest of the Koolau Range and other mountainous regions within the watershed are considerably wetter with a mean annual rainfall that can exceed 275 inches. Rainfall is seasonal, varying from 4 inches per month during the winter (December to February) to 1 inch per month during the summer (June to July) (Earth Tech Inc., 2005). The volume of freshwater entering Pearl Harbor has been estimated at 50 million gallons per day (mgd) during dry periods and greater than 100 mgd during rainy periods.

Streams

Stream flow into Pearl Harbor ranges from approximately 8 mgd of freshwater during dry periods to 56 mgd during wet periods. Halawa Stream, located along the northern boundary of Makalapa Crater, is a perennial (year round) stream which flows into East Loch. Only 20 percent of all stream flow entering Pearl Harbor flows into East Loch, with the majority of stream flow entering Middle Loch (40 percent) and West Loch (40 percent). Other perennial streams flowing into the Pearl Harbor estuary include Aiea, Kalauao, Waimalu, Honouliuli, Waiawa, and Waikele Streams. Several intermittent streams and springs also flow into the harbor. The perennial and intermittent streams drain agricultural and urban lands before passing through highly urbanized lands near the harbor. Stream water is fresh up until a short distance upstream from the mouth of the streams where they enter into the saline waters of the estuary. High flood peaks and low base flow above the areas of spring influence characterize Pearl Harbor streams (DON, 2011a).

Springs

Five large springs heavily influence the stream flows into Pearl Harbor: (1) Waikele; (2) Waiawa; (3) Waimanu; (4) Waiau; and (5) Kalauao. These springs are located along the shoreline and are considered the largest and most significant spring complex in the Hawaiian Islands. The largest spring is the Waimanu-Waiau Spring which drains into East Loch; it has a median flow of 32 mgd. Stream flow into the harbor contributes 31 mgd during dry periods and 87 mgd during wet periods and heavily influences the harbor water chemistry and associated marine biological conditions of the harbor (Earth Tech Inc., 2005). None of the Pearl Harbor springs are located in the immediate vicinity of the Makalapa Compound or offsite sewer infrastructure areas.

Makalapa Crater

There are presently no streams or other surface water resources within the Makalapa Compound or near the offsite sewer infrastructure areas. The Makalapa Crater was at one time occupied by a lake formed by precipitation runoff, discharge from early artesian irrigation wells, or a combination of the two, and was used as a commercial fish pond. The lake was drained prior to fill activities in the 1930s and 1940s. Before the lake was drained, surface water runoff from the crater may have drained through manmade tunnels into Halawa Stream and then into Pearl Harbor.

The existing surface topography, soil conditions, and subsurface geology of Makalapa Crater suggest that currently, surface water generated by rainfall in the crater remains within the crater, infiltrates through the permeable surface and near surface soils, and flows toward the center of the crater. Observations and data collected during a 2016 Remedial Investigation of the Makalapa Crater Geographic Study Area (DON, 2016) suggest that surface water runoff in the undeveloped portion of Makalapa Crater, including the proposed JIOC site, is limited due to the relatively dry conditions, heavy vegetation, and permeable surface soils. The drainage conditions indicate that surface water runoff generated within Makalapa Crater does not flow out of the crater, and likewise, runoff generated outside of the crater does not flow into the crater (DON, 2016).

3.3.2.3 Marine Waters

Pearl Harbor is the State of Hawaii's largest estuary, a coastal area where fresh water from rivers and streams mix with salt water from the ocean. The State of Hawaii Department of Health classifies the waters of the harbor as an inland estuary, Class 2 and as an impaired water body. The objective of Class 2 water is to protect their use for recreational purposes, propagation aquatic life, agricultural and industrial water supplies, shipping, and navigation. Discharges into Class 2 waters must receive the best degree of treatment or control compatible with the criteria established for this class (HDOH, 2021).

Like all estuaries, Pearl Harbor is a natural sediment trap, and is the ultimate recipient of the contaminant load from many sources within the watershed. It is estimated that approximately 96,300 tons (180,000 cubic yards) of sediment per year is delivered to Pearl Harbor from basin streams (Grovhoug, 1992 in DON, 2001).

Pearl Harbor has been identified by HDOH as one of eighteen "Water Quality-Limited Segments" around the State. After heavy rains, the nearshore waters of the harbor often turn red from the sediment-laden runoff. This sediment discharge is due primarily to poor erosion and sediment control in upland areas—along stream banks, unstable slopes, and cleared land (e.g., agricultural land, urban construction sites). Heavy metals and other chemical contaminants (e.g., pesticides, herbicides, etc.) frequently adsorb to sediment particles and are transported to the harbor waters. These contaminants can adversely impact the marine ecosystem. Although the Navy is required by law to meet State and federal water quality standards, it has little control over activities in the watershed that impact water quality. At its closest point (i.e., eastern end of the South Avenue relief sewer), the offsite sewer improvements are approximately 1,000 feet from the waters of Pearl Harbor.

As noted above, the 2016 Remedial Investigation of the Makalapa Crater Geographic Study Area (DON, 2016) concluded that the surface water runoff generated in Makalapa Crater remains within the crater, and infiltrates through the permeable soils. As a result, soils from Makalapa Crater are not likely to contribute significantly to the sediment load discharged into Pearl Harbor. While Halawa Stream, which

parallels the north rim of Makalapa Crater, discharges into East Loch, runoff from Makalapa Crater does not contribute to sedimentation in Pearl Harbor (DON, 2016).

3.3.2.4 Wetlands

As noted previously, wetlands are regulated by the USACE under Section 404 of the CWA. The USACE defines wetlands as having all three of the following characteristics: (1) vegetation that is at least periodically present and supports hydrophytes (i.e., water-loving plants); (2) soil substrate that is predominately undrained, hydric soil (soil which is permanently or seasonally saturated by water, resulting in anaerobic conditions, which prevents plants from respiring through their roots); and (3) water substrate that is non-soil and is saturated with water or covered by shallow water at some point during the growing season of each year. A USACE-defined jurisdictional wetland is subject to regulation under Section 404 of the CWA (see Section 3.3.1).

USACE performed a wetland inventory of Pearl Harbor in 1999 (USACE, 1999), and an update was conducted by NAVFAC Pacific in 2006 (NAVFAC Pacific, 2007). In the past, wetland areas have been defined in the interior of Makalapa Crater. During the 1999 and 2006 USACE wetland inventory and update, several wetland plants were recorded in the vicinity of a former pond. However, the absence of soil and hydrology indicators (parameters 2 and 3 above) prevents this area as being defined as a USACE-defined wetland (USACE, 1999; NAVFAC, 2007). There are no USACE jurisdictional wetlands within Makalapa Crater or the offsite sewer improvement areas.

The U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) uses a much broader definition of wetlands than the CWA, requiring that only one or more of the wetland parameters (vegetation, soil, water) be present to be considered a wetland. NWI-designated wetlands that are not USACE jurisdictional wetlands are not subject to federal laws and regulations. However, they may contain important habitat and are important from a natural resources management perspective. The 1999 NWI for Pearl Harbor identified a total of 5,207.2 acres of wetlands within Pearl Harbor, but none were identified in Makalapa Crater or the offsite sewer improvement areas.

3.3.2.5 Floodplains

Flood Insurance Rate Maps for the area (FEMA, 2014) indicate that the entire Makalapa Compound, including the project site, is located in Zone D, areas of undetermined, but possible, flood hazards (see Figure 3-5). The offsite sewer improvement areas are also within Zone D.

3.3.2.6 Shorelines

The entire Makalapa Compound and the offsite sewer improvement areas are located upland from the harbor and do not abut the shoreline.

3.3.3 Environmental Consequences

In this EA, the analysis of water resources looks at the potential impacts on groundwater, surface water, marine waters, wetlands, floodplains, and shorelines. Groundwater analysis focuses on the potential for impacts to the quality, quantity, and accessibility of the water. The analysis of surface water quality considers the potential for impacts that may change the water quality, including both improvements and degradation of current water quality. Marine waters analysis includes potential changes to physical and chemical characteristics. The impact assessment of wetlands considers the potential for impacts that may change the local hydrology, soils, or vegetation that support a wetland. The analysis of

floodplains considers if any new construction is proposed within a floodplain or may impede the functions of floodplains in conveying floodwaters. The analysis of shorelines considers if the Proposed Action would affect shoreline ecological functions such as channel movement and hydrological systems, flooding or storm surge areas, areas of erosion and sedimentation, water quality and temperature, presence of nutrients and pathogens, and sites with the potential for protection or restoration.

3.3.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline water resources. Therefore, no impacts to water resources would occur under the No Action Alternative.

3.3.3.2 JIOC Facility-North (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to water resources includes the project site and the surrounding Makalapa Compound. Construction of the proposed facility would include site preparation activities (clearing, grubbing, grading), and ground disturbing earthwork with the potential to cause erosion and runoff, impacting stream or nearshore water quality. The use of construction BMPs would minimize soil erosion and runoff and avoid adverse impacts to surface water and marine resources.

The JIOC facility includes a grass-lined stormwater detention facility south of the new building, to accommodate the increase in runoff over existing conditions. There would be no net increase in off-site runoff. The project also includes low impact development strategies, such as vegetated bioswales, to manage stormwater in an environmentally friendly manner. There are no wetlands in the project vicinity.

Construction of the South Avenue and Center Drive relief sewers and surge mitigation on Nimitz Highway near the Nimitz Gate would involve ground disturbance for trenching. Best management practices would be employed to avoid or minimize the transport of sediments or pollutants to Pearl Harbor waters during construction.

Operation and maintenance of the JIOC facility would require the provision of potable water, but this would not adversely impact groundwater resources. Operation of the sewer system improvements would not increase demand for groundwater resources. The improvements would reduce the risk of failure of the segments of the sewer system that were replaced or upgraded, and subsequently reduce the risk of spills that could pollute receiving waters or groundwater. Overall, implementation of the Preferred Alternative would not result in significant impacts to water resources.

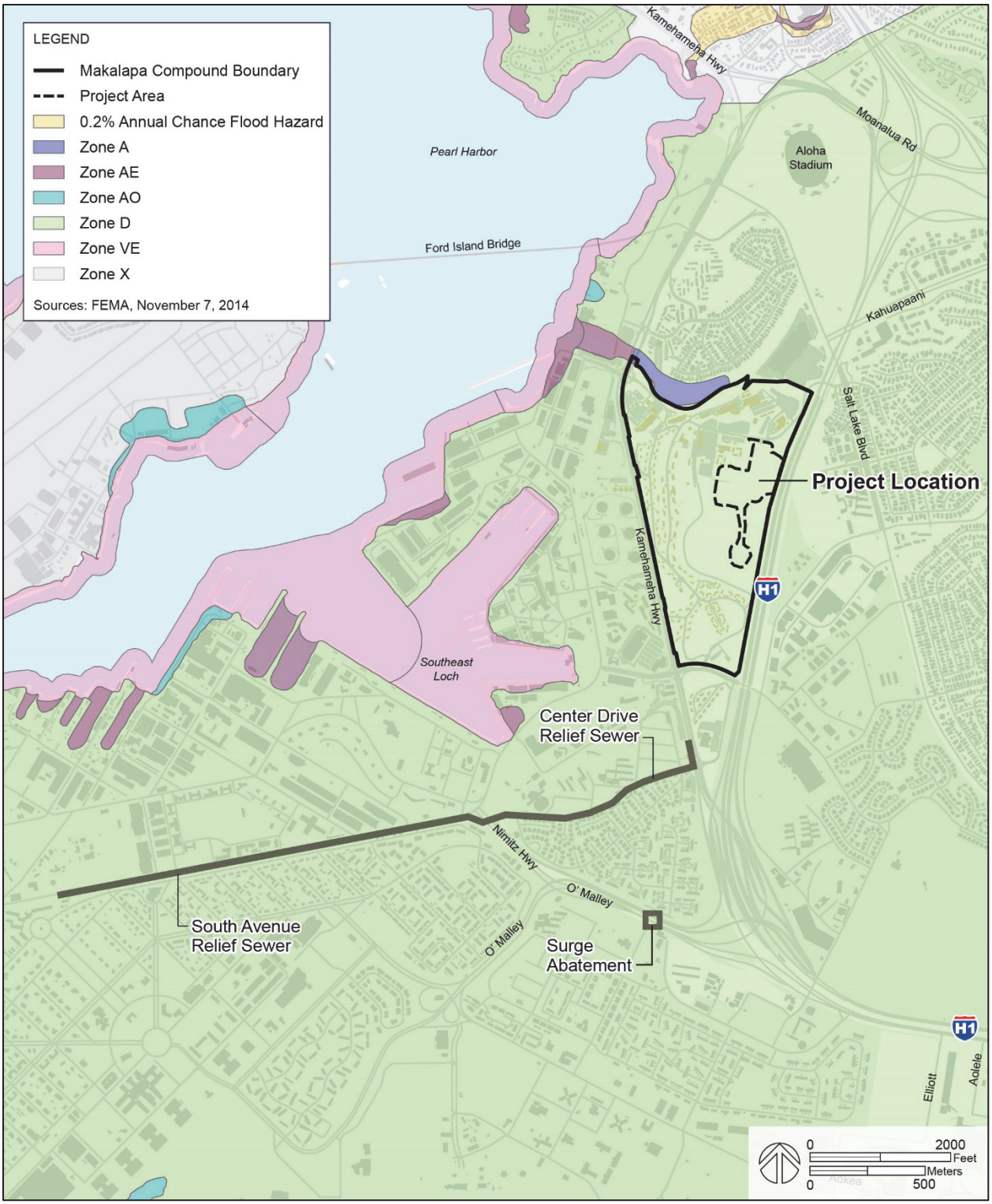


Figure 3-5 Flood Zones

3.3.3.3 JIOC Facility-South Alternative Potential Impacts

Like the Preferred Alternative, construction of the JIOC Facility-South would require vegetation clearing and ground disturbing activities, including excavation and pile driving, that have the potential to increase runoff and impact surface water resources. As with the preferred alternative, construction impacts would be mitigated through the use of construction BMPs. The JIOC Facility-South alternative would also include a stormwater detention system to avoid an increase in off-site runoff. This alternative would not result in significant impacts to water resources.

3.4 Geological Resources

This discussion of geological resources includes topography, geology, and soils of a given area. For projects involving in-water demolition or construction, this may also include bathymetry and marine sediments. Topography is typically described with respect to the elevation, slope, and surface features found within a given area. The geology of an area may include bedrock materials, mineral deposits, and fossil remains. The principal geological factors influencing the stability of structures are soil stability and seismic properties. Soil refers to unconsolidated earthen materials overlying bedrock or other parent material. Soil structure, elasticity, strength, shrink-swell potential, and erodibility determine the ability for the ground to support structures and facilities. Soils are typically described in terms of their type, slope, physical characteristics, and relative compatibility or limitations with regard to particular construction activities and types of land use.

No portion of the project site is within marine or coastal waters and bathymetry and marine sediments are not a concern.

3.4.1 Affected Environment

The majority of JBPHH lies on Oahu's coastal plain. The Makalapa Compound, where the JIOC facility is proposed, is within Makalapa Crater, a crater formed from post-erosional volcanics of the Koolau Volcano. The following sections describe the existing conditions at the Makalapa Compound for each of the relevant categories under geological resources.

3.4.1.1 Topography

The majority of land adjacent to the JBPHH waterfront is very flat and low-lying. As one moves away from the harbor toward Kamehameha Highway and Makalapa Crater, the topography rises. At the rim of Makalapa Crater, maximum elevation is 80 feet above mean sea level (MSL). Ground elevations in the project area range from 40 to 50 feet above MSL for the Preferred Alternative and 30 to 52 feet above MSL for the South Alternative. The topography of the offsite sewer improvement construction areas near South Avenue and Center Drive is generally flat to gently sloping, with ground elevations between 15 and 20 feet above MSL and 20 to 35 feet above MSL, respectively.

Makalapa Crater is a bowl-shaped geologic structure formed by relatively low-permeability volcanic tuff deposits, filled with dredged sediments consisting primarily of low-permeability clay, and overlain by relatively permeable surface and near-surface soils. The interior portions of the crater are relatively flat, although previous landfill activities have affected local relief in some areas. The interior and exterior slopes of the crater rim are steeper, reaching grades up to approximately 20 percent. In general, topography is not a major factor or development constraint within the JBPHH Makalapa Compound or at the offsite sewer improvement areas.

3.4.1.2 Geology

The Pearl Harbor basin is a drowned river system with several tributaries that form the three main lochs (West Loch, Middle Loch, and East Loch) that join to form a single channel entrance. The geologic processes that formed Pearl Harbor include sea level fluctuations, stream erosion, alluvial deposits, and volcanism. During periods of sea-level rise and fall, marine and terrestrial sediments were deposited over lavas of the Koolau and Waianae Volcanoes (Stearns, 1985).

The Pearl Harbor inlet or re-entrant was created by the banking of the younger Koolau lavas against the older Waianae lavas. Several streams, including Waikele (Waikakalaua) and Waiawa Streams flowed off the Koolau Range following the southward path of the lava flows, and eroded these lavas. At that time, the sea level was at a lower level or stand and these four streams flowed farther out to sea than Pearl Harbor.

As the polar ice caps grew during the next glaciation, the sea retreated and fell approximately 350 feet, lower than the present shoreline. During this time, the rivers and tributaries cut steep sided deep valleys across the flat (the former broad embayment). Salt Lake Crater erupted and deposited several feet of well-bedded ash (tuff) over the area. Slowly, as the glacial epoch ended, the sea level rose again and valleys were again flooded with water reaching a height of 25 feet above the present sea level. With the next glaciation, the sea receded again, beginning a new cycle of stream erosion.

Makalapa Crater is the westernmost of six tuff and ash cones that compose the Salt Lake group of volcanic craters. The craters generally feature low cones with broad rims and wide craters that have filled with lake and pond sediments. Makalapa Crater, along with Salt Lake and Aliamanu Craters, was formed approximately 0.5 million years ago by secondary eruptions that occurred after the Koolau Range had been inactive for more than a million years and had become deeply eroded.

The oldest crater, Aliamanu, erupted during a period of high sea level, while the Salt Lake and Makalapa craters are younger and erupted during periods of low sea level (i.e., regression) (MacDonald, Abbott, and Peterson, 1983 in DON, 2016).

3.4.1.3 Soils

The new JIOC facility project area is situated in the interior of the Makalapa Crater and the offsite sewer improvement areas are located within existing roadway ROWs. The Soil Survey (Figure 3-6), prepared by the U.S. Natural Resources Conservation Service (NRCS), identifies the soils series type in the Makalapa Crater project area as Makalapa clay, 2 to 6 percent slopes (MdB) (USDA, 2017). Makalapa clay is classified as CH (Unified Soil Classification System) and is characterized by a high shrink-swell potential and a low permeability. Most of the soils in the offsite sewer improvement areas are also classified as MdB, with a small area along the South Avenue project area classified as Coral Outcrop (CR). Coral Outcrop soil properties include slopes of 0 to 25 percent, low runoff, and are excessively drained.

Soil conditions in the Makalapa Compound area include about 5 to 10 feet (or more) of surface fills mixed with construction and demolition debris, which overlay the expansive Makalapa clays. The Soil Survey indicates that the Makalapa clay is typically underlain by medium hard volcanic tuff at depths ranging from about 27 to 49 inches (ASMD, 2017).

Areas with MdB soils, such as the project site, as well as surrounding areas with Kokokahi very stony clay, 0 to 35 percent (Soil Type KTKE in Figure 3-6), present some development concerns due to the soil's high shrink-swell potential. Structures constructed on these materials can be susceptible to cracking. In

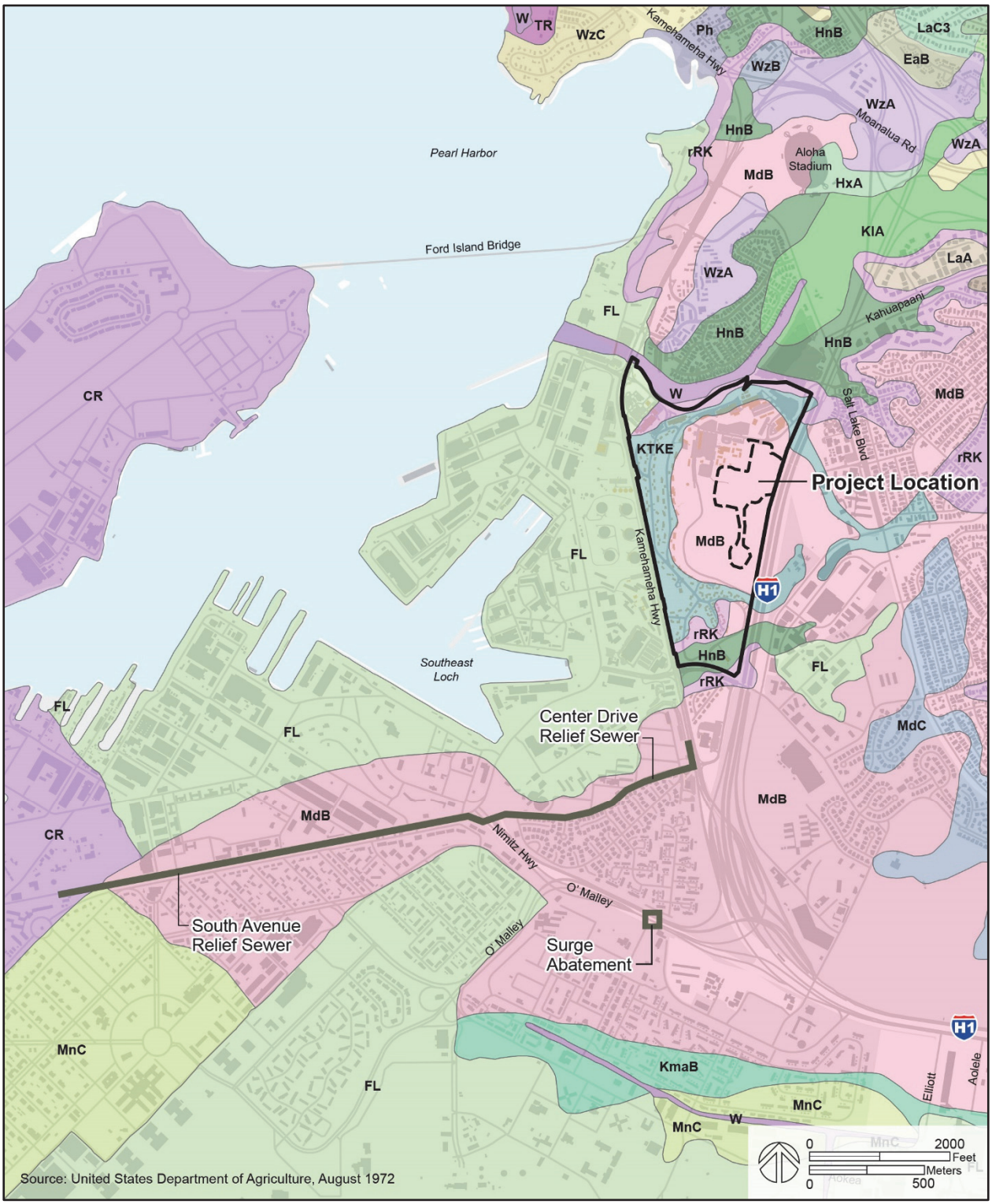


Figure 3-6 Natural Resources Conservation Service Soils

addition, the KTKE soil type and the soils associated with rockland are characterized by moderate to severe erosion hazard (USDA, 1972).

The University of Hawaii's Land Study Bureau (LSB) prepared an inventory and evaluation of the State's land resources during the 1960s and 1970s. The LSB evaluated the quality or productive capacity of certain lands for selected crops and overall suitability for agricultural use. A five-class productivity rating system was established with "A" representing the class of highest productivity and "E" the lowest. The project area for both action alternatives (including the offsite sewer improvement areas), is within lands unclassified by LSB for Oahu in its 1972 Detailed Agricultural Land Productivity Ratings for Kauai, Oahu, Maui, Molokai, Lanai, and Hawaii (i.e., no project area soils have an LSB rating).

The Agricultural Lands of Importance in the State of Hawaii (ALISH) land classification system was developed by the State of Hawaii Department of Agriculture in 1977, and establishes classes of agricultural lands based on soil characteristics. The ALISH system categorizes lands as Prime, Unique, or Other. The project area for both action alternatives is within lands that are not classified under the ALISH system (State of Hawaii Department of Agriculture, 1977).

3.4.2 Environmental Consequences

Geological resources are analyzed in terms of drainage, erosion, prime farmland, land subsidence, beach stability and erosion, and seismic activity. The analysis of topography and soils focuses on the area of soils that would be disturbed, the potential for erosion of soils from construction areas, and the potential for eroded soils to become pollutants in downstream surface water during storm events. The analysis also examines potential impacts related to seismic events. Best Management Practices are identified to minimize soil impacts and prevent or control pollutant releases into stormwater. The potentially affected environment for geological resources is limited to lands that would be disturbed by any proposed facility development or demolition, including the offsite sewer improvement areas.

3.4.2.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline geology, topography, or soils. Therefore, no impacts to geological resources would occur with the No Action Alternative.

3.4.2.2 JIOC Facility-North (Preferred Alternative) Potential Impacts

The study area encompasses the proposed construction and ground disturbance areas related to the Preferred Alternative. Construction of the JIOC facility on a currently undeveloped site would require site clearing and grubbing, and removal of any buried construction debris that may be encountered during excavation and site grading. Due to the characteristics of the soil at the project site, the proposed JIOC facility would require deep foundations such as precast driven piles bearing on the underlying medium hard volcanic tuff. Due to the presence of construction and demolition debris mixed in the surface fills, pre-drilling for installation of precast driven piles may be required. Remedial work may include over-excavation and removal of the near surface fill and replacement with imported granular structural fill. Alternatives may include deep foundations that extend through the surface fill to support the building, or if the building is supported on shallow foundations, surcharging the site to help reduce the potential settlement of loose pockets of fill.

Excavation of trenches would be required for the South Avenue and Center Drive relief sewer lines and the surge mitigation work near Nimitz Gate. The excavated areas would be backfilled with appropriate material and the final finished grade would match the existing grade.

During construction, BMPs would be implemented to avoid soil erosion and stormwater discharge offsite, including reducing the risk of sediments or pollutants from the offsite sewer improvement areas reaching surface or marine waters. The proposed project infrastructure includes an on-site network of inlets and piping to convey stormwater runoff around the new facilities to an at-grade detention facility located south of the new JIOC building. The grass-lined detention facility is sized to accommodate the increase in runoff over existing conditions, limiting discharge from the site to pre-development levels. Low impact development strategies, including vegetated bioswales and water quality units, would be included in the project. Operation of JIOC is not expected to increase soil erosion or stormwater runoff, or have other impacts to geological resources. Operation of the proposed offsite sewer improvements would be via below grade lines and would not have ongoing effects on soil conditions. Therefore, implementation of this alternative would not result in significant impacts to geological resources.

3.4.2.3 JIOC Facility-South Alternative Potential Impacts

The site for the South Alternative is located in the same general vicinity, and would have construction-period impacts similar to the Preferred Alternative. Because the proposed construction and operation activities of the offsite sewer improvements would be the same as in the Preferred Alternative, they would have the same impacts to geological resources under this alternative. As in the Preferred Alternative, deep foundations, including driven piles, would be required at this site in response to existing soil conditions. In this alternative, a stormwater detention system is proposed that would collect and detain stormwater beneath the at-grade parking lot and involve greater ground disturbance; however construction BMPs would be implemented to avoid soil erosion and stormwater runoff that may reach surface or marine waters. No adverse impacts associated with soils, stormwater runoff, or geological resources are anticipated. Therefore, implementation of this alternative would not result in significant impacts to geological resources.

3.5 Visual Resources

This discussion of visual resources includes the natural and built features of the landscape visible from public views that contribute to an area's visual quality. Visual perception is an important component of environmental quality that can be impacted through changes created by various projects. Visual impacts occur as a result of the relationship between people and the physical environment. This section does not include analysis of cultural landscapes, which are discussed in Section 3.6.

3.5.1 Regulatory Setting

The City and County of Honolulu's (CCH) Primary Urban Center Development Plan (PUC DP) is the regional plan maintained by the CCH to regulate development in Oahu's Primary Urban Center (PUC) (in which Makalapa Crater is situated). The PUC DP also identifies prominent public viewplanes for protection. The DP includes a policy of establishing and maintaining an integrated open space network throughout the PUC. The open space network comprises—among other elements—the preservation of panoramic views of the Koolau and Waianae Mountain Ranges, Punchbowl, Diamond Head, Pearl Harbor, and other natural landmarks. The PUC DP also seeks to protect scenic public views of:

- Koolau and Waianae Mountain Ranges and their foothills (notably, Red Hill and Puu Ualakaa, or Round Top);
- Pacific Ocean, Pearl Harbor's East Loch, Ford Island, Honolulu Harbor, Keehi Lagoon and Kewalo Basin, and their respective shorelines; and
- craters of Leahi (Diamond Head), Puowaina (Punchbowl) and Aliamanu.

Makalapa Crater is not specifically mentioned in the PUC DP as a prominent landmark for protection of public views.

3.5.2 Affected Environment

Makalapa Crater is one of several remnant volcanic features on the south shore of Oahu. Others in the vicinity include Salt Lake Crater, Aliamanu Crater, and further east, Punchbowl Crater. Makalapa Crater is one of the smallest features in this group and is bounded by Kamehameha Highway on the west, the H-1 Freeway on the east and Halawa Stream on the north. Views of the outside of the crater are most prominent from Kamehameha Highway in the vicinity of Halawa Steam where the Navy administrative buildings on the northwestern rim overlooking Halawa Stream are quite visible, and along the western Kamehameha Highway frontage where the officer family housing is located. The interior of the crater (where the JIOC facility is proposed), is only visible from within the crater (i.e., no public views are available), with the exception of views from Bougainville Road in the vicinity of Radford High School.

The interior of the crater is visible from most points along the crater rim including the Navy's administrative buildings on the north side and the senior officer's quarters just inside the rim on the west and southwest side. Views of the crater interior from the north side are blocked by the two-story Navy Gateway Inns and Suites (NGIS) facility. Important vantage points include views of and across the crater from the officers' quarters and the administrative buildings (see Figures 3-9, 3-10, and 3-11 for representative views from the crater rim).

The H-1 Freeway was cut through the east side of the crater in the 1960s and the east rim is no longer extant (a manmade berm runs along the west side of the H-1 freeway, blocking views of the crater from the Freeway and vice versa). The north and west sides of the crater rim are approximately 90 feet above MSL while the crater floor, where the JIOC facility would be constructed, is approximately 45 feet above MSL. The stands of kiawe (*Prosopis pallida*) that dominate the crater floor are in the 60-foot range, so views of the crater interior from the rim are slightly downward and predominantly of the kiawe forest. A landscaped ballfield, two play courts, tot lot and cabana are located at the base of the western wall. Views from the crater floor in the vicinity of the JIOC facility are truncated by the dense stands of kiawe and lower level brush, but there are glimpses of the crater wall and the buildings along the rim.

Looking from the crater rim from ground floors of the administrative and housing uses along the north, west, and east perimeters of the rim, the landscape middle ground beyond the crater is urban in character with the large commercial building masses at the adjacent Bougainville Industrial Park, the HECO Bougainville electrical substation, and the two large Honolulu Board of Water Supply reservoirs at the lower entrance of the nearby Aliamanu Military Reservation, and Aloha Stadium to the northeast. Slightly above the middle ground, views of the slopes and ridgeline of the Koolau Range are visible, with Camp Smith and Halawa Valley to the northeast, Moanalua Valley and Tripler Hospital to the east, and Kalihi Valley further to the east.

The offsite sewer improvement areas are below grade and located in existing urbanized areas and the surrounding views include industrial, residential, and roadways.

3.5.3 Environmental Consequences

The evaluation of visual resources in the context of environmental analysis typically addresses the contrast between visible landscape elements. Collectively, these elements comprise the aesthetic environment, or landscape character. The landscape character is compared to the Proposed Action's visual qualities to determine the compatibility or contrast resulting from the buildout and demolition activities associated with the Proposed Action.

3.5.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to visual resources. Therefore, no impacts would occur with the No Action Alternative.

3.5.3.2 JIOC Facility-North (Preferred Alternative) Potential Impacts

The site proposed for the Preferred Alternative in Makalapa Crater and adjacent lands define the study area for visual resources analyses. The offsite sewer improvement areas are not included in the visual resources study area because the proposed infrastructure would be located underground or within existing sewer infrastructure facilities.

The visual impact analysis is based on the visual impacts from several key view points; three from within and one from outside the crater:

1. ground level on the north wall of the crater
2. top of the main exterior staircase on the west wall of the crater
3. Samoa Place cul-de-sac on the south side of the crater
4. Bougainville Drive on the east side (outside the crater)

These four points are depicted in Figure 3-7 and generally represent the four points of the compass and the views most likely to be encountered.

As noted in Chapter 2, the new JIOC facility is anticipated as a large, three-story building with floor to ceiling heights in the 16- to 17-foot range (estimated 50-foot total height above adjacent finished grade). For the purposes of the visual resources impact analysis, a proxy building based on an earlier building design was used. The proxy building was 210,000 sq ft that was assumed to include a low slope roof (4:12 pitch), adding approximately eight feet to the three-story building height. The first two floor plates were approximately 315 feet by 225 feet, with third floor dimensions of 315 feet by 140 feet (a half-floor). The long axis of the proxy building was oriented generally east-west.

The ground floor of the proposed (proxy) facility analyzed would be located at an elevation of approximately 45 feet MSL, resulting in the roof peak at about the 105-foot MSL range (i.e., 60 feet above finished grade).

An analysis was conducted using a 3-dimensional (3D) model to anticipate the Preferred Alternative's impacts on views within and outside Makalapa Crater. The methodology and assumptions of the analysis follow and Figure 3-8 provides a schematic drawing showing the building dimensions used in the analysis.

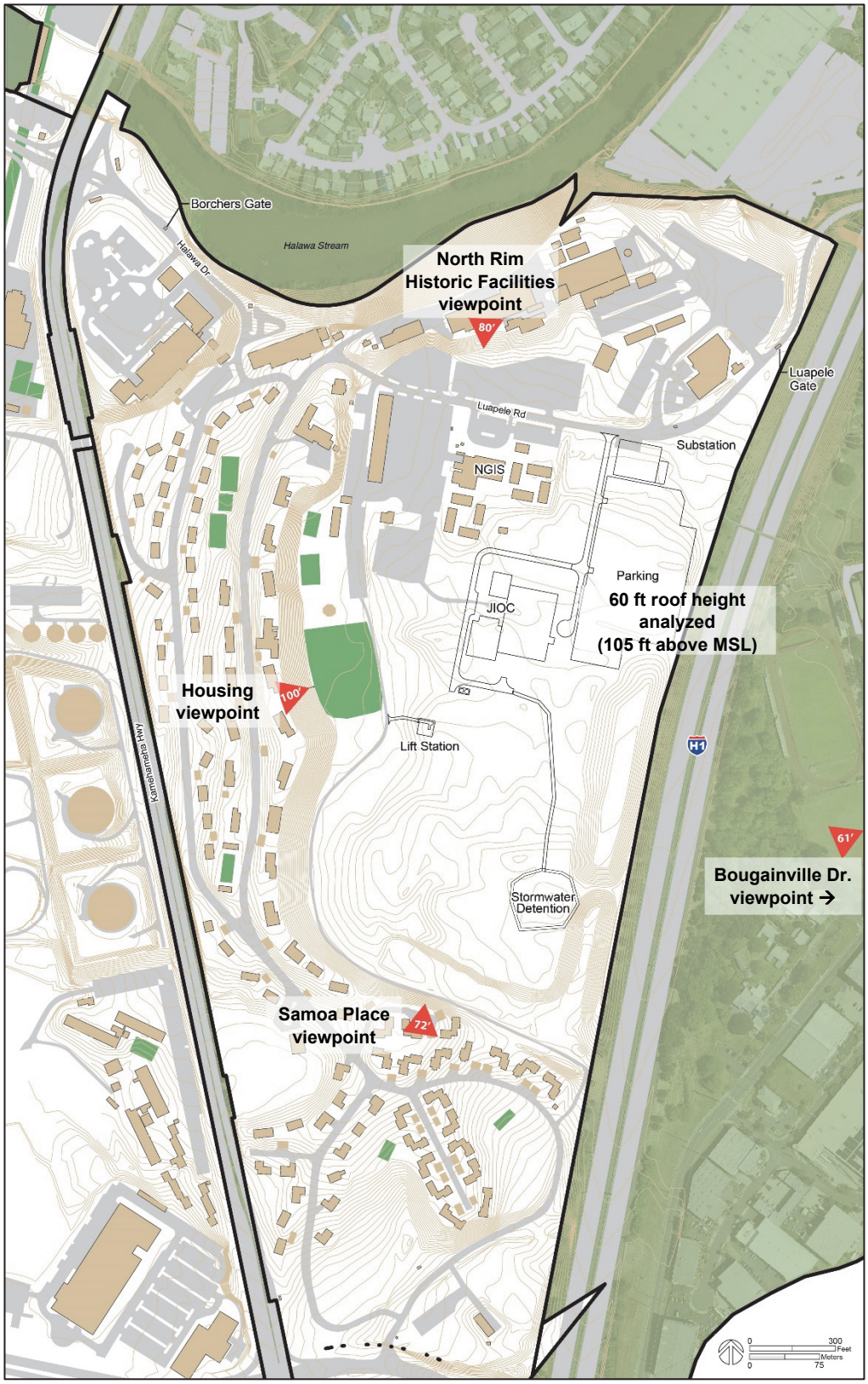


Figure 3-7 Visual Analysis Viewpoint Locations (Preferred Alternative)

1. Using a rough outline of the building perimeter from design information in programming documents available at the time of the 3D modeling (i.e., site plan dated July 7, 2017), a proxy building with standard measurements for roof and ceiling heights was modeled using building information modeling software (i.e., Autodesk Revit).

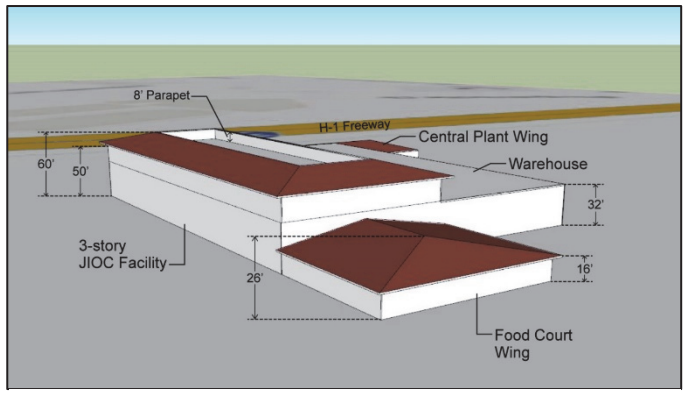


Figure 3-8 Proxy Building Modeled Dimensions (view to southeast)

2. The total height of the building was assumed to be a **maximum of 60 feet from finished grade to rooftop (ten feet higher than the proposed building height)**.
3. The roof slope was based on a standard 4:12 slope, which allowed for a parapet on the roof to house mechanical systems of the buildings (i.e., results in 8-foot vertical rise from top of roof to top of parapet, behind which mechanical equipment could be installed).
4. Other dimensions assumed in visual analysis include:
    a. 16 feet to bottom of first floor roof (i.e., food court and central plant wings)
    b. 26 feet to top of first floor roof
    c. 32 feet to top of warehouse/2nd floor of main facility
    d. 60 feet to top of 3rd floor roof
5. The model was imported into a 3D modeling computer program (i.e., SketchUp 2017) to be placed at the appropriate elevation.
6. The building was placed at the elevation of 45 feet above MSL, which is the mid-elevation of the proposed site layout.
7. The final product was exported as a KMZ file for use in Google Earth. Google Earth provided context and 3D modeling of surrounding area.

(Note: **The current building design is approximately 10 ft shorter than the proxy building modeled in the visual analysis** due to the lack of a roof parapet that was assumed in the 3D model. Therefore, the visual analyses that follow conservatively represents the visual impacts of the proposed JIOC building.)

Ground Level on the North Rim of Makalapa Crater

Before and after images of this scene are provided below. The images represent the view from the ground level looking south toward the proposed JIOC facility. The existing scene (Figure 3-9A) is dominated by the short-term lodging facility—Navy Gateway Inns and Suites (NGIS)—complex immediately to the north, with its distinctive high-pitched roofs, and parking lots in the foreground. (Note: All photographs included in this section were taken by HHF Planners staff on November 13, 2017

under a DoD-issued photo pass.) The kiawe (*Prosopis pallida*) forest behind the NGIS complex is visible above the rooftops. Figure 3-9B superimposes the new building into the scene, with the top edge of the roof barely visible above the kiawe forest. The red arrow indicates the top edge of the roof. As modeled, the new building would be barely visible, screened by the NGIS buildings and the existing kiawe forest. Even if the building were more visible, it would not impact any established public vistas or view planes.

A: Existing view from historic facilities on north rim of Makalapa Crater

B: Potential view from historic facilities on north rim of Makalapa Crater

Figure 3-9 Existing and Potential Views from Historic Facilities on North Rim of Makalapa Crater (Preferred Alternative)

Top of slope on West Rim of Makalapa Crater

Before and after images of this scene are provided in Figure 3-10. The images represent the view to the east from the top of the exterior stair landing connecting the family housing along the crater's west rim to the recreational facilities below. As seen in Figure 3-10A, the foreground is dominated by the baseball field, the octagonal recreational pavilion, and other recreational buildings, with large trees to the left and right framing the view. The extensive kiawe forest is very visible in the mid ground with the Koolau Mountain ridgeline and lower slopes visible in the background above the treetops. Figure 3-10B superimposes the new building into the scene, with the top edge of the building's roof visible above the kiawe forest. The red arrow indicates the top edge of the roof.

As shown, the building is barely visible above the existing kiawe forest. Even if the building were more visible above the treetops, it would not obscure views of the Koolau range or its lower slopes.

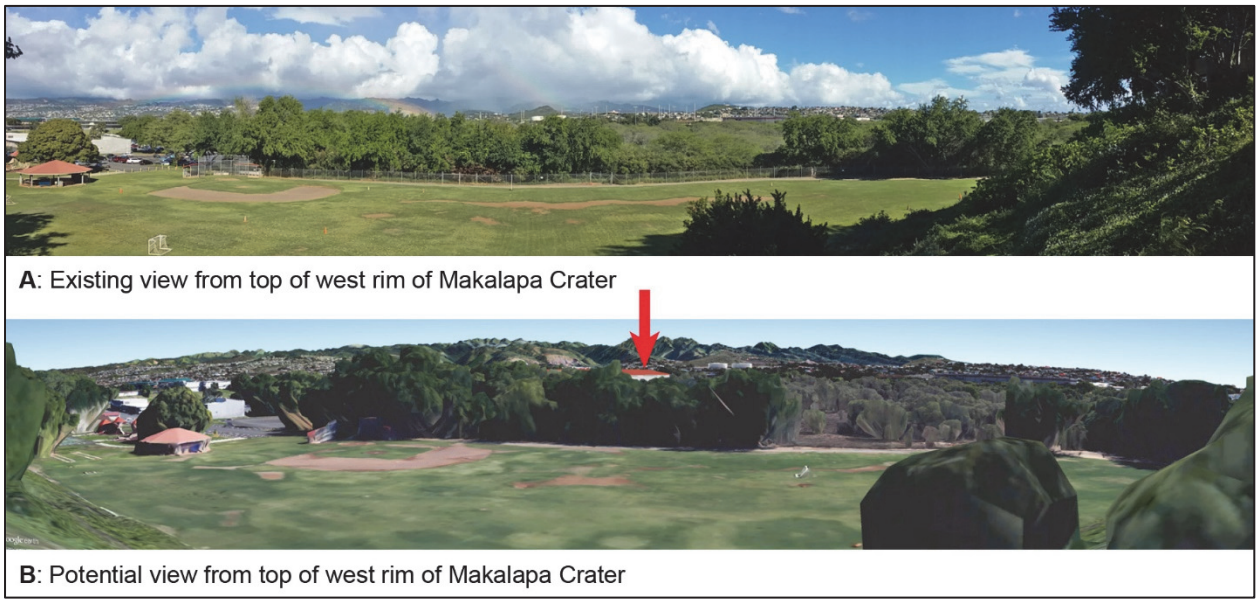


Figure 3-10 Existing and Potential Views from West Rim of Makalapa Crater (Preferred Alternative)

Samoa Place on South Rim of Makalapa Crater

Before and after images of this scene are provided in Figure 3-11. The images represent the view to the north from Samoa Place, a residential cul-de-sac at the south end of the crater. The foreground is dominated by the kiawe forest and dense koa haole scrub (*Leucaena leucocephala*), interspersed with understory of buffelgrass (*Cenchrus ciliaris*). The extensive kiawe forest is very visible in the mid ground with the Koolau ridgeline and lower slopes visible in the distant background, above the treetops (Figure 3-11A). Figure 3-11B superimposes the new building into the scene, with the building's roof visible above the kiawe forest. The red arrow indicates the top edge of the roof.

As shown in Figure 3-11B, the building roof is more visible than in the other scenes but does not intrude into the more distant views of the Koolau Range, as it is screened by the existing kiawe forest. Even if the building were more visible above the treetops, it would not obscure views of the Koolau Range lower slopes.

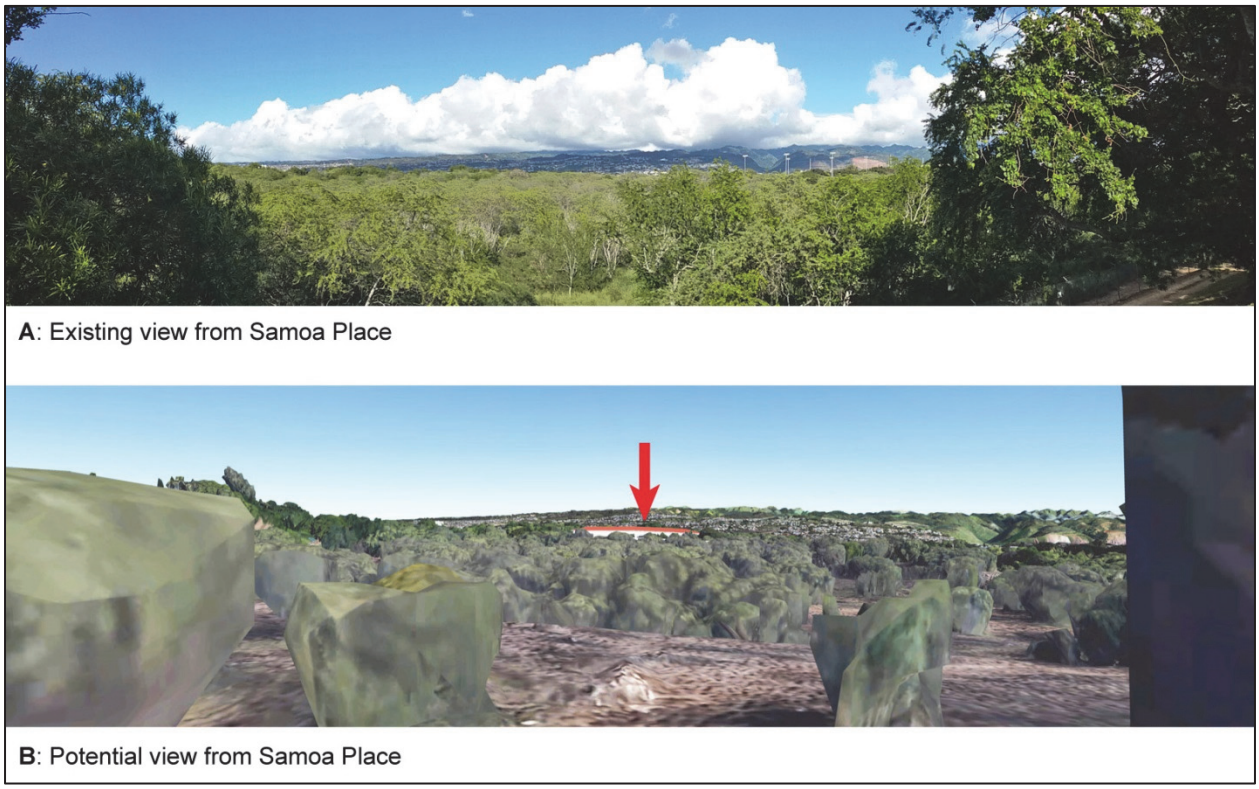


Figure 3-11 Existing and Potential Views from Samoa Place (Preferred Alternative)

Outside Makalapa Crater: Bougainville Drive

Outside Makalapa Crater, the crater walls on the north, west, and south sides would block public views of the proposed JIOC building. On the east, it would be visible from Bougainville Drive in the vicinity of the Radford High School baseball field looking to the northwest across the H-1 Freeway. Figure 3-12A is a photograph taken towards the crater from Bougainville Drive. Figure 3-12B is a simulation of the same scene with the JIOC building model introduced. The slight red area showing above the kiawe forest (see red arrow) represents the extent that the building may be visible from this location. As shown, the building would be barely visible, screened by the existing kiawe forest. Even if the building were more visible, it would not impact any established public vistas or view planes.

Therefore, implementation of the Preferred Alternative would not result in significant impacts to visual resources.

A: Existing view from Bougainville Drive (looking northwest across the Radford High School baseball field)

B: Potential view from Bougainville Drive

Figure 3-12 Existing and Potential Views from Bougainville Drive (Preferred Alternative)

3.5.3.3 JIOC Facility-South Alternative Potential Impacts

The site proposed for the JIOC Facility-South Alternative in Makalapa Crater and adjacent lands define the study area for visual resources analyses. Because this alternative would also be located on the floor of Makalapa Crater, the visual analysis used the same four viewpoints as in the Preferred Alternative analysis. The notional South Alternative site plan and viewpoints are shown in Figure 3-13.

As noted in Section 2.3.3, the South Alternative would include the same components as the Preferred Alternative and be of a similar size. A similar 3D modeling analysis was conducted for the South Alternative. The same building methodology and assumptions as the Preferred Alternative were assumed for the South Alternative in the 3D modeling analysis, with the following exceptions: The building location was moved about 700 feet south of the Preferred Alternative, which resulted in an assumed finished floor elevation of 41 feet above MSL (also the mid-elevation of the proposed site layout).

As with the Preferred Alternative, this alternative also assumes that existing vegetation around the site perimeter would be left in place for visual screening purposes.

Ground Level on the North Wall of Makalapa Crater

From this vantage point, the South Alternative would not be visible as it would be screened by the NGIS buildings and the existing kiawe forest (see Figure 3-14). Even if the building were more visible, it would not impact any established public vistas or view planes.

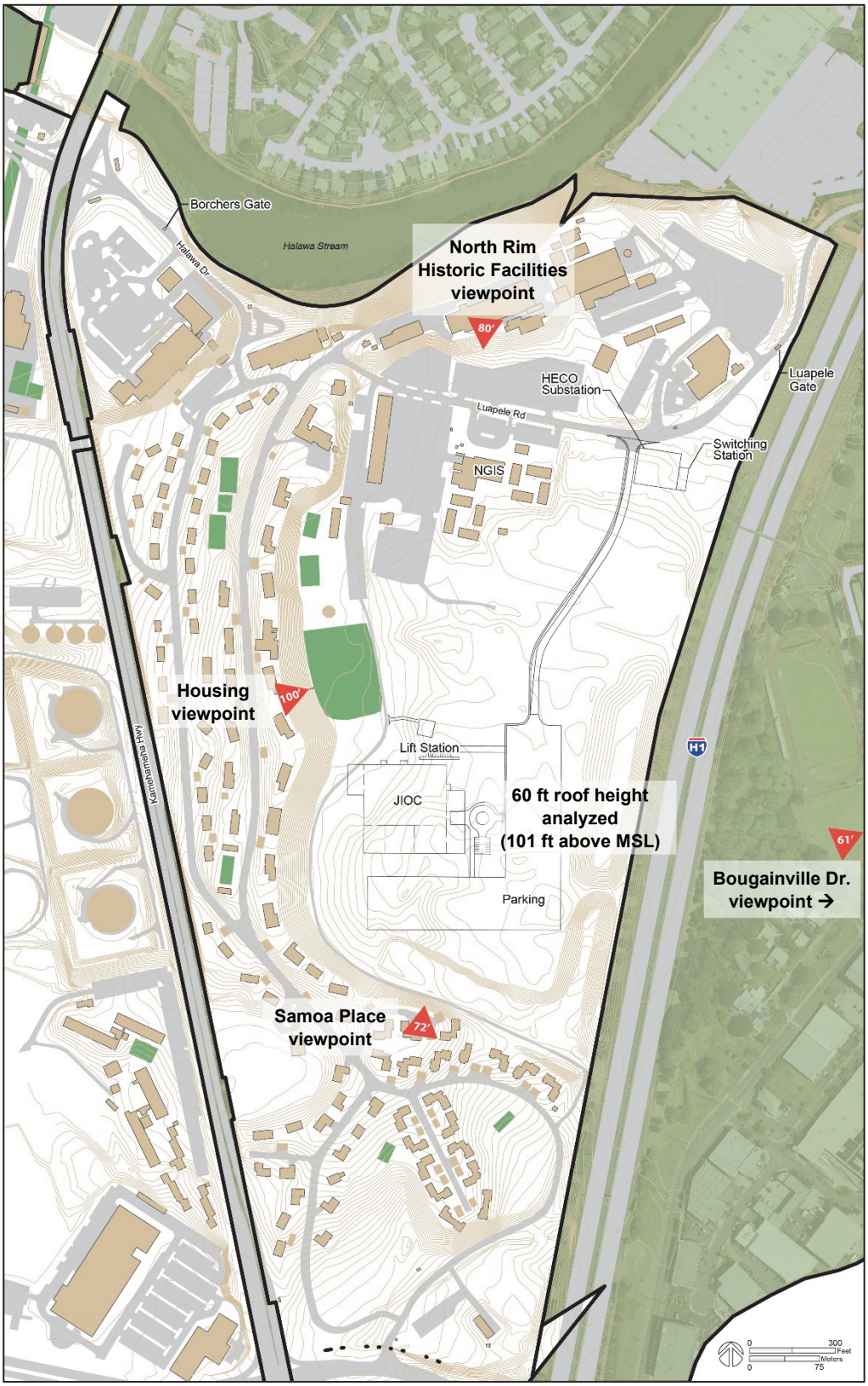


Figure 3-13 Visual Analysis Viewpoint Locations (JIOC Facility South Alternative)

Figure 3-14 Potential View from facilities on north rim of Makalapa Crater, South Alternative

Top of West Rim of Makalapa Crater

From this vantage point, although still largely screened from view by vegetation, more of the new facility would be visible than in the Preferred Alternative (see Figure 3-15). This is due to the lower elevation of the South Alternative, which would result in greater visibility into the development area from the Officer Housing viewpoint. However, similar to the Preferred Alternative, the South Alternative would not obscure views of the Koolau range or its lower slopes.

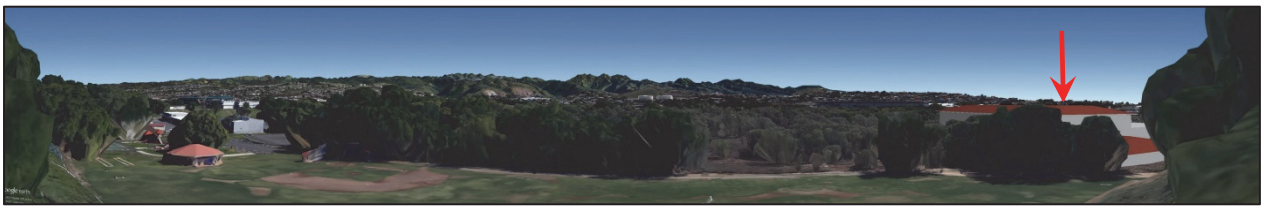


Figure 3-15 Potential View of South Alternative from West Rim of Makalapa Crater

Samoa Place on South Rim of Makalapa Crater

From the Samoa Place viewpoint, the South Alternative would be much more visible than the Preferred Alternative (see Figure 3-16). It may even obscure some distant views of the lower slopes of the Koolau Range, though not the ridgeline.

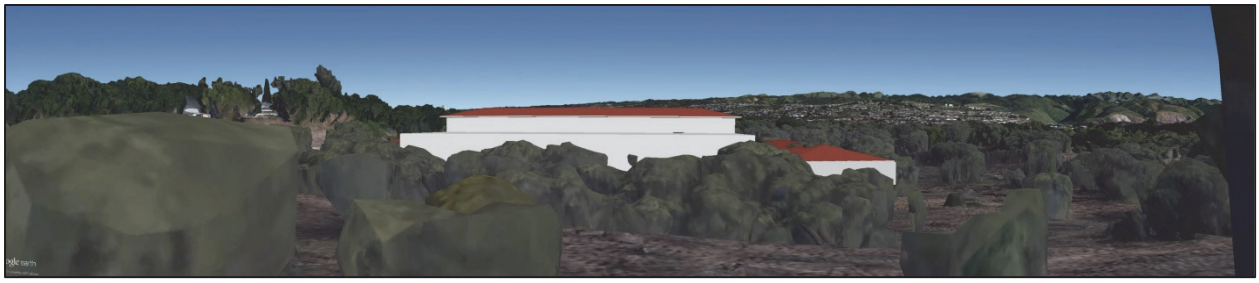


Figure 3-16 Potential View of South Alternative from Samoa Place

Outside Makalapa Crater: Bougainville Drive

The South Alternative would not be visible from Bougainville Drive in the vicinity of the Radford High School baseball field looking to the northwest across the H-1 Freeway (see Figure 3-17 for approximate location if visible). Even if the building were more visible, it would not impact any established public vistas or view planes.

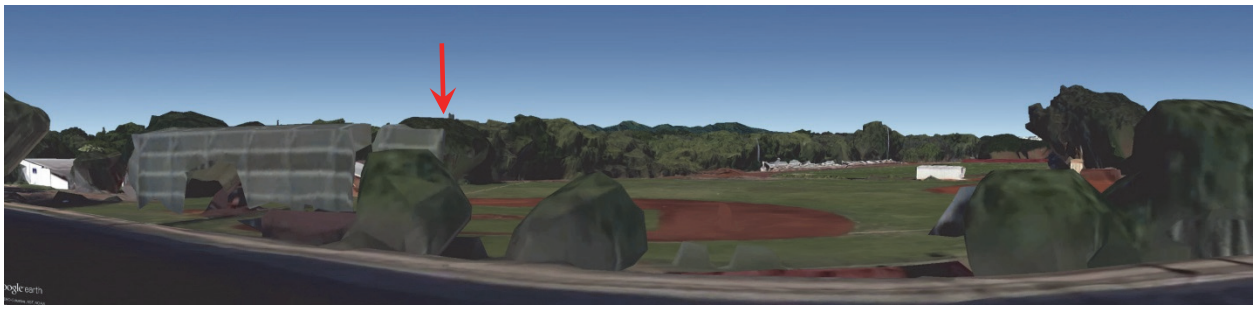


Figure 3-17 Potential View of South Alternative from Bougainville Drive

Therefore, implementation of the South Alternative would not result in significant impacts to visual resources.

3.6 Cultural Resources

This discussion of cultural resources includes prehistoric and historic archaeological sites; historic buildings, structures, and districts; and physical entities and human-made or natural features important to a culture, a subculture, or a community for traditional, religious, or other reasons. Cultural resources can be divided into three major categories:

- Archaeological resources (prehistoric and historic) are locations where human activity measurably altered the earth or left deposits of physical remains.
- Architectural resources include standing buildings, structures, landscapes, and other built-environment resources of historic or aesthetic significance.
- Traditional cultural properties may include archaeological resources, structures, neighborhoods, prominent topographic features, habitat, plants, animals, and minerals that Native Americans or other groups consider essential for the preservation of traditional culture.

3.6.1 Regulatory Setting

Cultural resources are governed by other federal laws and regulations, including the National Historic Preservation Act (NHPA), Archeological and Historic Preservation Act, American Indian Religious Freedom Act, Antiquities Act, Archaeological Resources Protection Act, and the Native American Graves Protection and Repatriation Act. Federal agencies' responsibility for protecting historic properties is defined primarily by sections 106 and 110 of the NHPA. Section 106 requires federal agencies to take into account the effects of their undertakings on historic properties. Section 110 of the NHPA requires federal agencies to establish—in conjunction with the Secretary of the Interior—historic preservation programs for the identification, evaluation, and protection of historic properties.

3.6.2 Affected Environment

Cultural resources listed in the National Register of Historic Places (NRHP) or eligible for listing in the NRHP are "historic properties" as defined by the NHPA. The list was established under the NHPA and is administered by the National Park Service on behalf of the Secretary of the Interior. The NRHP includes properties on public and private land. Properties can be determined eligible for listing in the NRHP by the Secretary of the Interior or by a federal agency official with concurrence from the applicable State Historic Preservation Office (SHPO). A NRHP-eligible property has the same protections as a property

listed in the NRHP. Historic properties include archaeological, architectural, and traditional cultural properties.

Prior to the 20th century, Native Hawaiians utilized the wetland areas around Pearl Harbor for subsistence activities such as fishponds and taro cultivation. Water quality was reportedly high and sedimentation and turbidity was low. It is estimated that at one time there were 26 inland and coastal Hawaiian fishponds comprising 564 acres in operation in the Pearl Harbor area (Hawaii Department of Agriculture, 1999 in DON, 2001). Hawaiians also constructed agricultural features such as wetland pond systems for taro cultivation. Spring fed areas such as those found at Kalauao, Waimalu, and Waiau were used for taro production. Maintaining the agricultural and aquacultural features in and around Pearl Harbor required significant manpower; the Native Hawaiian traditional hierarchy of chiefs and stewards controlled the land and commoners provided the labor. The Great Mahele of 1848 altered land ownership patterns in Hawaii and distributed lands in fee to smaller owners. It was more difficult for the landowners to maintain the large fishponds and keep taro lands in production. Most of the fishponds became the property of the Hawaiian government, and some of the agricultural features fell into disuse. The assimilation of western and eastern diets led to a lower demand for taro, and some farmers converted taro lands into rice production. This conversion to rice farming occurred at Pearl City Peninsula in the late 1800s (USACE, 1999).

In 1877, King Kalakaua gave the U.S. the exclusive rights to enter Pearl Harbor to establish a coaling station for Navy vessels (eventually constructed within the western portion of the Shipyard), and to improve the entrance to the harbor. Prior to the construction of the Pearl Harbor Entrance Channel, the harbor was more restricted from the open ocean by a sandy barrier at the entrance. In 1893, the Hawaiian Monarchy was overthrown and, in 1896, the U.S. government annexed Hawaii. The U.S. government began condemnation proceedings in 1901 so that the U.S. could acquire land for a naval station around Pearl Harbor. The Pearl Harbor shore establishment was created in 1901 with the Fleet and Industrial Supply Center at what is now Kuahua Peninsula, and a strip on the southeast side of Ford Island.

Previous cultural resource studies have identified historic properties at Pearl Harbor Naval Complex (PHNC), including Native Hawaiian sites, ranching and agricultural sites, and World War II era military sites. Cultural resources at PHNC are addressed in the Integrated Cultural Resources Management Plan (ICRMP) (DON, 2008); however, a brief discussion of PHNC cultural resources and their relationship to natural resources management is presented here. The majority of PHNC has been designated a National Historic Landmark (NHL) and is listed on the NRHP. Landmarks and historic sites within the PHNC include: (1) U.S. Naval Base, Pearl Harbor; (2) USS Arizona and Memorial; (3) USS Utah; (4) USS Bowfin; (5) Nimitz Headquarters, Commander in Chief Pacific Fleet (Building 250); and (6) Loko Okiokiolepe.

Early newspapers in Hawaii reported that the 89-acre Makalapa Pond was put up for auction by the Bernice P. Bishop Estate. Other lands near Makalapa being leased were Loko Kunana, Loko Muliwai, and the Umikii Stream at Halawa (*The Pacific Commercial Advertiser*, 1901a). Loo Chit Sam, a trustee of the Chinese fishing company Sing Chan Company, purchased the lease for Makalapa Pond for an annual rental of $1,900 for the term of 21 years. (*The Honolulu Republican*, June 16, 1901). The only other mention of the pond was regarding a suit for injunction filed by Honolulu Plantation Company against Soo Chit San (sic. Loo Chit Sam). The plantation claimed Soo Chit San was tunneling under the center of Makalapa (*The Pacific Commercial Advertiser*, 1901b). This suggests that by 1901, the sugar plantation was utilizing water from Makalapa Pond to irrigate its nearby sugar fields. During World War I, Makalapa Crater was used periodically for military training. Exercises included reconnaissance and mapping terrain

(Honolulu Star Bulletin, 1912 and Honolulu Star Bulletin, 1916). By 1930, lands surrounding the crater, including portions of the crater slopes, were cultivated in sugarcane (Helber Hastert & Fee, Planners with the Offices of Cheryl Barton, 2002).

During the build-up of Pearl Harbor, following the acquisition of a portion of Makalapa Crater, the Navy began using the pond to deposit dredged materials and excavated soil from the harbor—as was standard practice of the time. By 1952, the pond had been largely filled and there were two areas of standing water remaining. By 1959, the entire Makalapa Pond was filled and scrub vegetation began to grow throughout the crater. Housing subdivisions were created east of Makalapa Crater and Radford High School was built at the east end of the crater. By the end of the 1970s, H-1 Freeway bisected Makalapa Crater and the scale of urban development, both housing and commercial, had expanded towards the mountains. Within the crater itself, there are recreational facilities and a garage (Fac. 259) constructed during the war period as well as 1970s bachelor officer quarters (today, NGIS). These facilities are concentrated towards the north edge of the crater adjacent to Luapele Road.

The area of potential effect (APE) for cultural resources is the geographic area or areas within which an undertaking (project, activity, program, or practice) may cause changes in the character or use of any historic properties present. The APE is influenced by the scale and nature of the undertaking and may be different for various kinds of effects caused by the undertaking.

Under the authority of the Historic Sites Act of 1935 (16 U.S.C. §§ 461–467), the Secretary of the Interior designated the U.S. Naval Base Pearl Harbor a National Historic Landmark in 1964, in recognition of its role in supporting the fleet and its related historic role in the expansion of the United States as a Pacific power. The Pearl Harbor National Historic Landmark (PHNHL) is listed in the NRHP. The project area and the APE are located outside the boundaries of the PHNHL. Figure 3-18 shows the cultural resources at JBPHH Makalapa Compound.

The Navy determined that the Proposed Action is an "undertaking" and defined the APE in consultation with the State Historic Preservation Officer through the State Historic Preservation Division, as well as other Historic Partners. Both direct (physical) effects, as summarized in Section 2.3.2, and indirect (visual) effects were considered (see Figure 3-18) and it was found that no historic properties would be affected by this Undertaking. Compliance with NHPA was conducted through the Navy's Programmatic Agreement Process.

3.6.2.1 Archaeological Resources

There are no NRHP-eligible archaeological resources within the APE and the area has been determined in the 2008 ICRMP to have no and/or low potential for archaeological resources (Helber, Hastert and Fee, 2008). Archaeological studies synthesized in Allen (2007) documented previous disturbance of the area and found no eligible archaeological resources.

3.6.2.2 Architectural Resources

Historic properties within JBPHH Makalapa Compound include a National Historic Landmark, a historic district comprising WWII-era military housing, and five National Register-eligible WWII-era buildings and structures.

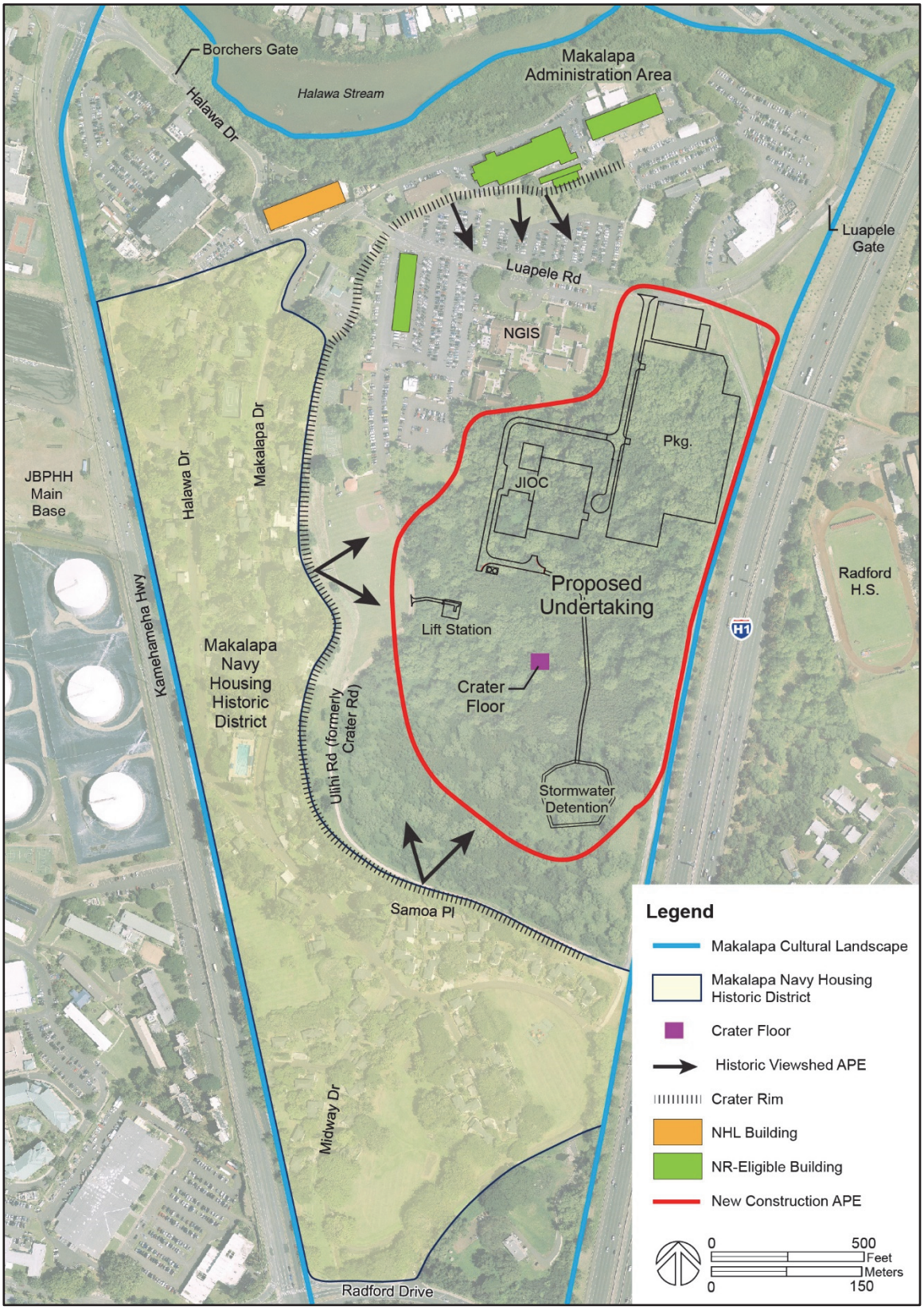


Figure 3-18 Cultural Resources

Makalapa Navy Housing Historic District is a WWII-era, Navy-planned neighborhood of officers' housing that is listed in the NRHP. The district is located on the southwestern rim and sloping outer wall of Makalapa Crater (see Figure 3-18). The crater rim and topography, and viewsheds from the crater rim into the crater have been identified as contributing to the integrity of the Makalapa Navy Housing Historic District.

The administration area of Makalapa Crater is eligible for the NRHP. The buildings were constructed during WWII and served administrative functions.

Although there are historic properties located within the JBPHH Makalapa Compound, none are located within the APE.

3.6.2.3 Traditional Cultural Properties

A Traditional Cultural Property (TCP) is a property that is eligible for inclusion in the NRHP because of its association with cultural practices, beliefs, lifeways, arts, crafts, or social institutions of a living community. TCPs are based on the history and continuing cultural identity of a traditional community. The TCP must be a physical property or place, a district, site, building, structure, or object. (U.S. Department of the Interior, 1998).

Makalapa is described as "an ancient crater perched above the Halawa coastal flats" (Maly and Maly, 2012). Pukui et al. (1974) provides a literal translation for Makalapa as "ridge features," and acknowledges the crater as well as Red Hill were formerly known as "Kapukaki." Kapukaki is well documented as a place that defines the eastern boundary of the traditional district of Ewa. (Tuggle and Tomonari-Tuggle, 2004). A review of two TCP reports suggests that although Makalapa is a traditional place name, there is insufficient information tying it to a traditional cultural property.

3.6.2.4 Cultural Landscapes

Makalapa Compound is considered a historic cultural landscape outside the boundaries of the PHNHL. A cultural landscape is "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Birnbaum, 1996). Historic landscapes are composed of a number of character-defining features, which individually or collectively contribute to the landscape's physical appearance as it has evolved over time. Character-defining features are defined as having "a prominent or distinctive aspect, quality, or characteristic of a cultural landscape that contributes significantly to its physical character" (Birnbaum, 1996).

A cultural landscape assessment (CLA) conducted for the Makalapa area was completed in 2002 (Helber Hastert & Fee, Planners with the Office of Cheryl Barton, 2002). The purpose of the CLA was to inventory and assess the character-defining features of the Makalapa neighborhood, particularly landscape features and structures that visually contribute to the cultural landscape. This CLA was limited to the Makalapa Navy Housing neighborhood corresponding to the boundary of the ICRMP Makalapa Historic Management Zone north of Radford Drive. The CLA identified the following character-defining features that are relevant to the Proposed Action.

- Views and Vantage Points
    - Views toward the Koolau mountains from Flag quarters on the crater rim
- Topography and Drainage

- Features of the Makalapa Crater landform (rim, wall, flank)

The PHNC Cultural Landscape Report (CLR) was prepared in 2011 and established three character areas in Makalapa: Makalapa Administration area on the north crater rim; Makalapa Housing, including Little Makalapa; and Makalapa Crater Floor (DON, 2011b). Although Makalapa Compound is outside the Pearl Harbor NHL District boundary, its landscapes retain historic character associated with the World War II and Cold War periods of significance. Mission uses of the area historically include housing, administration, and force protection.

In the 2011 CLR, topography and views were defined as character-defining features for all three character areas at Makalapa Compound, in addition to others. The steep crater rim and the flat expanse of the minimally developed crater floor were identified as two of the most prominent, organizing spatial elements of the Makalapa area in general. The natural topography with the elevated and abrupt crater rim creates the conditions for panoramic views to Main Base and to the Koolau range to the northeast.

3.6.3 Environmental Consequences

Analysis of potential impacts to cultural resources considers both direct and indirect impacts. Direct impacts may be the result of physically altering, damaging, or destroying all or part of a resource, altering characteristics of the surrounding environment that contribute to the importance of the resource, introducing visual, atmospheric, or audible elements that are out of character for the period the resource represents (thereby altering the setting), or neglecting the resource to the extent that it deteriorates or is destroyed. Indirect impacts are those impacts caused by the action but are later in time or farther removed in distance, or that may be induced by changes cause by the action.

3.6.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to cultural resources. Therefore, no impacts to cultural resources would occur with the No Action Alternative.

3.6.3.2 JIOC Facility-North (Preferred Alternative) Potential Impacts

The Preferred Alternative would have no impact to cultural resources during project construction or operation. The DON determined that the Proposed Action would have no effect on historic properties under NHPA. As defined in the implementing regulations for Section 106 of the NHPA, impacts of an undertaking on significant cultural resources are considered adverse if they “diminish the integrity of the property’s location, design, setting, materials, workmanship, feeling, or association” (36 CFR § 800.5(a)(1)).

In accordance with the Navy’s 2012 Programmatic Agreement, the DON consulted with the Hawaii SHPO as well as other Historic Partners regarding the undertaking. The project area and APE are located outside the PHNHL and there are no NRHP-eligible archaeological resources within the APE. Previous disturbance of the APE is documented and it was determined to have no and/or low potential for archaeological resources. The Preferred Alternative is not within the immediate setting or viewshed of the individually-listed NHL or NRHP-eligible facilities in the Makalapa Crater administration area. The Preferred Alternative would not affect the NHL or facilities within it, which are all located outside of the APE. In addition, vegetative screening would be retained as an added measure to maintain the current landscape views from the Makalapa Navy Housing Historic District, and the Preferred Alternative would not affect this NRHP-listed district (see Figures 3-10 through 3-13 for results of 3D visual modeling

analysis in Section 3.5.3.2). Vegetative screening would also maintain the current landscape views from the administration area and NRHP-eligible buildings into the crater. No landscape viewsheds would be obstructed or affected by the proposed project because the elevation difference between the historic landscape viewsheds in comparison to the proposed undertaking within the crater is great enough not to cause an impact. Further, no historic facilities would be abandoned, since all facilities in which JIOC occupies space are shared facilities, with other facility users to remain after any JIOC departure. Because of these factors, the DON determined that the proposed undertaking would have no effect on historic properties and documented this determination in accordance with Stipulations IX.A.1 and IX.A.2 of the 2012 Programmatic Agreement Among the Commander Navy Region Hawaii, the Advisory Council on Historic Preservation and the Hawaii State Historic Preservation Officer Regarding Navy Undertakings in Hawaii.

Recommended transportation-related improvements, if warranted by future conditions, within DoD-controlled land include re-striping an existing roadway intersection (i.e., Luapele Drive and Salt Lake Boulevard, under a perpetual easement from the HDOT, with the Navy having the prerogative and responsibility for maintenance) in order to formalize a de-facto right-turn lane onto Salt Lake Blvd, and adjusting traffic signal phasing and timing at the Salt Lake Boulevard-Kahuapaani Street intersection (HDOT property) to provide an acceptable level of service at this intersection under the Preferred Alternative. These types of activities do not have the potential to cause effects on historic properties.

Based on its historical and current land use, there are no Native Hawaiian or other ethnic group's cultural customs and traditions exercised for subsistence, cultural or religious purposes known to be practiced within the project area at this time. The Preferred Alternative would not impact traditional Hawaiian, or other ethnic group's, rights related to gathering, access, or other customary activities exercised for subsistence, cultural and religious purposes because construction activities would take place generally in DON-controlled limited access areas and public roadways. No changes to access to public roadways are proposed or anticipated.

The Preferred Alternative would not impact TCPs, as there are no TCPs identified within Makalapa Crater or the project area.

The Preferred Alternative has the potential to impact the Makalapa cultural landscape by interfering with historic viewplanes into Makalapa Crater and across the crater to Red Hill and the Koolau range. The Preferred Alternative also has the potential to impact the Makalapa Crater floor, another character-defining feature of the Makalapa cultural landscape. As shown in the 3D modeling visual analysis in Section 3.5.3.2, panoramic views from the Navy Housing Historic District and the administration area would not be significantly impacted by construction of the Preferred Alternative. From the north (administration area) (Figure 3-9), the roof of the new JIOC facility would be barely visible, almost entirely screened by existing vegetation. Viewed from the west (historic housing area), the top of the roof would be more visible, but would not obstruct distant views of the Koolau Range or Red Hill (Figure 3-10). Viewed from the south (historic housing area along Samoa Place), the top of the new JIOC facility would be more visible, but also not impede distant views of the Koolau Range or Red Hill (Figure 3-11).

Although detailed grading plans for the Preferred Alternative have not yet been developed, it is anticipated that earthwork would be required to provide suitable foundations and level areas for the new building and parking areas, as well as for access roads and pedestrian walkways. The total Preferred Alternative footprint (including on-site stormwater and wastewater infrastructure) is approximately 10 acres. This represents about 23 percent of the total 42-acre undeveloped crater floor. As recommended

in the 2011 PHNC CLR, new areas of cut and fill would be minimized and limited to the generally flat crater floor; the Preferred Alternative would not involve alteration of the crater walls or rim. As also recommended in the 2011 CLR, the proposed new construction takes into account impacts on natural resource values and the quality of views from the rim by retaining some existing vegetation to screen views from historic resources surrounding the project area. As noted earlier, distant views of the Koolau Range and Red Hill would not be adversely impacted by the Preferred Alternative.

Therefore, implementation of the Preferred Alternative would have no impacts to cultural resources.

3.6.3.3 JIOC Facility-South Alternative Potential Impacts

Like the Preferred Alternative, the South Alternative would have no impacts to cultural resources during project construction or operation. As with the Preferred Alternative, the South Alternative project area has no and/or low potential for archaeological resources and no eligible archaeological resources (Helber, Hastert & Fee, 2008). The South Alternative is not within the immediate setting or viewshed of NRHP-listed or -eligible facilities in the Makalapa Crater administration area and would not adversely affect them (see results of 3D visual modeling analysis in Section 3.5.3.3). The South Alternative would be more visible than the Preferred Alternative when viewed from the Makalapa Navy Housing Historic District (see Figures 3-16 and 3-17). Vegetative screening would be retained to maintain the current landscape views from the Makalapa Navy Housing Historic District. When viewed from portion of the historic housing area to the west, the South Alternative would not impede views of Red Hill and the Koolau Range. From the south, this alternative may obscure some lower slopes of the Koolau Range.

As with the Preferred Alternative, limited traffic-related improvements on existing CCH- and HDOT-controlled roadways are also identified for the South Alternative, if warranted by future conditions. These types of activities do not have the potential to cause effects on historic properties.

As with the Preferred Alternative, based on its historical and current land use, there are no Native Hawaiian or other ethnic group's cultural customs and traditions exercised for subsistence, cultural or religious purposes known to be practiced within the South Alternative project area at this time. The South Alternative would not impact traditional Hawaiian, or other ethnic group's, rights related to gathering, access, or other customary activities exercised for subsistence, cultural and religious purposes because construction activities would take place generally in DON-controlled limited access areas and public roadways. No changes to access to public roadways are proposed or anticipated.

The South Alternative would not impact TCPs, as there are no TCPs identified within Makalapa Crater or the project area.

Like the Preferred Alternative, the South Alternative has the potential to impact the Makalapa cultural landscape by interfering with historic viewplanes into Makalapa Crater and across the crater to Red Hill and the Koolau range. The South Alternative also has the potential to impact the Makalapa Crater floor, another character-defining feature of the Makalapa cultural landscape. As shown in the 3D modeling visual analysis in Section 3.5.3.3, panoramic views from the administration area would not be significantly impacted by construction of the South Alternative. From the north (administration area), the roof of the new JIOC facility would not be visible due to retained vegetation and ground elevation. Viewed from the west (historic housing area), the building mass would be more visible than in the Preferred Alternative, but not obstruct distant views of the Koolau Range or Red Hill. Viewed from the south (historic housing area), the top of the new JIOC facility South Alternative would be more visible than in the Preferred Alternative. Although this alternative would generally not impede distant views of

the Koolau Range, it would obstruct views of some of the lower slopes. Views of Red Hill would not be affected. Therefore, implementation of the JIOC Facility-South Alternative would result in no impacts to cultural resources.

3.7 Biological Resources

Biological resources include living, native, or naturalized plant and animal species and the habitats within which they occur. Plant associations are referred to generally as vegetation, and animal species are referred to generally as wildlife. Habitat can be defined as the resources and conditions present in an area that support a plant or animal.

Within this EA, biological resources are divided into four major categories: (1) terrestrial vegetation, (2) terrestrial wildlife, (3) marine vegetation, and (4) marine wildlife. Threatened, endangered, and other special status species are discussed in their respective categories.

3.7.1 Regulatory Setting

Special-status species, for the purposes of this assessment, are those species listed as threatened or endangered under the Endangered Species Act (ESA) and species afforded federal protection under the Marine Mammal Protection Act (MMPA) or the Migratory Bird Treaty Act (MBTA).

The purpose of the ESA is to conserve the ecosystems upon which threatened and endangered species depend and to conserve and recover listed species. Section 7 of the ESA requires action proponents to consult with the U.S. Fish and Wildlife Service (USFWS) or National Oceanic and Atmospheric Administration Fisheries to ensure that their actions are not likely to jeopardize the continued existence of federally listed threatened and endangered species, or result in the destruction or adverse modification of designated critical habitat. Critical habitat cannot be designated on any areas owned, controlled, or designated for use by the DoD where an Integrated Natural Resources Management Plan has been developed that, as determined by the Department of Interior or Department of Commerce Secretary, provides a benefit to the species subject to critical habitat designation.

All marine mammals are protected under the provisions of the MMPA. The MMPA prohibits any person or vessel from “taking” marine mammals in the United States or the high seas without authorization. The MMPA defines “take” to mean “to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any marine mammal.”

Birds, both migratory and most native-resident bird species, are protected under the MBTA, and their conservation by federal agencies is mandated by EO 13186 (Migratory Bird Conservation). Under the MBTA it is unlawful by any means or in any manner, to pursue, hunt, take, capture, kill, attempt to take, capture, or kill, [or] possess migratory birds or their nests or eggs at any time, unless permitted by regulation. The 2003 National Defense Authorization Act gave the Secretary of the Interior authority to prescribe regulations to exempt the Armed Forces from the incidental taking of migratory birds during authorized military readiness activities. The final rule authorizing the DoD to take migratory birds in such cases includes a requirement that the Armed Forces must confer with the USFWS to develop and implement appropriate conservation measures to minimize or mitigate adverse effects of the proposed action if the action would have a significant negative effect on the sustainability of a population of a migratory bird species.

See Section 3.8.1 for the discussion regarding the CZMA.

3.7.2 Affected Environment

The following discussions provide a description of the existing conditions for each of the categories under biological resources at JBPHH Makalapa Compound. The offsite sewer improvement areas are currently developed in urban uses. Threatened and endangered species are discussed in each respective section below with a composite list applicable to the Proposed Action provided in Table 3-14.

The native terrestrial ecosystem of the inshore portions of PHNC are described as lowland dry and mesic (moist – 50 to 100 inches of rainfall/year) forest, woodland, and shrubland. Forests and woodlands are dominated by trees and a forest canopy is dense (60 to 100 percent cover), while a woodland canopy is more open (10 to 60 percent). Shrublands are distinguished by multi-branched shrubs over 3.3 feet in height (Juvik and Juvik, 1998). Relatively undisturbed or undisturbed areas of Makalapa Crater is an example of this type of ecosystem.

The biological resources study area (study area) is a 36-acre undeveloped area located within the 180-acre Makalapa Crater on the eastern edge of Pearl Harbor (AECOS, 2016). It encompasses areas that would be directly affected by the Preferred Alternative and South Alternative. The study area is bordered on all sides by urbanized uses and development, such as Interstate H-1, housing, administrative offices, and recreational areas. There is consistent exposure to noise from military use, air traffic from Honolulu International Airport and JBPHH, and freeway traffic.

The study area of disturbed but natural growth (AECOS, 2016) is one of the few remaining undeveloped areas at JBPHH (DON, 2011a). The study area, once used as a fishpond, has been gradually altered since the 1930s and is filled with dredged spoils, scrap cleanup from the bombing of Pearl Harbor, and garbage (AECOS 2016). Materials such as rusted metal, concrete slabs, chunks of asphalt, and piles of boulders are common throughout the study area, with vegetation growing over and around them (Char, 1999).

3.7.2.1 Terrestrial Vegetation

Vegetation includes terrestrial plant as well as freshwater aquatic communities and constituent plant species.

The project area is vegetated with nonnative trees consisting of kiawe (*Prosopis pallida*) and Opiuma (*Pithecellobium dulce*) reaching heights of 40 feet. The understory consists of koa haole (*Leucaena leucocephala*) and grasses (NAVFAC Pacific, 2021). Historically, the project area is located within Makalapa Crater, which has been developed since the 1940s. Wetlands do not currently exist in the Makalapa Crater project area and the surrounding environment has been altered to inhibit wetland conditions. All plants recorded in and around the study area can be found in similar habitats throughout Hawaii (Char, 1999). Makalapa Crater has been developed since the 1940s. The offsite sewer improvement areas are currently developed and in urban uses.

3.7.2.2 Terrestrial Wildlife

Wildlife includes all animal species (i.e. insects and other invertebrates, freshwater fish, amphibians, reptiles, birds, and mammals) focusing on the species and habitat features of greatest importance or interest.

Birds

In total, 23 bird species were documented in the study area between 1999, 2006, and 2015 (Bruner, 1999; NAVFAC Pacific, 2006; Hamer Environmental, 2016; see Table 3-13). Of these species, six were federally protected MBTA species: white tern (*Gygis alba*), cattle egret (*Bulbulcus ibis*), Pacific golden plover (*Pluvialis fulva*), barn owl (*Tyto alba*), northern cardinal (*Cardinalis cardinalis*), and house finch (*Carpodacus mexicanus*). The white tern is listed as a threatened species by the State of Hawaii on the island of Oahu. Though the MBTA-protected black-crowned night heron was not observed during any of the survey years, suitable roosting and nesting habitat exists for night herons, and precautions should be taken to minimize impacts to nests, as discussed in Section 3.7.3.2 under MBTA-Protected Birds. In all survey years, the most common birds observed were all introduced species. No endemic species were seen or heard.

Table 3-13 Birds Observed at the Makalapa Study Area in 1999, 2006, and 2015

Common Name	*Latin Binomial*	*Notes*
White tern	*Gygis alba*	MBTA, ST
Barn owl	*Tyto alba*	MBTA
Cattle egret	*Bulbulcus ibis*	MBTA
House finch	*Carpodacus mexicanus*	MBTA
Northern cardinal	*Cardinalis*	MBTA
Pacific golden plover	*Pluvialis fulva*	MBTA
Chestnut munia	*Lonchura atricapilla*	Introduced
Common myna	*Acridotheres tristis*	Introduced
Common waxbill	*Estrilda astrild*	Introduced
House sparrow	*Passer domesticus*	Introduced
Japanese bush warbler	*Cettia diphone*	Introduced
Japanese white-eye	*Zosterops japonicus*	Introduced
Java sparrow	*Padda oryzivora*	Introduced
Nutmeg manikin	*Lonchura punctulata*	Introduced
Red-crested bulbul	*Paroaria coronata*	Introduced
Red-crested cardinal	*Paroaria coronata*	Introduced
Red-vented bulbul	*Pycnonotus cafer*	Introduced
Red-whiskered bulbul	*Pycnonotus jocosus*	Introduced
Saffron finch	*Sicalis flaveola*	Introduced
Spotted dove	*Streptopelia chinensis*	Introduced
White-rumped shama	*Copsychus malabaricus*	Introduced
Yellow-fronted canary	*Serinus mozambicus*	Introduced
Zebra dove	*Geopelia striata*	Introduced

Notes: MBTA = protected by the Migratory Bird Treaty Act, ST = state-listed as threatened.

Non-Native Mammals and Reptiles

A 2006 survey of the study area documented three non-native mammal species: feral cat (*Felis catus*), mongoose (*Herpestes auropunctatus*), and rat (*Rattus rattus*) (NAVFAC Pacific, 2006). Rat numbers appeared to be low, but observations could have been skewed due to mongoose interference with rat traps (NAVFAC Pacific, 2006). Two species of reptiles were also reported, the house gecko (*Hemidactylus frenatus*) and mourning gecko (*Lepidodactylus lugubris*) (NAVFAC Pacific, 2006). None of these species are indigenous to Hawaii or are listed as threatened or endangered. All can be found throughout urbanized areas of Oahu.

Threatened and Endangered Species

No state-listed or federally listed threatened, endangered, or candidate plant species or rare native Hawaiian plant species have been reported within the study area in recent decades (AECOS, 2016). There is the potential for the occurrence of federally listed and state-listed species in the study area (Table 3-14), but no critical habitat has been designated for these species in the study area (NAVFAC Pacific, 2021).

Table 3-14 Threatened and Endangered Species Known to Occur or Potentially Occurring in the ROI and Critical Habitat Present in ROI

Common Name	*Scientific Name*	*Federal Listing Status*	*State Listing Status*	*Critical Habitat Present?*
White tern	*Gygis alba*		ST	No
Hawaiian short-eared owl	*Strix sandwichensis*		SE	No
Hawaiian hoary bat	*Lasiurus cinereus semotus*	FE	SE	No
Hawaiian petrel	*Pterodroma sandwichensis*	FE		No
Band-rumped storm-petrel	*Oceanodroma castro*	FE		No
Newell's shearwater	*Puffinus auricularis newelli*	FT		No
Hawaiian stilt	*Himantopus mexicanus knudseni*	FE		No

Notes: FE = federally-listed as endangered; FT = federally-listed as threatened; SE = state-listed as endangered; ST = state-listed as threatened

White Tern

Individual white terns were observed at the study area during a field survey in 2015. The white tern is listed by the State of Hawaii as threatened for the Island of Oahu. On Oahu, white terns most commonly nest in banyans (*Ficus* spp.), monkeypod (*Samanea saman*), mahogany (*Swietenia mahogany*), and kukui (*Aleurites moluccana*), although other tree species have also been documented for nesting and roosting (Vanderwerf, 2003). Both banyans and monkeypod trees were found within the study area in 1999 (Char, 1999).

Hawaiian Short-Eared Owl

The Hawaiian short-eared owl was not observed at the study area during field surveys. However, these owls could forage and nest within the grassy understories of the study area's kiawe or koa haole forests. Hawaiian short-eared owls are active during the day and occur in a variety of habitats, including wet and dry forests, grasslands, and shrublands (Mitchell et al., 2005). The owl's diet consists of small mammals and birds (Holt and Leasure, 2006).

This species is listed by the state as endangered on Oahu and can be found throughout the main Hawaiian Islands from sea level to 8,000 feet. Little is known about the breeding biology of the Hawaiian short-eared owl, but nesting occurs throughout the year (USFWS, 2013). Nests are made on the ground and lined with grasses and feathers.

Hawaiian Hoary Bat

The Hawaiian hoary bat (*Lasiurus cinereus semotus*) may be present within the action area. The Hawaiian hoary bat was listed as federally endangered on October 13, 1970 and a recovery plan for the species was completed in 1998 (USFWS, 1998 in NAVFAC Pacific, 2021). Critical habitat for this species has not been designated. The Hawaiian hoary bat is a solitary species that has been recorded on all of the main Hawaiian Islands, with the largest populations thought to be on Kauai and Hawaiʻi Island (Amlin and Siddiqi, 2015 in NAVFAC Pacific, 2021). Accurate estimates of the population are not available, but estimates for all islands have ranged from hundreds to a few thousand (USFWS, 1998 in NAVFAC Pacific, 2021). Most observations of bats have been made between sea level and 7,500 feet in elevation, but their presence has been documented up to 13,198 feet in elevation (Gon et al., 1993 in NAVFAC Pacific, 2021).

Hawaiian petrel, Band-rumped storm-petrel, and Newell's shearwater

The Hawaiian petrel (*Pterodroma sandwichensis*) is known to nest on Kauai, Maui, Lanai, Hawaii Island and possibly on Molokai (DNLR, 2015 in NAVFAC Pacific, 2021). Grounded birds have been recovered on Oahu and recently detected via acoustic monitoring in the lower Kaala region, likely attracted by low frequency sound of a satellite communication facility (Young et al., 2019 in NAVFAC Pacific, 2021). The Hawaiian petrel has not been documented at JBPHH installations and the potential to occur in the action area is very low to unlikely. Populations of the Band–rumped storm petrel (*Oceanodroma castro*) are known to occur on Kauai, Maui, and Hawaii island (DNLR, 2015 in NAVFAC Pacific, 2021). The Band–rumped storm petrel has not been documented at JBPHH installations and the potential to occur in the action area is very low to unlikely. Newell's shearwater (*Puffinus auricularis newelli*) may fly over the action area to reach nesting habitats, but birds have not been documented at JBPHH installations and the potential to occur in the action area is very low to unlikely.

Hawaiian Stilt

The Hawaiian stilt (*Himantopus mexicanus knudseni*) is present on JBPHH installations within wetland habitats such as ditches, tidal flats, and waterways (NAVFAC Pacific, 2011 in NAVFAC Pacific, 2021). The Makalapa compound does not support wetland habitats for Hawaiian stilt, but grassy areas exist that could attract stilts after heavy rain events. Hawaiian stilts do not typically frequent the action area or adjacent grassy sites, but their presence within the proposed site is possible after the vegetation is cleared.

3.7.2.3 Marine Species

Because of the upland location of the Proposed Action, there is no potential for marine species (i.e., marine vegetation, marine mammals, sea turtles, fish, coral, or benthic invertebrates) to occur within the study area; therefore these species are not discussed further in this document.

3.7.3 Environmental Consequences

This analysis focuses on wildlife or vegetation types that are important to the function of the ecosystem or are protected under federal or state law or statute.

3.7.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to biological resources. Therefore, no impacts to biological resources would occur with the No Action Alternative.

3.7.3.2 JIOC Facility-North Alternative (Preferred Alternative) Potential Impacts

The study area for the analysis of effects to biological resources associated with the Preferred Alternative includes a 36-acre undeveloped area within Makalapa Crater and the offsite sewer improvement areas. The Makalapa Crater study area is bordered on all sides by urbanized uses and development, such as Interstate H-1 Freeway, housing, administrative offices, and recreational areas. The offsite sewer improvement areas are located within existing roadway ROWs and are surrounded by urban development. The offsite sewer improvement areas are currently developed and in urban uses. There is consistent exposure to noise at both the Makalapa Crater and offsite sewer improvement project areas from military use, air traffic from Honolulu International Airport and JBPHH, and freeway/roadway traffic.

The Preferred Alternative project footprint is approximately ten acres, with the majority of the project footprint located in the northern half of the study area. The Preferred Alternative consists of a JIOC building, walkways and an access road, parking, a detention basin (located in the southern half of the study area), a wastewater lift station, and an electrical substation. Impacts likely to occur as a result of the Preferred Alternative would be similar to those described for the South Alternative, with the exception that a larger footprint of vegetation would be removed for the latter (i.e., approximately five percent more).

Vegetation

The Preferred Alternative is not expected to have a substantial, adverse effect on vegetation. Construction of the Preferred Alternative would remove all vegetation within the project footprint, but the study area consists primarily of common, introduced, and alien vegetation species (as described in Section 3.7.2.1). The primary vegetation types that would be removed are non-native trees (e.g., kiawe and koa haole) and non-native grasses.

To prevent the spread of the Coconut Rhinoceros Beetle (CRB) (*Oryctes rhinoceros*), any green waste generated by the project would follow the *JBPHH Green Waste Policy* (JBPHH, 2022). All green waste generated at the Makalapa Compound project area must be chipped with excess soil removed, and transported to the biosolids treatment facility (BTF) at Kalaeloa within 24 hours. If the 24-hour period includes overnight, material must stay at JBPHH and in a fully enclosed container/vehicle with immediate next-day delivery- to the BTF. During transport to the BTF, if the vehicle is not enclosed, an

approved cover/tarp must be used. If any life stage of the CRB is suspected in green waste, stop green waste clearing and call the Hawaii Department of Agriculture Pest Hotline immediately.

Using off-island equipment or introducing landscaping vegetation could introduce invasive species to the study area. To minimize the potential for invasive species introduction, all construction equipment, vehicles, and materials that have been sourced off-island would be inspected and decontaminated of any excessive debris or plant material prior to use onsite. Inspection and cleaning activities would be conducted at a designated location. If portions of the project footprint are landscaped as a result of the project, native Hawaiian plants well-adapted to the environmental conditions at Makalapa Crater would be employed for landscaping around the study area to the maximum extent possible. If native plants do not meet landscaping objectives, plants with a low risk of becoming invasive would be substituted.

Terrestrial Wildlife

Most of the habitat removed by the Preferred Alternative would be kiawe and koa haole forest, which would primarily impact forest-dwelling species. In the short term, the noise and human activity associated with construction of the Preferred Alternative would displace wildlife from an area greater than the project footprint. The noise associated with construction could extend a minimum of 1,000 feet from the project area. The 1,000-foot buffer is based on the distance a 100-A-weighted-decibel (dBA) noise (e.g., a rock drill, paver, or impact pile driver) would attenuate to background levels (approximately 50 dBA) over flat terrain with little to no vegetation (FHWA, 2014). However, the actual distance that noise effects would occur is likely less than 1,000 feet because topography and vegetation would shield the produced noise. In the long term, wildlife would return to the habitat remaining in the study area but would be permanently displaced from the project footprint. However, the observed species are expected to use suitable nearby habitats for temporary relocation and foraging.

MBTA-Protected Birds

MBTA-protected birds would be impacted if active nests are disturbed or damaged during vegetation removal. Construction at the study area may temporarily displace some of the observed MBTA species, and forest-dwelling species would permanently lose nesting and foraging habitat. The temporary displacement of these individuals is not expected to affect individuals' survival or overall species' populations.

To minimize impacts to MBTA-protected birds, nest surveys would be conducted a maximum of seven days before construction. Active nests would be left in place and undisturbed until chicks have fledged, which may take up to eight weeks. A qualified biologist would monitor active nests during construction activities to reduce the chances of nest abandonment by temporarily shutting down construction activities that disrupt the normal daily patterns of the birds. Activities would resume when birds have voluntarily left the area.

All outdoor lights would be shielded to prevent light trespass including upward radiation. This has been shown to reduce the potential for seabird attraction (Reed et al., 1985; Telfer et al., 1987). Outside lights that are not needed for security and safety would be turned off from dusk through dawn. Motion-censored LED lights with full cut-off fixtures would be used whenever possible, as compliant with MBTA guidelines. A selection of acceptable seabird-friendly lights can be found online at the at the International Dark-Sky Association website (http://www.darksky.org).

Threatened and Endangered Species

No federal- or state-listed threatened or endangered plants occur in the study area and, therefore, none would be affected by the Preferred Alternative.

One state-listed as threatened bird species (i.e., white tern) was observed in the study area (Hamer Environmental, 2016). Temporary impacts to threatened and endangered terrestrial species listed in Table 3-14 could occur from noise or habitat disturbances associated with construction activities. However, threatened and endangered species in the study area are already habituated to high levels of noise associated with military use, air and freeway traffic, and urban development. Increases in noise levels from construction activities to the ambient noise environment would be negligible and temporary.

Permanent loss of non-native kiawe and koa haole forest would occur under the Preferred Alternative. Construction activities would not threaten the existence of any protected species or critical or sensitive habitats. Additionally, installation personnel would continue to manage habitats according to the INRMP, which is designed to protect and benefit threatened and endangered species.

No temporary or permanent areas of standing water would be created by the action; the storm water detention facility would be designed such that there is no exposed standing water or standing water that is accessible to water birds.

The Navy conducted informal consultation with the USFWS pursuant to Section 7(a)(2) of the ESA for the Proposed Action and developed a Biological Evaluation to assess the potential impacts to threatened and endangered species. The Navy determined that the Proposed Action may affect, but is not likely to adversely affect ESA-listed species potentially occurring within the project area. The USFWS concurred with the Navy's determination (see Appendix C for consultation correspondence).

White Tern

White terns are tolerant of people and noise and could nest within the kiawe and koa haole forest. White terns typically nest year-round, with a peak nesting period from February to July (Vanderwerf, 2003). White terns lay eggs directly on branches, and eggs and flightless chicks are highly vulnerable to tree trimming and removal activities (Vanderwerf, 2003). Construction of the Preferred Alternative would permanently remove potential nesting habitat for white terns and constitute a long-term indirect impact. However, nesting sites are not likely to be a limiting factor for long-term survival of white terns.

A direct impact would occur if eggs or chicks were disturbed. To avoid direct impacts to white terns, nest surveys would be conducted by a qualified biologist a maximum of seven days before construction. If a white tern egg or chick is discovered within the construction footprint, work would not begin until the chick has fledged, which may take between 12 and 15 weeks.

Hawaiian Short-Eared Owl

Although not observed during surveys, suitable habitat exists within the study area for the Hawaiian short-eared owl. In the short term, the human noise and disturbance associated with construction activities could temporarily displace owls from roosting or foraging habitats. This displacement could alter an individual's typical foraging and roosting patterns, forcing it to expend energy to search for new foraging and roosting locations.

The permanent removal of roosting and foraging habitat would constitute a long-term indirect impact. Hawaiian short-eared owls create nests on the ground, and a direct impact would occur if young owls that are unable to fly were disturbed. Chicks may fledge from the nest before being able to fly and are

dependent on their parents for approximately two months (Mitchell et al., 2005; USFWS, 2013). Short-eared owls are also known to become entangled in barbed wire (Holt and Leasure, 2006).

Approximately nine acres of potential roosting, foraging, and nesting habitat would be removed under the Preferred Alternative; however, there is available roosting and nesting habitat with similar vegetation nearby within Makalapa Crater.

To minimize impacts to the Hawaiian short-eared owl, nest surveys would be conducted a maximum of seven days prior to construction. Regular on-site staff would be trained to identify this species and know the appropriate measures to be taken if the species is present. If a Hawaiian short-eared owl is observed in the area during construction activities, all activities within 100 feet of the species would cease, and work would not continue until the species leaves the area on its own accord. If a Hawaiian short-eared owl nest is discovered, all activities within 100 feet of the nest would cease, and the JBPHH Natural Resources Manager would be contacted. Work would not resume until directed by the JBPHH Natural Resources Manager.

Hawaiian Hoary Bat

Though not observed during surveys, suitable habitat exists within the study area for Hawaiian hoary bat. In the short term, the human noise and disturbance associated with construction activities could temporarily displace bats from roosting or foraging habitats. This displacement could alter an individual's typical foraging and roosting patterns, forcing it to expend energy to search for new foraging and roosting locations.

Clearing of vegetation at the site would not take place during June 1 through September 15, when juvenile bats that are not yet capable of flying may be present in the trees. If any bat pups are discovered in the construction zone, outside the season, vegetation clearing would stop and move 100 yards away. Construction would not resume until the bat pups have departed the area of their own accord.

The permanent removal of roosting habitat could constitute a long-term indirect impact. Approximately nine acres of roosting habitat would be removed under the Preferred Alternative. However, available roosting habitat with similar vegetation is available nearby within Makalapa Crater, and the Hawaiian hoary bat does not appear to be limited by roosting habitat availability. Direct impacts to bats would occur if a juvenile bat that is too small to fly, but too large to be carried by a parent, was present in a tree that is cut down.

The use of barbed wire fencing presents a risk to Hawaiian hoary bat of entanglement or impalement. Although the Navy's informal Section 7 ESA consultation with USFWS evaluated the impact of the use of barbed wire on project-related security fencing, current plans do not include the use of barbed wire in the project. However, any installation of barbed wire beyond what was included in the consultation with the USFWS (Appendix C), may involve additional consultation.

Hawaiian petrel, Band-rumped storm-petrel, and Newell's shearwater

Hawaiian seabirds may traverse the project area at night during the breeding, nesting and fledging seasons (March 1 to December 15). Outdoor lighting could result in seabird disorientation, fallout, and injury or mortality. The proposed project would shield all lights, so the bulb may only be seen from below, as allowable by safety, security, and anti-terrorism force protection requirements and nighttime

construction would be avoided between March 1 and December 15, so seabird fallout and other negative impacts to seabirds is unlikely. Therefore, the effect to Hawaiian seabirds is discountable.

Hawaiian Stilt

Hawaiian stilts may be found in a variety of wetland habitats including wherever ephemeral or persistent standing water may occur. Although the JIOC is bound at its north side by the Halawa stream, this water body does not provide valuable habitat to Hawaiian stilts. Further, construction plans for the proposed project would utilize bioswales and other methods to limit or fully remove standing water present at the facility, so standing water acting as an attractant to Hawaiian stilts is unlikely. No temporary or permanent areas of standing water would be created by the action and the storm water detention facility would be designed such that there is no exposed standing water or standing water that is accessible to water birds (e.g., bioswale). Therefore the threat to Hawaiian stilts is considered discountable.

With the implementation of conservation measures described in this section, as well as management measures outlined in the INRMP, construction of the Preferred Alternative would not likely result in significant impacts to biological resources. The USFWS concurred with the Navy's determination that the Proposed Action may affect, but is not likely to adversely affect the endangered Hawaiian hoary bat, Hawaiian stilt, Hawaiian petrel, Hawaiian DPS of the band-rumped storm petrel, or the threatened Newell's Townsend's shearwater (see Appendix C for ESA Section 7 correspondence).

3.7.3.3 JIOC Facility-South Alternative Potential Impacts

The study area for the analysis of effects to biological resources associated with the South Alternative is the same as for the Preferred Alternative. Construction of the South Alternative would include the same elements as the Preferred Alternative (including offsite sewer improvements), except for the exclusion of a stormwater detention facility (assumed to be located beneath an at-grade parking lot). The majority of the South Alternative project footprint would be located in the southern half of the study area, with an access road through the northern half. The total area affected would be approximately ten acres. Impacts likely to occur as a result of the South Alternative are similar to those described for the Preferred Alternative, with the exception that a larger footprint of vegetation would be removed (i.e., approximately five percent more).

Vegetation

The South Alternative is not expected to have a substantial, adverse effect on vegetation. Construction of the South Alternative would remove all vegetation within the project footprint, but the area consists primarily of common, introduced, and alien vegetation species (as described in Section 3.7.2.1). The South Alternative would remove more vegetation than under the Preferred Alternative.

Terrestrial Wildlife

In the short term, the noise and human activity associated with construction of the South Alternative would displace wildlife from an area greater than the project footprint. The noise associated with construction could extend a minimum of 1,000 feet from the project area. In the long term, wildlife would return to the habitat remaining in the study area but would be permanently displaced from the project footprint. Most observed species in the study area are common throughout urban Oahu and would be able to use suitable nearby habitats for temporary relocation and foraging. Displacement of

individuals from the project footprint would not be expected to affect the survival of individuals or populations.

Threatened and Endangered Species

Temporary impacts to threatened and endangered terrestrial species from the South Alternative would be similar to those from the Preferred Alternative and would result from noise and habitat disturbances associated with construction activities. Permanent impacts would include loss of potential foraging or nesting habitat (approximately five percent more than under the Preferred Alternative). However, implementation of the South Alternative would not result in substantial impacts to threatened and endangered species individuals or populations.

The JIOC Facility-South Alternative may affect, but is not likely to adversely affect, biological resources (including listed species) based on the mitigation measures described in this section. Therefore, implementation of this action alternative would not result in significant impacts to biological resources.

3.8 Land Use

This discussion of land use includes current and planned uses and the regulations, policies, or zoning that may control the proposed land use. The term land use refers to real property classifications that indicate either natural conditions or the types of human activity occurring on a parcel. Two main objectives of land use planning are to ensure orderly growth and compatible uses among adjacent property parcels or areas. However, there is no nationally recognized convention or uniform terminology for describing land use categories. As a result, the meanings of various land use descriptions, labels, and definitions vary among jurisdictions. Natural conditions of property can be described or categorized as unimproved, undeveloped, conservation or preservation area, and natural or scenic area. There is a wide variety of land use categories resulting from human activity. Descriptive terms often used include residential, commercial, industrial, agricultural, institutional, and recreational.

Visual resources are discussed in Section 3.5, Visual Resources.

3.8.1 Regulatory Setting

In many cases, land use descriptions are codified in installation master planning and local zoning laws. Office of the Chief of Naval Operations Instruction (OPNAVINST) 11010.40 establishes an encroachment management program to ensure operational sustainment that has direct bearing on land use planning on installations. Additionally, the joint instruction OPNAVINST 11010.36C and Marine Corps Order 11010.16 provides guidance administering the Air Installation Compatible Use Zone (AICUZ) program, which recommends land uses that are compatible with noise levels, accident potential, and obstruction clearance criteria for military airfield operations. OPNAVINST 3550.1A and Marine Corps Order 3550.11 provide guidance for a similar program, Range AICUZ (RAICUZ). This program includes range safety and noise analyses, and provides land use recommendations which will be compatible with Range Compatibility Zones and noise levels associated with military range operations.

Through the Coastal Zone Management Act of 1972 (CZMA), Congress established national policy to preserve, protect, develop, restore, or enhance resources in the coastal zone. This Act encourages coastal states to properly manage use of their coasts and coastal resources, prepare and implement coastal management programs, and provide for public and governmental participation in decisions affecting the coastal zone. To this end, CZMA imparts an obligation upon federal agencies whose actions or activities affect any land or water use or natural resource of the coastal zone to be carried out in a

manner consistent to the maximum extent practicable with the enforceable policies of federally approved state coastal management programs. However, Federal lands, which are "lands the use of which is by law subject solely to the discretion of…the Federal Government, its officers, or agents," are statutorily excluded from the State's "coastal uses or resources" [16 U.S.C. § 1453(1)]. If, however, the proposed federal activity affects coastal uses or resources beyond the boundaries of the federal property (i.e., has spillover effects), the CZMA Section 307 federal consistency requirement applies. As a federal agency, the Navy is required to determine whether its proposed activities would affect the coastal zone. This takes the form of a consistency determination, a negative determination, or a determination that no further action is necessary.

In October 2006, the DoD issued Instruction number 2000.16, "DoD Antiterrorism Standards," requiring all DoD Components to adopt and adhere to common criteria and minimum construction standards to mitigate antiterrorism vulnerabilities and terrorist threats (Note: Current applicable reference is UFC 4-010-01, Change 1 August 19, 2020). The intent of these building standards is to integrate greater resistance to a terrorist attack into all inhabited buildings. That philosophy affects the general practice of designing inhabited buildings. ATFP standards consist of restrictions for onsite planning, including standoff distances, building separation, unobstructed space, drive-up and drop-off areas, access roads, and parking; structural design; structural isolation; and electrical and mechanical design. ATFP standards would be incorporated into the design of the new JIOC facilities, where applicable.

The Farmland Protection Policy Act (FPPA) is intended to minimize the impact Federal programs have on the unnecessary and irreversible conversion of farmland to nonagricultural uses. For the purpose of FPPA, farmland includes prime farmland, unique farmland, and land of statewide or local importance. Farmland subject to FPPA requirements does not have to be currently used for cropland. It can be forest land, pastureland, cropland, or other land, but not water or urban built-up land.

Federal Aviation Administration (FAA) Advisory Circular 150/5200-33B Hazardous Wildlife Attractants on or Near Airports provides guidance on land uses that have the potential to attract wildlife on or near public-use airports. In addition to implementation by public-use airport operators, the FAA recommends that the guidance in the advisory circular be implemented by land use planners and developers of projects, facilities, and activities on or near airports.

3.8.2 Affected Environment

The following discussions provide a description of the existing conditions for each of the categories under land use resources at JBPHH Makalapa Compound.

3.8.2.1 Land Use Compatibility

JBPHH Makalapa Compound

The primary land uses within JBPHH Makalapa Compound are administrative facilities (including headquarters and intelligence functions) located on the north and northeast sectors, officer family housing along the west and south rims of the crater, temporary lodging (i.e., NGIS) in the northern sector of the crater floor, and recreational facilities on the western sector of the crater floor. The Preferred Alternative facilities would be located on undeveloped land on the crater floor, south of Luapele Road. The site is currently overgrown with vegetation that overlies soils made up of about 5 to 10 feet (or more) of surface fills mixed with past construction and demolition debris, which in turn overlay the expansive clay soils. Security fencing surrounds the approximately 37-acre vegetated, undeveloped area on its west and south perimeters. The main facilities would be located adjacent to the

south of NGIS, with the 650-stall surface parking lot on the east of NGIS, near the compound's eastern boundary. A surface stormwater detention facility would be located about 800 feet to the south, also on undeveloped land. Aside from NGIS, there are no other facilities adjacent to the proposed project area.

Offsite, the potential intersection improvements, if warranted by future conditions, would occur at existing public roadways/intersections and would be compatible with existing land use.

The offsite sewer improvements would be located within existing roadway ROWs or existing sewer easements adjacent and/or near JBPHH operational and support areas.

3.8.2.2 Federal, State, and County Land Use Plans, Policies, and Controls

Federal

JBPHH Installation Development Plan

The JBPHH Installation Development Plan (IDP) (The Urban Collaborative, LLC, 2013) is a planning document intended to guide and shape development across the entire JBPHH installation (including outlying annexes). It illustrates planning actions that guide development at the installation and establishes a strategy for executing the planning vision and describes the implementation of planning principles at 11 planning districts within the installation. The IDP comprises installation-wide network plans and more specific Area Development Plans (ADP) for each of the 11 planning districts. Makalapa Compound—in which the project area is located—is one of the JBPHH's planning districts. The planning vision for the Makalapa ADP is to create a compact walkable campus with sustainable facilities and infrastructure, district parking, and parks and quads connected by pedestrian-oriented streets, which maintain the historic character of Makalapa. The Makalapa ADP maintains family housing along the west and south perimeters of the compound along with some renovation and expansion of existing administrative buildings along the north boundary. It includes a JIOC facility footprint adjacent to the south of NGIS and a few notional long-term infill buildings in the undeveloped area on the crater floor to the north of the Samoa Place family housing. Most of the balance of the crater floor is identified as open space, encircled by a recreational trail. An existing unpaved path aligns north-south from the existing recreational area around the undeveloped, heavily vegetated area and curves to the east at the south edge of the crater floor (north of Samoa Place family housing). The path then becomes paved on the eastern perimeter of the undeveloped area, and parallels an unpaved vehicle road adjacent to the compound's eastern boundary (i.e., next to H-1 Freeway). The Makalapa ADP shows the western and southern portions this path formalized into a vehicle road and providing over 600 parking stalls in linear parking areas on either side. A new 100-stall parking area is also shown adjacent to Luapele Road, east of NGIS.

Farmland Protection Policy Act

Federal actions that affect prime or unique farmlands are subject to the federal Farmland Protection Policy Act (FPPA, subtitle I of Title XV, Section 1539-1549) administered by the NRCS, if they may irreversibly convert farmland (directly or indirectly). Neither the project area nor the recommended intersection improvement area (i.e., Salt Lake Boulevard-Kahuapaani Street intersection) is classified by the State of Hawaii Department of Agriculture as Prime or Unique Agricultural Lands (State of Hawaii Department of Agriculture, 1977). The provisions of the FPPA do not apply to the proposed action.

Antiterrorism/Force Protection Standards

As a substantial portion of the redevelopment would be occupied by DoD personnel, the applicability of ATFP requirements is evaluated in this EA. ATFP standards consist of restrictions on site planning, including standoff distances, building separation, unobstructed space, drive-up and drop-off areas, access roads, and parking; structural design; structural isolation; and electrical and mechanical design.

Coastal Zone Management Act

The National Coastal Zone Management Act (CZMA) of 1972, as amended, authorizes a national program for the management, beneficial use, protection, and development of the natural resources in the nation's coastal zone. However, lands owned, leased, held in trust, or whose use is otherwise subject solely to the discretion of the federal government, its officers, or agents are excluded from the coastal zone area. Because it is federal land, JBPHH Makalapa Compound is excluded from the coastal zone of Hawaii. However, because the Proposed Action would redistribute traffic volumes and have localized effects on public roadway intersections outside the boundaries of federal property, the CZMA Section 307 federal consistency requirement applies. The State of Hawaii Department of Business, Economic Development and Tourism Office of Planning (DBEDT OP) is the lead agency for coastal management and is responsible for enforcing the State's federally approved coastal management plan. Consistency with the enforceable policies of the Hawaii Coastal Zone Management Program is discussed in Section 3.8.3.

FAA Advisory Circular 150/5200-33B Hazardous Wildlife Attractants on or Near Airports

Facilities that involve temporary standing water—such as the surface stormwater detention facility included in the Preferred Alternative—could attract wildlife that is potentially hazardous to aircraft operations. The FAA encourages proponents of projects that propose land use changes that may attract hazardous wildlife within five statute miles of its airports (such the Preferred Alternative) to notify the FAA early in the planning process. In its Advisory Circular 150/5200-33B, the FAA recommends that off-airport stormwater management systems within five statute miles of an airport's air operations area be designed and operated so as not to create above-ground standing water. The Advisory Circular recommends that stormwater detention ponds be designed, engineered, constructed, and maintained for a maximum 48-hour detention period after the design storm and remain completely dry between storms. In addition, to facilitate the control of hazardous wildlife, the FAA recommends the use of steep-sided, rip-rap lined, narrow, and linearly shaped detention basins. Physical barriers such as netting may also be used to prevent access of hazardous wildlife to open water.

State

State Land Use Districts

The State Land Use Law, Chapter 205, HRS, establishes a state land use management framework by classifying all lands in the State into four land use districts: Urban, Agricultural, Conservation, and Rural. The State Land Use Commission, the governing body that administers this statewide zoning law, is responsible for preserving and protecting the lands in the State, and encouraging those uses to which lands are best suited.

The State Land Use District designation for the Makalapa Compound project area is Conservation (Figure 3-19); the balance of JBPHH Makalapa Compound is in the Urban District. HRS Chapter 183, Conservation District, states that the State's Land Use Conservation District contains important natural

resources essential to the preservation of the State's fragile natural ecosystems and the sustainability of the State's water supply. Makalapa Crater—including the project area—was acquired by the Navy in 1939 as part of a 672-acre land acquisition in Halawa to support the buildup of Pearl Harbor. The majority of the facilities in the Makalapa Compound were originally developed in the 1940s, well before the State Land Use Law (codified as Chapter 205, HRS) was enacted in 1961. As described in Section 3.8.2.1, the project area is overgrown with vegetation that overlies soils made up of about 5 to 10 feet (or more) of surface fills mixed with past construction and demolition debris.

The offsite sewer improvement areas are located in the State Land Use Urban District.

Hawaii Coastal Zone Management Program

The National Coastal Zone Management Program was created through passage of the Coastal Zone Management Act of 1972. Hawaii's CZM Program, adopted as Chapter 205A, HRS, provides a basis for protecting, restoring, and responsibly developing coastal communities and resources. The objectives and policies of the Hawaii CZM Program encompass broad concerns such as impact on recreational resources, historic and archaeological resources, coastal scenic resources and open space, coastal ecosystems, coastal hazards, and the management of development.

City and County of Honolulu

General Plan

The General Plan for the City and County of Honolulu, adopted in 1977 and last amended in 2002, identifies long term objectives and policies along with the strategies and actions to achieve them. The Plan is a statement of the long-range social, economic, environmental, and design objectives for the general welfare and prosperity of the people of Oahu. The identified objectives contain statements of desirable conditions to be achieved in the long run, within an approximate 20-year timeframe. The broad policies are intended to facilitate the attainment of the objectives of the Plan. The Plan includes eleven subject areas which provide a framework of the City's expression of public policy concerning the needs of the people and the functions of government. The eleven areas of concern include: population; economic activity; the natural environment; housing; transportation and utilities; energy; physical development and urban design; public safety; health and education; cultural and recreation; and government operations and fiscal management. The objectives and policies of the General Plan that are relevant to the proposed action are as follows:

I. Population

Objective C: To establish a pattern of population distribution that will allow the people of Oahu to live and work in harmony.

Policy 1: Facilitate the full development of the primary urban center.

Policy 2: Encourage development within the secondary urban center at Kapolei and the Ewa and Central Oahu urban-fringe areas to relieve developmental pressures in the remaining urban-fringe and rural areas and to meet housing needs not readily provided in the primary urban center.

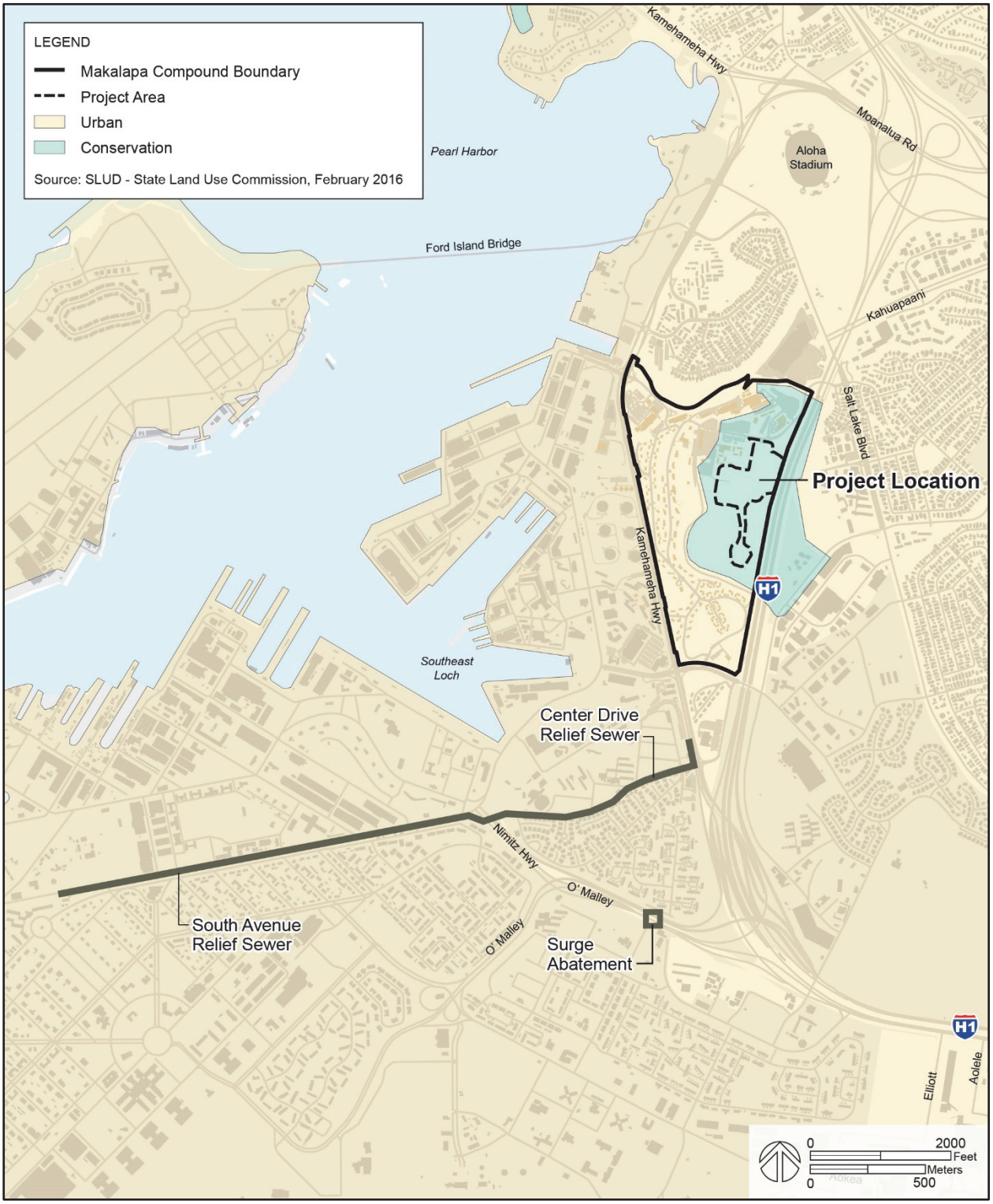


Figure 3-19 State Land Use Districts

Policy 3: Manage physical growth and development in the urban-fringe and rural areas so that:

a. An undesirable spreading of development is prevented; and

b. Their population densities are consistent with the character of development and environmental qualities desired for such areas.

Policy 4: Direct growth according to Policies 1, 2, and 3 above by providing land development capacity and needed infrastructure to seek a 2025 distribution of Oahu's residential population (such that the primary urban center share is 46.0 percent).

II. Economic Activity

Objective A: To promote employment opportunities that will enable all the people of Oahu to attain a decent standard of living.

Policy 6: Encourage the continuation of a significant level of federal employment on Oahu.

Objective F: To increase the amount of federal spending on Oahu.

Policy 3: Encourage the federal government to lease new facilities rather than construct them on tax-exempt public land.

Objective G: To bring about orderly economic growth on Oahu.

Policy 4: Encourage the continuation of a high level of military-related employment in the Hickam-Pearl Harbor, Wahiawa, Kailua-Kaneohe, and Ewa areas.

III. Natural Environment

Objective A: To protect and preserve the natural environment.

Policy 4: Require development projects to give due consideration to natural features such as slope, flood and erosion hazards, water- recharge areas, distinctive land forms, and existing vegetation.

Policy 7: Protect the natural environment from damaging levels of air, water, and noise pollution.

Policy 8: Protect plants, birds, and other animals that are unique to the State of Hawaii and the Island of Oahu.

Policy 9: Protect mature trees on public and private lands and encourage their integration into new developments.

Primary Urban Center Development Plan

The City and County of Honolulu provides a conceptual framework for implementing the objectives and policies of the General Plan though its Development Plan (DP) program. There are eight geographical DP areas established on Oahu, which each have community-oriented plans intended to guide public policy and decision-making through 2025.

Major growth in population and economic activity will be directed into two of the eight planning areas, the Primary Urban Center (PUC) and Ewa, and are guided under their respective Development Plans. The remaining six planning regions are considered Sustainable Communities Plans, and are envisioned to remain relatively stable.

The project area is located within the Primary Urban Center Development Plan (PUC DP) area, which extends from Waialae-Kahala in the east to Pearl City in the west. The PUC DP, adopted in 2004,

establishes policy to shape the growth and development of the PUC through 2025. The PUC is home to almost half of the island's population and contains a diverse mix of neighborhoods, business, and industries.

The Pearl Harbor area (from Aliamanu to Pearl City) includes various military bases and functions centered around JBPHH and Fort Shafter, includes Aloha Stadium, regional commercial activities on Kamehameha Highway, and the industrial areas at Waiawa, Waiau, Bougainville, and Halawa. It is considered a major job center of the PUC. According to the PUC DP, land use patterns on military installations within the PUC are compatible with adjacent civilian uses.

The PUC DP Land Use Map (Figure 3-20) identifies the JIOC facility project area as Major Parks and Open Space, while the JBPHH Makalapa Compound administration area is shown as Military, and the balance of the crater (i.e., family housing recreational areas) is shown as Lower-Density Residential. The Parks and Open Space land use includes larger land areas such as golf courses, regional and district parks, botanical gardens, and zoological parks that contribute to the region's open space network.

The PUC DP Land Use Map identifies the offsite sewer improvement areas as Lower-Density Residential, and Medium and Higher-Density Residential/Mixed Use.

In its description of Military land uses, the PUC DP notes that military bases are exempt from local planning and zoning. Along with civilian neighborhoods spread throughout the PUC DP, Lower-Density Residential areas include neighborhoods around Aliamanu Crater and Salt Lake, including military housing.

The policy of the PUC DP that is relevant to the proposed action includes:

- Support continuation of military uses – The City should support long-range land use planning by the military services and coordinate with them to achieve common goals of employment, housing, and recreation.

Land Use Ordinance

The Land Use Ordinance (LUO) of the City and County of Honolulu regulates land use in accordance with adopted land use polices from the General Plan and Development Plans. The provisions, also referred to as the Zoning Ordinance, of the LUO are intended to provide reasonable development and design standards. Under current LUO zoning, the project area is located within the P-1 Preservation district, generally corresponding with the State Land Use Conservation district. The rest of JBPHH (including the balance of Makalapa Compound and most of the offsite sewer improvement areas) is within the F-1 Military and Federal Preservation district. Limited areas of the offsite sewer improvement areas near Nimitz Gate and Kamehameha Highway are located within the R-5 Residential district (see City and County Zoning and Special Management Area Map, Figure 3-21). As noted in the discussion of the PUC DP, military bases are exempt from local planning and zoning.

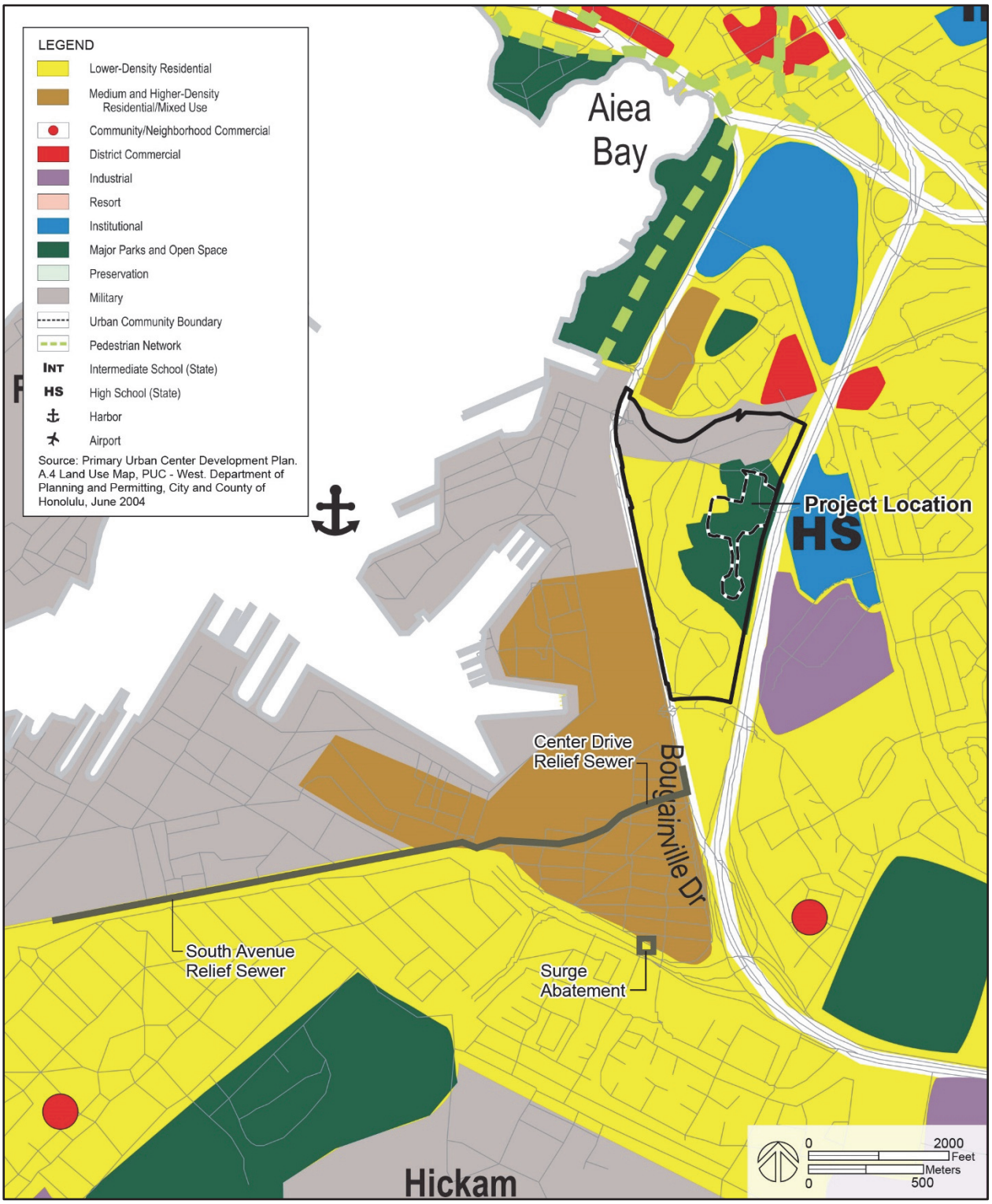


Figure 3-20 Primary Urban Center Development Plan Land Use Map

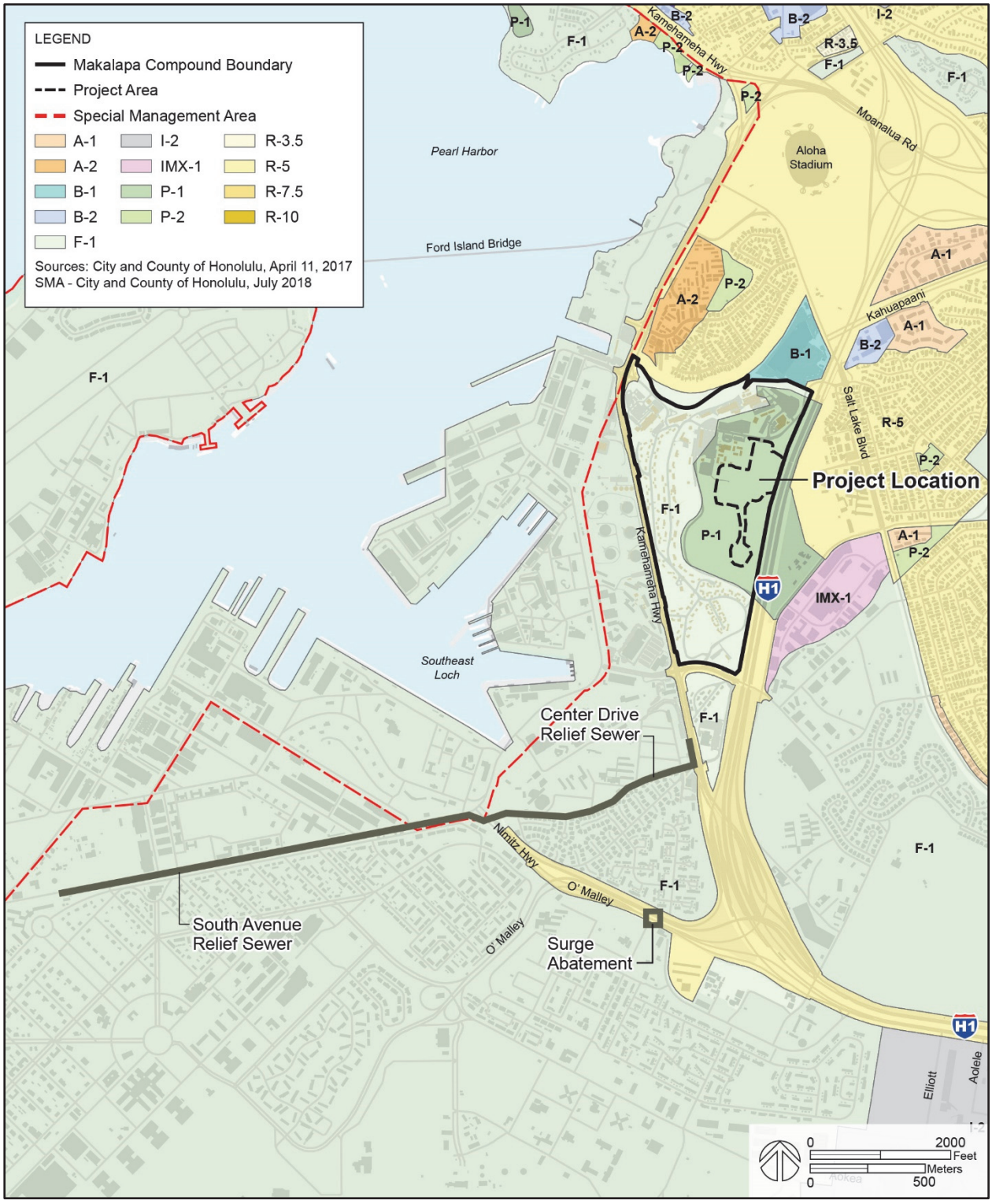


Figure 3-21 City and County Zoning and Special Management Area Map

Special Management Area and Shoreline Setback

Established in 1975 with the enactment of Act 176, the Special Management Area (SMA) permit is also known as the Shoreline Protection Act. The SMA, conferred by HRS Chapter 205A, is designed to preserve, protect, and restore the natural resources of Hawaii's coastal zone. Along the shoreline, special controls on development are necessary in order to avoid the permanent loss of valuable resources and insure adequate access to beaches, recreation areas, and natural reserves. Permissible land uses, allowed by various land use policies such as county general plans, are regulated through the SMA permit. The SMA permit ensures that uses, activities, or operations on land, in water, or under water within the SMA comply with SMA guidelines, as well as the CZM objectives and policies.

The JIOC facility project area is not within the SMA (see City and County Zoning and Special Management Area (Figure 3-21). However, a small segment of the offsite sewer improvement area within South Avenue is located with the SMA.

3.8.3 Environmental Consequences

The location and extent of a proposed action needs to be evaluated for its potential effects on a project site and adjacent land uses. Factors affecting a proposed action in terms of land use include its compatibility with on-site and adjacent land uses, restrictions on public access to land, or change in an existing land use that is valued by the community. Other considerations are given to proximity to a proposed action, the duration of a proposed activity, and its permanence.

3.8.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to land use. Therefore, no impacts would occur with the No Action Alternative.

3.8.3.2 JIOC Facility-North Alternative (Preferred Alternative) Potential Impacts

The site proposed for the Preferred Alternative and adjacent lands (including the offsite sewer improvement areas) define the study area for land use analyses.

Land Use Compatibility

The Preferred Alternative would not impact existing land uses at JBPHH Makalapa Compound or the offsite sewer improvement areas. The Makalapa Compound project site is on undeveloped land that is currently off-limits to the general public due to its uneven topography and evidence of soil contamination associated with its past uses (e.g., disposal site for dredged materials and Navy solid waste, pesticide and herbicide rinse area, receiver site of fill materials). Project construction would not displace the existing surrounding administrative, housing, or recreational land uses at JBPHH Makalapa Compound or encroach upon the full extent of those uses. Offsite, construction of the JIOC facilities, offsite sewer improvements, or the potential intersection improvements would not affect surrounding commercial, retail, industrial, or residential land uses. There may be short-term, temporary lane closures to the affected roadways, but implementation of construction and traffic management plans would ensure that access to the surrounding uses is maintained.

In the operational period, the new JIOC facilities would be compatible with the surrounding land uses at JBPHH Makalapa Compound. As they would be primarily administrative in function (versus training or industrial), the JIOC facilities are not expected to operate differently than the current facilities, which are also located near family housing in Makalapa Compound. The Preferred Alternative is consistent

with the general locations and uses of the JBPHH IDP in that it locates the proposed JIOC facilities on undeveloped land on the crater floor, south of NGIS. The proposed JIOC parking lot is located in the same general area as the 100-stall lot shown in the Makalapa ADP.

The offsite sewer improvements would be compatible with surrounding land uses as they would be located below ground or within existing above-ground sewer easements.

The Preferred Alternative would not affect or be affected by the AICUZ contours from the runways shared by JBPHH and the Daniel K. Inouye International Airport, two miles to the south.

Federal, State, and County Land Use Plans and Controls

JBPHH Installation Development Plan

The Preferred Alternative is generally consistent with the Makalapa ADP, as it would be located south of NGIS—along with surface parking—in the currently undeveloped area on the crater floor. The Makalapa ADP depicts the surface parking along a new vehicle road on the eastern perimeter of the existing western fenceline of the undeveloped crater floor. The Proposed Action does not include creating a new vehicle roadway where the ADP depicts one; rather, it co-locates parking along an access road from Luapele Road. The ADP also includes a surface parking lot along Luapele Road. The creation of a larger parking lot in this area does not foreclose the potential to construct other infill buildings in the southern sector of the crater floor, along with a vehicle access road and parking.

The offsite sewer improvements would be compatible with surrounding land uses as they would not change any above-ground land uses.

Antiterrorism Force Protection Standards

The Preferred Alternative would include physical features to comply with ATFP standards in accordance with DoD Minimum Antiterrorism Standards for Buildings.

Coastal Zone Management Act

By the exchange of letters dated June 1, 2009 and July 9, 2009, the Navy and the State of Hawaii's Department of Business, Economic Development and Tourism, Office of Planning respectively proposed and concurred that those activities listed on the "Navy/Marine Corps De Minimis Activities under CZMA" (De Minimis Activity List) are expected to have insignificant direct or indirect (including cumulative) coastal effects and should not be subject to further review by the Hawaii CZM Program when such an activity was conducted in compliance with the corresponding "Project Mitigation/General Conditions" (see Appendix D for correspondence).

The Preferred Alternative falls within the following two De Minimis Activity List items:

<u>Item 1 - New Construction</u>

Construction of new facilities and structures wholly within Navy/Marine Corps controlled areas (including land and water) that is similar to present use and, when completed, the use or operation of which complies with existing regulatory requirements.

<u>Item 2 - Utility Line Activities</u>

Acquisition, installation, operation, construction, maintenance, or repair of utility or communication systems that uses rights of way, easements, distribution systems, or facilities on Navy/Marine Corps

controlled property. This also includes the associated excavation, backfill, or bedding for the utility lines, provided there is no change in preconstruction contours.

The Preferred Alternative would be subject to and bound by the full compliance to the project mitigation/general conditions specified below.

1. Navy/Marine Corps controlled property refers to land areas, rights of way, easements, roads, safety zones, danger zones, ocean, and naval defensive sea areas under active Navy/Marine Corps control.

3. Turbidity and siltation from project related work shall be minimized and contained to within the vicinity of the site through appropriate use of effective silt containment devices and the curtailment of work during adverse tidal and weather conditions.

6. No project related materials (fill, revetment rock, pipe, etc.) should be stockpiled in the water (intertidal zones, reef flats, stream channels, wetlands, etc.).

8. No contamination (trash or debris disposal, alien species introductions, etc.) of adjacent marine/aquatic environments, (reef flats, channels, open ocean, stream channels, wetlands, etc.) shall result from project-related activities.

9. Fueling of project-related vehicles and equipment would take place away from the water, and a contingency plan would be developed to control accidental petroleum releases during project construction. Absorbent pads and containment booms would be stored on-site, if appropriate, to facilitate clean-up of accidental petroleum releases.

10. Any under-layer fills used in the project shall be protected from erosion with stones (or core-loc units) as soon after placement as practicable.

11. Any soil exposed near water as part of the project shall be protected from erosion (with plastic sheeting, filter fabric, etc.,) after exposure and stabilized as soon as practicable (with vegetation matting, hydroseeding, etc.).

12. Section 106 of the NHPA consultation requirements must be met and guidelines in the area-specific ICRMP followed, if applicable.

13. Navy/Marine Corps shall evaluate the possible impact of the action on species and habitats protected under the Endangered species act (ESA).

14. The National Environmental Policy Act (NEPA) review process will be completed.

16. Navy or Marine Corps staff shall notify state CZM of *de minimis* list usage for projects which require an Environmental Assessment. Notification may be sent via email.

The State CZM office was advised by electronic mail on February 8, 2022 of the Navy's usage of the De Minimis Activity List and the preparation of this EA; it acknowledged receipt of the Navy's notification on the same day. CZMA correspondence is included in Appendix D.

FAA Advisory Circular 150/5200-33B Hazardous Wildlife Attractants on or Near Airports

The stormwater detention facility would be designed so as not to attract wildlife that could pose a hazard to aviation. The project proponent would notify the FAA about the proposed project prior to final design of the stormwater detention facility.

State Land Use District

As an administrative-type office and operational facility, the Preferred Alternative is not a use consistent with the State Conservation District identified in Makalapa Crater; however, as a federal agency, the Navy has not waived its sovereign immunity from state and local land use controls. Therefore, it has no requirement to comply with state land use regulations and no Conservation District Use Permit is required for the Proposed Action. Through adherence to its federal environmental stewardship requirements (for example, preparation and implementation of the JBPHH INRMP), the Navy is consistent with the Conservation District designation to the maximum extent practicable.

City and County of Honolulu General Plan

The Preferred Alternative is consistent with the relevant objectives and policies of the General Plan. Specifically:

- Population: The Preferred Alternative does not move activities and functions from the PUC to urban-fringe and rural areas, rather, it concentrates it within an existing DoD compound. The Preferred Alternative would not in itself impact the distribution of residential population among the Development Plan or Sustainable Communities Plan areas.
- Economic Activity: The Preferred Alternative would encourage the continuation of federal employment on Oahu, in particular, military-related employment in the Hickam-Pearl Harbor area. It does not include leasing new (private sector) facilities due to security requirements of the JIOC operations.
- Natural Environment: This EA evaluates the Preferred Alternative's impacts on natural features in Sections 3.2 Air Quality, 3.3 Water Resources, 3.4 Geological Resources, and 3.7 Biological Resources. Because of the site's prior use as a construction and demolition landfill, along with the extensive alteration of the crater floor, current lack of sensitive habitat, and proposed conservation measures during and after construction, the Preferred Alternative would not result in significant impacts to biological resources. As described in Sections 3.2, 3.3, and 3.9, the Preferred Alternative would not have significant impacts on air, water, or noise environments. Selected mature trees around the periphery of the project area may be retained for visual screening purposes.

City and County Primary Urban Center Development Plan

The Preferred Alternative is consistent with the relevant PUC DP policy to support the continuation of military uses. Although the Makalapa Compound project area is shown on the PUC DP Land Use map as "Parks and Open Space," the area does not fulfill the definition of that land use, which is to include larger land areas such as golf courses, regional and district parks, botanical gardens, and zoological parks that contribute to the region's open space network. Furthermore, military land uses are exempt from local planning and zoning; therefore, the Preferred Alternative would not require a PUC DP amendment. It should be noted that the 2.5-acre footprint of the three-story building is only about six percent of the total 40-acre area designated in the PUC DP Land Use map as Parks and Open Space. The majority of the area would remain in open space, low-profile infrastructure (e.g., detention basin), or at-grade walkways or parking, retaining the open space perceived by vehicles passing by on H-1 Freeway. As discussed in Section 3.5, the Preferred Alternative would not result in significant impacts to visual resources.

The offsite sewer improvement areas are shown as Lower-Density Residential and Medium and Higher-Density Residential/Mixed Use in the PUC DP. Because the sewer improvements would be below grade

in existing roadway ROWs and easements, and would not change the existing land uses, they are compatible with these land use designations.

City and County Land Use Ordinance

The Preferred Alternative is not consistent with the City and County of Honolulu's P-1 Preservation zoning district in which it is located. However, military bases are exempt from local planning and zoning requirements and a zone change application is not required.

City and County Special Management Area and Shoreline Setback

A portion of the sewer line improvements project area is within the SMA (east end of proposed South Avenue relief sewer – within JBPHH property and beneath an existing roadway that contains other subsurface sewer lines). As noted above, the Navy is not required to obtain a SMA permit for the Proposed Action. However, through adherence to its federal environmental stewardship requirements (for example, preparation and implementation of the JBPHH INRMP), the Proposed Action would be consistent with the SMA designation to the maximum extent practicable. As described in the discussion of CZMA compliance earlier in this section, the Proposed Action would be conducted in compliance with applicable project mitigation/general conditions to avoid and/or minimize impacts to the coastal zone, including areas within CCH's defined SMA.

Therefore, implementation of the Preferred Alternative would not result in significant impacts to land use.

3.8.3.3 JIOC Facility-South Alternative Potential Impacts

The site proposed for the JIOC Facility-South Alternative and adjacent lands define the study area for land use analyses.

Land Use Compatibility

Like the Preferred Alternative, this alternative would not impact existing land uses at JBPHH Makalapa Compound during the construction or operational periods. The site is located about 700 feet south of the Preferred Alternative site, also on existing undeveloped, heavily vegetated land on the crater floor of JBPHH Makalapa Compound. The facility would be of similar size, construction methods, and function as the Preferred Alternative and would not displace or change any existing surrounding land uses. The offsite sewer improvements in this alternative would be identical to those in the Preferred Alternative and would have the same impacts to land use as the Preferred Alternative.

The JIOC Facility-South Alternative would involve the same potential offsite intersection improvements as the Preferred Alternative. Implementation of these improvements would comply with construction and traffic management plans to minimize or avoid limitations on access to the surrounding commercial, retail, and residential uses.

During the operational period, this alternative would have the same insignificant land use impacts as the Preferred Alternative due to their similarity in function, size, and operations.

Like the Preferred Alternative, the JIOC Facility-South Alternative would not affect or be affected by the AICUZ from runways shared by JBPHH and Daniel K. Inouye International Airport. Because it would have the same general project area and activities as the Preferred Alternative, its consistency with CZMA would be the same as that of the Preferred Alternative.

Federal, State, and County Land Use Plans, Policies, and Controls

JBPHH Installation Development Plan

Although its location is farther south than the JIOC facility site shown in the Makalapa ADP, this alternative is also located on the crater floor in JBPHH Makalapa Compound and is generally consistent with the plan's intent.

Antiterrorism Force Protection Standards

This alternative would also include physical features to comply with ATFP standards in accordance with governing DoD Minimum Anti-Terrorism Standards for Buildings.

Coastal Zone Management Act

As with the Preferred Alternative, this alternative would also fall within the De Minimis Activities identified in the 2009 correspondence between the Navy and the Hawaiʻi DBEDT Office of Planning. Because it would also be conducted in compliance with the corresponding "Project Mitigation/General Conditions," it would not be subject to further review by the Hawaiʻi CZM Program, and notification would be made to the State CZM office of the Navy's usage of the De Minimis Activity List and the preparation of a NEPA EA.

FAA Advisory Circular 150/5200-33B Hazardous Wildlife Attractants on or Near Airports

This alternative would have less than significant impacts to airport hazardous wildlife attractants. Because it would not include a surface stormwater detention basin, it would not introduce a potential attractant for wildlife within five statute miles of HNL.

State Land Use District

The South Alternative would also not be consistent with the State Conservation District. However, as with the Preferred Alternative, the Navy is not required to comply with state land use regulations and no Conservation District Use Permit would be required for the South Alternative.

City and County of Honolulu General Plan

Similar to the Preferred Alternative, the South Alternative would be consistent with the relevant policies of the General Plan in the areas of population, economic activity, and natural environment.

Primary Urban Center Development Plan

As with the Preferred Alternative, the South Alternative would be consistent with the PUC DP policy to support the continuation of military uses. It would not be consistent with the PUC DP Land Use map designations of "Parks and Open Space," "Lower-Density Residential," and "Medium and Higher-Density Residential/Mixed Use;" however, because military land uses are exempt from local planning and zoning, a PUC DP amendment is not required.

City and County Land Use Ordinance

Like the Preferred Alternative, the South Alternative is not consistent with the City and County of Honolulu's P-1 Preservation zoning district in which it is located. However, military bases are exempt from local planning and zoning requirements and a zone change application is not required.

City and County Special Management Area and Shoreline Setback

Under this alternative, a portion of the sewer line improvements project area would also be within the SMA. As with the Preferred Alternative, the Navy is not required to obtain a SMA permit for the Proposed Action. However, through adherence to its federal environmental stewardship requirements (for example, preparation and implementation of the JBPHH INRMP), the Proposed Action would be consistent with the SMA designation to the maximum extent practicable. The Proposed Action would be conducted in compliance with applicable project mitigation/general conditions to avoid and/or minimize impacts to the coastal zone, including areas within CCH's defined SMA.

Therefore, implementation of this action alternative would not result in significant impacts to land use.

3.9 Noise

This discussion of noise includes the types or sources of noise and the associated sensitive receptors in the human environment. Noise in relation to biological resources and wildlife species is discussed in the Biological Resources section.

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water, and are sensed by the human ear. Sound is all around us. The perception and evaluation of sound involves three basic physical characteristics:

- Intensity – the acoustic energy, which is expressed in terms of sound pressure, in decibels (dB)
- Frequency – the number of cycles per second the air vibrates, in Hertz (Hz)
- Duration – the length of time the sound can be detected

Noise is defined as unwanted or annoying sound that interferes with or disrupts normal human activities. Although continuous and extended exposure to high noise levels (e.g., through occupational exposure) can cause hearing loss, the principal human response to noise is annoyance. The response of different individuals to similar noise events is diverse and is influenced by the type of noise, perceived importance of the noise, its appropriateness in the setting, time of day, type of activity during which the noise occurs, and sensitivity of the individual. While aircraft are not the only sources of noise in an urban or suburban environment, they are readily identified by their noise output and are given special attention in this EA.

3.9.1 Basics of Sound and A-Weighted Sound Level

The loudest sounds that can be detected comfortably by the human ear have intensities that are a trillion times higher than those of sounds that can barely be detected. This vast range means that using a linear scale to represent sound intensity is not feasible. The dB is a logarithmic unit used to represent the intensity of a sound, also referred to as the sound level. All sounds have a spectral content, which means their magnitude or level changes with frequency, where frequency is measured in cycles per second or Hz. To mimic the human ear's non-linear sensitivity and perception of different frequencies of sound, the spectral content is weighted. For example, environmental noise measurements are usually on an "A-weighted" scale that filters out very low and very high frequencies in order to replicate human sensitivity. It is common to add the "A" to the measurement unit in order to identify that the measurement has been made with this filtering process (dBA). In this document, the dB unit refers to A-weighted sound levels. Table 3-15 provides a comparison of how the human ear perceives changes in loudness on the logarithmic scale.

Table 3-15 Subjective Responses to Changes in A-Weighted Decibels

Change	*Change in Perceived Loudness*
3 dB	Barely perceptible
5 dB	Quite noticeable
10 dB	Dramatic – twice or half as loud
20 dB	Striking – fourfold change

Figure 3-22 (Cowan, 1994) provides a chart of A-weighted sound levels from typical noise sources. Some noise sources (e.g., air conditioner, vacuum cleaner) are continuous sounds that maintain a constant sound level for some period of time. Other sources (e.g., automobile, heavy truck) are the maximum sound produced during an event like a vehicle pass-by. Other sounds (e.g., urban daytime, urban nighttime) are averages taken over extended periods of time. A variety of noise metrics have been developed to describe noise over different time periods, as discussed below.

Noise levels from aircraft operations that exceed background noise levels at an airfield typically occur beneath main approach and departure corridors, in local air traffic patterns around the airfield, and in areas immediately adjacent to parking ramps and aircraft staging areas. As aircraft in flight gain altitude, their noise contributions drop to lower levels, often becoming indistinguishable from the background noise.

3.9.2 Noise Metrics

A metric is a system for measuring or quantifying a particular characteristic of a subject. Since noise is a complex physical phenomenon, different noise metrics help to quantify the noise environment. The noise metrics used in this EA are described in summary format below and in a more detailed manner in Appendix E. While the Day-Night Average Sound Level (DNL) noise metrics are the most commonly used tools for analyzing noise generated at an airfield, the DoD has been developing additional metrics (and analysis techniques). These supplemental metrics and analysis tools provide more detailed noise exposure information for the decision process and improve the discussion regarding noise exposure.

3.9.2.1 Day-Night Average Sound Level

The DNL metric is the energy-averaged sound level measured over a 24-hour period, with a 10-dB penalty assigned to noise events occurring between 10 p.m. and 7 a.m. (acoustic night). DNL values are average quantities, mathematically representing the continuous sound level that would be present if all of the variations in sound level that occur over a 24-hour period were averaged to have the same total sound energy. The DNL metric quantifies the total sound energy received and is therefore a cumulative measure, but it does not provide specific information on the number of noise events or the individual sound levels that occur during the 24-hour day. DNL is the standard noise metric used by the U.S. Department of Housing and Urban Development (HUD), FAA, USEPA, and DoD. Studies of community annoyance in response to numerous types of environmental noise show that DNL correlates well with

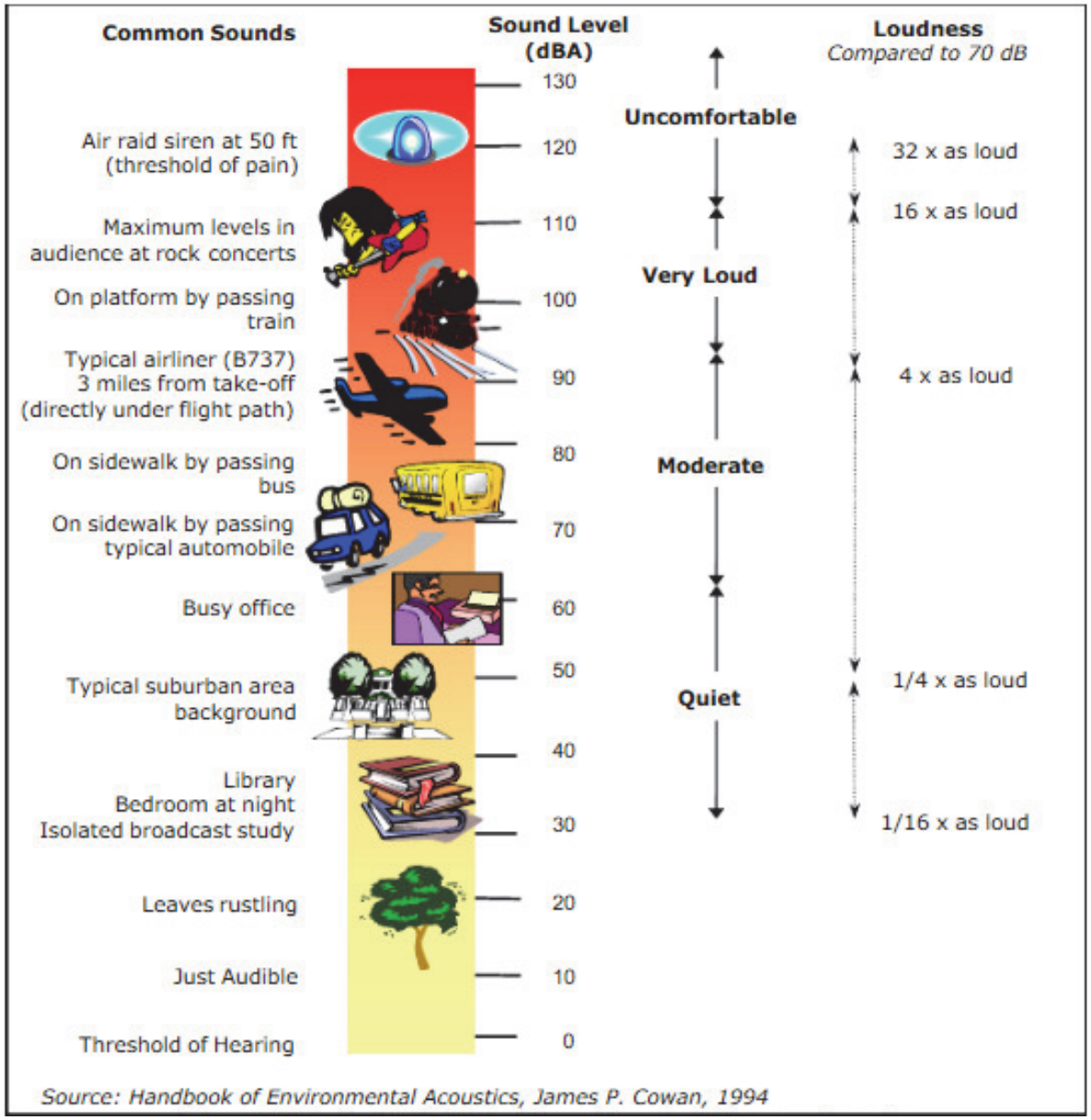


Figure 3-22 A-Weighted Sound Levels from Typical Sources

impact assessments; there is a consistent relationship between DNL and the level of annoyance. Most people are exposed to sound levels of 50 to 55 DNL or higher on a daily basis.

Research has indicated that about 87 percent of the population is not highly annoyed by outdoor sound levels below 65 dB DNL (Federal Interagency Committee on Urban Noise, 1980). Therefore, the 65 dB DNL noise contour is used to help determine compatibility of military aircraft operations with local land use, particularly for land use associated with airfields.

3.9.2.2 Equivalent Sound Level

A cumulative noise metric useful in describing noise is the Equivalent Sound Level (Leq). Leq is the continuous sound level that would be present if all of the variations in sound level occurring over a

specified time period were smoothed out as to contain the same total sound energy. The same calculation for a daily average time period such as DNL but without the penalties is a 24 hour equivalent sound level, abbreviated Leq(24). Other typical time periods for Leq are 1 hour and 8 hours.

3.9.2.3 Sound Exposure Level

The Sound Exposure Level (SEL) metric is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. SEL provides a measure of total sound energy of the entire acoustic event, but it does not directly represent the sound level heard at any given time. During an aircraft flyover, SEL captures the total sound energy from the beginning of the acoustic event to the point when the receiver no longer hears the sound. It then condenses that energy into a 1-second period of time and the metric represents the total sound exposure received. The SEL has proven to be a good metric to compare the relative exposure of transient sounds, such as aircraft overflights, and is the recommended metric for sleep disturbance analysis (DoD Noise Working Group, 2009). In this EA, SEL is used in aircraft comparison and sleep disturbance analyses.

3.9.2.4 Maximum Sound Level

The highest A-weighted sound level measured during a single event where the sound level changes value with time (e.g., an aircraft overflight) is called the maximum A-weighted sound level or Lmax. During an aircraft overflight, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer, and returns to the background level as the aircraft recedes into the distance. Lmax defines the maximum sound level occurring for a fraction of a second. For aircraft noise, the “fraction of a second” over which the maximum level is defined is generally 1/8 second (American National Standards Institute, 1988). For sound from aircraft overflights, the SEL is usually greater than the Lmax because an individual overflight takes seconds and the Lmax occurs instantaneously. In this EA, Lmax is used in the analysis of aircraft comparison and speech interference.

3.9.2.5 Number of Events Above a Threshold Level

The “Number of Events Above a Threshold Level” metric provides the total number of noise events that exceed a selected noise level threshold during a specified period of time (DoD Noise Working Group, 2009). Combined with the selected noise metric, Lmax or SEL, the Number of Events Above metric is symbolized as NAXXmetric (NA = number of events above, XX = dB level, metric = Lmax or SEL). For example, the Lmax and SEL Number of Events Above metrics are symbolized as NA75Lmax and NA75SEL, respectively, with 75 dB as the example dB level. In this EA, an Lmax threshold is selected to analyze speech interference and an SEL threshold is selected for analysis of sleep disturbance.

3.9.3 Noise Effects

An extensive amount of research has been conducted regarding noise effects including annoyance, speech interference, sleep disturbance, noise-induced hearing impairment, non-auditory health effects, performance effects, noise effects on children, effects on domestic animals and wildlife, property values, structures, terrain, and archaeological sites. These effects are summarized below.

3.9.3.1 Annoyance

As previously noted, the primary effect of aircraft noise on exposed communities is long-term annoyance, defined by USEPA as any negative subjective reaction on the part of an individual or group. The scientific community has adopted the use of long-term annoyance as a primary indicator of community response and there is a consistent relationship between DNL and the level of community annoyance (Federal Interagency Committee on Noise, 1992).

3.9.3.2 Potential Hearing Loss

People living in high noise environments for an extended period of time (40 years) can be at risk for hearing loss called Noise Induced Permanent Threshold Shift (NIPTS). The NIPTS defines a permanent change in hearing level, or threshold, caused by exposure to noise (United States Environmental Protection Agency, 1982). According to USEPA (1974), changes in hearing level of less than 5 dB are generally not considered noticeable. There is no known evidence that an NIPTS of less than 5 dB is perceptible or has any practical significance for the individual affected. Furthermore, the variability in audiometric testing is generally assumed to be plus or minus 5 dB. The preponderance of available information on hearing loss risk is from the workplace with continuous exposure throughout the day for many years.

Based on a report by Ludlow and Sixsmith (1999), there were no major differences in audiometric test results between military personnel, who as children, had lived in or near installations where fast jet operations were based, and a similar group who had no such exposure as children. Hence, for the purposes of this EA, the limited data are considered applicable to the general population, including children, and are used to provide a conservative estimate of the risk of potential hearing loss.

DoD policy directive requires that hearing loss risk be estimated for the at-risk population, defined as the population exposed to DNL greater than or equal to 80 dB (Department of Defense, 2009). To assess the potential for NIPTS, the Navy generally uses the 80 dB DNL noise contour as a threshold to identify the exposed population who may be at the most risk of possible hearing loss from aircraft noise (USEPA, 1982; DoD Noise Working Group, 2009). However, it should be recognized that characterizing noise exposure in terms of DNL overestimates hearing loss risk but suffices when nighttime operations are 5 percent or less than the total operations. When nighttime operations are greater than 5 percent, Leq(24) is recommended for calculating potential hearing loss since hearing loss is a physical phenomenon due to the sound level and independent of annoyance. This EA calculates potential hearing loss using Leq(24) to get the accuracy necessary for the larger amount of nighttime and evening operations.

3.9.3.3 Speech Interference

Speech interference associated with aircraft noise is a primary cause of annoyance for communities. Speech interference can cause disruption of routine activities, such as enjoyment of radio or television programs, telephone use, or family conversation, giving rise to frustration or irritation. In extreme cases, speech interference may cause fatigue and vocal strain to individuals who try to communicate over the noise. In this EA, speech interference is measured by the number of daily indoor events (from 7 a.m. to 10 p.m.) that exceed 50 dB Lmax at selected locations. This metric also accounts for noise level reduction provided by buildings with windows open or closed.

3.9.3.4 Classroom Criteria and Noise Effects on Children

Research suggests that environments with sustained high background noise can have variable effects, including effects on learning and cognitive abilities and various noise-related physiological changes. Research on the impacts of aircraft noise, and noise in general, on the cognitive abilities of school-aged children has received more attention in recent years. Several studies suggest that aircraft noise can affect the academic performance of school children. Physiological effects in children exposed to aircraft noise and the potential for health effects have been the focus of limited investigation (DoD Noise Working Group, 2009).

Analyses for school-aged children are similar to speech interference by using the indoor number of events exceeding 50 dB Lmax, but also has the added restriction of using an outdoor equivalent noise level of 60 dB Leq(9hr) (i.e., Leq over 9 hours). This represents a level that a person with normal hearing can clearly hear a speaker (teacher) speaking at a level of 50 dB indoors in a classroom setting.

3.9.3.5 Sleep Disturbance

The disturbance of sleep is a major concern for communities exposed to nighttime aircraft noise. In this EA, sleep disturbance uses the SEL noise metric and calculates the probability of awakening from single aircraft overflights. These are based upon the particular type of aircraft, flight profile, power setting, speed, and altitude relative to the receptor. The results are then presented as a percent probability of people awakening (United States Environmental Protection Agency, 1974).

3.9.3.6 Workplace Noise

In 1972, the National Institute for Occupational Safety and Health (NIOSH) published a criteria document with a recommended exposure limit of 85 dBA as an 8-hour time-weighted average. This exposure limit was reevaluated in 1998 when NIOSH made recommendations that went beyond conserving hearing by focusing on the prevention of occupational hearing loss. Following the reevaluation using a new risk assessment technique, NIOSH published another criteria document in 1998, which reaffirmed the 85 dB recommended exposure limit (National Institute for Occupational Health and Safety, 1998).

3.9.4 Non-auditory Health Effects

Studies have been conducted to examine the non-auditory health effects of aircraft noise exposure, focusing primarily on stress response, blood pressure, birth weight, mortality rates, and cardiovascular health. Exposure to noise levels higher than those normally produced by aircraft in the community can elevate blood pressure and also stress hormone levels. However, the response to such loud noise is typically short in duration: after the noise goes away, the physiological effects reverse and levels return to normal. In the case of repeated exposure to aircraft noise, the connection is not as clear. The results of most cited studies are inconclusive, and it cannot be conclusively stated that a causal link exists between aircraft noise exposure and the various type of non-auditory health effects that were studied (DoD Noise Working Group, 2009).

3.9.4.1 Noise Effects on Children

A review of the scientific literature indicated that there has not been a tremendous amount of research in the area of aircraft noise effects on children. The research reviewed does suggest that environments with sustained high background noise can have variable effects, including effects on learning and cognitive abilities and various noise-related physiological changes. Research on the impacts of aircraft

noise, and noise in general, on the cognitive abilities of school-aged children has received more attention in recent years. Several studies suggest that aircraft noise can affect the academic performance of schoolchildren. Physiological effects in children exposed to aircraft noise and the potential for health effects have been the focus of limited investigation (DoD Noise Working Group, 2009).

3.9.4.2 Noise Effects on the Elderly

Based upon a study by the Harvard School of Public Health, older people exposed to aircraft noise, especially at higher levels, may experience an increased risk of hospitalization for cardiovascular disease (BMJ, 2013). This study concluded a statistically significant association between exposure to aircraft noise and risk of hospitalization for cardiovascular diseases among older people living near airports.

3.9.5 Regulatory Setting

Under the Noise Control Act of 1972, the Occupational Safety and Health Administration established workplace standards for noise. The minimum requirement states that constant noise exposure must not exceed 90 A-weighted decibels (dBA) over an 8-hour period. The highest allowable sound level to which workers can be constantly exposed is 115 dBA and exposure to this level must not exceed 15 minutes within an 8-hour period. The standards limit instantaneous exposure, such as impact noise, to 140 dBA. If noise levels exceed these standards, employers are required to provide hearing protection equipment that will reduce sound levels to acceptable limits.

The joint instruction, Chief of Naval Operations Instruction (OPNAVINST) 11010.36C and Marine Corps Order 11010.16, *Air Installations Compatible Use Zones (AICUZ) Program,* provides guidance administering the AICUZ program which recommends land uses that are compatible with aircraft noise levels. OPNAVINST 3550.1A and Marine Corps Order 3550.11 provide guidance for a similar program, RAICUZ. This program includes range safety and noise analyses, and provides land use recommendations which will be compatible with Range Compatibility Zones and noise levels associated with military range operations. Per OPNAVINST 11010.36C, NOISEMAP is to be used for developing noise contours and is the best noise modeling science available today for fixed-wing aircraft until the new Advanced Acoustic Model is approved for use.

3.9.6 Affected Environment

Many components may generate noise and warrant analysis as contributors to the total noise impact. The federal government supports conditions free from noise that threaten human health and welfare and the environment. Response to noise varies, depending on the type and characteristics of the noise, distance between the noise source and whoever hears it (the receptor), receptor sensitivity, and time of day. A noise sensitive receptor is defined as a land use where people involved in indoor or outdoor activities may be subject to stress or considerable interference from noise. Such locations or facilities often include residential dwellings, hospitals, nursing homes, educational facilities, and libraries. Sensitive receptors may also include noise-sensitive cultural practices, some domestic animals, or certain wildlife species. The nearest sensitive receptors to the project site are the NGIS and family housing units in JBPHH Makalapa Compound, which are located approximately 265 feet north and 780 feet west of the center of the project site, respectively. Off-base noise sensitive receptors include private residences along Salt Lake Boulevard near its intersection with Luapele, Makalapa Elementary School, Radford High School (on Salt Lake Boulevard), and Navy Hale Keiki School (on Bougainville Drive). The closest of these offsite noise sensitive receptors is Makalapa Elementary School, which is 1,400 feet

from the center of the project site. Potentially noise-sensitive wildlife species are discussed in Section 3.7.2.2.

3.9.6.1 Aircraft Noise

Daniel K. Inouye International Airport (HNL), operated by HDOT-A, is located approximately two miles south of the project area. It is comprised of about 2,500 acres and has 4 active runways. JBPHH and HNL share runways and taxiways. The project area is not within an area exposed to sound levels of 65 DNL or greater from HNL (HDOT-A, 2004 in Parsons and Environet, Inc., 2013).

3.9.6.2 Installation Noise Environment

Ambient noise levels at JBPHH Makalapa Compound and offsite sewer improvement areas are generally low and consistent with administrative office, housing, and recreational uses. The predominant noise sources for the Makalapa Compound are vehicle traffic on H-1 Freeway and Kamehameha Highway, which primarily affect the eastern and western perimeters of JBPHH Makalapa Compound, respectively. Nimitz Highway and Kamehameha Highway are the primary noise sources at the offsite sewer improvement areas. Off-site noise sources include aircraft associated with Daniel K. Inouye International Airport. The crater's topography generally shields the project site from industrial waterfront noises (e.g., construction or maintenance equipment, machinery, generators, and operations) from Pearl Harbor Main Base. Noise levels associated with these activities are normally minor, sporadic, and of short-duration.

3.9.7 Environmental Consequences

Analysis of potential noise impacts includes estimating likely noise levels from the Proposed Action and determining potential effects to sensitive receptor sites.

3.9.7.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to baseline noise levels. Therefore, no impacts to the noise environment would occur with the No Action Alternative.

3.9.7.2 JIOC Facility-North Alternative (Preferred Alternative) Potential Impacts

The study area for noise for the Preferred Alternative includes noise sensitive areas within JBPHH Makalapa Compound (e.g., family housing and NGIS) and in the adjacent civilian community (i.e., private residences along Salt Lake Boulevard near its intersection with Luapele Drive [i.e., on Luaole Street), Makalapa Elementary School, Radford High School, and Navy Hale Keiki School). (See Figure 2-1 for locations of noise sensitive receptors.) Noise sensitive uses (family housing, Hickam Elementary School, and Pearl Harbor Kai Elementary School) are located adjacent to the proposed offsite sewer line along the South Avenue and Center Drive ROWs.

During project construction, there would be short-term, temporary noise impacts to noise sensitive receptors. Construction of the Preferred Alternative would generate noise associated with the use of ground clearing and site preparation equipment, and construction vehicles, equipment, and tools. Due to the site's soil characteristics and presence of past construction debris fill, a deep foundation system would be required to support the new facilities, which could consist of driven piles, drilled shafts, or cast piles. Specific construction methodology would be determined by the construction contractor, but it is

likely that noise generated by impact pile driving (if employed) would be the dominant source during the construction period.

A planning level assessment of construction noise was conducted for the Preferred Alternative to provide an order-of-magnitude estimate of potential impacts on noise sensitive receptors within JBPHH Makalapa Compound and in the surrounding civilian community. The dominant noise sources during construction in this area would be from pile driving associated with installing pile supports for the new facility. The pile driving activity may occur over a period of several weeks to a few months within the footprint of the new JIOC building and adjacent central plant, warehouse, and food court. The construction work is anticipated to be conducted Monday through Friday during normal daytime working hours.

Typical noise emission levels of impact pile drivers are reported in Federal Highways Administration construction noise level guidance at 101 dBA at a reference distance of 50 feet (15.2 m) (U.S. DOT, 2006; Table 12-1). For each doubling of distance from the source, there is a 6 dB decrease in sound level. A calculation of the reduction in atmospheric sound level from reference distance to the nearest noise sensitive receptors indicated that noise from the pile driving would be attenuated to about 87 dB at the NGIS building nearest to the proposed JIOC building footprint (see Appendix E for noise calculations). Although construction activities would occur during daytime hours, as shown in Figure 3-22, this noise level is generally perceived as “very loud.” Typical sound level reductions of buildings are estimated at 24 dB in warm climates with closed windows (USEPA, 1978). Using the USEPA typical sound level reductions of buildings (i.e., 24 dB), the pile driving noise levels would be reduced to about 63 dB within the nearest NGIS building, which could be perceived as “moderate” (see Figure 3-22 A-Weighted Sound Levels from Typical Sources).

At the nearest family housing units on Makalapa Drive, impact pile driving sound levels could be in the range of 77 dB during the construction period. Applying the typical sound level reductions of 24 dB, sound levels from the pile driving would be reduced to about 53 dB within the family housing units, which could be perceived as “quiet,” similar to sound levels in a busy office.

At the closest offsite sensitive noise receptor (i.e., Makalapa Elementary School classroom), impact pile driving sound levels could be in the range of 72 dB during the construction period. Applying the typical sound level reductions of 24 dB, sound levels from the pile driving would be reduced to about 48 dB within the classroom, which could be perceived similarly to sound levels in typical suburban area background noise, i.e., “quiet.” Other offsite sensitive noise receptors (e.g., Radford High School, Navy Hale Keiki School, private residences on Luapele Drive and Salt Lake Boulevard) are farther from the project area and would be exposed to lower construction period noise.

Family housing areas, Hickam Elementary School, and Pearl Harbor Kai Elementary School would be exposed to temporary construction period noise along South Avenue and Center Drive from the offsite sewer improvements. Construction activities would involve excavation of trenches, and installation of new sewer lines in the roadways. These activities would proceed along the relief sewer line routes, therefore reducing the noise exposure for any one location as the noise source moves along the construction route.

Noise control measures such as temporary noise barriers and avoidance of nighttime operations would be considered and implemented—as appropriate—to minimize adverse impacts at the noise sensitive receptors.

During the operational period, new onsite sources of noise associated with the Preferred Alternative include mechanical systems for interior air cooling and handling along with periodic testing of emergency generators. The equipment would be located in the central plant building, which would provide sound attenuation to minimize effects on surrounding uses. The emergency generator mechanical support would include a discharge silencer/muffler to further reduce noise impacts.

Offsite, because the Preferred Alternative would shift vehicle transportation routes from Borchers Gate (via Kamehameha Highway) to Luapele Gate (via Salt Lake Boulevard), there would be a corresponding shift in noise impacts associated with roadway traffic. A HUD DNL assessment tool was used to estimate planning level rough order of magnitude impacts of the project on offsite noise sensitive areas (www.hudexchange.info/environmental-review/dnl-calculator/) (see Appendix E). Due to its proximity to the project area, Salt Lake Boulevard, and H-1 Freeway, the residential community on Luaole Street (located between Salt Lake Boulevard and H-1 Freeway near the Salt Lake Boulevard-Luapele Drive intersection) was used as the noise sensitive receiver site in the calculation. According to the DNL calculation tool results, the area is currently exposed to high levels of atmospheric noise from H-1 Freeway and Salt Lake Boulevard, likely above 75 dB DNL. (Note: The calculation tool does not account for existing sound attenuating features or conditions, such as curvature of Luaole Street, which eliminates line-of-sight/sound exposure to H-1 Freeway for some homes, and the large lot coverage of the homes, which shields residences on the opposite side of the street from noise from Salt Lake Boulevard or H-1 Freeway.) All the homes along the east side of Luaole Street have concrete masonry unit walls (approximately eight feet high) along their Salt Lake Boulevard frontage that provide noise attenuation for these properties; however, many of these homes have second stories that do not benefit from this noise attenuation.

For the purposes of evaluating funding assistance from federal agencies (i.e., HUD), an interior noise level of 45 dB or lower is considered acceptable. Using the USEPA typical sound level reductions of buildings in warm climates with closed windows (i.e., 24 dB), interiors of the homes on Luaole Street may not currently meet HUD interior noise goals. With the project's associated traffic route changes (i.e., most JIOC-related vehicles entering and exiting through Luapele Gate), noise levels in this residential area are estimated to rise by less than 0.05 dB DNL above the without-project scenario. This is unlikely to be perceptible to residents given the high existing background noise levels (see Table 3-15 for perceived loudness of changes to A-weighted decibels). Additionally, most of the increased JIOC-associated traffic volumes would occur during the morning and evening peak commuting hours when most residents may not be at home.

During the operational period, there would be no noise impacts from the offsite sewer improvements because the new infrastructure would operate below grade.

The Preferred Alternative would have minor beneficial noise impacts to residences along Kamehameha Highway north of Borchers Gate with the reduction of traffic volumes resulting from most JIOC-related vehicle traffic using Luapele Gate via Salt Lake Boulevard.

Therefore, implementation of the Preferred Alternative would not result in significant impacts to the noise environment.

3.9.7.3 JIOC Facility-South Alternative Potential Impacts

The study area for this alternative is the same as the Preferred Alternative.

Construction period impacts for this alternative would be similar to the Preferred Alternative, but with differences in the pile driving impact noise exposure to onsite and offsite noise sensitive areas. In this alternative, the nearest noise sensitive receivers would be DoD family housing units along Makalapa Drive and NGIS facilities, approximately 380 feet west and 950 feet north of the project area, respectively. Offsite, the nearest noise sensitive receptor is Navy Hale Keiki School, approximately 1,300 feet to the southeast. Table 3-16 summarizes the differences in the estimated construction period impact noise levels from the Preferred Alternative and JIOC Facility-South Alternative.

Table 3-16 Comparison of Construction Period Pile Driving Noise Impacts

Receptor	*Preferred Alt. (dB)*	*JIOC South (dB)*	*Difference (dB)*	*Notes*
NGIS *attenuated (-24 dB)*	86.5 *62.5*	75.4 *51.4*	-11.1 *-11.1*	
Makalapa Family Housing *attenuated (-24 dB)*	77.1 *53.1*	83.4 *59.4*	6.2 *6.2*	
Elementary School *attenuated (-24 dB)*	72.1 *48.1*	72.7 *48.7*	0.6 *0.6*	Makalapa Elem. for Preferred Alternative Navy Hale Keiki School for JIOC South Alternative

At the nearest family housing units on Makalapa Drive, impact pile driving sound levels could be in the range of 83 dB during the construction period. Applying the typical sound level reductions of 24 dB, sound levels from the pile driving would be reduced to about 59 dB within the family housing units—about 6 dB higher than the Preferred Alternative. This would still be perceived as “quiet, ” similar to sound levels in a busy office.

At NGIS, impact pile driving sound levels could be in the 75 dB range, attenuated to about 51 dB when typical sound level reductions of 24 dB are applied. This is about 11 dB lower than the Preferred Alternative, due to its location further south of NGIS.

At the closest offsite sensitive noise receptor (i.e., Navy Hale Keiki School classroom), impact pile driving sound levels could be in the range of 73 dB during the construction period. Applying the typical sound level reductions of 24 dB, sound levels from the pile driving would be reduced to about 49 dB within the classroom, which could be perceived similarly to sound levels in typical suburban area background noise, i.e., “quiet.” This is about 1 dB more than the Preferred Alternative’s pile driving noise impacts on Makalapa Elementary School (likely imperceptible). Other offsite sensitive noise receptors (e.g., Radford High School, Makalapa Elementary School, private residences on Luapele Drive and Salt Lake Boulevard) are farther from the JIOC Facility-South Alternative project area and would be exposed to lower construction period noise.

This alternative would have the same less than significant construction period noise impacts from the offsite sewer improvements as in the Preferred Alternative.

Noise control measures such as temporary noise barriers and avoidance of nighttime operations would be considered and implemented—as appropriate—to minimize adverse impacts at the noise sensitive receptors.

During the operational period, the JIOC Facility-South Alternative would have the same impacts to on- and offsite noise sensitive receptors as the Preferred Alternative, including from the offsite sewer improvements . This is because it would have the same operational noise sources (e.g., mechanical equipment, emergency generators) and same effects on nearby transportation facilities as the Preferred

Alternative. This alternative would also have minor beneficial noise impacts on Kamehameha Highway near Borchers Gate because of the redistribution of JIOC-related traffic from Kamehameha Highway to Salt Lake Boulevard.

Therefore, implementation of this action alternative would not result in significant impacts to the noise environment.

3.10 Infrastructure

This section discusses infrastructure such as utilities (including drinking water production, storage, and distribution; wastewater collection treatment and disposal; stormwater management, solid waste management, energy production, transmission, and distribution; and communications), and facilities (including airfields, buildings, ranges, training and testing areas, wharves, piers, housing, etc.) Transportation systems and traffic are addressed separately in Section 3.1.

3.10.1 Regulatory Setting

Chief of Naval Operation Instruction 4100.5E outlines the Secretary of the Navy's vision for shore energy management. The focus of this instruction is establishing the energy goals and implementing strategy to achieve energy efficiency.

Antiterrorism Force Protection Standards have been adopted by the DoD through Instruction number 2000.16 of October 2006. (Note: Current applicable reference is UFC 4-010-01, Change 1 August 19, 2020.) The standards require all DoD Components to adopt and adhere to common criteria and minimum construction standards to mitigate antiterrorism vulnerabilities and terrorist threats.

3.10.2 Affected Environment

The following discussions provide a description of the existing conditions for each of the categories under infrastructure at JBPHH Makalapa Compound.

3.10.2.1 Utilities

This section describes the utility systems that may be impacted by the Proposed Action.

Potable Water

One hundred percent of the potable water demand for the Navy's facilities within JBPHH comes from the Navy's Waiawa Pumping Station, which averages 10 to 17 million gallons per day throughout the year. Makalapa Compound is served by existing DON potable water distribution lines, although they do not currently extend into the project area.

Wastewater

The existing JBPHH wastewater collection system has limited capacity in areas downstream of the project area (i.e., between the proposed JIOC facility and the existing JBPHH Fort Kamehameha Waste Water Treatment Plant). The proposed on- and offsite sewer improvements included in the Preferred Alternative would provide the necessary wastewater transmission capacity needed for the proposed new JIOC facility at Makalapa Compound.

Stormwater

Although the developed areas within JBPHH Makalapa Compound are served by a network of inlets and piping that collects stormwater runoff and conveys it offsite, there is no existing storm drainage infrastructure that serves the project area.

Solid Waste Management

Currently, no municipal solid waste is generated at the project area, which is undeveloped, heavily vegetated, and set off from the public use areas of JBPHH Makalapa Compound by security fencing. Non-hazardous solid waste generated at JBPHH Makalapa Compound is managed through a combination of diversion (i.e., recycling, reuse, composting), incineration at the municipal waste-to-energy H-POWER plant for conversion into electrical power, or disposal at the municipal Waimanalo Gulch Landfill (Element Environmental, LLC, 2014). Construction and demolition waste generated at JBPHH Makalapa Compound is disposed of at a permitted private construction and demolition landfill in West Oahu. As described in Section 3.7.3.2, to prevent the spread of the invasive Coconut Rhinoceros Beetle (*Oryctes rhinoceros*), disposal of green waste at JBPHH must follow the *JBPHH Green Waste Policy* (JBPHH, 2018). All green waste is delivered to a designated green waste collection point on JBPHH.

The DoD has identified solid waste management goals for waste diversion and JBPHH's Integrated Solid Waste Management Plan (ISWMP) includes recommendations to increase its municipal solid waste diversion rates toward DoD goals (Element Environmental, LLC, 2014). According to the ISWMP, JBPHH achieved solid waste diversion rates ranging from 22.5 percent in 2010 to 14.8 percent in FY 2012. In order to meet waste diversion and recycling goals major recommendations of the ISWMP include: designating a solid waste program manager; making recycling program mandatory for major facilities; co-composting food waste with green waste and biosolids; and better education of employees, residents, and contractors.

Energy

Electrical power is provided to JBPHH Makalapa Compound by HECO via 46-kV circuits on Kamehameha Highway and Salt Lake Boulevard. The developed areas of JBPHH Makalapa Compound are served by existing overhead and underground electrical transmission lines. The two electrical feeders that serve JBPHH Makalapa Compound do not have sufficient capacity to support the proposed JIOC facility.

Communications

Telecommunications cables (copper and fiber optic) are available at JBPHH Makalapa Compound. Cable television service at JBPHH Makalapa Compound is provided by Spectrum. The majority of the existing underground infrastructure is shared between power and communications lines.

3.10.2.2 Facilities

There are several general types of facilities at JBPHH Makalapa Compound: administration, operational, housing, and recreational. The project area is located in an open space area. The nearest existing facility is the Navy Gateways Inns and Suites complex immediately to the north, which provides short-term lodging for eligible guests traveling on government business or for leisure. Administration and operational facilities are located north of the project area and recreational and housing facilities to its west and south.

3.10.3 Environmental Consequences

This section analyzes the magnitude of anticipated increases or decreases in public works infrastructure demands considering historic levels, existing management practices, and storage capacity, and evaluates potential impacts to public works infrastructure associated with implementation of the alternatives. Impacts are evaluated by whether they would result in the use of a substantial proportion of the remaining system capacity, reach or exceed the current capacity of the system, or require development of facilities and sources beyond those existing or currently planned.

3.10.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to the existing infrastructure of JBPHH Makalapa Compound. Therefore, no impacts to transportation, utilities, or facilities would occur with the No Action Alternative.

3.10.3.2 JIOC Facility-North Alternative (Preferred Alternative) Potential Impacts

The study area for infrastructure for the Preferred Alternative is the area within JBPHH Makalapa Compound affected by the new facility footprint or its supporting infrastructure.

Utilities

Construction Period Impacts

During the construction period, the Preferred Alternative is not likely to impact existing utilities service at JBPHH Makalapa Compound. Construction of the required utility system improvements within Makalapa Crater or the offsite sewer improvement areas would require little to no temporary disruption to existing service. Connections would be made to existing systems as the improvements are completed. The connections to existing systems would be planned to avoid or minimize interruption to utility service.

Construction and demolition waste would be generated under the Preferred Alternative, and be managed by the construction contractor. Demolition waste would be limited to ground clearing, grubbing, and removal of any buried construction that may be encountered during site preparation. Because Makalapa Crater was used in the past as a dump site for construction and demolition waste, soils at the project site are anticipated to include surface fills mixed with earlier construction and demolition debris. Past construction and demolition waste would be characterized according to HDOH standards prior to transfer and disposal offsite.

Vegetation removal at the project site would result in green waste, although trees along the perimeter of the development area would be retained as visual screening. Disposal of green waste generated due to site preparation would follow guidelines in *JBPHH Green Waste Policy* (JBPHH, 2018) to prevent the spread of the highly invasive Coconut Rhinoceros Beetle (see discussion in Section 3.7.3.2).

Operational Period Impacts

Potable Water. Proposed improvements to the water distribution system at JBPHH Makalapa Compound would provide adequate flow and pressure to the new JIOC facility, including for fire flow. Incorporation of high efficiency plumbing fixtures would minimize potable water demand during the operational period, and water usage would be subject to smart metering. The Preferred Alternative would not use a substantial proportion of the remaining potable water system capacity, reach or exceed the current

capacity of the system, or require development of facilities and sources beyond those existing or currently planned.

Wastewater. There are no sewer utilities at the project area, although wastewater infrastructure serves the developed areas of JBPHH Makalapa Compound. The new sanitary sewer lift station and force main proposed for construction southwest of the new JIOC building would discharge into the existing collection system on Makalapa Drive. With the implementation of planned sewer improvements associated with the Proposed Action, the Navy's wastewater system would have adequate capacity to accommodate the Preferred Alternative. The Preferred Alternative would not use a substantial proportion of the remaining overall wastewater system capacity or require development of facilities and sources beyond those currently planned.

Stormwater. A substantial increase in site stormwater is anticipated due to an increase in impervious surface areas associated with the Preferred Alternative. Due to the lack of base storm drain systems in the project area, a new onsite system would be installed to collect runoff from the site. The system would consist of a network of inlets and piping, which would convey runoff around the newly developed area to a surface detention system (i.e., detention facility). The surface detention system would provide the required stormwater storage to limit discharge from the site to pre-development levels. Low impact development strategies (e.g., vegetated swales and water quality units) would reduce the quantity and improve the quality of stormwater flows that eventually reach receiving waters. The Preferred Alternative would not use a substantial proportion of the remaining stormwater system capacity, reach or exceed the current capacity of the overall system, or require development of facilities and sources beyond those currently planned.

Solid Waste Management. Operation of the new JIOC facility would generate domestic solid waste typical of administrative or office-type facilities. No industrial-level solid waste generation would occur with the Preferred Alternative. Recycling receptacles would be provided at the new facility to reduce solid waste generation. Green waste would be generated at the project area during the operational period; disposal would comply with *JBPHH Green Waste Policy* (JBPHH, 2018) guidelines. The Preferred Alternative would not use a substantial proportion of the remaining solid waste system capacity, reach or exceed the current capacity of the system, or require development of facilities and sources beyond those existing or currently planned.

Energy. Electrical power for the Preferred Alternative is proposed to be connected to a new HECO substation/Navy switching station (see Figure 2-1 for proposed location). Two 46 kV HECO circuits from Kamehameha Highway, Salt Lake Boulevard, or both would supply the new substation/switching station. Two 11.5 kV circuits from the new substation/switching station would serve the new JIOC building for redundancy. The proposed electrical improvements (i.e., electrical substation/switching station, distribution system, back-up generator) would provide adequate service for the new facility during the operational period. The building's energy management system, smart metering of all utilities (including electricity and gas), and energy saving features would reduce the overall energy demand during the operational period. The Preferred Alternative would not use a substantial proportion of the remaining energy system capacity, reach or exceed the current capacity of the system, or require development of facilities and sources beyond those existing or currently planned.

Communications. The proposed fiber optic, telephone, and CATV systems would provide adequate service to the new facility and would not impact existing service to other users, use a substantial

proportion of the remaining system capacity, reach or exceed the current capacity of the system, or require development of facilities and sources beyond those existing or currently planned.

Facilities

Construction Period Impacts

During project construction, no existing facilities would be altered or demolished. Access to surrounding operational, administration, housing and recreational facilities would be maintained, unless temporary, short-term detours or closures of recreational areas are required to protect public safety.

Operational Period Impacts

During the operational period, the planned onsite and offsite infrastructure improvements would meet anticipated demands of the new JIOC facility, which considered occasional testing and maintenance of the various systems. Construction of the Preferred Alternative would support the Navy's mission and achieve efficiency through the collocation of currently dispersed JIOC personnel in functionally designed facilities, which is considered a positive impact on Navy facilities.

Therefore, implementation of the Preferred Alternative would not result in significant impacts to infrastructure.

3.10.3.3 JIOC Facility-South Alternative Potential Impacts

The study area for infrastructure for the South Alternative is the area within JBPHH Makalapa Compound affected by the new facility footprint and its on- and offsite supporting infrastructure.

Construction Period Impacts

Due to their common project scope, corresponding infrastructure requirements and improvements, and location within Makalapa Crater, the South Alternative would have the same insignificant impacts on utilities and facilities as the Preferred Alternative during the construction period.

Operational Period Impacts

During the operational period, the planned onsite and offsite infrastructure improvements for the South Alternative would meet anticipated demands of the new JIOC facility, which considered occasional testing and maintenance of the various systems. Construction of the South Alternative would also support the Navy's mission and achieves efficiency through the collocation of currently dispersed JIOC personnel in functionally designed facilities, which is considered a positive impact on Navy facilities.

As with the Preferred Alternative, the South Alternative would not result in the use of a substantial proportion of the remaining capacities of the various infrastructure systems or require development of facilities and sources beyond those currently planned. Therefore, implementation of this action alternative would not result in significant impacts to infrastructure.

3.11 Public Health and Safety

This discussion of public health and safety includes consideration for any activities, occurrences, or operations that have the potential to affect the safety, well-being, or health of members of the public. A safe environment is one in which there is no, or optimally reduced, potential for death, serious bodily injury or illness, or property damage. The primary goal is to identify and prevent potential accidents or impacts on the general public. Public health and safety within this EA discusses information pertaining to

community emergency services, construction activities, operations, and environmental health and safety risks to children.

Community emergency services are organizations which ensure public safety and health by addressing different emergencies. The three main emergency service functions include police, fire and rescue service, and emergency medical service.

Public health and safety during construction, demolition, and renovation activities is generally associated with construction traffic, as well as the safety of personnel within or adjacent to the construction zones.

Operational safety may refer to the actual use of the facility or built-out proposed project, or training or testing activities and potential risks to inhabitants or users of adjacent or nearby land and water parcels. Safety measures are often implemented through designated safety zones, warning areas, or other types of designations.

The AICUZ Program, which is discussed in the Land Use section, delineates accident potential zones (APZs), which are areas around an airfield where an aircraft mishap is most likely to happen. APZs are not predictors of accidents nor do they reflect accident probability. The DoD defines an APZ as a planning tool for local planning agencies. The APZs follow departure, arrival, and flight pattern tracks from an airfield and are based upon historical accident data. RAICUZ, which is also discussed in the Land Use section, addresses range safety.

The US Notice to Mariners provides timely marine safety information for the correction of all US Government navigation charts and publications from a wide variety of sources, both foreign and domestic. To ensure the safety of life at sea, the information published in the Notice to Mariners is designed to provide for the correction of unclassified nautical charts, the unclassified NGA/DLIS Catalog of Hydrographic Products, United States Coast Pilots, NGA List of Lights, USCG Light Lists, and other related nautical publications produced by NGA, NOS and the USCG.

Environmental health and safety risks to children are defined as those that are attributable to products or substances a child is likely to come into contact with or ingest, such as air, food, water, soil, and products that children use or to which they are exposed.

3.11.1 Regulatory Setting

Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, requires federal agencies to “make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children and shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.”

3.11.2 Affected Environment

JBPHH Makalapa Compound, in which the project area for the proposed JIOC facility is located, is a secured DoD installation and the offsite sewer improvement areas are either in secured DoD-controlled areas or in existing easements within public roadway ROWs. The Makalapa Compound project area is currently vacant and surrounded by fencing and off-limits to the public, including children. The Federal Fire Department provides fire protection, hazardous material response, and emergency medical services to JBPHH (Makalapa Compound and offsite sewer improvement areas) and provides mutual aid to the

City and County of Honolulu. JBPHH Security Department provides security and law enforcement operations at JBPHH.

3.11.3 Environmental Consequences

The safety and environmental health analysis contained in the respective sections addresses issues related to the health and well-being of military personnel and civilians living on or in the vicinity of Makalapa Compound and offsite sewer improvement areas. Specifically, this section provides information on hazards associated with construction and operation of the proposed new JIOC facility and its associated on- and offsite infrastructure. Additionally, this section addresses the environmental health and safety risks to children.

3.11.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to public health and safety. Therefore, no impacts would occur with the No Action Alternative.

3.11.3.2 JIOC Facility-North Alternative (Preferred Alternative) Potential Impacts

The study area for the Preferred Alternative is the primary project area within JBPHH Makalapa Compound and the immediate areas of the offsite sewer improvements and two intersections on Salt Lake Boulevard.

Construction Period

During the construction of the new JIOC facility and offsite sewer improvements, additional traffic volumes leading to the project sites would pose the greatest hazard to public health and safety. Compliance with traffic control plans would minimize impacts and risks to pedestrians, bicyclists, and motorists during the construction period at the Makalapa Crater and offsite sewer improvements project areas and the Salt Lake Boulevard intersections with potential mitigation. Hazards to personnel in or adjacent to construction zones would be mitigated through the use of standard operating procedures and BMPs in accordance with applicable federal and state regulations.

Consistent with Executive Order (EO) 13045, Protection of Children from Environmental Health and Safety Risks (April 21, 1997), the Navy's policy is to identify and address any disproportionately high and adverse human or environmental effects of its actions on children. The Proposed Action would occur on JBPHH Makalapa Compound and in installation and public roadway ROWs. Construction sites that are located within the entry-controlled installation boundaries would prevent public access. Access to the offsite sewer improvement construction areas would be controlled and open trenches covered at the end of each work day. Construction Management Plans that include public safety measures would be implemented to ensure the public is not exposed to construction site hazards. Therefore, construction under the Proposed Action would not present elevated health and safety risks to children.

Operational Period

During the operational period, there would be no military training, testing or airfield activities associated the Preferred Alternative. Due to the nature of the functions located in the proposed new JIOC facility (i.e., administrative-type), no new risks to inhabitants or users of adjacent or nearby land and water parcels are expected. The new facility would also be secured from access by the general public. No training, testing, maritime, or airfield activities—or changes to operational facilities—are associated with the Preferred Alternative. The offsite sewer improvements would be located below grade and would not

result in changes in JBPHH operations or activities. Because the Preferred Alternative would not introduce new uses to JBPHH or the CCH, they would not change demand or provision of community emergency services. The recommended intersection improvements, if required, and potential hazards would be addressed through the implementation of standard operating procedures. Therefore, implementation of the Preferred Alternative would not result in significant impacts to public health and safety.

Due to the secured premises and administrative nature of the activities that would take place in the new JIOC, the Navy has determined that there are no environmental health and safety risks associated with the Proposed Action that would disproportionately affect children.

Therefore, implementation of the Preferred Alternative would not result in significant impacts to public health and safety.

3.11.3.3 JIOC Facility-South Alternative Potential Impacts

The study area for this alternative is its project area at Makalapa Crater, the offsite sewer improvement areas, and the intersections along Salt Lake Boulevard recommended for improvements.

Construction Period

Because this alternative would have largely the same construction areas, construction methodology, secured location, BMPs and standard operating procedures during the construction period, it would have similar insignificant impacts to public health and safety (including to children) as the Preferred Alternative. The difference would be in below grade stormwater detention facilities, which would require more excavation.

Operational Period

This alternative would result in the same size facility and usage and the same on- and offsite sewer improvements as the Preferred Alternative. The potential mitigation (i.e., striping and signalization changes) at two intersections on Salt Lake Boulevard would be the same as the Preferred Alternative and, therefore, result in the same insignificant impacts to public health and safety. As in the Preferred Alternative, the JIOC Facility-South Alternative would not increase the likelihood that a child would come in contact with or ingest products or substances that present environmental health and safety risks to children in the operational period.

Therefore, implementation of this action alternative would not result in significant impacts to public health and safety or have environmental health and safety risks that would disproportionately affect children.

3.12 Hazardous Materials and Wastes

This section discusses hazardous materials, hazardous waste, toxic substances, and contaminated sites.

3.12.1 Regulatory Setting

Hazardous materials are defined by 49 CFR section 171.8 as “hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, materials designated as hazardous in the Hazardous Materials Table, and materials that meet the defining criteria for hazard classes and divisions in 49 CFR part 173.” Transportation of hazardous materials is regulated by the U.S. Department of Transportation regulations.

Hazardous wastes are defined by the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments, as: "a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (A) cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed." Certain types of hazardous wastes are subject to special management provisions intended to ease the management burden and facilitate the recycling of such materials. These are called universal wastes and their associated regulatory requirements are specified in 40 CFR part 273. Four types of waste are currently covered under the universal wastes regulations: hazardous waste batteries, hazardous waste pesticides that are either recalled or collected in waste pesticide collection programs, hazardous waste thermostats, and hazardous waste lamps, such as fluorescent light bulbs.

Special hazards are those substances that might pose a risk to human health and are addressed separately from other hazardous substances. Special hazards include asbestos-containing material (ACM), polychlorinated biphenyls (PCBs), and lead-based paint (LBP). USEPA is given authority to regulate special hazard substances by the Toxic Substances Control Act (TSCA). Asbestos is also regulated by USEPA under the Clean Air Act, and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

The DoD established the Defense Environmental Restoration Program (DERP) to facilitate thorough investigation and cleanup of contaminated sites on military installations (active installations, installations subject to Base Realignment and Closure, and formerly used defense sites). The Installation Restoration Program and the Military Munitions Response Program are components of the DERP. The Installation Restoration Program requires each DoD installation to identify, investigate, and clean up hazardous waste disposal or release sites. The Military Munitions Response Program addresses nonoperational rangelands that are suspected or known to contain unexploded ordnance, discarded military munitions, or munitions constituent contamination. The Environmental Restoration Program is the Navy's initiative to address DERP.

3.12.2 Affected Environment

The Navy has implemented a strict Hazardous Material Control and Management Program and a Hazardous Waste Minimization Program for all activities. These programs are governed Navy-wide by applicable OPNAV instructions and at the installation by specific instructions issued by the Base Commander. The Navy continuously monitors its operations to find ways to minimize the use of hazardous materials and to reduce the generation of hazardous wastes.

3.12.2.1 Hazardous Materials, Waste, and Special Hazards

Previous studies indicated evidence of soil contamination in Makalapa Crater due to past uses of the area—e.g., disposal site for sediment dredged from Pearl Harbor (1930s and 1940s), disposal site for general Navy wastes from base dumpsters (1950s and 1960s), rinse area for containers of pesticides and herbicides (1950s to 1974), and receiver site of clean, noncombustible fill materials such as earth, rock, concrete, and asphalt (1972 to 1976) (DON, 2002 in NAVFAC Hawaii, 2016). As noted in Section 2.3.2.6, a CERCLA investigation is being conducted under the Navy's Environmental Restoration program. CERCLA COPCs include asbestos, PCBs, metals, PAHs, and dioxins/furans. All soil with COPCs above USEPA

Regional Screening Levels and HDOH Environmental Action Levels would be handled and disposed of as CERCLA waste.

Petroleum contaminated soil is present at the South Avenue relief sewer site and may be present at the Center Drive relief sewer site.

There is a low likelihood of encountering munitions and explosives of concern (MEC) or material potentially presenting an explosive hazard (MPPEH) in the project area (NAVFAC Hawaii, 2016).

3.12.3 Environmental Consequences

The hazardous materials and wastes analysis contained in the respective sections addresses issues related to the use and management of hazardous materials and wastes as well as the presence and management of specific cleanup sites at JBPHH Makalapa Compound.

3.12.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change associated with hazardous materials and wastes. Therefore, no impacts would occur under the No Action Alternative.

3.12.3.2 JIOC Facility-North Alternative (Preferred Alternative) Potential Impacts

The study area for hazardous materials, waste, and special hazards for the Preferred Alternative is the area within JBPHH Makalapa Compound affected by the new facility footprint or its supporting on- or offsite infrastructure.

Construction Period

Due to the potential presence of past construction, landfill, and dredged material debris at the Makalapa Crater project site, hazardous wastes and materials may be encountered during site preparation and project construction. The offsite sewer improvements would require excavation along South Avenue, Center Drive, and at the surge mitigation infrastructure site near Nimitz Gate. If hazardous materials or waste are encountered during the construction period, they would be handled, transported, disposed of and/or remediated in accordance with applicable federal and state regulations and procedures.

Although the likelihood of encountering MEC or MPPEH in the project area is low, precautions would be taken during project site preparation and construction in accordance with applicable DoD procedures and standards, including the submission of an Explosive Safety Submission Determination Request to Naval Ordnance Safety and Security Activity for the planned excavation/ground disturbance activities.

Operational Period

Limited quantities of hazardous materials and wastes typical of operating and maintaining an administrative-type facility would be stored, used, and or generated during the operational period (e.g., diesel fuel for the emergency generator, cleaning products). The warehouse receiving area would be provided with an eyewash/shower and dedicated hazardous waste collection system consisting of floor drains and a dedicated underground storage tank to address any biohazard threats and waste that cannot be directed to the sanitary sewer system. All hazardous materials, wastes, and special hazards would be transported, stored, handled, and disposed of in accordance with federal and state regulations. After construction, use of the project area (including the offsite sewer improvement areas)

would not include land disturbing activities that could encounter MEC or MPPEH. If ground disturbance is necessary during the operational period, applicable DoD procedures and standards would be followed.

Therefore, implementation of the Preferred Alternative would not result in significant impacts with hazardous materials and wastes.

3.12.3.3 JIOC Facility-South Alternative Potential Impacts

The study area for hazardous materials, waste, and special hazards for the JIOC Facility-South Alternative is the area within JBPHH Makalapa Compound affected by the new facility footprint or its on- or offsite supporting infrastructure.

Construction Period

Due to its location also within Makalapa Crater, same offsite sewer improvements, and its similar ground disturbance requirements, the JIOC Facility-South Alternative would have similar construction period impacts for hazardous materials, wastes, and special hazards as the Preferred Alternative (the below grade stormwater detention facility would require more excavation in the South Alternative).

Operational Period

Because the JIOC Facility-South Alternative would result in the same facility size and operating and maintenance requirements (including for the offsite sewer improvements), it would have the same operational period impacts for hazardous materials, wastes, and special hazards as the Preferred Alternative.

Therefore, implementation of this action alternative would not result in significant impacts with hazardous materials and wastes.

3.13 Environmental Justice

USEPA defines Environmental Justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA, 2014).

3.13.1 Regulatory Setting

Consistent with EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (February 11, 1994), and EO 14008, *Tackling the Climate Crisis at Home and Abroad*, the Navy's policy is to identify and address any disproportionately high and adverse human health or environmental effects of its actions on minority and low-income populations.

3.13.2 Affected Environment

The potential for impacts to minority populations and low-income populations was evaluated, informed by the Federal Interagency Working Group on Environmental Justice guidance (Federal Interagency Working Group, 2016). Steps included initial screening to determine the presence of minority populations and low-income populations and consideration of the potential of the proposed action to cause disproportionately high and adverse human health or environmental effects on any minority or low-income populations if present.

The State of Hawaii is home to a tremendously diverse population, where no single race constitutes a majority of residents. The areas adjacent to the proposed sites are generally indicative of this diverse cultural make up. Data created for the Oahu Metropolitan Planning Organization (OMPO) to assess the spatial distribution of racial minorities and people living in poverty were used to identify low-income and minority populations that may be disproportionately impacted by the Proposed Action. These data came from the 2010 U.S. Decennial Census data (for distribution of racial minorities) and the 2009-2014 American Community Survey (for distribution of people living in poverty). The assessment was based on a methodology that identified environmental justice areas based on disproportionate settlement patterns of minority and low-income people, which took into account the fact that the majority of the population in Hawaii is comprised of federally-defined minority populations. The methodology incorporates disparities in the settlement patterns of minority races (OMPO and Honolulu Department of Planning and Permitting, 2004). Initial screening showed that minority populations and low-income populations are present in the vicinity of the project area, including the offsite sewer improvement areas (Figure 3-23). As seen in Figure 3-23, minority populations are located within the project site and in the areas surrounding the project sites at Makalapa Crater and the offsite sewer improvement areas. Both minority and low-income populations are located north of the Makalapa Crater project area, in an area bounded by Kamehameha Highway, Salt Lake Boulevard, and Halawa Stream. A 260-unit federally-subsidized public housing project (Puuwai Momi) is located within this geographic area.

3.13.3 Environmental Consequences

This analysis focuses on the potential for a disproportionate and adverse exposure of specific off-base population groups to the projected adverse consequences discussed in the previous sections of this chapter.

3.13.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no effect to Environmental Justice. Therefore, no impacts would occur under the No Action Alternative.

3.13.3.2 JIOC Facility-North Alternative (Preferred Alternative) Potential Impacts

The study area for environmental justice analysis for the Preferred Alternative is defined as the project area and communities immediately surrounding Makalapa Compound and the offsite sewer improvement areas.

Consistent with Executive Order (EO) 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (February 11, 1994) the Navy's policy is to identify and address any disproportionately high and adverse human or environmental effects of its actions on minority and low-income populations. Minority are located within the project area. Construction period impacts that could affect health and safety of those minority populations (e.g., noise and air quality) would be intermittent and temporary, and would be managed through BMPs. No significant environmental impacts from the project would extend beyond the immediate project site to the surrounding minority population and low-income population areas.

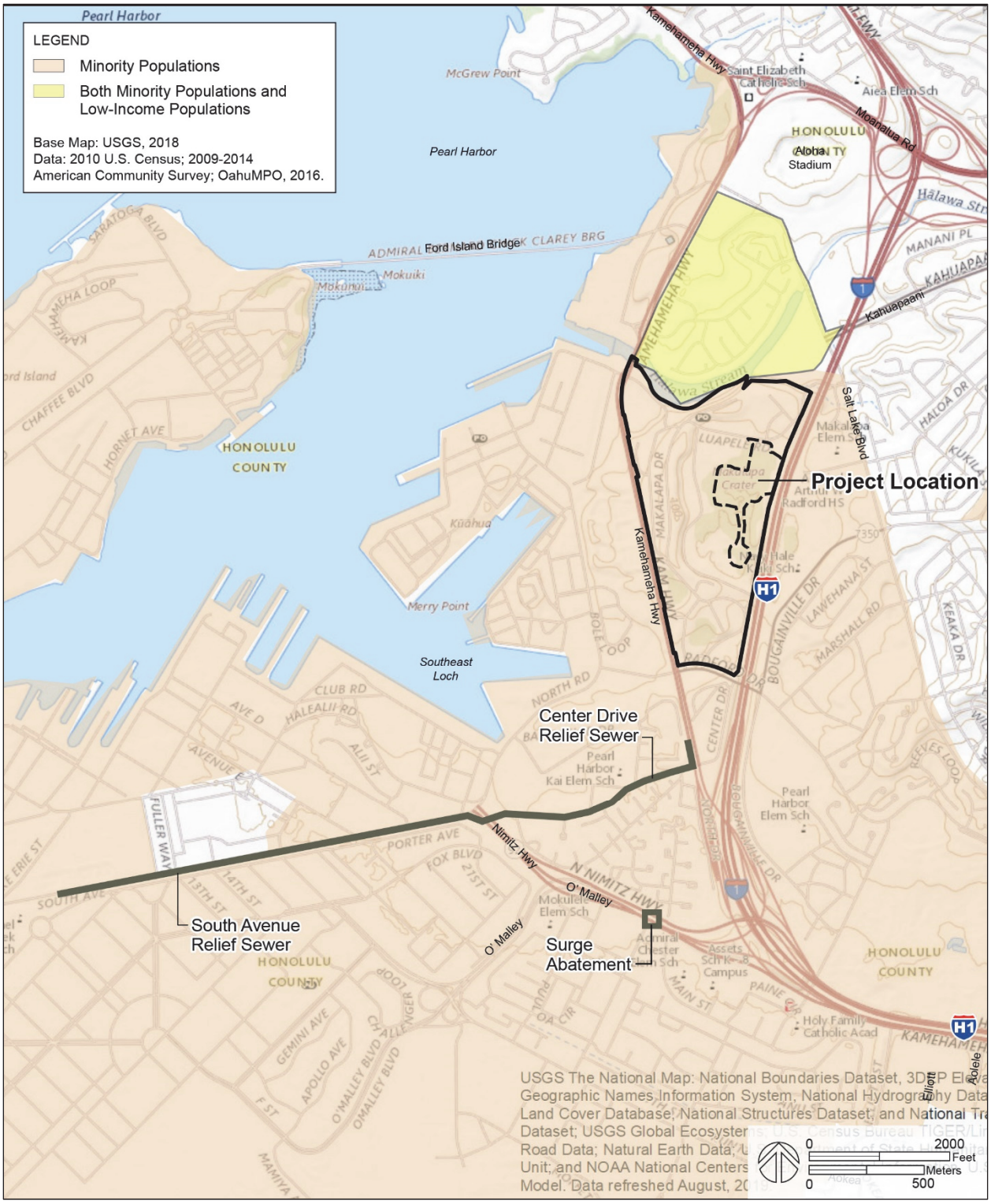


Figure 3-23 Environmental Justice Populations

Following construction, the type and nature of JBPHH Makalapa Compound operations and activities would not substantially change, as the new JIOC facility would operate essentially as an office building, with administrative-type functions taking place within the facility structures. The proposed stormwater detention facility would be surrounded by security fencing to protect children and other unauthorized individuals from accessing the detention facility. The Preferred Alternative would result in vehicle traffic associated with existing JIOC facilities at Makalapa Compound shifting from entering and exiting at Borchers Gate to Luapele Gate—i.e., away from Kamehameha Highway. Potential intersection improvements would be limited to the intersections of Salt Lake Boulevard with Kahuapaani Street and with Luapele Drive. The proposed offsite sewer improvements would be located below ground and would not be accessible or present safety risks to the public. As described earlier in this chapter, the Preferred Alternative would not result in significant impacts to air quality, water resources, noise, transportation, public health and safety, or hazardous materials and wastes. Therefore, implementation of the Preferred Alternative would not cause disproportionately high and adverse human health or environmental effects on any minority or low-income populations.

3.13.3.3 JIOC Facility-South Alternative Potential Impacts

The study area for environmental justice analysis for the JIOC Facility-South Alternative is the same as the Preferred Alternative because they are in similar locations (only 700 feet apart) and have the same general capacity, function, and construction methods, including for the offsite sewer improvements. Like the Preferred Alternative, this alternative would not substantially change the type and nature of JBPHH operations and activities at Makalapa Compound or the offsite sewer improvement areas, and the new facility would operate similarly to an administrative-type building. In this alternative, the stormwater detention facility would be located subsurface (below the parking lot) and not be accessible to unauthorized individuals.

As in the Preferred Alternative, this alternative would not result in significant impacts to air quality, water resources, noise, transportation, public health and safety, hazardous materials and wastes. Therefore, implementation of the JIOC Facility-South Alternative would not cause disproportionately high and adverse human health or environmental effects on any minority or low-income populations.

3.14 Summary of Potential Impacts to Resources and Impact Avoidance and Minimization

A summary of the potential impacts associated with each of the action alternatives and the No Action Alternative and impact avoidance and minimization measures are presented in Tables 3-17 and 3-18, respectively. Table 3-18 provides a comprehensive list of all mitigation requirements associated with the Proposed Action.

Table 3-17 Summary of Potential Impacts to Environmental Resources/Components

Resource Area	*No Action Alternative*	*JIOC Facility-North Alternative (Preferred Alternative)*	*JIOC Facility-South Alternative*
Transportation	No impact	Less than significant temporary construction period impacts on roadways leading to project area. Operational period impacts at Salt Lake Boulevard-Kahuapaani Street intersection due in part to shifting of traffic volumes from Borchers Gate to Luapele Gate. Analyses using conservative assumptions and factors that are currently in flux indicated that project-related traffic volumes could result in over capacity conditions (i.e., from LOS D to LOS F). Suggested mitigation measures (i.e., traffic signal modifications and lane striping), if needed, would result in less than significant impacts if the conservative volumes are reached (timing and ultimate need should be re-evaluated closer to project occupancy). Therefore, no mitigations are proposed for implementation at this time. Tandem manual processing of driver credentials at Luapele Gate would be considered if gate operations result in extended queues or delays in the future.	Same less than significant impacts as in the Preferred Alternative.
Air Quality	No impact	Less than significant impacts during construction due to equipment exhaust, ground disturbance and possible traffic congestion. Less than significant operational period impacts from relocated vehicle trips to JBPHH Makalapa Compound.	Similar less than significant impacts as in the Preferred Alternative (minor additional construction period emissions due to greater ground disturbance needed for below-grade stormwater detention facility).
Water Resources	No impact	Less than significant construction and operational period impacts with implementation of construction BMPs.	Same less than significant impacts as in the Preferred Alternative
Geological Resources	No impact	Less than significant temporary construction period impacts with implementation construction BMPs and soil remediation. Less than significant operational period impacts.	Similar less than significant impacts as in the Preferred Alternative (slightly greater ground disturbance due to the below-grade stormwater detention facility)

Resource Area	*No Action Alternative*	*JIOC Facility-North Alternative (Preferred Alternative)*	*JIOC Facility-South Alternative*
Visual Resources	No impact	Less than significant construction and operational period impacts as new facility would generally not be visible from offsite locations and would not impede distant views of the Koolau range and Red Hill from important view points within the crater.	Less than significant construction and operational period impacts similar to Preferred Alternative; however, more visible than Preferred Alternative from Makalapa Navy Housing Historic District.
Cultural Resources	No impact	No impacts, as Preferred Alternative results in no historic properties affected determination and would not impact traditional Hawaiian (or other ethnic group's) rights related to gathering, access, or other customary activities exercised for subsistence, cultural, and religious purposes. No historic properties would be left unoccupied.	No impacts (same as Preferred Alternative).
Biological Resources	No impact	Less than significant construction or operational period impacts as the Preferred Alternative may affect, but is not likely to adversely affect, biological resources (including listed species) with implementation of BMPs and conservation measures.	Less than significant impacts similar to Preferred Alternative; about five percent larger area of vegetation to be cleared within Makalapa Crater than in the Preferred Alternative.
Land Use	No impact	Less than significant impacts. Action is compatible with surrounding land uses and adopted DON development plans and is expected to have insignificant coastal effects. It is considered a de minimis activity under the Coastal Zone Management Act and is not subject to further review by the Hawaii Coastal Zone Management program.	Same less than significant impacts as in the Preferred Alternative.
Noise	No impact	Less than significant impacts during the construction period with implementation of BMPs. Less than significant operational period impacts.	Same less than significant impacts as in the Preferred Alternative
Infrastructure	No impact	Less than significant impacts during the construction and operational periods. The proposed on- and offsite sewer improvements	Same less than significant impacts as in the Preferred Alternative

Resource Area	*No Action Alternative*	*JIOC Facility-North Alternative (Preferred Alternative)*	*JIOC Facility-South Alternative*
		would provide adequate wastewater capacity for Proposed Action.	
Public Health and Safety	No impact	Less than significant construction and operational period impacts. No increased environmental health and safety risks that would disproportionately affect children.	Same less than significant impacts as in the Preferred Alternative
Hazardous Materials and Wastes	No impact	Less than significant construction and operational period impacts.	Same less than significant impacts as in the Preferred Alternative
Environmental Justice	No impact	Less than significant impacts during the construction and operational periods with no disproportionately high and adverse human health or environmental effects on any minority or low-income populations.	Same less than significant impacts as in the Preferred Alternative

Table 3-18 Impact Avoidance And Minimization Measures

Measure	*Anticipated Benefit / Evaluating Effectiveness*	*Implementing and Monitoring*	*Responsibility*	*Estimated Completion Date*
JIOC Facility-North Alternative				
Develop and comply with traffic control plans	Reduce construction transportation impacts	Contractor to prepare plans; Regional Officer in Charge of Construction (ROICC) to monitor	Contractor; Regional Officer In Charge of Construction will oversee Contractor activities	Traffic Control Plans: 2025 Plan implementation: 2026
Transfer construction materials and equipment during off-peak traffic hours	Reduce peak hour construction traffic impacts	Implementation would be completed as part of P-079; monitoring by ROICC	Contractor; ROICC will oversee Contractor activities	2026-2030
Salt Lake Boulevard-Luapele Drive intersection pavement striping	Formalize existing two-lane use of single, wide lane	Implementation and monitoring by Navy	Navy	TBD
Salt Lake Boulevard-Kahuapaani Street intersection traffic signal modifications (if warranted)	Improve PM Peak Hour operation of intersection to LOS D	Implementation and monitoring by HDOT	HDOT	TBD

Measure	*Anticipated Benefit / Evaluating Effectiveness*	*Implementing and Monitoring*	*Responsibility*	*Estimated Completion Date*
Implement tandem manual processing of driver credentials at Luapele Gate if gate operations result in extended queues or delays in the future.	Reduce traffic delays or extended vehicle queues entering Luapele Gate during the AM Peak Hour	JBPHH	JBPHH	TBD; post-2030
Prepare and implement a construction period dust control plan	Avoid or minimize construction period offsite fugitive particulate emissions impacts	Implementation would be completed as part of P-079; monitoring by ROICC	Contractor; ROICC will oversee Contractor activities	2026-2030
Implement construction period and stormwater quality BMPs, SWPPP, USACE, and NPDES permit conditions for site preparation and ground disturbing earthwork	Avoid or minimize construction period erosion and runoff impacts to receiving waters	[same as above]	[same as above]	[same as above]
Construct grass-lined detention facility, water quality units, and vegetated bioswales	Limit stormwater runoff to pre-development levels and improve quality of stormwater runoff that reaches receiving waters	[same as above]	[same as above]	[same as above]
Retain existing vegetation to serve as visual screening	Minimize or avoid visual and cultural impacts from offsite public vantage points and from historic housing and administrative areas within JBPHH Makalapa Compound	[same as above]	[same as above]	[same as above]
Green waste disposal to comply with JBPHH Green Waste Policy	Prevent spread of Coconut Rhinoceros Beetle	[same as above]	[same as above]	[same as above]
Inspect and clean construction equipment, vehicles, and materials sourced off-island at a designated location	Minimize potential for introduction of invasive species	[same as above]	[same as above]	[same as above]
Employ native Hawaiian plants well-adapted to the environmental conditions at Makalapa Crater for landscaping around the project area to the maximum extent possible or substitute with plants with a low risk of becoming invasive	Minimize potential for spread of invasive species	Implementation would be completed as part of P-079; monitoring by ROICC	Contractor with input by NAVFAC Pacific Natural Resources staff; ROICC will oversee Contractor activities	[same as above]

Measure	*Anticipated Benefit / Evaluating Effectiveness*	*Implementing and Monitoring*	*Responsibility*	*Estimated Completion Date*
Conduct nest surveys for protected bird species prior to construction and monitor active nests during construction.	Avoid or minimize impacts to protected bird species	Implementation would be completed as part of P-079; monitoring by qualified biologist	[same as above]	[same as above]
Shield all outdoor lights to prevent light trespass; turn off outside lights between dusk and dawn when not needed for security and safety	Avoid or minimize impacts to protected bird species	Implementation would be completed as part of P-079; monitoring by ROICC	Contractor; ROICC will oversee Contractor activities	[same as above]
Train regular on-site staff to identify Hawaiian short-eared owl. If observed, cease all activities within 100 feet of the species until the species leaves the area on its own accord. If a Hawaiian short-eared owl nest is discovered, all activities within 100 feet of the nest would cease, and the Hawaii DLNR would be contacted. Work would not resume until directed by the DLNR.	Avoid or minimize impacts to Hawaiian short-eared owl	Implementation would be completed as part of P-079; monitoring by ROICC	Contractor and/or NAVFAC Pacific Natural Resources staff; ROICC would oversee Contractor activities	[same as above]
Any fences erected as part of the project would have barbless top-strand wire to prevent entanglement of owls or bats, unless barbed wire is mandated by safety and security regulations	Avoid or minimize impacts to protected avian species and Hawaiian hoary bat	Implementation would be completed as part of P-079; monitoring by ROICC	Contractor; ROICC would oversee Contractor activities	[same as above]
Clearing of vegetation at the site to avoid June 1 through September 15	Avoid impacts to juvenile bats (that are not able to fly) that may be present in trees	Implementation would be completed as part of P-079; monitoring by ROICC	Contractor; ROICC would oversee Contractor activities	[same as above]
If Hawaiian hoary bat pups are discovered in the construction zone, outside June 1 through September 15, vegetation clearing would stop and move 100 yards away. Construction would not resume until the bat pups have departed the area.	Avoid impacts to juvenile bats (that are not able to fly) that may be present in trees	Implementation would be completed as part of P-079; monitoring by ROICC	Contractor; ROICC would oversee Contractor activities	[same as above]

Measure	*Anticipated Benefit / Evaluating Effectiveness*	*Implementing and Monitoring*	*Responsibility*	*Estimated Completion Date*
Design stormwater detention facility so as not to attract wildlife that could pose a hazard to aviation and notify the FAA about the proposed project prior to final design of the stormwater detention facility.	Avoid or minimize impacts to aviation	Implementation and coordination would be completed as part of P-079 design and execution	DON	2026
Employ construction noise control measures such as temporary noise barriers and avoidance of nighttime operations, as appropriate	Reduce construction noise impacts on nearby noise-sensitive receptors	[same as above]	[same as above]	[same as above]
Emergency generator mechanical support to include discharge silencer/muffler	Reduce potential operational period noise impacts from testing and running emergency generators	[same as above]	[same as above]	2026-2030
Implement smart energy management system, smart metering, and energy saving features in new facility	Reduce new facility's overall energy demand	Contractor to implement; ROICC to monitor	Contractor; ROICC to oversee Contractor activities	2030
Comply with approved traffic control plans and employ standard operating procedures during implementation of Salt Lake Boulevard-Kahuapaani Street traffic signal modifications and Salt Lake Boulevard-Luapele Drive intersection roadway striping	Improve public safety around off-site construction areas	Implementation would be completed by HDOT contractors and monitoring would be completed by HDOT	HDOT contractors; HDOT to oversee contractor activities	TBD
If MEC or MPPEH is encountered in the project area, implement applicable DoD procedures and standards	Reduce health and safety risks to construction contractor personnel	Contractor to implement; ROICC to monitor	Contractor; ROICC to oversee Contractor activities	2026-2030
JIOC Facility-South Alternative				
Same as those for Preferred Alternative				

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4 Cumulative Impacts

This section (1) defines cumulative impacts, (2) describes past, present, and reasonably foreseeable future actions relevant to cumulative impacts, (3) analyzes the incremental interaction the proposed action may have with other actions, and (4) evaluates cumulative impacts potentially resulting from these interactions.

4.1 Definition of Cumulative Impacts

The approach taken in the analysis of cumulative impacts follows the objectives of the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ) regulations, and CEQ guidance. According to 40 CFR section 1508.7, cumulative impacts are defined as "the impact on the environment that results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

To determine the scope of environmental impact analyses, agencies shall consider cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact analysis document.

In addition, CEQ and USEPA have published guidance addressing implementation of cumulative impact analyses—Guidance on the Consideration of Past Actions in Cumulative Effects Analysis (CEQ, 2005) and Consideration of Cumulative Impacts in USEPA Review of NEPA Documents (USEPA, 1999). CEQ guidance entitled *Considering Cumulative Impacts Under NEPA* (1997) states that cumulative impact analyses should

"…determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative impacts of other past, present, and future actions...identify significant cumulative impacts…[and]…focus on truly meaningful impacts."

Cumulative impacts are most likely to arise when a relationship or synergism exists between a proposed action and other actions expected to occur in a similar location or during a similar time period. Actions overlapping with or in close proximity to the proposed action would be expected to have more potential for a relationship than those more geographically separated. Similarly, relatively concurrent actions would tend to offer a higher potential for cumulative impacts. To identify cumulative impacts, the analysis needs to address the following three fundamental questions.

- Does a relationship exist such that affected resource areas of the proposed action might interact with the affected resource areas of past, present, or reasonably foreseeable actions?
- If one or more of the affected resource areas of the proposed action and another action could be expected to interact, would the proposed action affect or be affected by impacts of the other action?
- If such a relationship exists, then does an assessment reveal any potentially significant impacts not identified when the proposed action is considered alone?

4.2 Scope of Cumulative Impacts Analysis

The scope of the cumulative impacts analysis involves both the geographic extent of the effects and the time frame in which the effects could be expected to occur. For this EA, the study area delimits the geographic extent of the cumulative impacts analysis. In general, the study area will include those areas previously identified in Chapter 3 for the respective resource areas. The time frame for cumulative impacts centers on the timing of the proposed action.

Another factor influencing the scope of cumulative impacts analysis involves identifying other actions to consider. Beyond determining that the geographic scope and time frame for the actions interrelate with the proposed action, the analysis employs the measure of "reasonably foreseeable" to include or exclude other actions. For the purposes of this analysis, public documents prepared by federal, state, and local government agencies form the primary sources of information regarding reasonably foreseeable actions. Documents used to identify other actions include notices of intent for EISs and EAs, management plans, land use plans, and other planning related studies.

4.3 Past, Present, and Reasonably Foreseeable Actions

This section will focus on past, present, and reasonably foreseeable future projects at and near the Proposed Action locale. In determining which projects to include in the cumulative impacts analysis, a preliminary determination was made regarding the past, present, or reasonably foreseeable action. Specifically, using the first fundamental question included in Section 4.1, it was determined if a relationship exists such that the affected resource areas of the Proposed Action (included in this EA) might interact with the affected resource area of a past, present, or reasonably foreseeable action. If no such potential relationship exists, the project was not carried forward into the cumulative impacts analysis. In accordance with CEQ guidance (CEQ, 2005), these actions considered but excluded from further cumulative effects analysis are not catalogued here as the intent is to focus the analysis on the meaningful actions relevant to informed decision-making. Projects included in this cumulative impacts analysis are listed in Table 4-1 and briefly described in the following subsections.

Table 4-1 Cumulative Action Evaluation

Action	***Level of NEPA Analysis Completed***
Past Actions	
Development of Makalapa Crater for military use	n/a
Present and Reasonably Foreseeable Future Actions	
Honolulu Rail Transit Project	Final EIS, Final Supplemental EIS Section 4(f) Evaluation and Amended Record of Decision
Reuse of current JIOC facilities in Joint Base Pearl Harbor-Hickam Makalapa Crater	To be determined
Improve Luapele Gate as Primary Entry Control Facility	To be determined
PHNSY & IMF Dry Dock Replacement and Waterfront Production Facility	EIS in progress
JBPHH Ambulatory Care Center Replacement	Draft EA
Halawa Area Transit-Oriented Development Plan	n/a

Action	*Level of NEPA Analysis Completed*
Airport Transit-Oriented Development Plan	n/a
Little Makalapa-NAVFAC Hawaii Compound Redevelopment	TBD
P-704 Sewer Lift Station and Relief Sewer Line	Categorical Exclusion
P-081 Pearl Harbor Domestic Wastewater System	Categorical Exclusion to be prepared
P-082 Pearl Harbor Ship Wastewater Collection Ashore Abatement System	EA to be prepared
P-084 Ford Island Wastewater System	Categorical Exclusion to be prepared
P-129 Makalapa Hillside Stabilization	To be determined
New Aloha Stadium Entertainment District	n/a
Halawa View Apartments Phases II and III	n/a

n/a = not applicable

4.3.1 Past Actions

As described in Section 3.6 Cultural Impacts, landforms and use in and around Makalapa Crater changed dramatically starting in the early 20th century with the acquisition and development of lands around Pearl Harbor by the U.S. government. Portions of the crater floor were used as a receiving site for materials dredged from Pearl Harbor and construction debris, the interior western rim developed for Navy officer family housing, and an area established for administrative facilities along the north rim.

4.3.2 Present and Reasonably Foreseeable Actions

Honolulu Rail Transit Project: As described in Section 3.1.1.3, the Honolulu Rail Transit Project (HRTP) is an elevated guideway in support of the CCH's new high-capacity transit service in the corridor between East Kapolei and Ala Moana Center. The project includes the guideway, transit stations, park-and-ride facilities, maintenance and storage facility, and other ancillary facilities to support the transit system. The project, currently under construction, includes construction and operation of a 20-mile elevated fixed guideway rail system with 21 stations. The entire 20-mile system is projected to be constructed by 2031, with the first phase (Kapolei to Aloha Stadium) estimated to open in 2022. Due to rising costs, the route may initially be shortened by two stations (1.25 miles) and end at South Street in Downtown Honolulu. The rail guideway route will run along Kamehameha Highway in front of the Borchers Gate entrance to JBPHH Makalapa Compound. The Halawa Station is located at the intersection of Kamehameha Highway and Salt Lake Boulevard, on the east side of Kamehameha Highway (see station locations and guideway route in Figure 3-1). Construction of the guideway from the Halawa Station to the Middle Street Transit Center (including the segment fronting JBPHH Makalapa Compound) is projected to be completed in 2022 (HART, 2022).

Reuse of existing JIOC facilities on Makalapa Compound: The reuse of facilities in Joint Base Pearl Harbor-Hickam Makalapa Crater that are currently used by JIOC operations has not yet been determined, but is expected to occur within several years after JIOC operations relocate to the new facilities. A long-term horizon year of 2037 was identified for use in the cumulative impact analyses. The backfill of facilities to be vacated by JIOC within the Makalapa Compound is assumed to result in a net

increase of about 800 persons employed at Makalapa Compound, based on the buildings' floor area and likely reuse for primarily administrative or office-type functions.

Improve Luapele Gate as Primary Entry Control Facility: This project would improve the existing entry control facility (ECF) at Luapele Gate and reassign it as the primary ECF for JBPHH Makalapa Compound. Borchers Gate would be reassigned as a secondary ECF equipped with a low volume hybrid automated vehicle gate. The purpose of the improvements and reassignment of gate functions is to improve compliance with DoD Unified Facilities Criteria and meet future traffic demand. Improvements include expanding Luapele Road from one to two incoming lanes, identification check gate/control house and a second guard booth, final guard booth, POV inspection area, rejection lane, POV and truck inspection areas, a sidewalk, utility improvements, and improvements to three nearby parking areas in JBPHH Makalapa Compound. The proposed Luapele ECF project takes into account traffic volumes resulting from implementation of MILCON P-079, but is an unrelated project that could be executed with or without the Proposed Action.

Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility (PHNSY & IMF) Dry Dock and Waterfront Production Facility: The proposed action includes construction and operation of a new dry dock and waterfront production facility to provide adequate to provide adequate dry dock capacity and a properly sized and configured waterfront production facility to enable efficient submarine maintenance. The project would also include a new electrical substation, construction support infrastructure, harbor dredging, and demolition of some existing buildings. The new facilities would be located approximately two miles southwest of the proposed new JIOC facility. Construction is anticipated to begin in 2023 and be completed in 2027, with operations beginning in 2028.

JBPHH Ambulatory Care Center Replacement: This project would construct and operate a new ambulatory care center, which would consolidate existing facilities and services now managed separately by the Navy, Air Force, and Army. The preferred site is adjacent to the Hickam Par 3 Golf Course, approximately 1.5 miles south of the proposed new JIOC facility. Construction would begin in 2023 at the earliest, with steady state operations anticipated in 2028.

Halawa Area Transit-Oriented Development (TOD) Plan: This CCH TOD plan focuses on the neighborhood surrounding the planned rail transit station at Aloha Stadium. It embodies a vision for redeveloping the 100-acre Aloha Stadium site into a mixed-use community surrounding a downsized stadium relocated on site. The Plan envisions over five million sq ft of potential new development consisting of residential, commercial, office, sports medical, sports entertainment, and cultural uses at the site (see New Aloha Stadium Entertainment District description below for more details). In addition, the Plan identifies neighboring areas such as Puuwai Momi public housing, Aiea Elementary School, and Stadium Mall, and Stadium Marketplace commercial centers as offering opportunities to increase density and provide a mix of uses. This plan suggests a six-phase implementation schedule: (1) Aloha Stadium Station transit plaza and connectivity; (2) relocate and build a new Aloha Stadium; (3) build gathering place and sports and entertainment district; (4) build mixed-use core and street enhancements; (5) infill the stadium site with office campus, parking, and native tree orchard; and (6) redevelop Puuwai Momi public housing site and revitalize neighboring sites (e.g., Stadium Mall, Stadium Marketplace, Aiea Elementary School, Halawa Stream). This TOD Plan would take several decades to implement (e.g., 20 to 40 years) and would require a combination of public and private investment. The Plan was approved by the City Council in 2020.

Airport Area TOD Plan: This CCH TOD plan is focused on areas around three HRTP stations: Pearl Harbor Naval Base, Daniel K. Inouye Airport, and Lagoon Drive, and includes areas south of the P-079 project area. For the Pearl Harbor Naval Base Station TOD Area (i.e., area closest to the P-079 project area), the Plan envisions a mixed-use community providing a range of housing and jobs within walking distance of the station. It recommends a new civilian retail area on the surface parking lot next to The Mall at Pearl Harbor (i.e., Navy Exchange) on Radford Drive; redevelopment of the Navy's Little Makalapa family housing site and the Federal Fire Station (south of JBPHH Makalapa Compound) in medium-density residential use; retail and dining amenities adjacent to the transit station; and complete redevelopment of the NAVFAC Hawaii compound located between Radford Drive and Salt Lake Boulevard into a new civilian community with various housing types, commercial and retail uses, and park/school/community uses. The Plan acknowledges that DoD-controlled lands within the TOD planning area are not subject to CCH or State land use controls. It also acknowledges that redevelopment of DoD-controlled property will require that the Navy either (1) determine the property as surplus and, therefore, eligible for disposal as excess property; or (2) make the property available to local agencies and private developers through an Enhanced Use Lease (City and County of Honolulu, 2017). Implementation of the major redevelopment recommendations are estimated to occur in the long-term timeframe (16 to 30 years). The Plan is undergoing review and will be considered by the City Council for approval.

Little Makalapa-NAVFAC Hawaii Compound Redevelopment: This initiative is included in concept in CCH's Airport Area TOD Plan described above. The Navy envisions establishing a public-private partnership to redevelop the 13-acre former Little Makalapa family housing site and 57-acre NAVFAC Hawaii compound, both of which are located within walking distance of the planned Pearl Harbor Naval Base Rail Transit Station. The preliminary proposal includes 2.3 million sq ft of low-, medium-, and high-rise residential and commercial space, a high-rise hotel, parks, and pedestrian walkways over H-1 Freeway and Kamehameha Highway connecting the new development with JBPHH (Honolulu Star Advertiser, 2020). This initiative is likely to occur in the long-term timeframe (i.e., decades).

P-704 Sewer Lift Station & Relief Sewer Line: This FY 2018 Navy project enacted by Congress included construction of a new 24-mgd wastewater lift station to replace the existing lift station at Building 1358 and a relief trunk sewer main along South Avenue in the Naval shipyard area of JBPHH. The project would accommodate flows from projects in regional JBPHH planning documents and address capacity deficiencies in the existing trunk sewer main that serves JBPHH, Camp Smith, and other offsite areas. The construction contract for this FY18 MILCON project was enacted by Congress and the project partially constructed due to lack of funding. The balance of the project scope (i.e., South Avenue relief sewer line) would be constructed under P-079 .

P-081 Upgrade Pearl Harbor Domestic Wastewater System: This Navy project would upgrade the Pearl Harbor domestic wastewater system by increasing pumping capacity of five lift stations and their force mains, and increasing undersized gravity mains and force mains. Work would take place in several locations around JBPHH, but not within JBPHH Makalapa Compound. The Navy plans to implement this project no earlier than FY 2023.

P-082 Pearl Harbor Ship Wastewater Collection Ashore Abatement System: This Navy project would upgrade the Pearl Harbor Ship Wastewater Collection Ashore Abatement System by constructing a new sewer pump station, installing new and replacement force mains, upgrading existing sewer pump stations, and providing an upgraded relief sewer line. Work would take place in several locations around JBPHH, but not within JBPHH Makalapa Compound. The Navy plans to implement this project no earlier than FY 2022.

P-084 Ford Island Wastewater System: This Navy project would upgrade pumping capacity of two lift stations on Ford Island, install a new 18-inch force main (submarine transmission main), and upgrade the capacities of deficient gravity mains at various locations on Ford Island. The Navy plans to implement this project no earlier than FY 2024.

P-129 Makalapa Hillside Stabilization: This Navy project would construct an erosion control system by installing sheet piling, drainage structures, retaining walls, and erosion control materials on the downslope side of the JBPHH Makalapa Compound security fence between Halawa Drive and Halawa Stream (near Borchers Gate) to reduce erosion of the ground surface. Timing of project implementation is to be determined.

New Aloha Stadium Entertainment District (NASED): This project, proposed by the State of Hawaii Department of Accounting and General Services and the Aloha Stadium Authority, would construct a new stadium to replace the existing Aloha Stadium on the existing 98-acre site. The new stadium would be supported by complementary mixed-use development that may include residential, retail, entertainment, office space, and hotel uses, along with ancillary facilities and supporting infrastructure, public amenities, and utility improvements. It would be built out through several construction phases by one or more private developers under a Public-Private Partnership procurement arrangement. An HRS 343 Programmatic Draft EIS (PDEIS) for the project was published in December 2020 and evaluated the potential effects of a 27,500- to 35,000-seat new stadium, approximately 1,813 residential units, 680,500 GSF of retail and entertainment space, 216,000 gross square feet (GSF) of office space, and 621 hotel rooms, for a total buildout of 3.2 million GSF (Wilson Okamoto Corporation, 2020). When project-level details are available as specific projects are proposed, additional HRS 343 environmental review may be required. According to the project website (nased.hawaii.gov), a three-year construction period is anticipated, with the initial phase of development expected to be delivered over a five-year timeframe. News media reporting indicates construction could begin in late 2022 or early 2023 (Honolulu Star Advertiser, November 17, 2021).

Halawa View Apartments Phases II and III: This private project, supported by state tax-exempt bonds, low-interest loans, and state and federal tax credits, would provide 302 low-income rental apartments in two 20-plus-story towers located about ½ mile south of Aloha Stadium. The new towers would be constructed on the existing site of the 121-unit low-income rental Halawa View Apartments complex (containing one 14-story high-rise and two 3-story low-rise structures, the latter of which are proposed for demolition). The U.S. Navy provided the City and County of Honolulu with concerns regarding security, viewplane, and potential electronic communications issues that the proposed additional Halawa View Apartments project could pose for the proposed JIOC project and other Navy property in the vicinity. Per the Navy's input, the City included conditions in the documentation for permitting the Halawa View proposed construction. The City also required a traffic assessment for the project. Construction is targeted for the 2023-2024 timeframe.

4.4 Cumulative Impact Analysis

The following analysis of cumulative impacts is organized by resource area in the same order presented in Chapter 3. Only the resource areas that have the potential to have cumulative impacts resulting from the incremental effects of the Preferred Alternative or South Alternative are addressed. The Proposed Action is not anticipated to have incremental impacts in the following resource areas that would overlap temporally or spatially in a way that would be cumulatively significant with those of the past, present, and reasonably foreseeable actions identified in Section 4.3: water resources, geological resources, land

use, infrastructure, public health and safety, hazardous materials and waste, and environmental justice. Therefore, these environmental resource areas are not analyzed in detail in this section. Where feasible, the cumulative impacts were assessed using quantifiable data; however, for many of the resources included for analysis, quantifiable data is not available and a qualitative analysis was undertaken. In addition, where an analysis of potential environmental effects for future actions has not been completed, assumptions were made regarding cumulative impacts related to this EA where possible. The analytical methodology presented in Chapter 3, which was used to determine potential impacts to the various resources analyzed in this document, was also used to determine cumulative impacts. The analyses show that, when considered with relevant past, present, and reasonably foreseeable projects, the incremental effects of the Preferred Alternative and the South Alternative would not contribute to cumulative impacts on pertinent resource areas. Because it would not contribute any incremental effects, the No Action Alternative would not result in cumulative impacts on the relevant resource areas during the construction or operational periods.

4.4.1 Transportation

4.4.1.1 Description of Geographic Study Area

The ROI for transportation includes the Kamehameha Highway and Salt Lake Boulevard roadway segments surrounding and leading to the entry gates and the Kamehameha Highway-Halawa Drive, Salt Lake Boulevard-Luapele Drive, and Salt Lake Boulevard-Kahuapaani Street intersections.

4.4.1.2 Relevant Past, Present, and Future Actions

The HRTP, reuse of vacated JIOC facilities, Pearl Harbor wastewater system upgrades, Halawa Area TOD Plan (which includes NASED) projects may interact with the Proposed Action's transportation impacts if construction of the Proposed Action occurs concurrently with any of the projects. Additional traffic volumes associated with the reuse of vacated JIOC facilities on Makalapa, and the Halawa Area TOD Plan, and the Halawa View Apartments Phases II and III have the potential to increase traffic in the ROI during the operational period. In the long-term, the HRTP project has the potential to offset vehicle traffic volumes in the vicinity as commuters and nearby residents utilize rail transit in lieu of private vehicle trips. The Luapele ECF project would improve peak hour traffic flow into JBPHH Makalapa Compound.

4.4.1.3 Cumulative Impact Analysis

Cumulative transportation impacts from past, present, and future actions within the ROI would be less than significant because construction of the HRTP, reuse of vacated JIOC facilities at Makalapa, Pearl Harbor wastewater system upgrades, and Halawa Area TOD Plan projects are not likely to overlap with construction of the Proposed Action.

Analysis of the Proposed Action's long-term traffic impacts (i.e., including the reuse of vacated JIOC facilities at Makalapa) was conducted in the traffic impact analysis report. Although long-term future traffic volumes are difficult to forecast due to changes in travel patterns and available modes of transportation, the traffic study includes an evaluation of future peak hour traffic conditions at the three intersections studied. Peak hour conditions without the proposed project for a twenty-year horizon were evaluated with background traffic volumes 10% higher than those in 2017, in addition to "with project" conditions (i.e., new JIOC facility and reuse of vacated JIOC facilities at Makalapa). See Appendix A for details of the analyses and results.

Because of the proximity to Borchers Gate, traffic impacts from the reuse of the vacated JIOC Makalapa Compound facilities are expected to be primarily at Borchers Gate. These impacts would be additive to the impacts of the new JIOC facility, and are estimated at 180 vehicles per hour (vph) entering and 36 vph exiting in the AM Peak Hour, and 33 vph entering and 184 vph exiting in the PM Peak Hour. The analysis showed that, at the intersection of Kamehameha Highway and Halawa Drive, increased traffic would increase average delays, but the overall level of service would remain at acceptable levels during both the AM and PM Peak Hours (LOS C for both time periods, with or without the project). (See Tables 12 and 13 in Appendix A.) The traffic impact analysis report recommends implementation of measures prior to reuse of vacated JIOC facilities to mitigate the expected increases in delays and utilization. Potential mitigation measures include reconstruction of Borchers Gate to address existing limited capacity, security concerns, and queuing onto Kamehameha Highway.

At the intersection of Salt Lake Boulevard and Luapele Drive, the increased volumes (due to background regional growth) would result in a slight increase in delays, but levels of service would continue to be acceptable. Because the Luapele ECF project (which is unrelated to the Proposed Action) would improve force protection and vehicle flow into JBPHH Makalapa Compound from the intersection of Salt Lake Boulevard and Luapele Drive, it would likely have a beneficial impact on traffic conditions entering JBPHH Makalapa Compound from external roadways.

At the intersection of Salt Lake Boulevard and Kahuapaani Street, the added volume would increase delays in both peak hours, but overall levels of service would not change (AM Peak Hour: LOS C with or without the project and PM Peak Hour: LOS D with or without the project). This assumes the potential mitigation measure identified for the near-term scenario is implemented, if conditions rise to that level that warrant improvements prior to the long-term timeframe. This is a reasonable assumption because the projected increase in background traffic volumes (without the project) would cause over-capacity conditions that could be addressed with minor intersection improvements within the 20-year horizon (i.e., the potential mitigation).

The Halawa Area TOD Plan envisions a much higher level of commercial, residential, and other uses near the transit station. Besides NASED, specific projects associated with the Halawa Area TOD Plan have not been identified or evaluated for their environmental impacts and, because the timeline for significant redevelopment would be 20 to 40 years in the future, impacts to specific roadway segments at that time (e.g., Salt Lake Boulevard) are difficult to predict. However, the TOD Plan also emphasizes use of alternative transportation modes (i.e., rail, bus and bicycle) and mixed uses (e.g., on-site residential) that would offset vehicle traffic increases in and around the area. The NASED EIS indicates no change in the LOS at the Kahuapaani Street-Salt Lake Boulevard intersection in 2026 (anticipated Phase 1 operations) with or without that project. (Note: The traffic study for NASED includes traffic from Halawa View Apartments Phases II and III in its with-project traffic assignments, so conclusions are applicable to both the NASED and Halawa View Apartments projects.) The additional vehicle movements at this intersection contributed by the NASED project (reported in its Draft EIS), if added to those of the Preferred Alternative, would not change the results of the analyses done for the long-term impacts.

Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would not result in significant cumulative impacts within the ROI.

4.4.2 Air Quality

4.4.2.1 Description of Geographic Study Area

The ROI for assessing air quality impacts is Makalapa Compound, offsite sewer improvement areas, and roadway intersections affected by changes in traffic patterns resulting from the Proposed Action. As noted in Section 3.2 Air Quality and in Appendix B-1 Air Quality Impact Study, air quality in the state is generally good, with criteria air pollutant levels well within federal and state standards. Due to the improvements in vehicle fuel efficiency over many years, as well as federal and state initiatives requiring reduced pollutant emissions and a transition to clean energy sources, vehicle-related pollutant emissions levels are predicted to decline even as development within the state and project vicinity has occurred over time.

4.4.2.2 Relevant Past, Present, and Future Actions

The HRTP, reuse of vacated JIOC facilities at Makalapa, Halawa Area TOD Plan, NASED, and Halawa View Apartments projects may interact with the Proposed Action's air quality resource area if construction of the Proposed Action occurs concurrently with any of the projects in the same area. However, this is improbable due to the timing of the projects. During the operational period, the Proposed Action is not expected to raise air pollutant concentrations in the areas most likely to be affected by additional vehicle volumes and congestion (i.e., the three intersections studied) (see Tables 3-10 and 3-11 in Section 3.2 Air Quality).

4.4.2.3 Cumulative Impact Analysis

Cumulative air quality impacts from past, present, and future actions within the ROI are expected to be less than significant. Construction period air quality impacts from the Proposed Action and any of the other relevant projects would be temporary and not likely to occur during the same time or at the same location. In the long-term, air pollution concentrations from vehicle emissions with the project and reuse of vacated JIOC facilities at Makalapa were estimated to continue to be well within federal and state standards. The reuse of the buildings is not expected to increase long-term concentrations of criteria pollutants in the areas studied compared with the "without project" scenario (see Tables 4-2 and 4-3). As discussed in Section 4.4.1.3, no cumulative long-term traffic impacts are anticipated from the Proposed Action in combination with other foreseeable projects in the ROI and air pollution concentrations would similarly continue to be within federal and state standards at the intersections studied.

Therefore, implementation of the Preferred Alternative or South Alternative combined with the past, present, and reasonably foreseeable future projects, would not result in significant air quality impacts within the ROI.

Table 4-2 Long-Term Estimated Highest 1-Hour Carbon Monoxide Concentrations Along Roadways Near JIOC Facility Project (ppm)

Roadway Intersection	*2037 Without Project*		*2037 With Project*	
	AM	*PM*	*AM*	*PM*
Halawa Drive at Kamehameha Highway	1.1	1.2	1.1	1.2
Luapele Drive at Salt Lake Boulevard	1.1	1.2	1.1	1.2
Kahuapaani Street at Salt Lake Boulevard	(1.1)	(1.2)	(1.1)	(1.2)

Hawaii State AAQS: 9 ppm National AAQS: 35 ppm
Note: Values in table enclosed within parentheses indicate projected emissions concentrations with implementation of mitigation identified in this project's 2018 draft traffic report (Julian Ng Inc., 2018). The mitigation measure identified in the 2018 traffic report was revised in an updated 2022 traffic report (see Appendix A); however, the revised mitigation (modified traffic signal phasing at the Salt Lake Boulevard-Kahuapaani Street intersection) would result in the same level of service (LOS D) and lower utilization rate and delays at the intersection, which indicate that the estimated highest 1-hour CO concentration would likely be similar to or lower than what was originally modeled. These concentrations are well under the State and National standards, at about 13 percent of the State AAQS and 3.5 percent of the NAAQS during the PM Peak Hour.

Table 4-3 Long-Term Estimated Highest 8-Hour Carbon Monoxide Concentrations Along Roadways Near JIOC Facility Project (ppm)

Roadway Intersection	*2037 Without Project*	*2037 With Project*
Halawa Drive at Kamehameha Highway	0.6	0.6
Luapele Drive at Salt Lake Boulevard	0.6	0.6
Kahuapaani Street at Salt Lake Boulevard	(0.6)	(0.6)

Hawaii State AAQS: 4.4 ppm National AAQS: 9 ppm
Note: Values in table enclosed within parentheses indicate projected emissions concentrations with implementation of mitigation identified in project's 2018 draft traffic report (Julian Ng Inc., 2018). As noted in Table 4-2, the traffic mitigation measure in the 2021 traffic report (modified traffic signal phasing at the Salt Lake Boulevard-Kahuapaani Street intersection) would result in the same intersection level of service (LOS D) and lower utilization rate and delays than with the mitigation measure proposed in the 2018. This minimal change in intersection operation indicates that the estimated highest 8-hour CO concentration would likely be similar to or lower than what was originally modeled. These concentrations are well under the State and National standards , at about 14 percent of the State AAQS and 7 percent of the NAAQS during the PM Peak Hour.

4.4.3 Visual Resources

4.4.3.1 Description of Geographic Study Area

The ROI for visual resources includes viewpoints within and outside Joint Base Pearl Harbor-Hickam Makalapa Crater described in Section 3.5 Visual Resources (i.e., scenic resources described in the PUC DP, views from the north rim of Makalapa Crater, and Bougainville Drive). Views from within the crater

(i.e., from the administration and family housing areas) have changed over time due to changes in land use within and around the crater.

4.4.3.2 Relevant Past, Present, and Future Actions

Past actions that might interact with visual resources include the development of Joint Base Pearl Harbor-Hickam Makalapa Crater and its surrounding areas. Reasonably foreseeable actions that might interact with visual resources include the implementation of the Halawa Area TOD Plan, which includes redevelopment of Aloha Stadium.

4.4.3.3 Cumulative Impact Analysis

Cumulative visual impacts from past, present, and future actions within the ROI would be less than significant because, although some components of the Halawa Area TOD Plan, NASED, and Halawa View Apartments projects (e.g., high-rise buildings) may affect long-distance views from the ROI, the Preferred Alternative and South Alternative would not impede views of Red Hill or the Koolau Range from the ROI. Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would not result in significant impacts within the ROI.

4.4.4 Cultural Resources

4.4.4.1 Description of Geographic Study Area

The ROI for cultural resources cumulative impacts for the Proposed Action is equivalent to the undertaking's APE described in Section 3.6 (i.e. historic properties and associated viewsheds potentially visible from the project area).

4.4.4.2 Relevant Past, Present, and Future Actions

Implementation of the Halawa Station TOD Plan, NASED, and Halawa View Apartments may interact with the Proposed Action's impacts on cultural resources if the suggested redevelopment includes high-rise structures visible from historic housing on the crater rim.

4.4.4.3 Cumulative Impact Analysis

Cumulative impacts to cultural resources from past, present, and future actions within the ROI would be less than significant because the Proposed Action would have no effect on historic properties under NHPA and would not impact any traditional Hawaiian, or other ethnic group's, rights related to gathering, access, or customary activities exercised for subsistence, cultural or religious purposes. The Proposed Action would not impact TCPs. The Preferred Alternative and South Alternative would not impede views of Red Hill or the Koolau Range from historically important vantage points within Joint Base Pearl Harbor-Hickam Makalapa Crater. Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would not result in significant impacts within the ROI.

4.4.5 Biological Resources

4.4.5.1 Description of Geographic Study Area

The ROI for biological resources cumulative impacts is the project areas for the Preferred Alternative and South Alternative. This ROI underwent major alterations in the early and mid-20th century due to changes in land use (e.g., fishpond, dredged material and construction debris receiver site). The areas

surrounding the ROI also experienced major land use changes (e.g., construction of Navy officer housing, headquarters and administration facilities, H-1 Freeway, civilian housing development). These land use changes, along with regional land use changes, affected the habitat for terrestrial biological resources. The ROI is currently dominated by non-native plants, birds, mammals, and reptiles.

4.4.5.2 Relevant Past, Present, and Future Actions

Past actions that might interact with biological resources include the development of JBPHH Makalapa Crater for military uses, including the use of the project area for dredged material and construction material disposal. Reasonably foreseeable actions that might interact with biological resources include P-081 Pearl Harbor Domestic Wastewater System upgrade, which would replace or upgrade existing sewer lift stations, force mains, and gravity mains.

4.4.5.3 Cumulative Impact Analysis

Cumulative biological resource impacts from past, present, and future actions within the ROI would be less than significant because, although the wildlife utilizing the project area would be displaced during the construction period due to the noise and activity, they are expected to return to the remaining habitat in the long-term or use suitable habitat nearby. Although the planned (non-project-related) wastewater system improvements would involve ground disturbance, they would occur outside the ROI and would generally involve already-developed lands that do not provide sensitive habitat for biological resources. Management measures would be implemented to protect and benefit MBTA-protected birds, the Hawaiian short-eared owl, and the Hawaiian hoary bat. Therefore, implementation of the Preferred Alternative or South Alternative combined with the past, present, and reasonably foreseeable future projects, would not result in significant impacts within the ROI.

4.4.6 Noise

4.4.6.1 Description of Geographic Study Area

The ROI for noise impacts is the area that contains noise sensitive receptors closest to the project area.

4.4.6.2 Relevant Past, Present, and Future Actions

The HRTP and P-129 Makalapa Hillside Stabilization projects may interact with the Proposed Action's noise impacts if construction of the projects occur concurrently in the same area. Additional traffic volumes associated with the Halawa Area TOD Plan, NASED, and Halawa View Apartments have the potential to increase traffic noise along Salt Lake Boulevard during the operational period. In the long-term, the HRTP project has the potential to offset vehicle traffic volumes (and associated noise impacts) in the vicinity as commuters and nearby residents utilize rail transit in lieu of private vehicle trips.

4.4.6.3 Cumulative Impact Analysis

Cumulative noise impacts from past, present, and future actions within the ROI would be less than significant because it is likely that construction of the HRTP guideway, Halawa Station, and P-129 would be completed prior to and not overlap with P-079 construction. The Halawa Area TOD Plan, NASED, and Halawa View Apartments envision a much higher level of commercial, residential, and other uses near the transit station. Specific projects associated with the Halawa Area TOD Plan have not been identified or evaluated for their environmental impacts, but the Plan also emphasizes use of alternative transportation modes (i.e., rail and bicycle) and mixed uses (e.g., on-site residential) that may offset

vehicle traffic increases in and around the area. According to the NASED PDEIS (Wilson Okamoto Corporation, 2020), by 2026, peak commuting period project traffic noise levels would not be significant. Because the timeline for significant redevelopment would be 20 to 40 years in the future, impacts to specific roadway segments in the long term (e.g., Salt Lake Boulevard) are difficult to predict. When considered along with the Preferred Alternative, traffic associated with the Halawa View Apartments (which is included in the NASED traffic study with-project traffic assignments) is not expected to significantly impact LOS at the intersections studied, and therefore, would not contribute to significant cumulative noise impacts. As described in Section 3.9 Noise, day-night average noise levels resulting from the Proposed Action are estimated to rise by less than 0.05 dB above the without-project scenario. This level of change could be considered a de minimis increase in light of the significant noise contributions of the existing roadway traffic. Therefore, implementation of the Proposed Action combined with the past, present, and reasonably foreseeable future projects, would not result in significant noise impacts within the ROI.

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5 Other Considerations Required by NEPA

5.1 Consistency with Other Federal, State, and Local Laws, Plans, Policies, and Regulations

In accordance with 40 Code of Federal Regulations (CFR) section 1502.16(c), analysis of environmental consequences shall include discussion of possible conflicts between the Proposed Action and the objectives of federal, regional, state, and local land use plans, policies, and controls. Table 5-1 identifies the principal federal and state laws and regulations that are applicable to the Proposed Action, and describes briefly how compliance with these laws and regulations would be accomplished.

Table 5-1 Principal Federal and State Laws Applicable to the Proposed Action

Federal, State, Local, and Regional Land Use Plans, Policies, and Controls	*Status of Compliance*
National Environmental Policy Act (NEPA); CEQ NEPA implementing regulations; Navy procedures for Implementing NEPA	EA completed
Clean Air Act	Proposed Action in CAA attainment area
Clean Water Act	NPDES permit to be obtained, as applicable
Coastal Zone Management Act	See Appendix D
National Historic Preservation Act	Section 106 compliance completed through the Navy's 2012 Programmatic Agreement
Endangered Species Act	Informal USFWS consultation completed (see Appendix C)
Migratory Bird Treaty Act	No significant effects
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations	No significant effects
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	No significant effects
Chapter 343, Hawaii Revised Statutes	Compliance requirements to be determined and completed (if any) by HDOT

5.1.1 State of Hawaii, Chapter 343, Hawaii Revised Statutes

Environmental review under Chapter 343, HRS is required for any program or project that proposes one or more of eight land uses or administrative acts, including use of State or County lands or funds other than for feasibility studies or the purchase of raw land. Because the Proposed Action could, if conditions warrant, involve potential modifications to traffic signals on a roadway under State jurisdiction, it may be subject to review under Chapter 343, HRS. The relevant state agency (HDOT) would determine the Proposed Action's Chapter 343, HRS compliance requirements and complete the appropriate level of environmental review.

5.2 Irreversible or Irretrievable Commitments of Resources

Resources that are irreversibly or irretrievably committed to a project are those that are used on a long-term or permanent basis. This includes the use of non-renewable resources such as metal and fuel, vacant land, and natural or cultural resources. These resources are irretrievable in that they would be used for this project when they could have been used for other purposes. Human labor is also

considered an irretrievable resource. Another impact that falls under this category is the unavoidable destruction of natural resources that could limit the range of potential uses of that particular environment.

Implementation of the Proposed Action would irreversibly and irretrievably involve human labor; the consumption of fuel, oil, and lubricants for construction vehicles; and loss of natural resources (e.g., existing non-native or protected vegetation that would be cleared for the new facility). Management measures would be implemented to protect and benefit protected bird species and the Hawaiian hoary bat. Implementing the Proposed Action would not result in significant irreversible or irretrievable commitment of resources.

5.3 Unavoidable Adverse Impacts

This EA has determined that the alternatives considered would not result in any significant impacts. Implementing the alternatives may result in the following unavoidable environmental impacts, which would be less than signficant:

- Short-term, temporary traffic, air quality and noise impacts during the construction period
- Operational period traffic and noise impacts at roadway segments and intersections leading to the Joint Base Pearl Harbor-Hickam Makalapa Crater entry gates

5.4 Relationship between Short-Term Use of the Environment and Long-Term Productivity

NEPA requires an analysis of the relationship between a project's short-term impacts on the environment and the effects that these impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. Impacts that narrow the range of beneficial uses of the environment are of particular concern. This refers to the possibility that choosing one development site reduces future flexibility in pursuing other options, or that using a parcel of land or other resources often eliminates the possibility of other uses at that site.

In the short-term, effects to the human environment with implementation of the Proposed Action would primarily relate to the construction activity itself. Traffic, air quality, and noise would be impacted in the short-term due to project construction. In the long-term, an existing undeveloped area within Joint Base Pearl Harbor-Hickam Makalapa Crater would be converted from non-native vegetation to impervious surfaces and landscaped areas. Some of the project area was previously used as a disposal site for dredged material and construction debris, which has curtailed reuse and productivity of the site. The Preferred Alternative construction area generally limits the new construction to less than 25 percent of the undeveloped crater floor, leaving most of it available for other uses. The construction of the facility and operation would not significantly impact the long-term natural resource productivity of the area. The Proposed Action would not result in any impacts that would significantly reduce environmental productivity or permanently narrow the range of beneficial uses of the environment.

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7 List of Preparers

This EA was prepared collaboratively between the Navy and contractor preparers.

U.S. Department of the Navy

John Bigay (NAVFAC Pacific)
Masters of Urban and Regional Planning
Years of Experience: 35
Responsible for: Contracting Officers Representative (COR)

Valerie Curtis (NAVFAC Pacific)
B.A., Anthropology (focus in Archaeology)
M.A., Anthropology (focus in Historic Preservation and Paleoenvironment)
Years of Experience: 30
Responsible for: Cultural Resources

HHF Planners (Prime Contractor)

Thomas A. Fee, AICP, LEED AP ND
B.A., Economics and Master of Urban and Regional Planning
Years of Experience: 36
Responsible for: Principal in charge; overall quality assurance/quality control

Gail Renard, LEED AP
B.A., International Relations
Years of Experience: 29
Responsible for: Primary Author; Purpose and Need, Proposed Action and Alternatives, Air Quality, Cultural Resources, Biological Resources, Land Use, Visual Resources, Noise, Infrastructure, Transportation, Public Health and Safety, Hazardous Materials and Wastes, and Environmental Justice, Cumulative Impacts

Leslie Kurisaki
Master of Arts in Urban Planning
Years of Experience: 30
Responsible for: Water Resources, Geological Resources, Land Use (contributing author)

Tina Bushnell, LEED Green Associate
B.A., Anthropology/Geology
Years of Experience: 17
Responsible for: Cultural Resources

HHF Planners Subcontractors

Julian Ng, PE, PTOE
B.S. Civil Engineering
Years of Experience: 46
Responsible for: Traffic Study

Barry D. Neal, Certified Consulting Meteorologist
B.S. and Graduate studies, Meteorology
Years of Experience: 42
Responsible for: Air Quality Study

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Traffic Impact Analysis Report

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Traffic Impact Analysis Report

P-079 Joint Intelligence Operations Center (JIOC) EA
Joint Base Pearl Harbor Hickam
Makalapa Compound

January 2022

Prepared for:
NAVFAC Pacific
and
Helber Hastert & Fee, Planners
(Navy Contract N62742-16-D-0200,
Contract Task Order N6274217F0123)

Prepared by

Julian Ng Incorporated

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Acronyms and Abbreviations

A.M.	Morning (ante meridian)
Ave.	Avenue
Blvd.	Boulevard
CY	calendar year
Dr.	Drive
EB	eastbound
ES	Executive Summary
Hwy.	Highway
JBPHH	Joint Base Pearl Harbor-Hickam
JIOC	Joint Intelligence Operations Center
LOS	Level of Service
MILCON	Military Construction
NB	northbound
P	Project
P.M.	Afternoon (post meridian)
Rd.	Road
SB	southbound
St.	Street
vph	vehicles per hour
WB	westbound

Executive Summary

This report documents field observations, analyses, and other work done prior to 2019 for a proposed project located within the Makalapa Compound of the Joint Base Pearl Harbor Hickam (JBPHH). This report includes updates to reflect the current parameters of the proposed project, and discusses how the changes to these parameters will not change the findings of the earlier study.

The proposed P-079 project would construct a new building to move existing functions of the JIOC (Joint Intelligence Operations Center) from two buildings within the JBPHH Makalapa Compound located near Kamehameha Highway to a new facility on undeveloped land on the east side of the compound near the Luapele Gate, which is accessed from Salt Lake Boulevard. Approximately 100 JIOC personnel who currently work elsewhere on O‘ahu would relocate to the new facility; the relocation of these personnel is addressed in the traffic analyses. The proposed project also includes utility upgrades, an approximately 650-stall parking lot, and internal access roads.

This traffic study evaluates the potential impacts to traffic conditions resulting from the P-079 project. Three intersections were identified as locations where peak hour traffic volume increases greater than 100 vehicles per hour could be expected: (1) Kamehameha Highway and Halawa Drive, (2) Luapele Drive and Salt Lake Boulevard, and (3) Salt Lake Boulevard and Kahuapaani Street. Along with baseline conditions, analyses for the with- and without-project scenarios were done for both post-construction operation of the new facility and the eventual long-term reuse of the vacated buildings.

Existing levels of service (LOS) at the intersections studied are generally acceptable. Traffic demands at nearby intersections that would change regardless of P-079 implementation were considered in evaluating future conditions. Changes to peak hour vehicular traffic patterns entering and exiting JBPHH Makalapa compound are expected in the short term as a result of P-079, as some traffic would use Luapele Gate instead of Borchers Gate. The analyses indicate that future near-term traffic conditions with the project would be acceptable during the AM and PM peak hours for the Kamehameha Highway-Halawa Drive and Salt Lake Boulevard-Luapele Drive intersections.

Near Luapele Gate, striping of the eastbound Luapele Drive approach for two lanes at its approach to Salt Lake Boulevard is recommended to formalize the existing two-lane use of the single, wide lane there, regardless of implementation of P-079. The analyses showed the Salt Lake Boulevard-Kahuapaani Street intersection would have an acceptable LOS during the AM Peak Hour in the near term, but be over-capacity during the PM peak hour with project implementation. A modified signal phasing that includes additional overlap of non-conflicting vehicular and pedestrian movements would provide sufficient capacities for all movements and acceptable overall LOS during the PM Peak Hour. This signal phasing modification would also enhance pedestrian safety by reducing potential conflicts with vehicular movements. If with- or without-project traffic volumes do not reach the conservatively projected levels due to telework practices accelerated by the COVID 19 pandemic, future rail transit use, or other currently unforeseen factors, the identified signal phasing modification may not be needed. Therefore, the timing and ultimate need for the identified signal modifications should be confirmed closer to project occupancy.

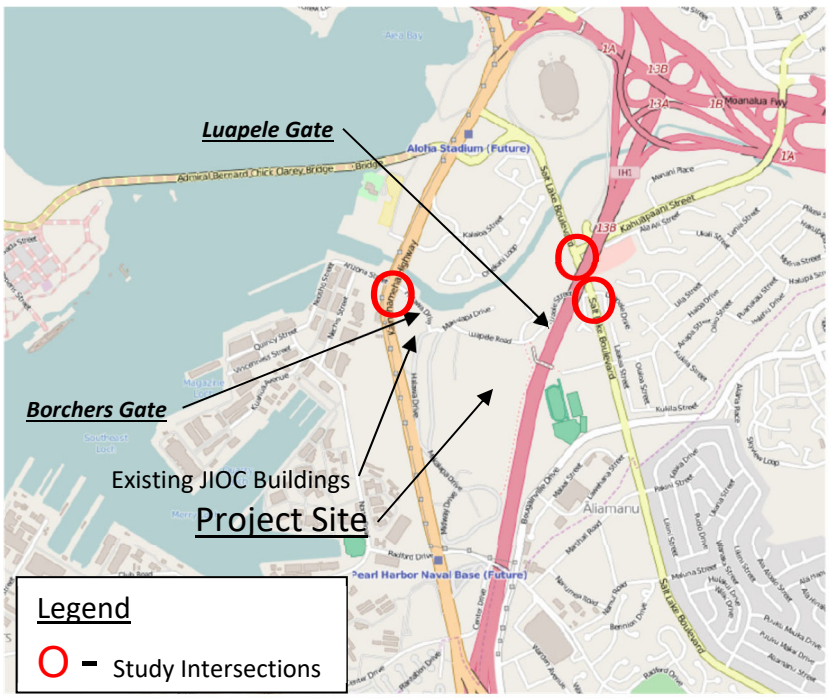
In the longer term, reuse of the vacated buildings would result in traffic volumes at the Kamehameha Highway-Halawa Drive intersection reverting to, and possibly exceeding, existing levels. Implementation of measures to mitigate existing problems (e.g., reconstruction of Borchers Gate) is recommended prior to reuse of these buildings to minimize the increase in delay. The reuse would not change the overall levels of service at the studied intersections (assuming the mitigation identified for the short-term over-capacity conditions are implemented, if warranted by future conditions).

With the mitigation measures discussed above, acceptable conditions were found for peak hour volumes at all three intersections studied.

1.0 Introduction

1.1 This report documents field observations, analyses, and other work done prior to 2019 for a proposed project located within the Makalapa Compound of the Joint Base Pearl Harbor Hickam (JBPHH). This report includes updates to reflect the current parameters of the proposed project, and discusses how the changes to these parameters will not change the findings of the earlier study.

1.2 This traffic study was prepared to evaluate the potential impacts to traffic conditions resulting from the construction of the P-079 project, which would relocate existing functions of the Joint Intelligence Operations Center (JIOC) from two buildings located near Kamehameha Highway to a new facility located near the Luapele Gate; the relocation would occur within the Joint Base Pearl Harbor Hickam (JBPHH) Makalapa Compound. Approximately 100 JIOC personnel who currently work elsewhere on O'ahu would relocate to the new facility; the relocation of these personnel is addressed in the traffic analyses. Three intersections near the compound were identified in an earlier study as locations where significant peak hour traffic volume increases (i.e., greater than 100 vehicles per hour[1]) could occur. Figure 1 shows the project location and the three intersections.



Basemap from goakamai.org

Figure 1 – Project Location and Study Intersections

1.3 The proposed P-079 project would construct a new building on a portion of the Makalapa Compound that is currently not developed. The Makalapa Compound is bounded by

[1] The 100 vehicles per hour increase is considered the threshold at which the preparation of traffic impact reports is triggered (reference: Institute of Transportation Engineers, *Transportation Impact Analyses for Site Development.* Washington, D.C., 2005).

Kamehameha Highway on the west, Radford Drive on the south, the H-1 Freeway on the east, and a shopping center and Halawa Stream on the north. Roadways within the compound are interconnected, and two vehicular gates provide access from off-base roadways: to the west, Borchers Gate is located on Makalapa Drive near its intersection with Kamehameha Highway, and to the east, Luapele Gate is located along Luapele Drive near its intersection with Salt Lake Boulevard. The proposed project will also construct a parking lot for approximately 650 cars and an access road connected to existing internal roadways.

The proposed project is anticipated to begin construction in calendar year (CY) 2026 with the goal of consolidating JIOC personnel at the new facility by CY 2032. (Note: The traffic analysis horizon dates are different from the project's currently programmed years due to changes in project schedule.) The new facility will accommodate approximately 1,000 personnel and relieve current overcrowded conditions in the existing spaces within the Makalapa Compound, as well as accommodate approximately 100 personnel currently located in other areas of JBPHH.

Earlier studies for the JIOC project and planning work related to improvements to the entry gates had estimated the traffic impacts of the proposed P-079 project. These estimates[2] are shown in Table 1, for the project itself, and in the longer term, with future reuse of the vacated JIOC spaces.

Table 1 – Projections of Impacts to Peak Hour Traffic Volumes Through Gates with P-079

	P-079 Project (only)				P-079 Project plus reuse of Vacated JIOC Buildings			
	Borchers Gate		Luapele Gate		Borchers Gate		Luapele Gate	
	enter	exit	enter	exit	enter	exit	enter	exit
AM Peak Hour	-104	-26	+173	+40	+76	+10	+173	+40
PM Peak Hour	-24	-117	+36	+187	+9	+67	+36	+187

Source: Julian Ng Inc., *Joint Base Pearl Harbor Hickam Makalapa Compound Traffic Impact Analysis Report,* 2016.

The reuse of vacated JIOC Buildings is expected to only affect traffic volumes at Borchers Gate, adding 180 vehicles per hour (vph) entering (the net result of 76 shown in the table is computed: -104 + 180) and 36 vph exiting in the AM Peak Hour, and 33 vph entering and 184 vph exiting in the PM Peak Hour.

[2] The estimates of traffic due to reuse of the existing JIOC buildings at Makalapa Crater are considered conservative since they are from an early planning stage. Actual traffic impact of the reuse may be less than shown in Table 1, for the following reasons: a) improvements in gate security and other force protection measures that may be implemented by the time of reuse could affect the use of the buildings and the nearby parking lots, b) existing overcrowding and inefficient spaces may be addressed prior to reuse, which may result in lower densities (employees per square foot of floor area), and c) modifications in existing buildings may result in less building areas.

1.4 Existing peak hours were determined from peak period counts taken in October 2017. The one-day samples are assumed to be representative of existing conditions of a typical weekday. Summaries of the count data are in Appendix A.

1.5 Sections 2 through 5 of this report provide the results of traffic analyses of the peak hour traffic at nearby off-base intersections where the proposed project is expected to result in significant volume increases (i.e., where 100 or more added vehicles per hour are expected). Summaries of these analyses are included in Appendix B.

1.6 The traffic analyses were done for existing and future conditions. Future traffic volumes were estimated from existing volumes and project impacts were applied. The estimates conservatively did not include scenarios with lower background growth that could be experienced due to increased remote working practices and utilization of rail transit. The signalized intersection analysis procedure from the *Highway Capacity Manual 2010* was used and the results of the analyses include utilization (volume/capacity ratio), average delay, and Level of Service for each lane group, as well an overall condition for the intersection.

The Levels of Service are based on the average delay per vehicle; peak hour Level of Service D or better for the overall average delay is considered adequate (levels of service for individual lane groups, especially those for minor movements, often will have very long delays due to the long signal cycles that may be needed to either provide overall capacity or to accommodate pedestrian crossings, and these levels of service are reported herein but not used as a trigger for mitigation).

Average Delay (seconds per vehicle)	**General Description of Delay**	**Level of Service (LOS)**
≤ 10	Little or no delay	A
> 10 and ≤ 25	Short traffic delays	B
> 25 and ≤ 35	Average traffic delays	C
> 35 and ≤ 55	Long traffic delays	D
> 55 and ≤ 80	Very long traffic delays	E
> 80	Very long traffic delays	F
from: *Highway Capacity Manual, 2010*		

Level of Service F also describes conditions when traffic volume exceeds capacity.

2.0 Existing Conditions at Nearby Intersections

2.1 The Makalapa Compound of JBPHH is located east of, and separated from the main base by, Kamehameha Highway. The Makalapa Compound is also bound by Halawa Stream and a shopping center to the north, the H-1 Freeway to the east, and Radford Drive to the south. Vehicular access into the Makalapa Compound is through Borchers Gate, located east of the intersection of Kamehameha Highway and Halawa Drive (opposite the Halawa Gate to the main base), and Luapele Gate, which is located west of the intersection of Salt Lake Boulevard and Luapele Drive. Pedestrian access is also available through a locked gate that connects to a footpath leading to a pedestrian overpass of the H-1 Freeway.

2.2 Intersection turning movement counts were taken at three signalized intersections near the gates to the Makalapa Compound: Halawa Drive and Kamehameha Highway, Luapele Drive and Salt Lake Boulevard, and Kahuapaani Street and Salt Lake Boulevard.

The turning movement counts were taken during weekday morning and afternoon peak periods in October 2017; public schools in the area were in normal session and no special activities were scheduled on the days the counts were taken. While some lane closures were observed along Kamehameha Highway, the construction activity did not appear to affect peak period traffic flows. Peak hour volumes at the study intersections are shown in Figures 2 and 3 below, along with overall intersection level of service for the AM and PM Peak Hours.

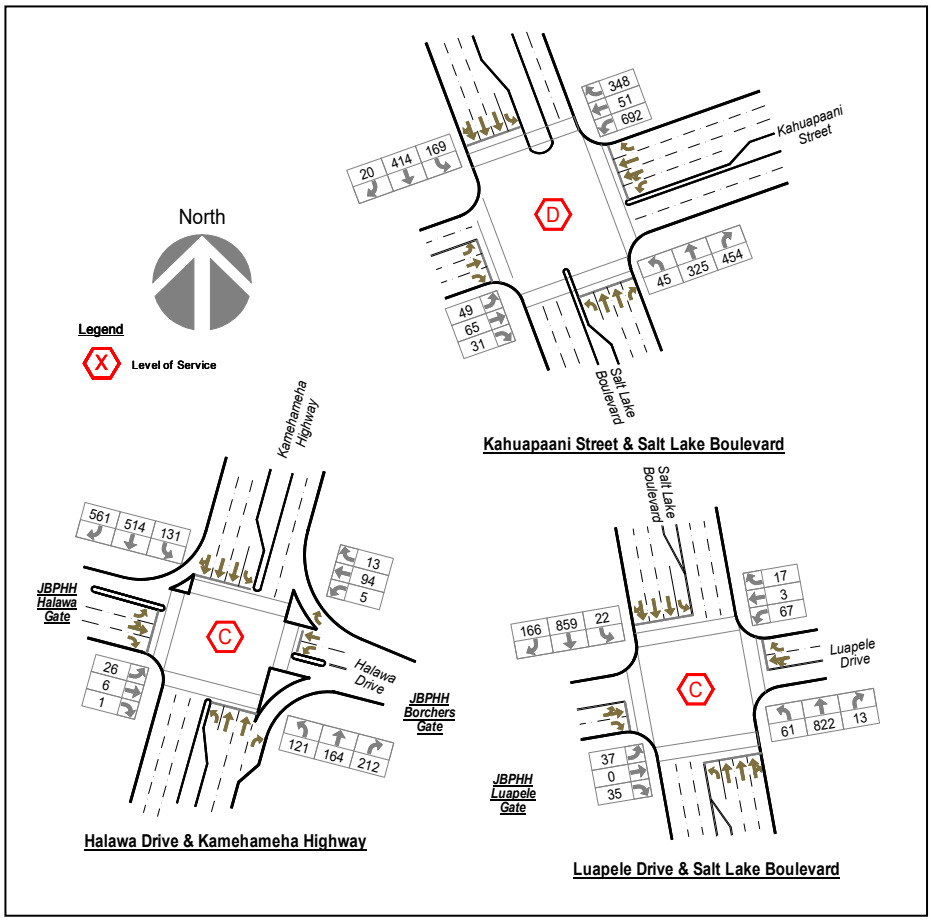


Figure 2 – Existing AM Peak Hour Traffic Volumes

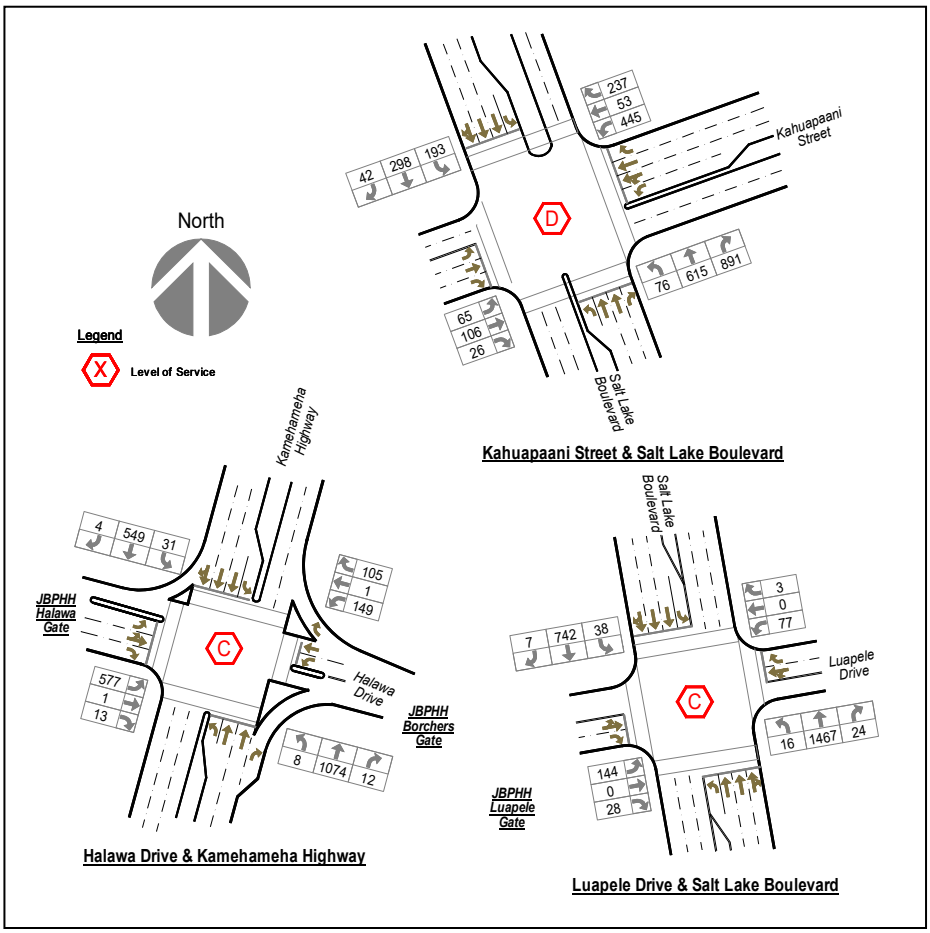


Figure 3 – Existing PM Peak Hour Traffic Volumes

The AM Peak Hour occurred between 0530 and 0630 hours at the intersection of Kamehameha Highway and Halawa Drive, and between 0700 and 0800 hours at the Salt Lake Boulevard intersections. The PM Peak Hour occurred between 1500 and 1600 hours at the intersection of Kamehameha Highway and Halawa Drive, and between 1615 and 1715 hours at the Salt Lake Boulevard intersections.

2.3 At the intersection of Halawa Drive and Kamehameha Highway, the signal operated in five phases. A single signal phase is provided for the Halawa Drive approach from Borchers Gate (westbound) and the Arizona Street approach from the main base's Halawa Gate (eastbound); pedestrians crossing Kamehameha Highway also use this phase. Leading left turn phases are provided for the turns from the highway – northbound to the Halawa Gate entrance and southbound to the Borchers Gate entrance. The opposing through movements on the highway follow the demand-actuated left turn phases. Observed cycle lengths during the peak periods varied from 110 seconds to more than 140 seconds.

The flow of traffic through the intersection was affected by delays at both the Halawa Gate and the Borchers Gate during the AM Peak Hour and at other times during the morning peak period. Queues of entering vehicles often backed onto the through lanes on the highway, but this blockage did not significantly affect the through traffic due to the low utilization of the through lanes. Afternoon conditions during and beyond the PM Peak Hour were affected by the signal phasing and the relative offset of the traffic signal at the intersection of

Kamehameha Highway and Arizona Memorial Drive (located 700 feet north); northbound through traffic on the highway and turns onto the northbound lanes at times could not move even during the appropriate green phase. However, there is sufficient capacity at the Halawa Drive intersection that these delays were not excessive. Table 2 provides a summary of the findings of the analyses of the existing peak hours.

Table 2 – Existing Conditions, Halawa Dr. & Kamehameha Hwy.

Note: Peak hour volumes from October 2017 manual counts	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.81	85.9	F	0.13	59.3	E
Northbound Through/Right	0.26	17.7	C	0.57	16.8	C
Southbound Left Turn	0.70	68.6	E	0.48	78.0	E
Southbound Through/Right	0.56	20.2	C	0.23	12.2	B
Eastbound Through/Left	0.05	30.6	C	0.89	56.2	E
Eastbound Right Turn	0.00	60.0	E	0.04	60.2	E
Westbound Left Turn	0.01	60.0	E	0.33	61.8	E
Westbound Through	0.20	32.8	C	0.04	33.0	C
Overall Intersection	**0.49**	**28.4**	**C**	**0.70**	**29.1**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

2.4 At the intersection of Luapele Drive and Salt Lake Boulevard, the signal operated in five phases. A single signal phase is provided for the Luapele Drive approaches, from Luapele Gate (eastbound) and from the westbound approach that serves the residential area (50± dwellings) across Salt Lake Boulevard; pedestrian crossings of Salt Lake Boulevard (when actuated) are also served during this phase. Leading left turn phases are provided for the turns from Salt Lake Boulevard – northbound toward Luapele Gate and southbound to the residential area. The opposing through movements on Salt Lake Boulevard follow the demand-actuated left turn phases. Observed cycle lengths during the peak periods varied from 50 seconds to more than 140 seconds.

While the eastbound approach is striped only as a single lane, it is wide enough and is used as if it were striped for two lanes, a left turn/through lane and a right turn lane. The east leg of this intersection serves not only the residential area, but includes a roadway linking to the parking lot of the Stadium Mall shopping center; this roadway provides an alternative access to that shopping center, especially for traffic wishing to proceed southbound on Salt Lake Boulevard. The reverse flow can also use a direct connection to Salt Lake Boulevard (right turns only) located between Luapele Drive and Kahuapaani Street.

Some congestion was observed on Salt Lake Boulevard to the south during the morning for approximately 15 minutes near the start of the school day (0740-0755) as queues from the driveways into the nearby schools backed onto the street. However, this congestion did not affect movements at the intersection of Luapele Drive and Salt Lake Boulevard.

In the afternoon, some queuing from the northbound right turn lane to Kahuapaani Street occurred, affecting left turn movements from Luapele Drive onto Salt Lake Boulevard. While

most drivers who wanted to enter that lane waited for the end of the queue to move up, others turned into the adjacent lane and merged into the desired lane between the two intersections. This occurrence was intermittent, due to the varying lengths of the northbound queue that resulted from the different cycle lengths of the signals at the two intersections. Table 3 shows the results of the analyses.

Table 3 – Existing Conditions, Luapele Dr. & Salt Lake Blvd.

Note: Peak hour volumes from October 2017 manual counts	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.50	64.9	E	0.24	63.6	E
Northbound Through/Right	0.29	10.6	B	0.51	15.4	C
Southbound Left Turn	0.36	70.0	E	0.57	85.5	F
Southbound Through/Right	0.39	13.9	B	0.26	12.4	B
Eastbound approach	0.13	35.2	D	0.25	33.3	C
Westbound approach	0.28	38.3	D	0.21	33.4	C
Overall Intersection	**0.39**	**16.4**	**C**	**0.45**	**17.7**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

2.5 At the intersection of Kahuapaani Street and Salt Lake Boulevard, the signal operated in six phases. Separate phases are provided for the westbound Kahuapaani Street approach and the opposing eastbound approach from the shopping center parking lot ("split-phase" operation). Pedestrian crossing of Salt Lake Boulevard (when actuated) is served during the phase in which there is no conflict with left turn traffic. Leading left turn phases are provided for the turns from Salt Lake Boulevard – northbound into the shopping center and southbound to Kahuapaani Street. The opposing through movements on Salt Lake Boulevard follow the demand-actuated left turn phases. Observed cycle lengths during the peak periods varied from 140 seconds to more than 200 seconds. Results of the analyses are shown in Table 4.

Table 4 – Existing Conditions, Kahuapaani St. & Salt Lake Blvd.

Note: Peak hour volumes from October 2017 manual counts	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.81	90.0	F	0.94	112.2	F
Southbound Through/Right	0.45	54.2	D	0.17	28.5	C
Northbound Left Turn	0.43	79.2	E	0.70	98.9	F
Northbound Through	0.75	73.1	E	0.52	40.7	D
Northbound Right Turn	0.73	44.9	D	0.95	47.6	D
Eastbound Left Turn	0.16	50.6	D	0.25	57.3	E
Eastbound Through	0.19	51.0	D	0.37	59.7	E
Eastbound Right Turn	0.10	49.6	D	0.10	54.5	D
Westbound Through/Left	0.39	32.5	C	0.43	50.2	D
Westbound Right Turn	0.57	26.9	C	0.64	47.8	D
Overall Intersection	**0.71**	**47.8**	**D**	**0.94**	**50.6**	**D**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3.0 Future Conditions without Proposed JIOC P-079 Project (Future Baseline)

3.1 Historically, as population and economic activity increase, traffic volumes have increased. While peak hourly volumes are constrained by available capacities in various parts of the transportation system, an evaluation of future baseline (without the traffic due to the subject project) conditions is often useful to determine what improvements may be needed before assessing project impacts. Future baseline traffic assignments[3] to evaluate the direct near-term and long-term cumulative impacts of the proposed project were developed by increasing the counted peak hour volumes by 5% and by 10%, respectively. The evaluations of the cumulative impacts are in Section 5.

3.2 For direct impacts, the projections of future near-term baseline peak hour volumes and the overall levels of service are shown in Figures 4 and 5 below.

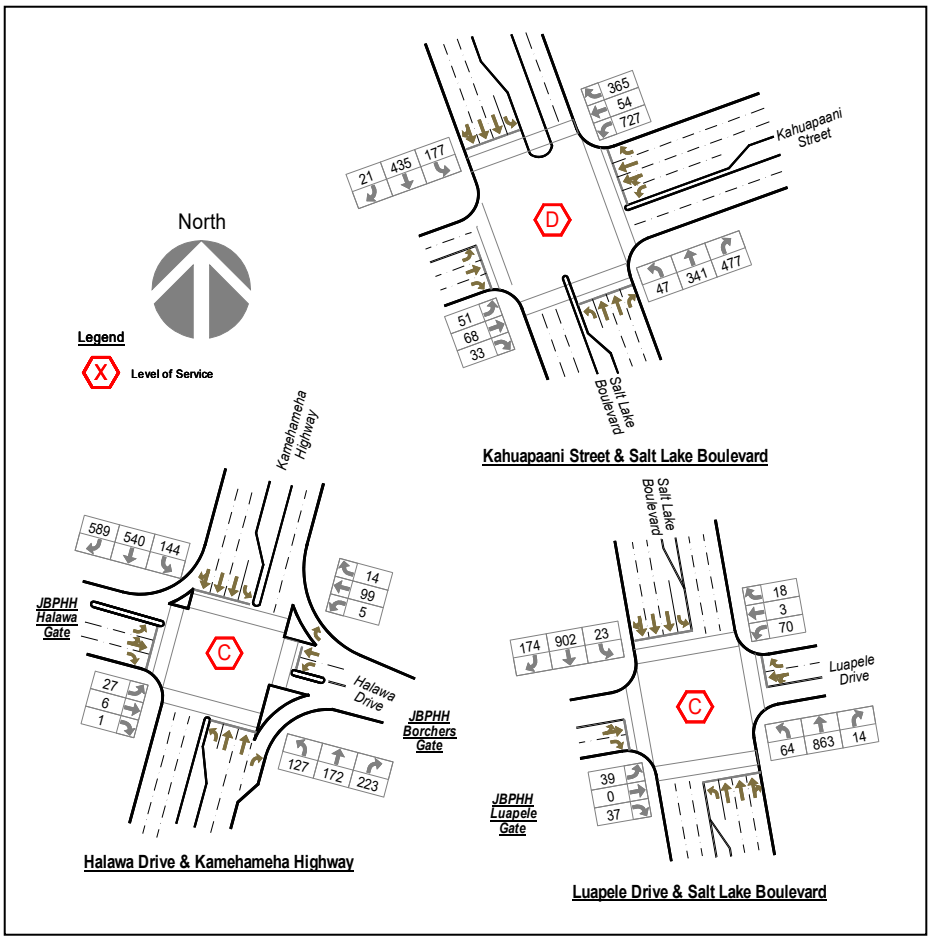


Figure 4 – Future (near-term) Baseline AM Peak Hour Traffic Assignments

[3] A 5% increase would be an average annual increase of 0.33% over 15 years. Similarly, a 10% increase would be an average annual increase of 0.48% over 20 years. While recent transportation planning studies have not focused on peak hour vehicular traffic volumes and do not provide growth rates, these average annual increases would be consistent with the increases that were forecasted in regional transportation studies done prior to the collection of existing data. However, recent changes in traffic patterns due to pandemic-related teleworking and future utilization of rail transit have not been considered in these traffic assignments.

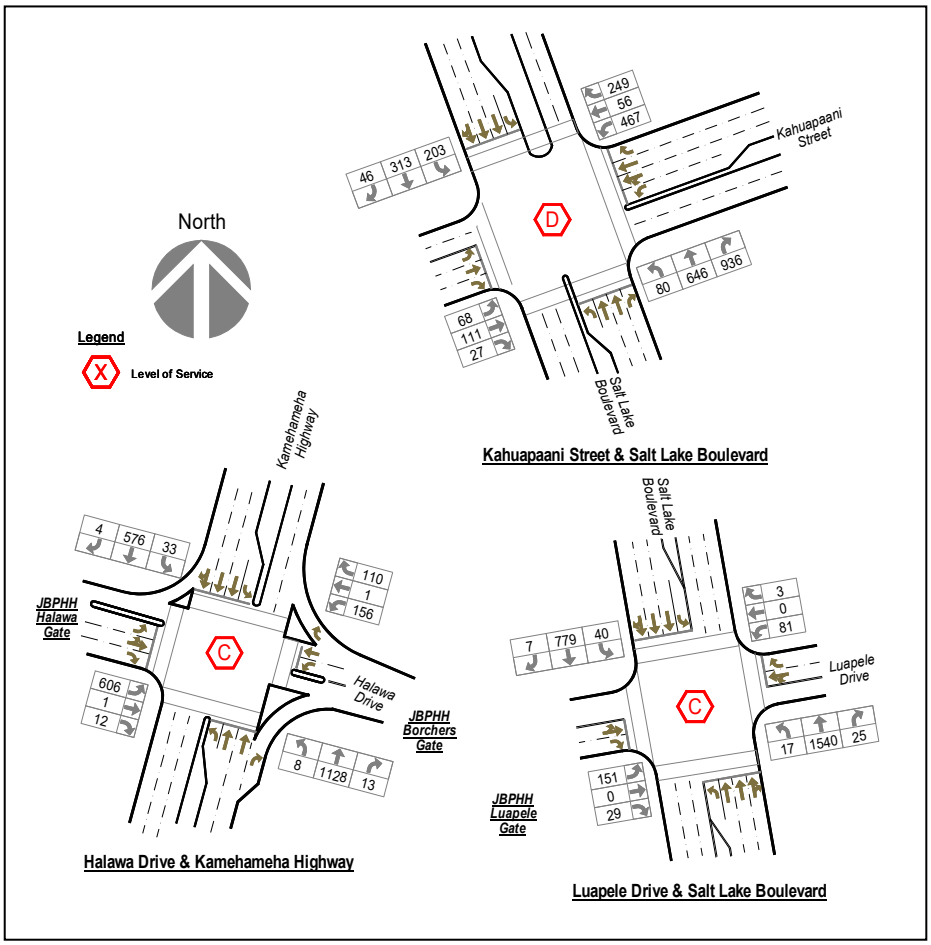


Figure 5 – Future (near-term) Baseline PM Peak Hour Traffic Assignments

3.2 At the intersection of Kamehameha Highway and Halawa Drive, the increased volumes will result in a slight increase in delays. The results of the analyses are shown in Table 5.

Table 5 – Future (near-term) Baseline Conditions, Halawa Dr. & Kamehameha Hwy.

	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.85	92.1	F	0.13	59.3	E
Northbound Through/Right	0.28	17.8	C	0.60	17.4	C
Southbound Left Turn	0.77	74.7	E	0.51	80.4	F
Southbound Through/Right	0.58	20.7	C	0.24	12.3	B
Eastbound Through/Left	0.05	30.6	C	0.93	62.4	E
Eastbound Right Turn	0.00	60.0	E	0.04	60.2	E
Westbound Left Turn	0.01	60.0	E	0.34	61.9	E
Westbound Through	0.21	32.9	C	0.04	33.0	C
Overall Intersection	**0.52**	**29.7**	**C**	**0.73**	**30.9**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3.3 At the intersection of Luapele Drive and Salt Lake Boulevard, the increased volumes will result in a slight increase in delays. The results of the analyses are shown in Table 6.

Table 6 – Future (near-term) Baseline Conditions, Luapele Dr. & Salt Lake Blvd.

	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.52	66.0	E	0.24	63.6	E
Northbound Through/Right	0.31	10.7	B	0.54	15.8	C
Southbound Left Turn	0.38	70.9	E	0.60	88.5	F
Southbound Through/Right	0.41	14.2	B	0.27	12.6	B
Eastbound approach	0.13	35.3	D	0.26	33.5	C
Westbound approach	0.30	38.7	D	0.23	33.6	C
Overall Intersection	**0.41**	**16.6**	**C**	**0.47**	**18.0**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

3.4 The future baseline condition at the Kahuapaani Street and Salt Lake Boulevard intersection will approach capacity even without the project, but overall level of service will still be acceptable. Results of the analyses are shown in Table 7.

Table 7 – Future (near-term) Baseline Conditions – Kahuapaani St. & Salt Lake Blvd.

	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.85	95.5	F	0.98	123.2	F
Southbound Through/Right	0.47	54.6	D	0.18	28.7	C
Northbound Left Turn	0.45	80.1	F	0.73	103.2	F
Northbound Through	0.78	75.5	E	0.55	41.3	D
Northbound Right Turn	0.76	47.0	D	0.99	58.0	E
Eastbound Left Turn	0.17	50.7	D	0.26	57.6	E
Eastbound Through	0.20	51.2	D	0.39	60.1	E
Eastbound Right Turn	0.11	49.7	D	0.10	54.6	D
Westbound Through/Left	0.41	32.9	C	0.45	50.5	D
Westbound Right Turn	0.59	27.8	C	0.67	49.5	D
Overall Intersection	**0.75**	**49.1**	**D**	**0.98**	**54.7**	**D**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

4.0 Impacts of Proposed JIOC P-079 Project to Traffic Conditions at Intersections near Makalapa

4.1 The changes in traffic volumes entering and exiting the Makalapa compound identified in Table 1 were assigned to the nearby intersections using existing traffic patterns as an indicator of trip distribution. Figures 6 and 7 show the traffic assignments for with-project conditions.

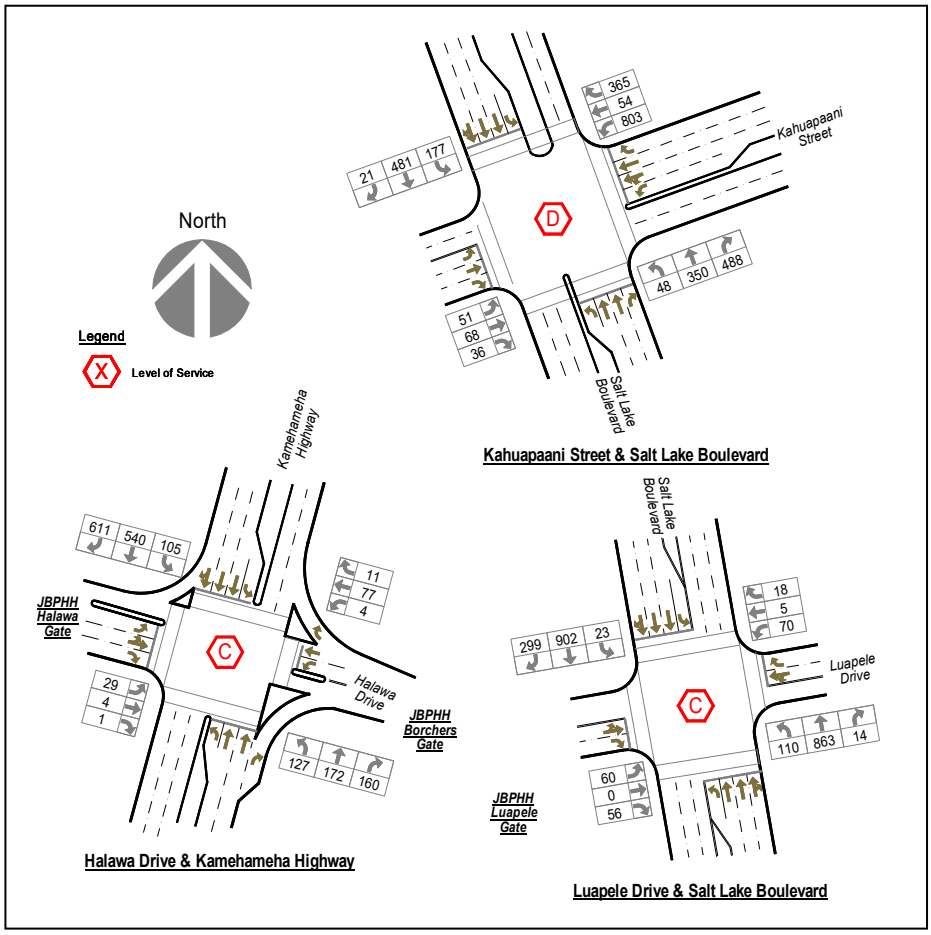


Figure 6 – AM Peak Hour – With-Project Traffic Assignments (near-term)

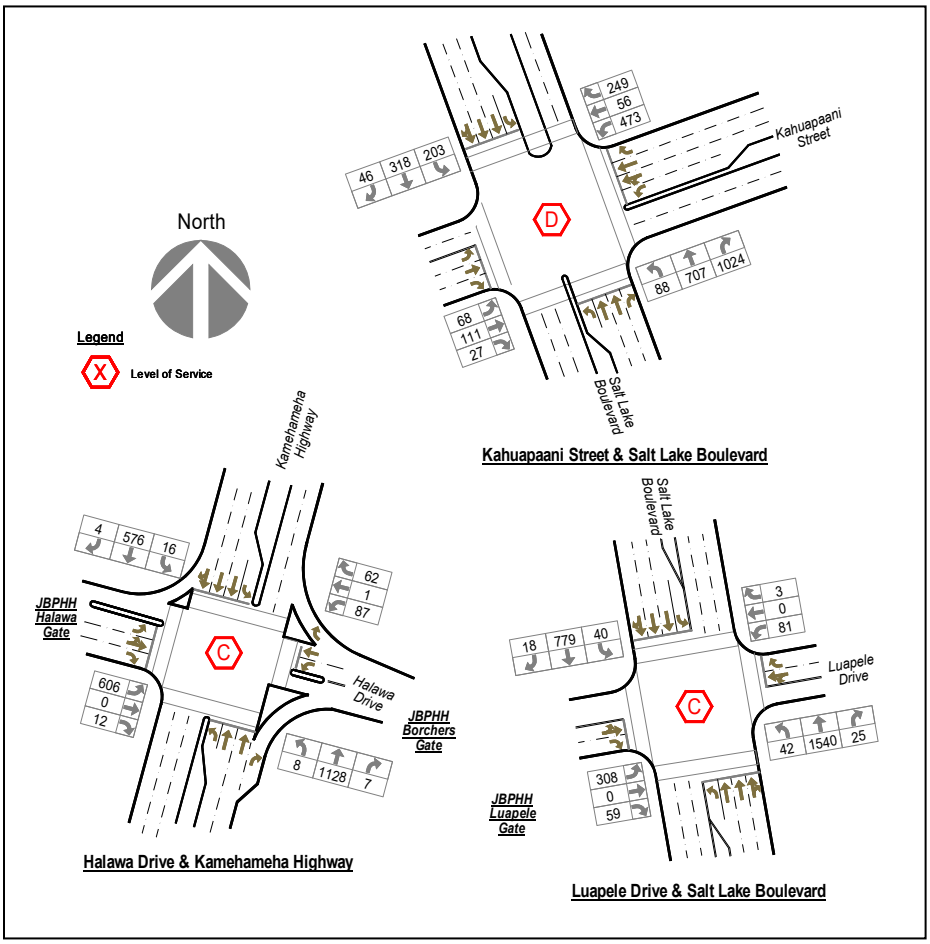


Figure 7 – PM Peak Hour – With-Project Traffic Assignments (near-term)

4.2 At the intersection of Halawa Drive and Kamehameha Highway, the reduction in traffic will improve conditions; results of the analyses are shown in Table 8.

Table 8 – Future with-Project Conditions, Halawa Dr. & Kamehameha Hwy. (near-term)

	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.85	92.1	F	0.13	59.3	E
Northbound Through/Right	0.23	17.3	C	0.60	17.3	C
Southbound Left Turn	0.56	60.1	E	0.25	64.0	E
Southbound Through/Right	0.60	20.9	C	0.24	12.3	B
Eastbound Through/Left	0.05	30.7	C	0.93	62.3	E
Eastbound Right Turn	0.00	60.0	E	0.04	60.2	E
Westbound Left Turn	0.01	60.0	E	0.19	60.9	E
Westbound Through	0.16	32.2	C	0.04	33.0	C
Overall Intersection	**0.51**	**28.2**	**C**	**0.72**	**29.5**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

4.3 At the intersection of Luapele Drive and Salt Lake Boulevard, the increased volumes will result in a slight increase in delays. The results of the analyses are shown in Table 9.

Table 9 – Future With-Project Conditions, Luapele Dr. & Salt Lake Blvd. (near-term)

	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.90	107.3	F	0.62	91.6	F
Northbound Through/Right	0.31	10.7	B	0.54	15.8	C
Southbound Left Turn	0.38	70.9	E	0.60	88.5	F
Southbound Through/Right	0.47	14.9	B	0.27	12.6	B
Eastbound approach	0.21	36.3	D	0.53	38.5	D
Westbound approach	0.32	39.4	D	0.22	33.4	C
Overall Intersection	**0.49**	**20.1**	**C**	**0.56**	**20.4**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

4.4 At the Kahuapaani Street and Salt Lake Boulevard intersection, the added traffic volume in the PM Peak Hour would increase delays in both peak hours and cause over-capacity conditions in the PM Peak Hour, as summarized in Table 10.

Table 10 – Future With-Project Conditions – Kahuapaani St. & Salt Lake Blvd. (near-term)

	AM Peak Hour			PM Peak Hour		
	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.85	95.5	F	0.98	123.2	F
Southbound Through/Right	0.52	55.5	E	0.18	28.7	C
Northbound Left Turn	0.46	80.6	F	0.81	114.7	F
Northbound Through	0.81	77.1	E	0.60	42.6	D
Northbound Right Turn	0.78	48.2	D	1.09	86.6	F
Eastbound Left Turn	0.17	50.7	D	0.26	57.6	E
Eastbound Through	0.20	51.2	D	0.39	60.1	E
Eastbound Right Turn	0.11	49.8	D	0.10	54.6	D
Westbound Through/Left	0.45	33.6	C	0.46	50.6	D
Westbound Right Turn	0.59	27.9	C	0.67	49.5	D
Overall Intersection	**0.75**	**49.6**	**D**	**1.04**	**64.0**	**F**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

The over-capacity condition[4] shown in Table 10 is due to the high volume of right turns projected with the project from northbound Salt Lake Boulevard to eastbound Kahuapaani Street (1,024 vehicles in the PM Peak Hour, of which at most 308, or 30%, could be attributable to Luapele Gate). Since mitigation would be needed before full occupancy of the proposed project if without-project growth reaches volumes assumed in this analysis, only mitigation measures that would have minor secondary impacts are considered herein (i.e., major realignment of the intersection would not be considered).

Several possible mitigation measures[5] were developed but not pursued due to factors such as physical constraints, time needed for implementation, need for right-of-way acquisition and potential for vehicle-pedestrian conflicts. One measure that could provide adequate capacities and acceptable level of service during the PM peak period would involve modification of the signal phasing. This mitigation measure would not require any changes in the roadway layout or designation of lane use, but would require additional signal heads, additional regulatory signing, and possibly an upgrade to the existing signal controller; additional details are in Appendix D. The results of the analyses are shown in Table 11.

Table 11 – Future With-Project Conditions – Kahuapaani St. & Salt Lake Blvd.
(PM Peak Hour – near-term, mitigation with signal phasing modification)

	Existing signal phasing			Modified signal phasing		
	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.98	123.2	F	0.94	109.7	F
Southbound Through/Right	0.18	28.7	C	0.25	40.1	D
Northbound Left Turn	0.81	114.7	F	0.54	76.3	E
Northbound Through	0.60	42.6	D	0.48	31.5	C
Northbound Right Turn	1.09	86.6	F	0.94	39.1	D
Eastbound Left Turn	0.26	57.6	E	0.63	91.8	E
Eastbound Through	0.39	60.1	E	0.93	132.5	F
Eastbound Right Turn	0.10	54.6	D	0.25	71.7	E
Westbound Through/Left	0.46	50.6	D	0.46	50.6	D
Westbound Right Turn	0.67	49.5	D	0.67	48.9	D
Overall Intersection	**1.04**	**64.0**	**F**	**0.90**	**49.8**	**D**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

[4] The analyses used the observed condition that the phase serving the shopping center exit did not always provide the minimum pedestrian crossing time. An average phase duration of 24 seconds of green time instead of 28 seconds was used for this phase. Reduction of the average phase duration to 16 seconds to provide under-capacity conditions with an overall delay of 52.7 seconds (Level of Service D) would be possible with a "NO PEDESTRIAN CROSSING" of the south leg of the intersection. However, because such a restriction would be contrary to recent trends to better serve pedestrian and bicycle travel, it was not used as a possible mitigation measure.

[5] Other mitigation measures considered in an initial screening but not recommended at this time include the following: a) adding a second southbound left turn lane from Salt Lake Boulevard to eastbound Kahuapaani Street - did not decrease delay sufficiently to improve LOS, b) adding a northbound lane to provide for the second right turn lane - would have impacts to upstream driveways and intersections and involve additional rights-of-way to provide appropriate approach geometry, c) creating a pedestrian refuge island - would constrain the ability of buses and other large vehicles to make the right turn from northbound Salt Lake Boulevard, d) converting the second lane on the northbound approach to an option lane for right turn and through traffic - while this alternative could provide acceptable LOS, vehicle-pedestrian conflict would increase.

5.0 Potential Long-Term (20-Year) Impact

5.1 While long-term future volumes would be difficult to forecast due to changes in travel patterns and available modes, evaluation of future peak hour traffic conditions at the three studied intersections were done and results presented in this section. Peak hour conditions without the proposed project for a twenty-year horizon were evaluated with traffic volumes 10% higher than those counted in 2017, and with the addition of project traffic (due to both the relocation of JIOC personnel and the reuse of the buildings currently used by JIOC).

5.2 Existing office space within the Makalapa complex will be vacated as JIOC personnel and functions relocate to the new facility built by the P-079 project. While no definitive use has yet been identified, the Navy has indicated that reuse of these buildings is likely, and that renovations to the interiors will probably take several years to plan and complete. Any traffic impact from this reuse is expected to be at Borchers Gate only, due to the proximity of the buildings to the gate. These impacts (which would be in addition to the impacts of the P-079 project) have been estimated to be increases of 180 vehicles per hour (vph) entering and 36 vph exiting in the AM Peak Hour, and 33 vph entering and 184 vph exiting in the PM Peak Hour. Figures 8 and 9 show Year 2037 peak hour traffic assignments for consideration of the reuse of vacated JIOC buildings, which includes reuse of the vacated buildings and the assumed background growth to that year.

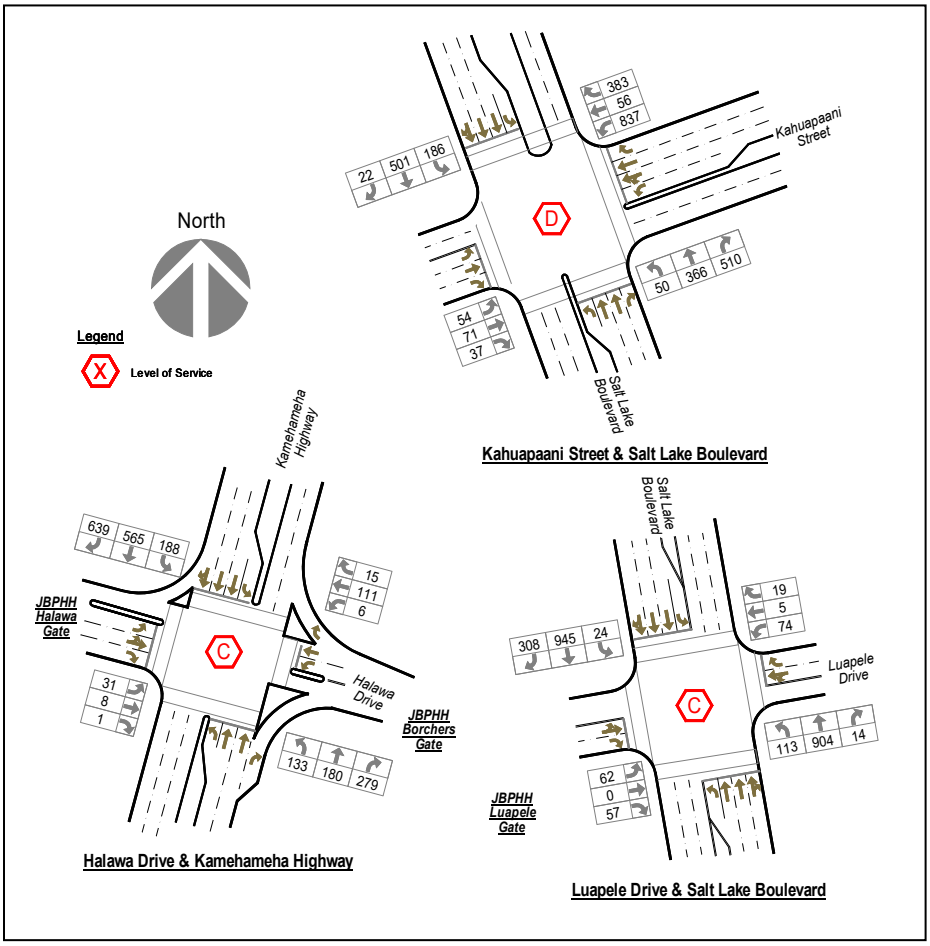


Figure 8 – AM Peak Hour – JIOC Building Reuse Traffic Assignments (long-term)

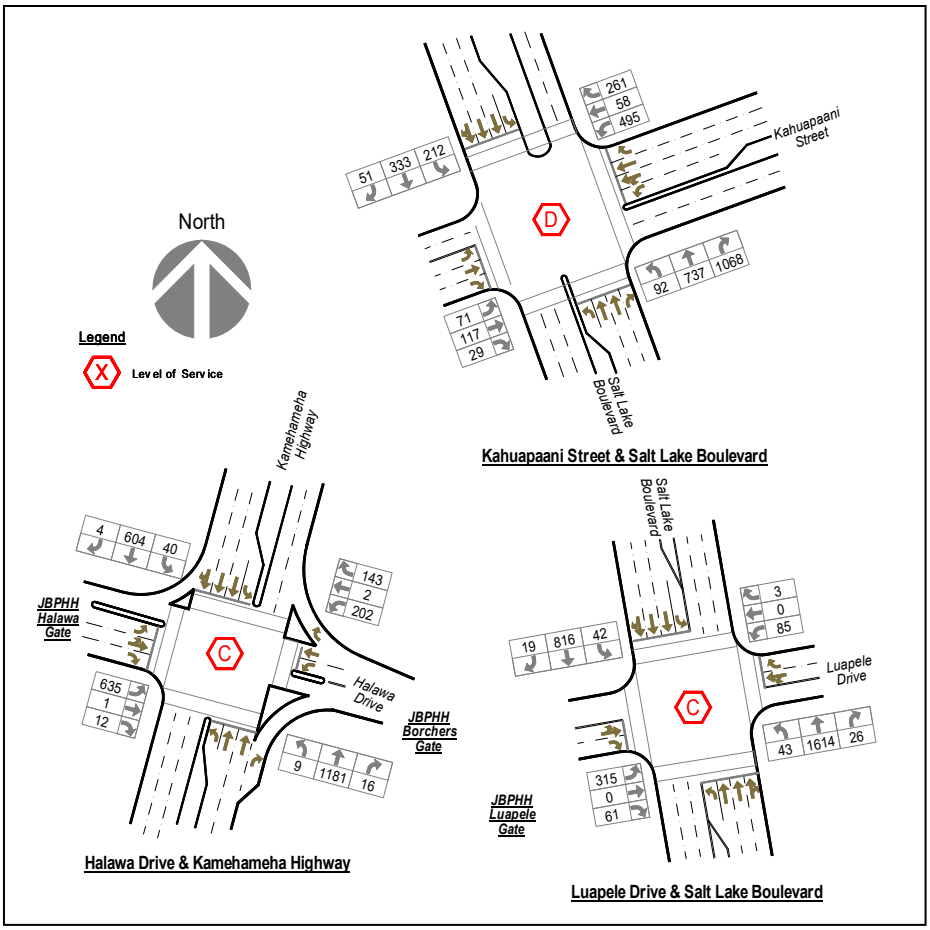


Figure 9 – PM Peak Hour – JIOC Building Reuse Traffic Assignments (long-term)

5.3 At the intersection of Halawa Drive and Kamehameha Highway, the increase in traffic will increase utilization, and increase average delays, but overall level of service will remain at acceptable level; results of the analyses are shown in Tables 12 and 13.

Table 12 – Future AM Peak Hour (long-term) Conditions – JIOC Building Reuse Halawa Dr. & Kamehameha Hwy.

	With P-079			Without P-079		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.89	99.4	F	0.89	99.4	F
Northbound Through/Right	0.33	19.7	C	0.30	19.2	C
Southbound Left Turn	0.89	85.8	F	0.75	69.0	E
Southbound Through/Right	0.62	21.5	C	0.61	21.2	C
Eastbound Through/Left	0.05	30.7	C	0.05	30.7	C
Eastbound Right Turn	0.00	60.0	E	0.00	60.0	E
Westbound Left Turn	0.01	60.1	E	0.01	60.0	E
Westbound Through	0.23	33.4	C	0.22	33.1	C
Overall Intersection	**0.55**	**32.5**	**C**	**0.54**	**30.6**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Table 13 – Future PM Peak Hour (long-term) Conditions – JIOC Building Reuse
Halawa Dr. & Kamehameha Hwy.

	With P-079			Without P-079		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.13	59.3	E	0.13	59.3	E
Northbound Through/Right	0.63	18.0	C	0.63	18.0	C
Southbound Left Turn	0.62	92.0	F	0.52	81.6	F
Southbound Through/Right	0.25	12.4	B	0.25	12.4	B
Eastbound Through/Left	0.97	70.6	E	0.98	70.8	E
Eastbound Right Turn	0.04	60.2	E	0.04	60.2	E
Westbound Left Turn	0.44	62.9	E	0.36	62.1	E
Westbound Through	0.07	36.1	D	0.04	33.0	C
Overall Intersection	**0.77**	**33.9**	**C**	**0.77**	**33.2**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

While overall levels of service in both peak hours would be acceptable, under the long-term conditions, delays and utilization would be greater than existing (Table 2). For the long-term conditions, implementation of measures to mitigate existing problems is recommended prior to reuse of these buildings to minimize the increase in delay. Suggested measures include reconstruction of Borchers Gate to address existing limited capacity, security concerns, and queuing onto the highway.

5.3 At the intersection of Luapele Drive and Salt Lake Boulevard, the increased volumes will result in a slight increase in delays, but levels of service will continue to be acceptable. The results of the analyses are shown in Tables 14 and 15.

Table 14 – Future AM Peak Hour (long-term) Conditions – JIOC Building Reuse
Luapele Dr. & Salt Lake Blvd.

	With P-079			Without P-079		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.92	111.8	F	0.54	67.2	E
Northbound Through/Right	0.32	10.8	B	0.32	10.8	B
Southbound Left Turn	0.39	71.8	E	0.39	71.8	E
Southbound Through/Right	0.49	15.2	C	0.43	14.4	B
Eastbound approach	0.21	36.4	D	0.14	35.4	D
Westbound approach	0.34	39.8	D	0.32	39.2	D
Overall Intersection	**0.51**	**20.4**	**C**	**0.43**	**16.9**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Table 15 – Future PM Peak Hour (long-term) Conditions – JIOC Building Reuse
Luapele Dr. & Salt Lake Blvd.

	With P-079			Without P-079		
	X	Delay	LOS	X	Delay	LOS
Northbound Left Turn	0.62	91.6	F	0.26	64.2	E
Northbound Through/Right	0.56	16.2	C	0.56	16.2	C
Southbound Left Turn	0.62	91.6	F	0.62	91.6	F
Southbound Through/Right	0.29	12.7	B	0.28	12.7	B
Eastbound approach	0.55	38.8	D	0.27	33.7	C
Westbound approach	0.23	33.6	C	0.24	33.8	C
Overall Intersection	**0.59**	**20.7**	**C**	**0.50**	**18.4**	**C**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

5.4 At the Kahuapaani Street and Salt Lake Boulevard intersection, the added traffic volume in the PM Peak Hour would increase delays in both peak hours, but overall levels of service would not change (previously discussed mitigation of PM Peak Hour over-capacity conditions have been assumed to be implemented), as summarized in Tables 16 and 17.

Table 16 – Future AM Peak Hour (long-term) Conditions – JIOC Building Reuse
Kahuapaani St. & Salt Lake Blvd. (Modified Signal Phasing)

	With P-079			Without P-079		
	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.89	102.2	F	0.89	102.2	F
Southbound Through/Right	0.55	56.0	E	0.50	55.0	E
Northbound Left Turn	0.49	82.1	F	0.48	81.6	F
Northbound Through	0.84	80.3	F	0.82	78.3	E
Northbound Right Turn	0.82	50.9	D	0.80	49.5	D
Eastbound Left Turn	0.17	50.8	D	0.17	50.8	D
Eastbound Through	0.21	51.3	D	0.21	51.3	D
Eastbound Right Turn	0.12	49.9	D	0.11	49.7	D
Westbound Through/Left	0.47	34.0	C	0.43	33.2	C
Westbound Right Turn	0.62	28.9	C	0.62	28.9	C
Overall Intersection	**0.79**	**51.2**	**D**	**0.78**	**50.6**	**D**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

Table 17 – Future PM Peak Hour (long-term) Conditions – JIOC Building Reuse
Kahuapaani St. & Salt Lake Blvd. (Modified Signal Phasing)

	With P-079			Without P-079		
	X	Delay	LOS	X	Delay	LOS
Southbound Left Turn	0.98	120.0	F	0.98	120.0	F
Southbound Through/Right	0.26	40.3	D	0.26	40.2	D
Northbound Left Turn	0.57	77.6	E	0.52	75.1	E
Northbound Through	0.50	31.9	C	0.46	31.1	C
Northbound Right Turn	0.99	47.9	D	0.90	32.8	E
Eastbound Left Turn	0.66	95.2	F	0.66	95.2	F
Eastbound Through	0.97	142.0	F	0.97	142.0	F
Eastbound Right Turn	0.26	72.0	E	0.26	72.0	E
Westbound Through/Left	0.48	51.0	D	0.47	50.9	D
Westbound Right Turn	0.70	50.9	D	0.70	50.9	D
Overall Intersection	**0.94**	**53.8**	**D**	**0.89**	**49.7**	**D**

X = utilization (volume/capacity ratio)
Delay = Average delay per vehicle, expressed in seconds
LOS = Level of Service

6.0 Other Factors That May Mitigate Poor Traffic Conditions

6.1 The traffic analyses assumed a continuation of past trends and vehicular usage. Future traffic estimates are based on existing (counted) volumes and expected increases in travel demand (while maintaining past modal choices). The traffic estimates used in the analyses were based on a plan that would relocate 216 personnel from other locations to the new building; current plans would reduce the number of relocated personnel. Another factor is that some personnel may be able to work-from-home. These conditions, along with changes in travel patterns of non-project traffic, could result in peak hour traffic volumes that are less than those used in the analyses. Therefore, the timing and ultimate need for the identified mitigation measures is unclear at this time and should be re-evaluated closer to project occupancy.

6.2 In the course of conducting the traffic study, several questions were raised that could alter the findings (i.e., reduce future traffic volumes or the project's impact to traffic); these are listed below but were not considered in the analyses. (By not taking these factors into account in the analyses of future conditions, any potential project-related impacts and necessary mitigation can be identified.)

6.2.1 An observation was made that many of the younger military personnel do not own private vehicles and trip generation based on employment levels may drop.

6.2.2 The impact of the addition of personnel to the Makalapa Compound and the changes in drivers' gate selection were based on an assumption that the affected personnel would commute during times of the day similar to the pattern of total entries to and exits from the Makalapa Compound. If the affected personnel have working hours that do not coincide with existing peak entry or exit times, traffic impacts during peak hours would be less than those shown in the analyses.

6.2.3 An assumption was made that neither gate would impede traffic flow or have limited capacity. If security issues or other factors constrict flows through the gates, impacts would be different. For example, vehicles exiting Luapele Gate (and proceeding to the Salt Lake Boulevard-Kahuapaani Street intersection) during the PM Peak Hour may choose to depart via Borchers Gate if queuing occurs at the gate due to "ramp metering" should that measure be instituted to control the exiting volume.

6.2.4 Additional information specific to JIOC operations indicate that its personnel commute at times that are not coincident with the existing peak hours. However, since the most critical conditions found occurred in the afternoon, when peak conditions are spread over a period of several hours (i.e., elevated volumes of vehicles over a longer period), preliminary analysis indicates that over capacity conditions would likely still occur at the Salt Lake Boulevard-Kahuapaani Street intersection during a PM Peak Hour that is earlier or later than the existing PM Peak Hour for Makalapa Crater. In other words, detailed analysis of an afternoon peak hour that tracks more closely to JIOC's actual commuting times is not expected to change the results of an analysis of a coincident afternoon peak hour.

6.3 A fixed-rail transit system is being constructed through the study area. Although one benefit of that system is the provision of an alternative mode (to automobile travel), which is hoped to slow down the increase in traffic volumes, its effects on non-project traffic volumes were not

considered because of the unavailability of consistent specific information from the transit agency on their expected effects on traffic.

6.4 With the implementation of a fixed-rail transit system, additional transit use may result as residents and businesses located with ½-mile of the train stations would be more prone to using rail transit, which could reduce peak hour traffic in the area. However, personnel assigned to Makalapa Crater would require a walk of more than ½-mile from the nearest fixed-rail stations, so this increase may not be realized unless enhanced public bus feeder service to the Makalapa Compound or other initiatives to increase ridership (yet to be determined) are provided. Absent specific transit-supportive programs and services (which could result in a 3 to 6 percent decrease in vehicle volumes), transit use by JIOC employees has been assumed to be minimal because existing use is minimal (based on field observations).

7.0 Pedestrian and Bicycle Impacts

7.1 Pedestrian and bicycle facilities are provided at the studied intersections, as described below.

7.1.1 At the intersection of Halawa Drive and Kamehameha Highway, striped crosswalks and pedestrian signals provide for pedestrian crossing of all approaches. Concrete sidewalks are provided on all corners, except the southwest corner, where pedestrians have use of paved (asphalt) shoulders.

While no separate bicycle lanes are designated on Halawa Drive, a striped bicycle lane is provided adjacent to the right shoulder of the northbound lanes of Kamehameha Highway; a striped shoulder with a minimum width of 5 feet exists adjacent to the right lane on the southbound side.

7.1.2 At the intersection of Luapele Drive and Salt Lake Boulevard, striped crosswalks and pedestrian-actuated signals provide for pedestrian crossing of all approaches. Concrete sidewalks are provided on all corners.

No separate bicycle lanes are designated on either Salt Lake Boulevard or on Luapele Drive, and bicycles use either the sidewalk or the lane next to the curb (which is approximately 15 feet wide on Salt Lake Boulevard).

7.1.3 At the intersection of Kahuapaani Street and Salt Lake Boulevard, striped crosswalks and pedestrian-actuated signals provide for pedestrian crossing of all approaches. Concrete sidewalks are provided on all corners, except along the south side of the shopping center access driveway located directly across Kahuapaani Street.

No separate bicycle lanes are designated on either Salt Lake Boulevard or on Luapele Drive, and bicycles use either the sidewalk or the lane next to the curb.

7.2 As part of the manual traffic counts taken for this study in October 2017, pedestrian and bicycle movements at the three intersections were recorded. Table 18 shows the total counted in the four-hour periods.

Table 18 – Pedestrian and Bicycle Use (2017)

	0500 to 0900 hours		1400 to 1800 hours	
	pedestrians	bicycles	pedestrians	bicycles
Kamehameha Highway & Halawa Drive Intersection	26	2	23	7
Salt Lake Boulevard & Luapele Drive Intersection	21	0	61	0
Salt Lake Boulevard & Kahuapaani Street Intersection	22	3	48	6

7.2.1 The highest hourly volumes of pedestrians at the intersection of Kamehameha Highway and Halawa Drive were recorded between 0715 and 0815 hours (10 pedestrians crossing the highway) and between 1500 and 1600 hours (17 pedestrians, 9 crossing Halawa Drive and 8 crossing the highway).

7.2.2 The highest hourly volumes of pedestrians at the intersection of Salt Lake Boulevard and Luapele Drive were recorded between 0715 and 0815 hours (20 pedestrians crossing Luapele Drive from north to south) and between 1400 and 1500 hours (32 pedestrians crossing Luapele Drive - 11 southbound and 21 northbound). Most of the pedestrian traffic was related to the nearby schools.

7.2.3 The highest hourly volumes of pedestrians at the intersection of Salt Lake Boulevard and Kahuapaani Street were recorded between 0715 and 0815 hours (10 pedestrians crossing the shopping center driveway) and between 1445 and 1545 hours (9 pedestrians crossing the shopping center driveway). The highest hourly pedestrian use of the crosswalk across Kahuapaani Street was 8 pedestrians between 1545 and 1645 hours).

7.3 There is no known development in the vicinity of the studied intersections that would be expected to increase pedestrian or bicycle use; however, increased emphasis on walking and bicycling as transportation alternatives could increase pedestrian and bicycle traffic. The increase, however, would need to be a significant (i.e., greater than 50% of existing) for pedestrian volumes to exceed 50 persons per hour at any one intersection. Bicycle volume, which is less than one-third that of pedestrians, would also need to increase by a large proportion of existing for it to be significant.

The completion and use of the fixed-rail transit system is not expected to have significant impacts to pedestrian use of any of the studied intersections due to the walking distances to the nearest stations (more than ½ mile).

7.4 The proposed project is not expected to change pedestrian or bicycle volumes.

7.5 The proposed project will increase vehicular traffic volumes; in the consideration for possible mitigation of adverse impacts to vehicular traffic conditions, existing pedestrian and bicycle accommodations were maintained—and pedestrian crossings enhanced[6] —with the proposed signal phasing modification mitigation.

[6] The possible mitigation measure identified in Section 4.4 would enhance pedestrian crossing by allowing for the minimum crossing times during every phase, and if desired, implementation of leading pedestrian intervals (LPI).

8.0 Conclusions and Recommendations

8.1 Existing conditions for vehicular access to the Makalapa compound of Joint Base Pearl Harbor Hickam were determined from field observations and peak period traffic counts at three signalized intersections near the gates serving the facility. Vehicular access to the compound is provided through Borchers Gate, on Halawa Drive off of Kamehameha Highway, and through Luapele Gate, on Luapele Drive, which intersects with Salt Lake Boulevard near the intersection of Salt Lake Boulevard and Kahuapaani Street. While there are some long delays, conditions at these intersections are generally acceptable.

8.2 Peak hour traffic patterns of vehicles entering and exiting JBPHH Makalapa compound is expected to change in the short term as a result of the P-079 implementation by shifting some traffic from Borchers Gate to Luapele Gate.

8.3 Traffic demands at nearby intersections are expected to change regardless of P-079 implementation. Level of service analyses of peak hour conditions at these intersections have identified future conditions, without and with the additional traffic due to the project.

8.3.1 A decrease in traffic volumes is anticipated at the intersection of Kamehameha Highway and Halawa Drive in the short-term with P-079 as the JIOC personnel would vacate existing buildings at Makalapa and move into their new complex before new tenants occupy their vacated spaces. In the long-term, traffic volumes are expected to return to existing levels as those buildings become reoccupied.

8.3.2 The project is expected to increase traffic volume at the intersection of Salt Lake Boulevard and Luapele Drive but acceptable levels of service would be maintained over both the short and long-term. Nevertheless, striping of the eastbound Luapele Drive approach for two lanes (a left turn/through option lane and a right turn only lane) is recommended to formalize the existing two-lane use of the single, wide lane on that approach, regardless of implementation of P-079.

8.3.3 At the intersection of Salt Lake Boulevard and Kahuapaani Street, AM Peak Hour conditions will continue to be acceptable in the short term; however, the projected increase in traffic volume with P-079 will exceed the capacity of the existing intersection during the PM Peak Hour. A modified signal phasing that includes additional overlap of non-conflicting vehicular and pedestrian movements is shown to produce acceptable results for the projected turning movements, while enhancing pedestrian safety by reducing potential conflicts with vehicular movements. The analysis indicates sufficient capacities for all movements and acceptable overall level of service during the PM Peak Hour. If background growth is lower than the assumed average annual growth due to continuation of pandemic-related teleworking practices, future rail transit use, or other unforeseen factors, the signal phasing modification may not be needed. Therefore, the timing and ultimate need for the identified signal modifications should be confirmed closer to project occupancy.

8.4 In the longer term, reuse of buildings vacated by JIOC have been projected to result in traffic volumes and delay at the intersection of Kamehameha Highway and Halawa Drive reverting to, and exceeding, existing levels. Implementation of measures (e.g., reconstruction of Borchers Gate) to mitigate existing problems concurrent to or prior to reuse of these buildings is recommended to minimize the increase in delay. In addition to security concerns, the mitigation measures should consider the existing lack of queue storage and limited capacity.

8.5 With the mitigation measures discussed above, acceptable conditions were found for peak hour volumes at all three intersections.

Appendix A
Field Count Summaries

Manual Turning Movement Counts
taken
October 2017

three sheets follow:

Kahuapaani Street at Salt Lake Boulevard

Luapele Drive and Salt Lake Boulevard

Arizona Street/Halawa Drive and Kamehameha Highway

Manual Traffic Count, Kahuapaani Street at Salt Lake Boulevard

count taken:		Eastbound (parking lot)			Southbound Salt Lake Boulevard			Northbound Salt Lake Boulevard			Westbound Kahuapaani Street		
Tuesday, October 03, 2017		Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
AM Peak Period counts	5:00 - 5:15	0	8	2	11	29	1	6	14	38	71	1	58
	5:15 - 5:30	3	6	8	21	32	1	5	18	43	92	0	65
	5:30 - 5:45	9	7	6	33	32	5	3	21	63	95	0	73
	5:45 - 6:00	9	8	4	30	46	5	7	26	68	128	0	87
	6:00 - 6:15	4	18	4	27	64	1	4	33	76	104	12	68
	6:15 - 6:30	16	14	5	33	60	5	6	44	106	126	7	93
	6:30 - 6:45	10	20	3	36	61	4	10	27	129	142	10	120
	6:45 - 7:00	7	13	9	31	84	6	6	58	111	140	12	98
	7:00 - 7:15	**9**	**17**	**7**	**33**	**91**	**5**	**14**	**62**	**108**	**176**	**15**	**98**
	7:15 - 7:30	**10**	**15**	**9**	**54**	**104**	**9**	**10**	**83**	**135**	**161**	**9**	**85**
	7:30 - 7:45	**18**	**16**	**6**	**50**	**136**	**4**	**11**	**93**	**102**	**176**	**13**	**87**
	7:45 - 8:00	**12**	**17**	**9**	**32**	**83**	**2**	**10**	**87**	**109**	**179**	**14**	**78**
	8:00 - 8:15	13	9	7	29	61	9	17	74	94	113	15	76
	8:15 - 8:30	18	12	4	28	52	6	8	67	76	108	13	72
	8:30 - 8:45	8	11	4	40	56	4	7	65	86	90	12	70
	8:45 - 9:00	11	14	3	30	48	5	16	60	88	96	11	53
PM Peak Period counts	14:00 - 14:15	10	21	3	41	78	11	13	78	119	69	9	45
	14:15 - 14:30	10	26	2	55	64	8	20	101	132	88	10	60
	14:30 - 14:45	9	29	5	51	82	7	20	97	168	92	15	54
	14:45 - 15:00	12	25	7	57	71	6	15	88	213	111	22	65
	15:00 - 15:15	20	19	8	69	65	8	12	92	199	121	20	58
	15:15 - 15:30	17	25	2	86	62	5	18	110	240	100	15	60
	15:30 - 15:45	15	28	7	64	54	4	19	131	230	105	15	54
	15:45 - 16:00	17	25	2	49	72	8	9	155	220	108	18	36
	16:00 - 16:15	16	15	9	44	80	10	21	141	199	102	17	45
	16:15 - 16:30	**11**	**19**	**5**	**64**	**82**	**12**	**14**	**164**	**216**	**93**	**15**	**60**
	16:30 - 16:45	**15**	**34**	**8**	**37**	**62**	**11**	**17**	**149**	**206**	**135**	**14**	**54**
	16:45 - 17:00	**15**	**38**	**7**	**37**	**75**	**10**	**23**	**144**	**235**	**105**	**11**	**65**
	17:00 - 17:15	**24**	**15**	**6**	**55**	**79**	**9**	**22**	**158**	**234**	**112**	**13**	**58**
	17:15 - 17:30	19	25	6	48	44	13	32	149	204	87	16	60
	17:30 - 17:45	19	29	3	49	56	8	25	124	160	81	14	54
	17:45 - 18:00	9	19	8	41	57	4	24	122	154	87	22	36

Count Totals (T=2.4%)

(AM) 5:00 - 9:00	157	205	90	518	1039	72	140	832	1432	1997	144	1281
(PM) 14:00 - 18:00	238	392	88	847	1083	134	304	2003	3129	1596	246	864
	395	**597**	**178**	**1365**	**2122**	**206**	**444**	**2835**	**4561**	**3593**	**390**	**2145**
approach total (18831)	**1170**			**3693**			**7840**			**6128**		
departures	***1040***			***5375***			***5893***			***6523***		

AM Peak Hour (T=3.5%, PH=0.94)

7:00 - 8:00	**49**	**65**	**31**	**169**	**414**	**20**	**45**	**325**	**454**	**692**	**51**	**348**
approach total (2663)	**145**			**603**			**824**			**1091**		
departures	***116***			***722***			***1137***			***688***		

PM Peak Hour (T=1.7%, PH=0.97)

16:15 - 17:15	**65**	**106**	**26**	**193**	**298**	**42**	**76**	**615**	**891**	**445**	**53**	**237**
approach total (3047)	**197**			**533**			**1582**			**735**		
departures	***171***			***917***			***769***			***1190***		

Manual Traffic Count, Luapele Drive and Salt Lake Boulevard

count taken:		Eastbound Luapele Drive			Southbound Salt Lake Boulevard			Northbound Salt Lake Boulevard			Westbound Luapele Drive		
Thursday, October 26, 2017		Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
AM Peak Period counts	5:00 - 5:15	3	0	0	1	67	9	2	48	2	0	0	5
	5:15 - 5:30	1	0	0	5	87	24	1	68	0	0	0	4
	5:30 - 5:45	0	0	2	0	103	12	4	84	0	0	2	7
	5:45 - 6:00	2	0	1	3	128	46	6	92	0	0	3	7
	6:00 - 6:15	4	0	0	3	131	36	12	96	2	10	0	6
	6:15 - 6:30	4	0	1	4	127	49	16	111	1	7	2	4
	6:30 - 6:45	9	0	4	1	146	38	8	133	0	18	2	11
	6:45 - 7:00	4	0	5	2	170	50	14	155	1	9	0	5
	7:00 - 7:15	**13**	**0**	**9**	**3**	**182**	**63**	**15**	**198**	**4**	**19**	**0**	**3**
	7:15 - 7:30	**7**	**0**	**6**	**5**	**216**	**40**	**13**	**184**	**3**	**16**	**0**	**5**
	7:30 - 7:45	**9**	**0**	**12**	**6**	**249**	**27**	**18**	**242**	**1**	**22**	**1**	**6**
	7:45 - 8:00	**8**	**0**	**8**	**8**	**212**	**36**	**15**	**198**	**5**	**10**	**2**	**3**
	8:00 - 8:15	5	0	8	5	145	26	3	161	4	10	0	2
	8:15 - 8:30	5	0	2	4	113	21	5	128	8	7	0	3
	8:30 - 8:45	3	0	5	7	140	9	1	142	4	6	1	6
	8:45 - 9:00	7	0	3	6	126	10	3	166	7	7	0	9
PM Peak Period counts	14:00 - 14:15	19	2	5	8	154	4	3	189	2	16	0	4
	14:15 - 14:30	17	0	7	10	191	0	3	252	0	10	0	2
	14:30 - 14:45	31	0	9	9	151	1	5	275	1	12	0	10
	14:45 - 15:00	14	0	5	11	165	6	4	241	8	14	1	4
	15:00 - 15:15	55	0	14	10	166	8	4	268	2	16	0	2
	15:15 - 15:30	19	0	10	8	180	5	5	305	10	15	0	4
	15:30 - 15:45	53	0	18	10	161	3	3	318	7	18	0	3
	15:45 - 16:00	46	0	13	15	188	3	5	306	8	13	0	1
	16:00 - 16:15	50	0	10	4	199	2	3	323	7	13	1	2
	16:15 - 16:30	**34**	**0**	**10**	**9**	**170**	**6**	**4**	**355**	**5**	**16**	**0**	**1**
	16:30 - 16:45	**49**	**0**	**5**	**14**	**175**	**0**	**3**	**331**	**16**	**16**	**0**	**0**
	16:45 - 17:00	**21**	**0**	**6**	**5**	**200**	**1**	**5**	**399**	**3**	**24**	**0**	**0**
	17:00 - 17:15	**40**	**0**	**7**	**10**	**197**	**0**	**4**	**382**	**0**	**21**	**0**	**2**
	17:15 - 17:30	28	0	8	5	155	2	1	378	6	17	0	3
	17:30 - 17:45	7	0	2	8	176	2	3	375	0	11	0	2
	17:45 - 18:00	3	0	1	9	151	1	4	311	4	28	0	3

Count Totals (T=1.9%)

(AM)	5:00 - 9:00	84	0	66	63	2342	496	136	2206	42	141	13	86
(PM)	14:00 - 18:00	486	2	130	145	2779	44	59	5008	79	260	2	43
		570	**2**	**196**	**208**	**5121**	**540**	**195**	**7214**	**121**	**401**	**15**	**129**
approach total (14712)		**768**			**5869**			**7530**			**545**		
departures		***750***			***7913***			***5718***			***331***		

AM Peak Hour (T=3.2%, PH=0.89)

7:00 - 8:00	**37**	**0**	**35**	**22**	**859**	**166**	**61**	**822**	**13**	**67**	**3**	**17**
approach total (2102)	**72**			**1047**			**896**			**87**		
departures	***230***			***876***			***961***			***35***		

PM Peak Hour (T=1.1%, PH=0.96)

16:15 - 17:15	**144**	**0**	**28**	**38**	**742**	**7**	**16**	**1467**	**24**	**77**	**0**	**3**
approach total (2546)	**172**			**787**			**1507**			**80**		
departures	***23***			***1614***			***847***			***62***		

Manual Traffic Count, Arizona Street/Halawa Drive and Kamehameha Highway

count taken:		Eastbound Arizona Street			Southbound Kamehameha Hwy.			Northbound Kamehameha Hwy.			Westbound Halawa Drive		
Thursday, October 26, 2017		Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn	Left Turn	Through	Right Turn
AM Peak Period counts	5:00 - 5:15	7	0	0	12	89	170	2	18	19	6	0	3
	5:15 - 5:30	6	2	0	23	104	173	18	29	35	3	10	3
	5:30 - 5:45	**7**	**1**	**0**	**26**	**108**	**152**	**28**	**33**	**38**	**2**	**13**	**4**
	5:45 - 6:00	**5**	**4**	**0**	**49**	**161**	**121**	**39**	**32**	**70**	**0**	**31**	**2**
	6:00 - 6:15	**6**	**0**	**0**	**40**	**139**	**140**	**19**	**40**	**58**	**1**	**35**	**5**
	6:15 - 6:30	**8**	**1**	**1**	**16**	**106**	**148**	**35**	**59**	**46**	**2**	**15**	**2**
	6:30 - 6:45	14	1	0	22	86	143	23	57	40	9	5	4
	6:45 - 7:00	16	1	1	25	119	119	11	84	51	8	2	4
	7:00 - 7:15	21	0	2	24	101	83	9	112	45	10	2	11
	7:15 - 7:30	6	2	0	28	101	69	7	149	61	15	9	8
	7:30 - 7:45	19	6	1	19	127	53	6	113	39	16	6	9
	7:45 - 8:00	12	8	0	27	96	61	10	122	44	11	4	5
	8:00 - 8:15	13	3	2	20	92	17	11	125	33	9	0	8
	8:15 - 8:30	28	2	2	12	104	15	7	85	32	20	1	9
	8:30 - 8:45	20	5	13	16	102	14	8	104	38	14	0	3
	8:45 - 9:00	14	2	2	9	96	6	5	96	23	12	0	8
PM Peak Period counts	14:00 - 14:15	37	0	7	12	146	4	7	96	7	37	0	30
	14:15 - 14:30	46	0	5	15	149	3	1	155	12	18	0	15
	14:30 - 14:45	133	0	5	9	153	0	5	159	10	40	1	23
	14:45 - 15:00	105	0	2	11	142	3	0	162	10	27	0	16
	15:00 - 15:15	**213**	**0**	**3**	**11**	**140**	**0**	**0**	**192**	**7**	**42**	**0**	**40**
	15:15 - 15:30	**150**	**0**	**3**	**8**	**152**	**2**	**3**	**298**	**2**	**34**	**0**	**16**
	15:30 - 15:45	**132**	**1**	**6**	**9**	**138**	**2**	**1**	**291**	**2**	**41**	**1**	**34**
	15:45 - 16:00	**82**	**0**	**1**	**3**	**119**	**0**	**4**	**293**	**1**	**32**	**0**	**15**
	16:00 - 16:15	93	2	1	4	157	1	4	274	2	45	0	22
	16:15 - 16:30	89	0	3	3	146	0	1	262	2	28	2	21
	16:30 - 16:45	56	1	3	7	122	1	3	322	1	36	0	14
	16:45 - 17:00	66	2	4	8	110	1	3	310	10	21	0	16
	17:00 - 17:15	37	1	8	5	95	2	0	350	3	27	0	15
	17:15 - 17:30	39	3	1	4	100	0	0	311	7	27	0	19
	17:30 - 17:45	0	0	0	9	66	0	0	278	5	27	0	25
	17:45 - 18:00	1	0	1	2	95	0	3	253	7	13	2	32

Count Totals (T=3.6%)

5:00 - 9:00	202	38	24	368	1731	1484	238	1258	672	138	133	88
14:00 - 18:00	1279	10	53	120	2030	19	35	4006	88	495	6	353
	1481	**48**	**77**	**488**	**3761**	**1503**	**273**	**5264**	**760**	**633**	**139**	**441**
approach total (14868)	**1606**			**5752**			**6297**			**1213**		
departures	***1915***			***7186***			***4471***			***1296***		

AM Peak Hour (T=2.6%, PH=0.90)

5:30 - 6:30	**26**	**6**	**1**	**131**	**514**	**561**	**121**	**164**	**212**	**5**	**94**	**13**
approach total (1848)	**33**			**1206**			**497**			**112**		
departures	***776***			***203***			***520***			***349***		

PM Peak Hour (T=2.7%, PH=0.94)

15:00 - 16:00	**577**	**1**	**13**	**31**	**549**	**4**	**8**	**1074**	**12**	**149**	**1**	**105**
approach total (2524)	**591**			**584**			**1094**			**255**		
departures	***13***			***1756***			***711***			***44***		

Appendix B
Intersection Analyses Worksheets
Existing Conditions

10 sheets follow:

Arizona Street/Halawa Drive and Kamehameha Highway (4)
Luapele Drive and Salt Lake Boulevard (4)
Kahuapaani Street at Salt Lake Boulevard (2)

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*December 13, 2017*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*2017 baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	121	164	212	131	514	561	26	6	1	5	94	13
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*12.0*	*60.0*		*15.0*	*63.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2017 baselineAM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*121*	*164*	*212*	*131*	*514*	*561*	*26*	*6*	*1*	*5*	*94*	*13*
Peak-hour factor, PHF		*0.90*	*0.90*		*0.90*	*0.90*		*0.90*			*0.90*	
Adjusted flow rate, v_p = V/PHF (veh/h)	*134*	*182*	*236*	*146*	*571*	*623*	*29*	*7*	*1*	*6*	*104*	*14*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*134*	*418*		*146*	*1194*			*36*	*1*	*6*	*104*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.321*	-	*0.565*	*0.122*	-	*0.522*	*0.806*	-				*0.135*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.785*	*0.785*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.915*		*1.000*	*0.922*			*1.000*	*1.000*	*1.000*	*0.982*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*0.999*	*0.999*		*0.999*	*0.999*			*0.988*	*0.988*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1659*	*3174*		*1658*	*4093*			*2719*	*1288*	*1660*	*1811*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2017 baselineAM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_0 (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*29*	*6*
Proportion of LT volume in LT lane group, P_{LT}			*0.806*	*0.000*
Proportion of LT volume in opposing flow, P_{LTO}			*0.000*	*0.806*
Adjusted flow rate for opposing approach, v_0 (veh/h)			*104*	*36*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*0.967*	*0.200*
Opposing flow per lane, per cycle, $v_{ok} = v_0C/3600$ (veh/C/ln)			*3.467*	*1.200*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*10.082*	*20.607*
Opposing queue ratio, $qr_0 = \max[1 - R_{po}(g_u/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{ok}^{0.762} qr_0^{1.061} - t_L$			*3.841*	*-1.061*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*24.918*	*14.393*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*0*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.194*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.4*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.103*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*0*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.785*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2017 baselineAM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	60.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	40	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \le 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \le 5000$)	*0.020*	*0.019*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \ge g_p$ then $f_{Lpb} = 1.0$	*0.188*	*0.127*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.018*	*0.018*	*0.028*	*0.030*
Opposing flow rate,[3] v_0 (veh/h)	1194	418	104	36
$OCC_r = OCC_{pedu}[e^{(15/3600)v_0}]$	*0.003*	*0.010*	*0.025*	*0.029*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.990*	*0.985*	*0.983*
Proportion of left turns,[5] P_{LT}	*0.321*	*0.122*	*0.806*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*0.999*	*0.999*	*0.988*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	60.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	40	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \le 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \le 5000$)	*0.020*	*0.019*	*0.034*	*0.034*
Effective green,[1] g (s)	60.0	63.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	40	38	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.035*	*0.034*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.054*	*0.053*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.946*	*0.968*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.565*	*0.522*	*0.000*	*0.135*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2017 baselineAM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	134	418		146	1194			36	1	6	104	
Saturation flow rate, s (veh/h)	1659	3174		1658	4093			2719	1288	1660	1811	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	12.0	60.0		15.0	63.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.1	0.5		0.125	0.525			0.2917	0.2917	0.2917	0.2917	
Lane group capacity,[1] c = s(g/C), (veh/h)	166	1,587		207	2,149			793	376	484	528	
v/c ratio, X	0.8077	0.2634		0.7044	0.5556			0.0454	0.0027	0.0124	0.1969	
Flow ratio, v/s	0.081	0.132		0.088	0.292			0.013	0.001	0.004	0.057	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.430											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.49**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*134*	*418*		*146*	*1194*			*36*	*1*	*6*	*104*	
Lane Group Capacity,[2] c (veh/h)	*166*	*1587*		*207*	*2149*			*793*	*376*	*484*	*528*	
v/c ratio[2], X = v/c	***0.808***	***0.263***		***0.704***	***0.556***			***0.045***	***0.003***	***0.012***	***0.197***	
Total green ratio,[2] g/C	*0.100*	*0.500*		*0.125*	*0.525*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*52.87*	*17.28*		*50.37*	*19.11*			*30.51*	*60.00*	*60.00*	*31.94*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*32.99*	*0.41*		*18.20*	*1.04*			*0.11*	*0.01*	*0.05*	*0.83*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***85.9***	***17.7***		***68.6***	***20.2***			***30.6***	***60.0***	***60.0***	***32.8***	
LOS by lane group (Exhibit 16-2)	***F***	***C***		***E***	***C***			***C***	***E***	***E***	***C***	
Intersection delay, $d_1 = \dfrac{\Sigma(d_n)(v_n)}{\Sigma v_A}$ (s/veh)	***28.4***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*December 13, 2017*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*2017 baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	8	1074	12	31	549	4	577	1	13	149	1	105
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2017 baselinePM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*8*	*1074*	*12*	*31*	*549*	*4*	*577*	*1*	*13*	*149*	*1*	*105*
Peak-hour factor, PHF		*0.94*	*0.94*		*0.94*	*0.94*		*0.94*			*0.94*	
Adjusted flow rate, v_p = V/PHF (veh/h)	*9*	*1143*	*13*	*33*	*584*	*4*	*614*	*1*	*14*	*159*	*1*	*112*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*9*	*1156*		*33*	*588*			*615*	*14*	*159*	*1*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.008*	-	*0.011*	*0.056*	-	*0.007*	*0.998*	-				*#####*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.690*	*0.690*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.999*			*1.000*	*1.000*	*1.000*	*0.050*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.983*	*0.983*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*3464*		*1660*	*4441*			*2377*	*1126*	*1660*	*92*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2017 baselinePM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*614*	*159*
Proportion of LT volume in LT lane group, P_{LT}			*0.998*	*0.000*
Proportion of LT volume in opposing flow, P_{LTo}			*0.000*	*0.998*
Adjusted flow rate for opposing approach, v_o (veh/h)			*1*	*615*
Lost time for LT lane group, t_L			*5*	*5*

Computation

LT volume per cycle, LTC = $v_{LT}C/3600$			*20.467*	*5.300*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*0.033*	*20.500*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*-4.888*	*-1.995*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*-4.743*	*29.249*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*39.743*	*5.751*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*31*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.002*
E_{L1} (refer to Exhibit C16-3)			*1.4*	*2.6*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.114*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*31*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.690*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2017 baselinePM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.016*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_0 (veh/h)	588	1156	1	615
$OCC_r = OCC_{pedu}[e^{(5/3600)v_0}]$	*0.007*	*0.003*	*0.028*	*0.013*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.996*	*0.997*	*0.983*	*0.992*
Proportion of left turns,[5] P_{LT}	*0.008*	*0.056*	*0.998*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.983*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Effective green,[2] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.049*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.951*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.011*	*0.007*	*0.000*	*0.000*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2017 baselinePM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	9	1156		33	588			615	14	159	1	
Saturation flow rate, s (veh/h)	1660	3464		1660	4441			2377	1126	1660	92	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	5.0	70.0		5.0	70.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.0417	0.5833		0.0417	0.5833			0.2917	0.2917	0.2917	0.2917	
Lane group capacity,[1] c = s(g/C), (veh/h)	69	2,021		69	2,591			693	328	484	27	
v/c ratio, X	0.1301	0.5721		0.4771	0.227			0.8871	0.0426	0.3284	0.0372	
Flow ratio, v/s	0.005	0.334		0.020	0.132			0.259	0.012	0.096	0.011	
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c; $Yc = \Sigma$ (critical lane groups, v/s)	0.612											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.70**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*9*	*1156*		*33*	*588*			*615*	*14*	*159*	*1*	
Lane Group Capacity,[2] c (veh/h)	*69*	*2021*		*69*	*2591*			*693*	*328*	*484*	*27*	
v/c ratio[2], X = v/c	***0.130***	***0.572***		***0.477***	***0.227***			***0.887***	***0.043***	***0.328***	***0.037***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.40*	*15.63*		*56.22*	*12.01*			*40.61*	*60.00*	*60.00*	*30.43*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*3.85*	*1.18*		*21.74*	*0.20*			*15.60*	*0.24*	*1.81*	*2.57*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***59.3***	***16.8***		***78.0***	***12.2***			***56.2***	***60.2***	***61.8***	***33.0***	
LOS by lane group (Exhibit 16-2)	***E***	***C***		***E***	***B***			***E***	***E***	***E***	***C***	
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***29.1***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*December 13, 2017*	Jurisdiction	*CCH DTS*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*2017 baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	61	822	13	22	859	166	37	0	35	67	3	17
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*10.0*	*75.0*		*5.0*	*70.0*			*30.0*			*30.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2017 baselineAM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*61*	*822*	*13*	*22*	*859*	*166*	*37*	*0*	*35*	*67*	*3*	*17*
Peak-hour factor, PHF		*0.89*	*0.89*		*0.89*	*0.89*		*0.89*			*0.89*	
Adjusted flow rate, v_p = V/PHF (veh/h)	*69*	*924*	*15*	*25*	*965*	*187*	*42*	*0*	*39*	*75*	*3*	*19*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*69*	*939*		*25*	*1152*			*81*			*97*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.073*	-	*0.016*	*0.022*	-	*0.162*	*0.519*	-	*0.481*	*0.773*	-	*0.196*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*			*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a ***(0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.824*			*0.742*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.976*			*0.928*			*0.974*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.991*			*0.986*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.975*			*0.990*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5118*		*1660*	*5005*			*2590*			*1387*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2017 baselineAM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*30.0*	*30.0*
Effective permitted green time for LT lane group,[1] g (s)			*30.0*	*30.0*
Opposing effective green time, g_o (s)			*30.0*	*30.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*42*	*75*
Proportion of LT volume in LT lane group, P_{LT}			*0.519*	*0.773*
Proportion of LT volume in opposing flow, P_{LTo}			*0.773*	*0.519*
Adjusted flow rate for opposing approach, v_o (veh/h)			*97*	*81*
Lost time for LT lane group, t_L			*5*	*5*

Computation

LT volume per cycle, LTC = $v_{LT}C/3600$			*1.400*	*2.500*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*3.233*	*2.700*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*5.366*	*1.494*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.750*	*0.750*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*3.908*	*2.765*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*24.634*	*27.235*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*1*
$P_{THo} = 1 - P_{LTo}$			*0.227*	*0.481*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.5*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.2*
$f_{min} = 2(1 + P_{LT})/g$			*0.101*	*0.118*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*1*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \le f_m \le 1.00)$			*0.824*	*0.742*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2017 baselineAM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.151*	*0.115*	*0.407*	*0.278*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.015*	*0.016*	*0.032*	*0.034*
Opposing flow rate,[3] v_o (veh/h)	1152	939	97	81
$OCC_r = OCC_{pedu}[e^{-(5/3600)v_o}]$	*0.003*	*0.004*	*0.028*	*0.031*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.996*	*0.983*	*0.982*
Proportion of left turns,[5] P_{LT}	*0.073*	*0.022*	*0.519*	*0.773*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.991*	*0.986*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Effective green,[1] g (s)	75.0	70.0	30.0	30.0
$v_{bicg} = v_{bic}(C/g)$	32	34	80	80
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.032*	*0.033*	*0.050*	*0.050*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.047*	*0.049*	*0.088*	*0.088*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.953*	*0.970*	*0.947*	*0.947*
Proportion of right turns,[5] P_{RT}	*0.016*	*0.162*	*0.481*	*0.196*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.975*	*0.990*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2017 baselineAM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2													
Phase type	P	P		P	P			P			P													
Lane Group																								
Adjusted flow rate, v (veh/h)	69	939		25	1152			81			97													
Saturation flow rate, s (veh/h)	1660	5118		1660	5005			2590			1387													
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0													
Effective green time, g (s), $g = G + Y - t_L$	10.0	75.0		5.0	70.0			30.0			30.0													
Green ratio, g/C	0.0833	0.625		0.0417	0.5833			0.25			0.25													
Lane group capacity,[1] c = s(g/C), (veh/h)	138	3,199		69	2,920			647			347													
v/c ratio, X	0.4988	0.2936		0.3614	0.3945			0.1251			0.2797													
Flow ratio, v/s	0.042	0.183		0.015	0.230			0.031			0.070													
Critical lane group/phase (v)	√				√						√													
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.342																							
Total lost time per cycle, L (s)	15																							
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.39**																							

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB		
Lane Group													
Adjusted flow rate,[2] v (veh/h)	*69*	*939*		*25*	*1152*			*81*			*97*		
Lane Group Capacity,[2] c (veh/h)	*138*	*3199*		*69*	*2920*			*647*			*347*		
v/c ratio[2], X = v/c	***0.499***	***0.294***		***0.361***	***0.395***			***0.125***			***0.280***		
Total green ratio,[2] g/C	*0.083*	*0.625*		*0.042*	*0.583*			*0.250*			*0.250*		
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*52.60*	*10.33*		*55.95*	*13.53*			*34.84*			*36.29*		
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*		
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*12.28*	*0.23*		*14.04*	*0.40*			*0.40*			*2.00*		
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*		
Uniform delay, d_1 (s/veh) (Appendix F)													
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*		
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***64.9***	***10.6***		***70.0***	***13.9***			***35.2***			***38.3***		
LOS by lane group (Exhibit 16-2)	***E***	***B***		***E***	***B***			***D***			***D***		
Approach flow rate, v_A (veh/h)	***69***	***939***		***25***	***1152***			***81***			***97***		
	4477.03	9922.627	0	1749.756	16049.52	0	0	2854.185	0	0	3714.176	0	

Intersection delay, $d_I = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***16.4***
Intersection Level of Service (Exhibit 16-2)	***C***

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*December 13, 2017*	Jurisdiction	*CCH DTS*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*2017 baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	16	1467	24	38	742	7	144	0	28	77	0	3
% heavy vehicles, %HV	1	1	1	1	1	1	1	1	1	1	1	1
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			10		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.3		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2017 baselinePM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*16*	*1467*	*24*	*38*	*742*	*7*	*144*	*0*	*28*	*77*	*0*	*3*
Peak-hour factor, PHF		*0.96*	*0.96*		*0.96*	*0.96*		*0.96*			*0.96*	
Adjusted flow rate, v_p = V/PHF (veh/h)	*17*	*1528*	*25*	*40*	*773*	*7*	*150*	*0*	*29*	*80*	*0*	*3*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*17*	*1553*		*40*	*780*			*179*			*83*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.011*	-	*0.016*	*0.051*	-	*0.009*	*0.838*	-	*0.162*	*0.964*	-	*0.036*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.990*	*0.990*		*0.990*	*0.990*			*0.990*			*0.990*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.721*			*0.676*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.999*			*0.976*			*0.995*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.987*			*0.986*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.992*			*0.998*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1693*	*5220*		*1693*	*5225*			*2463*			*1328*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2017 baselinePM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_0 (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*150*	*80*
Proportion of LT volume in LT lane group, P_{LT}			*0.838*	*0.964*
Proportion of LT volume in opposing flow, P_{LTo}			*0.964*	*0.838*
Adjusted flow rate for opposing approach, v_0 (veh/h)			*83*	*179*
Lost time for LT lane group, t_L			*5*	*5*

Computation

LT volume per cycle, LTC = $v_{LT}C/3600$			*5.000*	*2.667*
Opposing flow per lane, per cycle, $v_{olc} = v_0C/3600$ (veh/C/ln)			*2.767*	*5.967*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC-0.629)}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*-1.717*	*2.110*
Opposing queue ratio, $qr_0 = \max[1 - R_{po}(g_0/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{-3.782} qr_0^{1.061} - t_L$			*2.445*	*8.372*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*32.555*	*26.628*
$n = \max[(g_q - g_f)/2, 0]$			*4*	*6*
$P_{THo} = 1 - P_{LTo}$			*0.036*	*0.162*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.7*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.2*
$f_{min} = 2(1 + P_{LT})/g$			*0.105*	*0.112*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*4*	*6*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \le f_m \le 1.00)$			*0.721*	*0.676*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2017 baselinePM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	10	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.008*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_o (veh/h)	780	1553	83	179
$OCC_r = OCC_{pedu}[e^{-(5/3600)v_o}]$	*0.003*	*0.002*	*0.025*	*0.024*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.998*	*0.985*	*0.986*
Proportion of left turns,[5] P_{LT}	*0.011*	*0.051*	*0.838*	*0.964*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.987*	*0.986*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	10
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Effective green,[1] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}$(C/g)	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.041*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.959*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.016*	*0.009*	*0.162*	*0.036*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.992*	*0.998*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2017 baselinePM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2	
Phase type	P	P		P	P			P			P	
Lane Group												
Adjusted flow rate, v (veh/h)	17	1553		40	780			179			83	
Saturation flow rate, s (veh/h)	1693	5220		1693	5225			2463			1328	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	
Effective green time, g (s), g = G + Y - t_L	5.0	70.0		5.0	70.0			35.0			35.0	
Green ratio, g/C	0.0417	0.5833		0.0417	0.5833			0.2917			0.2917	
Lane group capacity,[1] c = s(g/C), (veh/h)	71	3,045		71	3,048			718			387	
v/c ratio, X	0.241	0.5101		0.5671	0.2559			0.2492			0.2142	
Flow ratio, v/s	0.010	0.298		0.024	0.149			0.073			0.062	
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c; $Y_c = \Sigma$ (critical lane groups, v/s)	0.394											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.45**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB	
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*17*	*1553*		*40*	*780*			*179*			*83*	
Lane Group Capacity,[2] c (veh/h)	*71*	*3045*		*71*	*3048*			*718*			*387*	
v/c ratio,[2] X = v/c	***0.241***	***0.510***		***0.567***	***0.256***			***0.249***			***0.214***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*			*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.66*	*14.83*		*56.44*	*12.24*			*32.46*			*32.11*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*7.92*	*0.61*		*29.08*	*0.20*			*0.83*			*1.26*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***63.6***	***15.4***		***85.5***	***12.4***			***33.3***			***33.4***	
LOS by lane group (Exhibit 16-2)	***E***	***C***		***F***	***B***			***C***			***C***	
Approach flow rate, v_A (veh/h)	***17***	***1553***		***40***	***780***			***179***			***83***	
	1080.876	23982.16	0	3420.841	9709.228	0	0	5959.508	0	0	2769.9	0

Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***17.7***
Intersection Level of Service (Exhibit 16-2)	***C***

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*December 13, 2017*	Jurisdiction	*CCH DTS*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*2017 baseline*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	169	414	20	45	325	454	49	65	31	692	51	348
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*30.0*		*10.0*	*20.0*	*60.0*	*30.0*	*30.0*	*30.0*		*60.0*	*60.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. 2017 baseline AM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*169*	*414*	*20*	*45*	*325*	*454*	*49*	*65*	*31*	*692*	*51*	*348*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*180*	*440*	*21*	*48*	*346*	*483*	*52*	*69*	*33*	*736*	*54*	*370*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*180*	*461*		*48*	*346*	*483*	*52*	*69*	*33*		*790*	*370*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.046*							*0.931*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.993*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.985*	*0.985*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5095*		*1660*	*3470*	*1660*	*1660*	*1845*	*1660*		*5089*	*1636*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. 2017 baseline AM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	180	461		48	346	483	52	69	33		790	370
Saturation flow rate, s (veh/h)	1660	5095		1660	3470	1660	1660	1845	1660		5089	1636
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	20.0	30.0		10.0	20.0	60.0	30.0	30.0	30.0		60.0	80.0
Green ratio, g/C	0.13	0.20		0.07	0.13	0.40	0.20	0.20	0.20		0.40	0.40
Lane group capacity,[1] c = s(g/C), (veh/h)	221	1,019		111	463	664	332	369	332		2,036	654
v/c ratio, X	0.813	0.452		0.434	0.748	0.727	0.157	0.187	0.099		0.388	0.566
Flow ratio, v/s	0.108	0.090		0.029	0.100	0.291	0.031	0.037	0.020		0.155	0.226
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.663											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.710**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*180*	*461*		*48*	*346*	*483*	*52*	*69*	*33*		*790*	*370*
Lane Group Capacity,[2] c (veh/h)	*221*	*1019*		*111*	*463*	*664*	*332*	*369*	*332*		*2036*	*654*
v/c ratio[2], X = v/c	***0.81***	***0.45***		***0.43***	***0.75***	***0.73***	***0.16***	***0.19***	***0.10***		***0.39***	***0.57***
Total green ratio,[2] g/C	*0.13*	*0.20*		*0.07*	*0.13*	*0.40*	*0.20*	*0.20*	*0.20*		*0.40*	*0.53*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*63.18*	*52.77*		*67.28*	*62.57*	*38.08*	*49.55*	*49.87*	*48.97*		*31.97*	*23.39*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*26.83*	*1.45*		*11.90*	*10.56*	*6.85*	*1.00*	*1.12*	*0.60*		*0.56*	*3.52*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***90.0***	***54.2***		***79.2***	***73.1***	***44.9***	***50.6***	***51.0***	***49.6***		***32.5***	***26.9***
LOS by lane group (Exhibit 16-2)	***F***	***D***		***E***	***E***	***D***	***D***	***D***	***D***		***C***	***C***
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***47.8***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	Julian Ng	Intersection	Salt Lake Blvd. & Kahuapaani St.
Agency or Company	JNI	Area Type	☐ CBD ☑ Other
Date Performed	December 13, 2017	Jurisdiction	HWY
Analysis Time Period	PM Peak Hour	Analysis Year	2017 baseline

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	193	298	42	76	615	891	65	106	26	445	53	237
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	19.0	61.0		10.0	52.0	87.0	24.0	24.0	24.0		35.0	35.0
Y + R (s) Cycle length, C = 150.0 s	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: Salt Lake Blvd. & Kahuapaani St. 2017 baseline PM Peak Hour

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	193	298	42	76	615	891	65	106	26	445	53	237
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adjusted flow rate, v_p = V/PHF (veh/h)	199	307	43	78	634	919	67	109	27	459	55	244
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	199	350		78	634	919	67	109	27		513	244
Proportion[1] of LT or RT (P_{LT} or P_{RT})			0.123							0.894		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	1900	1900		1900	1900	1900	1900	1900	1900		1900	1900
Number of lanes, N	1	3		1	2	1	1	1	1		3	1
Approach width	12	36		12	24	12	12	12	12		36	12
Lane width, W	12	12		12	12	12	12	12	12		12	12
Lane width adjustment factor, f_w	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Heavy-vehicle adjustment factor, f_{HV}	0.980	0.980		0.980	0.980	0.980	0.980	0.980	0.980		0.980	0.980
Grade adjustment factor, f_g	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Parking adjustment factor, f_p	0.900	1.000		0.900	1.000	0.900	0.900	1.000	0.900		1.000	0.900
Bus blockage adjustment factor, f_{bb}	1.000	0.993		1.000	0.990	1.000	1.000	1.000	1.000		1.000	1.000
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Lane utilization adjustment factor, f_{LU}	1.000	0.933		1.000	0.950	1.000	1.000	1.000	1.000		0.933	1.000
Left-turn adjustment factor, f_{LT}	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Right-turn adjustment factor, f_{RT}	1.000	0.982		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Left-turn ped/bike adjustment factor, f_{Lpb}	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		0.978	0.978
Right-turn ped/bike adjustment factor, f_{Rpb}	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	1676	5085		1676	3504	1676	1676	1863	1676		5102	1640

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: Salt Lake Blvd. & Kahuapaani St. 2017 baseline PM Peak Hour

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	199	350		78	634	919	67	109	27		513	244
Saturation flow rate, s (veh/h)	1676	5085		1676	3504	1676	1676	1863	1676		5102	1640
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	19.0	61.0		10.0	52.0	87.0	24.0	24.0	24.0		35.0	54.0
Green ratio, g/C	0.13	0.41		0.07	0.35	0.58	0.16	0.16	0.16		0.23	0.23
Lane group capacity,[1] c = s(g/C), (veh/h)	212	2,068		112	1,215	972	268	298	268		1,191	383
v/c ratio, X	0.937	0.169		0.698	0.522	0.945	0.250	0.366	0.101		0.431	0.638
Flow ratio, v/s	0.119	0.069		0.047	0.181	0.548	0.040	0.059	0.016		0.101	0.149
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	0.874											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.937**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	199	350		78	634	919	67	109	27		513	244
Lane Group Capacity,[2] c (veh/h)	212	2068		112	1215	972	268	298	268		1191	383
v/c ratio[2], X = v/c	**0.94**	**0.17**		**0.70**	**0.52**	**0.95**	**0.25**	**0.37**	**0.10**		**0.43**	**0.64**
Total green ratio,[2] g/C	0.13	0.41		0.07	0.35	0.58	0.16	0.16	0.16		0.23	0.36
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	64.91	28.35		68.52	39.09	29.28	55.12	56.21	53.79		49.02	39.89
Incremental delay calibration,[3] k	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5
Incremental delay[1], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	47.29	0.18		30.40	1.61	18.31	2.22	3.44	0.75		1.14	7.92
Initial queue delay, d_3 (s/veh) (Appendix F)	0	0		0	0	0	0	0	0		0	0
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	**112.2**	**28.5**		**98.9**	**40.7**	**47.6**	**57.3**	**59.7**	**54.5**		**50.2**	**47.8**
LOS by lane group (Exhibit 16-2)	**F**	**C**		**F**	**D**	**D**	**E**	**E**	**D**		**D**	**D**
Intersection delay, $d_1 = \frac{\Sigma(d_a)(v_a)}{\Sigma v_A}$ (s/veh)	**50.6**											
Intersection Level of Service (Exhibit 16-2)	**D**											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

Appendix C
Intersection Analyses Worksheets
Future Baseline Conditions

10 sheets follow:

Arizona Street/Halawa Drive and Kamehameha Highway (4)
Luapele Drive and Salt Lake Boulevard (4)
Kahuapaani Street at Salt Lake Boulevard (2)

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*near-term baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	127	172	223	144	540	589	27	6	1	5	99	14
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*12.0*	*60.0*		*15.0*	*63.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. near-term baselineAM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*127*	*172*	*223*	*144*	*540*	*589*	*27*	*6*	*1*	*5*	*99*	*14*
Peak-hour factor, PHF	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*
Adjusted flow rate, v_p = V/PHF (veh/h)	*141*	*191*	*247*	*160*	*600*	*654*	*30*	*7*	*1*	*6*	*110*	*15*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*141*	*438*		*160*	*1254*			*37*	*1*	*6*	*110*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.322*	-	*0.564*	*0.128*	-	*0.522*	*0.811*	-				*0.136*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.779*	*0.779*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.915*		*1.000*	*0.922*			*1.000*	*1.000*	*1.000*	*0.982*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*0.999*	*0.999*		*0.999*	*0.999*			*0.988*	*0.988*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1659*	*3174*		*1658*	*4093*			*2698*	*1278*	*1660*	*1811*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. near-term baselineAM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_0 (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*30*	*6*
Proportion of LT volume in LT lane group, P_{LT}			*0.811*	*0.000*
Proportion of LT volume in opposing flow, P_{LTO}			*0.000*	*0.811*
Adjusted flow rate for opposing approach, v_0 (veh/h)			*110*	*37*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*1.000*	*0.200*
Opposing flow per lane, per cycle, $v_{olc} = v_0C/3600$ (veh/C/ln)			*3.667*	*1.233*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*9.811*	*20.607*
Opposing queue ratio, $qr_0 = \max[1 - R_{po}(g_u/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_0^{1.061} - t_L$			*4.227*	*-0.977*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*25.189*	*14.393*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*0*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.189*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.4*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.103*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*0*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.779*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. near-term baselineAM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	60.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	40	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \le 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \le 5000$)	*0.020*	*0.019*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \ge g_p$ then $f_{Lpb} = 1.0$	*0.188*	*0.127*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.018*	*0.018*	*0.028*	*0.030*
Opposing flow rate,[3] v_o (veh/h)	1254	438	110	37
$OCC_r = OCC_{pedu}[e^{(15/3600)v_o}]$	*0.003*	*0.010*	*0.024*	*0.029*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.990*	*0.985*	*0.983*
Proportion of left turns,[5] P_{LT}	*0.322*	*0.128*	*0.811*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*0.999*	*0.999*	*0.988*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	60.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	40	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \le 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \le 5000$)	*0.020*	*0.019*	*0.034*	*0.034*
Effective green,[1] g (s)	60.0	63.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	40	38	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.035*	*0.034*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.054*	*0.053*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.946*	*0.968*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.564*	*0.522*	*0.000*	*0.136*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. near-term baselineAM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	141	438		160	1254			37	1	6	110	
Saturation flow rate, s (veh/h)	1659	3174		1658	4093			2698	1278	1660	1811	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	12.0	60.0		15.0	63.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.100	0.500		0.125	0.525			0.292	0.292	0.292	0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	166	1,587		207	2,149			787	373	484	528	
v/c ratio, X	0.850	0.276		0.772	0.584			0.047	0.003	0.012	0.208	
Flow ratio, v/s	0.085	0.138		0.096	0.306			0.014	0.001	0.004	0.061	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.452											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.52**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*141*	*438*		*160*	*1254*			*37*	*1*	*6*	*110*	
Lane Group Capacity,[2] c (veh/h)	*166*	*1587*		*207*	*2149*			*787*	*373*	*484*	*528*	
v/c ratio[2], X = v/c	***0.85***	***0.28***		***0.77***	***0.58***			***0.05***	***0.00***	***0.01***	***0.21***	
Total green ratio,[2] g/C	*0.100*	*0.500*		*0.125*	*0.525*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*53.11*	*17.40*		*50.84*	*19.52*			*30.52*	*60.00*	*60.00*	*32.05*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*38.95*	*0.43*		*23.85*	*1.17*			*0.11*	*0.01*	*0.05*	*0.89*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***92.1***	***17.8***		***74.7***	***20.7***			***30.6***	***60.0***	***60.0***	***32.9***	
LOS by lane group (Exhibit 16-2)	***F***	***C***		***E***	***C***			***C***	***E***	***E***	***C***	
Intersection delay, $d_1 = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***29.7***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*near-term baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	8	1128	13	33	576	4	606	1	12	156	1	110
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. near-term baselinePM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*8*	*1128*	*13*	*33*	*576*	*4*	*606*	*1*	*12*	*156*	*1*	*110*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*9*	*1200*	*13*	*35*	*613*	*4*	*645*	*1*	*13*	*166*	*1*	*117*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*9*	*1213*		*35*	*617*			*646*	*13*	*166*	*1*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.007*	-	*0.011*	*0.057*	-	*0.006*	*0.998*	-				*#####*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.690*	*0.690*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.999*			*1.000*	*1.000*	*1.000*	*0.050*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.983*	*0.983*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*3464*		*1660*	*4442*			*2377*	*1126*	*1660*	*92*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. near-term baselinePM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*645*	*166*
Proportion of LT volume in LT lane group, P_{LT}			*0.998*	*0.000*
Proportion of LT volume in opposing flow, P_{LTo}			*0.000*	*0.998*
Adjusted flow rate for opposing approach, v_o (veh/h)			*1*	*646*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*21.500*	*5.533*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*0.033*	*21.533*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*-4.906*	*-2.191*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_u/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*-4.743*	*30.557*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*39.743*	*4.443*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*33*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.002*
E_{L1} (refer to Exhibit C16-3)			*1.4*	*2.7*
$E_{L2} = \max[(1 - P_{THo}^n)/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.114*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*33*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.690*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. near-term baselinePM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.016*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_0 (veh/h)	617	1213	1	646
$OCC_r = OCC_{pedu}[e^{(5/3600)v_0}]$	*0.007*	*0.003*	*0.028*	*0.012*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.996*	*0.997*	*0.983*	*0.993*
Proportion of left turns,[5] P_{LT}	*0.007*	*0.057*	*0.998*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.983*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Effective green,[2] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.049*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.951*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.011*	*0.006*	*0.000*	*0.000*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. near-term baselinePM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	9	1213		35	617			646	13	166	1	
Saturation flow rate, s (veh/h)	1660	3464		1660	4442			2377	1126	1660	92	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	5.0	70.0		5.0	70.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.042	0.583		0.042	0.583			0.292	0.292	0.292	0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	69	2,021		69	2,591			693	328	484	27	
v/c ratio, X	0.1301	0.6003		0.5061	0.2381			0.9318	0.0396	0.3428	0.0372	
Flow ratio, v/s	0.005	0.350		0.021	0.139			0.272	0.012	0.100	0.011	
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c; $Y_c = \Sigma$ (critical lane groups, v/s)	0.643											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.73**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*9*	*1213*		*35*	*617*			*646*	*13*	*166*	*1*	
Lane Group Capacity,[2] c (veh/h)	*69*	*2021*		*69*	*2591*			*693*	*328*	*484*	*27*	
v/c ratio[2], X = v/c	***0.13***	***0.60***		***0.51***	***0.24***			***0.93***	***0.04***	***0.34***	***0.04***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.40*	*16.03*		*56.29*	*12.10*			*41.34*	*60.00*	*60.00*	*30.43*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], d_2; $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*3.85*	*1.33*		*24.06*	*0.22*			*21.04*	*0.23*	*1.93*	*2.57*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***59.3***	***17.4***		***80.4***	***12.3***			***62.4***	***60.2***	***61.9***	***33.0***	
LOS by lane group (Exhibit 16-2)	***E***	***C***		***F***	***B***			***E***	***E***	***E***	***C***	
Intersection delay, $d_1 = \frac{\Sigma(d_n)(v_n)}{\Sigma v_A}$ (s/veh)	***30.9***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*near-term baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	64.05	863.1	13.65	23.1	901.95	174.3	38.85	0	36.75	70.35	3.15	17.85
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

	NB			SB			EB			WB		
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*10.0*	*75.0*		*5.0*	*70.0*			*30.0*			*30.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. near-term baseline AM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*64*	*863*	*14*	*23*	*902*	*174*	*39*	*0*	*37*	*70*	*3*	*18*
Peak-hour factor, PHF	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*
Adjusted flow rate, v_p = V/PHF (veh/h)	*72*	*970*	*15*	*26*	*1013*	*196*	*44*	*0*	*41*	*79*	*4*	*20*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*72*	*985*		*26*	*1209*			*85*			*103*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.073*	-	*0.015*	*0.022*	-	*0.162*	*0.518*	-	*0.482*	*0.767*	-	*0.194*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

	NB			SB			EB			WB		
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*			*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.820*			*0.733*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.976*			*0.928*			*0.974*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.991*			*0.986*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.975*			*0.990*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5118*		*1660*	*5005*			*2575*			*1371*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. near-term baseline AM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*30.0*	*30.0*
Effective permitted green time for LT lane group,[1] g (s)			*30.0*	*30.0*
Opposing effective green time, g_o (s)			*30.0*	*30.0*
Number of lanes in LT lane group,[4] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*44*	*79*
Proportion of LT volume in LT lane group, P_{LT}			*0.518*	*0.767*
Proportion of LT volume in opposing flow, P_{LTo}			*0.767*	*0.518*
Adjusted flow rate for opposing approach, v_o (veh/h)			*103*	*85*
Lost time for LT lane group, t_L			*5*	*5*

Computation

	NB	SB	EB	WB
LT volume per cycle, LTC = $v_{LT}C/3600$			*1.467*	*2.633*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*3.433*	*2.833*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC^{*}0.629)}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*5.044*	*1.172*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.750*	*0.750*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*4.325*	*3.055*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*24.956*	*26.945*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*2*
$P_{THo} = 1 - P_{LTo}$			*0.233*	*0.482*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.5*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.4*
$f_{min} = 2(1 + P_{LT})/g$			*0.101*	*0.118*
$g_{diff} = \max[g_q - g_o, 0]$ (except when left-turn volume is 0)[4]			*0*	*2*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \le f_m \le 1.00)$			*0.820*	*0.733*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term baseline AM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{pb} = 1.0$	*0.151*	*0.115*	*0.407*	*0.278*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.015*	*0.016*	*0.032*	*0.034*
Opposing flow rate,[3] v_o (veh/h)	1209	985	103	85
$OCC_r = OCC_{pedu}[e^{-(5/3600)v_o}]$	*0.003*	*0.004*	*0.028*	*0.031*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.996*	*0.983*	*0.982*
Proportion of left turns,[5] P_{LT}	*0.073*	*0.022*	*0.518*	*0.767*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.991*	*0.986*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Effective green,[1] g (s)	75.0	70.0	30.0	30.0
$v_{bicg} = v_{bic}(C/g)$	32	34	80	80
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.032*	*0.033*	*0.050*	*0.050*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.047*	*0.049*	*0.088*	*0.088*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.953*	*0.970*	*0.947*	*0.947*
Proportion of right turns,[5] P_{RT}	*0.015*	*0.162*	*0.482*	*0.194*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.975*	*0.990*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term baseline AM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2	
Phase type	P	P		P	P			P			P	
Lane Group												
Adjusted flow rate, v (veh/h)	72	985		26	1209			85			103	
Saturation flow rate, s (veh/h)	1660	5118		1660	5005			2575			1371	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	
Effective green time, g (s), $g = G + Y - t_L$	10.0	75.0		5.0	70.0			30.0			30.0	
Green ratio, g/C	0.083	0.625		0.042	0.583			0.250			0.250	
Lane group capacity,[1] c = s(g/C), (veh/h)	138	3,199		69	2,920			644			343	
v/c ratio, X	0.520	0.308		0.376	0.414			0.132			0.301	
Flow ratio, v/s	0.043	0.192		0.016	0.242			0.033			0.075	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.360											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.41**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB	
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*72*	*985*		*26*	*1209*			*85*			*103*	
Lane Group Capacity,[2] c (veh/h)	*138*	*3199*		*69*	*2920*			*644*			*343*	
v/c ratio[2], X = v/c	***0.52***	***0.31***		***0.38***	***0.41***			***0.13***			***0.30***	
Total green ratio,[2] g/C	*0.083*	*0.625*		*0.042*	*0.583*			*0.250*			*0.250*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*52.70*	*10.45*		*55.98*	*13.73*			*34.90*			*36.49*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	
Incremental delay[3], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*13.30*	*0.25*		*14.88*	*0.43*			*0.42*			*2.24*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***66.0***	***10.7***		***70.9***	***14.2***			***35.3***			***38.7***	
LOS by lane group (Exhibit 16-2)	***E***	***B***		***E***	***B***			***D***			***D***	
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***16.6***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*near-term baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	17	1540	25	40	779	7	151	0	29	81	0	3
% heavy vehicles, %HV	1	1	1	1	1	1	1	1	1	1	1	1
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			10		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.3		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. near-term baseline PM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*17*	*1540*	*25*	*40*	*779*	*7*	*151*	*0*	*29*	*81*	*0*	*3*
Peak-hour factor, PHF	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*
Adjusted flow rate, v_p = V/PHF (veh/h)	*17*	*1605*	*26*	*42*	*812*	*8*	*157*	*0*	*31*	*84*	*0*	*3*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*17*	*1631*		*42*	*820*			*188*			*87*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.010*	-	*0.016*	*0.051*	-	*0.010*	*0.835*	-	*0.165*	*0.966*	-	*0.034*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.990*	*0.990*		*0.990*	*0.990*			*0.990*			*0.990*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.721*			*0.672*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.999*			*0.975*			*0.995*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.987*			*0.987*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.992*			*0.998*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1693*	*5220*		*1693*	*5224*			*2463*			*1323*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. near-term baseline PM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*157*	*84*
Proportion of LT volume in LT lane group, P_{LT}			*0.835*	*0.966*
Proportion of LT volume in opposing flow, P_{LTo}			*0.966*	*0.835*
Adjusted flow rate for opposing approach, v_o (veh/h)			*87*	*188*
Lost time for LT lane group, t_L			*5*	*5*

Computation

LT volume per cycle, LTC = $v_{LT}C/3600$			*5.233*	*2.800*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*2.900*	*6.267*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC^{-0.629})}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*-1.936*	*1.766*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*2.717*	*8.881*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*32.283*	*26.119*
$n = \max[(g_q - g_f)/2, 0]$			*5*	*7*
$P_{THo} = 1 - P_{LTo}$			*0.034*	*0.165*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.7*
$E_{L2} = \max[(1 - P_{THo}^n)/P_{LTo}, 1.0]$			*1.0*	*1.2*
$f_{min} = 2(1 + P_{LT})/g$			*0.105*	*0.112*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*5*	*7*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \le f_m \le 1.00)$			*0.721*	*0.672*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term baseline PM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	10	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_o/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_o/g_p)]$	*0.008*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_o (veh/h)	820	1631	87	188
$OCC_r = OCC_{pedu}[e^{-(5/3600)v_o}]$	*0.003*	*0.002*	*0.025*	*0.023*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.998*	*0.985*	*0.986*
Proportion of left turns,[5] P_{LT}	*0.010*	*0.051*	*0.835*	*0.966*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.987*	*0.987*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	10
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Effective green,[1] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.041*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.959*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.016*	*0.010*	*0.165*	*0.034*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.992*	*0.998*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term baseline PM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2	
Phase type	P	P		P	P			P			P	
Lane Group												
Adjusted flow rate, v (veh/h)	17	1631		42	820			188			87	
Saturation flow rate, s (veh/h)	1693	5220		1693	5224			2463			1323	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	
Effective green time, g (s), $g = G + Y - t_L$	5.0	70.0		5.0	70.0			35.0			35.0	
Green ratio, g/C	0.042	0.583		0.042	0.583			0.292			0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	71	3,045		71	3,047			718			386	
v/c ratio, X	0.241	0.536		0.595	0.269			0.262			0.226	
Flow ratio, v/s	0.010	0.312		0.025	0.157			0.076			0.066	
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.414											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.47**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB			EB			WB	
Lane Group											
Adjusted flow rate,[2] v (veh/h)	*17*	*1631*		*42*	*820*		*188*			*87*	
Lane Group Capacity,[2] c (veh/h)	*71*	*3045*		*71*	*3047*		*718*			*386*	
v/c ratio[2], X = v/c	***0.24***	***0.54***		***0.60***	***0.27***		***0.26***			***0.23***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*		*0.292*			*0.292*	
Uniform delay, $d_1 = \dfrac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.66*	*15.15*		*56.51*	*12.36*		*32.59*			*32.22*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*		*0.5*			*0.5*	
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8klX/cT}]$ (s/veh)	*7.92*	*0.68*		*31.95*	*0.22*		*0.89*			*1.35*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*		*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)											
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*		*1.000*			*1.000*	
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***63.6***	***15.8***		***88.5***	***12.6***		***33.5***			***33.6***	
LOS by lane group (Exhibit 16-2)	***E***	***C***		***F***	***B***		***C***			***C***	
Intersection delay, $d_I = \dfrac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***18.0***										
Intersection Level of Service (Exhibit 16-2)	***C***										

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*near-term baseline*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	177	435	21	47	341	477	51	68	33	727	54	365
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*30.0*		*10.0*	*20.0*	*60.0*	*30.0*	*30.0*	*30.0*		*60.0*	*60.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term baseline AM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*177*	*435*	*21*	*47*	*341*	*477*	*51*	*68*	*33*	*727*	*54*	*365*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*189*	*462*	*22*	*50*	*363*	*507*	*55*	*73*	*35*	*773*	*57*	*389*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*189*	*484*		*50*	*363*	*507*	*55*	*73*	*35*		*830*	*389*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.045*							*0.931*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.993*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.985*	*0.985*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5096*		*1660*	*3470*	*1660*	*1660*	*1845*	*1660*		*5089*	*1636*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term baseline AM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	189	484		50	363	507	55	73	35		830	389
Saturation flow rate, s (veh/h)	1660	5096		1660	3470	1660	1660	1845	1660		5089	1636
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	20.0	30.0		10.0	20.0	60.0	30.0	30.0	30.0		60.0	80.0
Green ratio, g/C	0.13	0.20		0.07	0.13	0.40	0.20	0.20	0.20		0.40	0.40
Lane group capacity,[1] c = s(g/C), (veh/h)	221	1,019		111	463	664	332	369	332		2,036	654
v/c ratio, X	0.854	0.475		0.452	0.785	0.763	0.166	0.198	0.105		0.408	0.594
Flow ratio, v/s	0.114	0.095		0.030	0.105	0.305	0.033	0.040	0.021		0.163	0.238
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.696											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.75**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*189*	*484*		*50*	*363*	*507*	*55*	*73*	*35*		*830*	*389*
Lane Group Capacity,[2] c (veh/h)	*221*	*1019*		*111*	*463*	*664*	*332*	*369*	*332*		*2036*	*654*
v/c ratio[2], X = v/c	***0.85***	***0.47***		***0.45***	***0.78***	***0.76***	***0.17***	***0.20***	***0.11***		***0.41***	***0.59***
Total green ratio,[2] g/C	*0.13*	*0.20*		*0.07*	*0.13*	*0.40*	*0.20*	*0.20*	*0.20*		*0.40*	*0.53*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*63.57*	*53.04*		*67.36*	*62.92*	*38.87*	*49.64*	*49.98*	*49.03*		*32.26*	*23.91*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*31.96*	*1.59*		*12.74*	*12.55*	*8.13*	*1.07*	*1.20*	*0.64*		*0.61*	*3.94*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***95.5***	***54.6***		***80.1***	***75.5***	***47.0***	***50.7***	***51.2***	***49.7***		***32.9***	***27.8***
LOS by lane group (Exhibit 16-2)	***F***	***D***		***F***	***E***	***D***	***D***	***D***	***D***		***C***	***C***
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***49.1***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☑ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*near-term baseline*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	203	313	46	80	646	936	68	111	27	467	56	249
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*19.0*	*61.0*		*10.0*	*52.0*	*87.0*	*24.0*	*24.0*	*24.0*		*35.0*	*35.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term baseline PM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*203*	*313*	*46*	*80*	*646*	*936*	*68*	*111*	*27*	*467*	*56*	*249*
Peak-hour factor, PHF	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*
Adjusted flow rate, v_p = V/PHF (veh/h)	*209*	*323*	*48*	*82*	*666*	*964*	*70*	*115*	*28*	*482*	*57*	*257*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*209*	*371*		*82*	*666*	*964*	*70*	*115*	*28*		*539*	*257*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.129*							*0.894*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.980*	*0.980*		*0.980*	*0.980*	*0.980*	*0.980*	*0.980*	*0.980*		*0.980*	*0.980*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.981*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.978*	*0.978*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1676*	*5081*		*1676*	*3504*	*1676*	*1676*	*1863*	*1676*		*5103*	*1640*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term baseline PM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	209	371		82	666	964	70	115	28		539	257
Saturation flow rate, s (veh/h)	1676	5081		1676	3504	1676	1676	1863	1676		5103	1640
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	19.0	61.0		10.0	52.0	87.0	24.0	24.0	24.0		35.0	54.0
Green ratio, g/C	0.13	0.41		0.07	0.35	0.58	0.16	0.16	0.16		0.23	0.23
Lane group capacity,[1] c = s(g/C), (veh/h)	212	2,066		112	1,215	972	268	298	268		1,191	383
v/c ratio, X	0.984	0.180		0.734	0.548	0.991	0.261	0.386	0.104		0.453	0.670
Flow ratio, v/s	0.125	0.073		0.049	0.190	0.575	0.042	0.062	0.017		0.106	0.156
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.918											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.98**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*209*	*371*		*82*	*666*	*964*	*70*	*115*	*28*		*539*	*257*
Lane Group Capacity,[2] c (veh/h)	*212*	*2066*		*112*	*1215*	*972*	*268*	*298*	*268*		*1191*	*383*
v/c ratio[2], X = v/c	***0.98***	***0.18***		***0.73***	***0.55***	***0.99***	***0.26***	***0.39***	***0.10***		***0.45***	***0.67***
Total green ratio,[2] g/C	*0.13*	*0.41*		*0.07*	*0.35*	*0.58*	*0.16*	*0.16*	*0.16*		*0.23*	*0.36*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*65.35*	*28.48*		*68.69*	*39.53*	*31.13*	*55.23*	*56.40*	*53.82*		*49.29*	*40.49*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*57.82*	*0.19*		*34.46*	*1.78*	*26.87*	*2.35*	*3.74*	*0.78*		*1.24*	*9.01*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***123.2***	***28.7***		***103.2***	***41.3***	***58.0***	***57.6***	***60.1***	***54.6***		***50.5***	***49.5***
LOS by lane group (Exhibit 16-2)	***F***	***C***		***F***	***D***	***E***	***E***	***E***	***D***		***D***	***D***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***54.7***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

Appendix D
Intersection Analyses Worksheets
Future with Project Conditions

13 sheets follow:

Arizona Street/Halawa Drive and Kamehameha Highway (4)
Luapele Drive and Salt Lake Boulevard (4)
Kahuapaani Street at Salt Lake Boulevard (2)
Kahuapaani Street at Salt Lake Boulevard – mitigated (3)

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*near-term + JIOC*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	127	172	160	105	540	611	29	4	1	4	77	11
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*12.0*	*60.0*		*15.0*	*63.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. near-term + JIOCAM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*127*	*172*	*160*	*105*	*540*	*611*	*29*	*4*	*1*	*4*	*77*	*11*
Peak-hour factor, PHF	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*
Adjusted flow rate, v_p = V/PHF (veh/h)	*141*	*191*	*177*	*117*	*600*	*679*	*33*	*5*	*1*	*5*	*85*	*12*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*141*	*368*		*117*	*1279*			*38*	*1*	*5*	*85*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.383*	-	*0.481*	*0.091*	-	*0.531*	*0.868*	-				*0.141*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.774*	*0.774*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.928*		*1.000*	*0.920*			*1.000*	*1.000*	*1.000*	*0.981*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*0.999*	*0.999*		*0.999*	*0.999*			*0.987*	*0.987*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1659*	*3217*		*1659*	*4088*			*2676*	*1268*	*1660*	*1810*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. near-term + JIOCAM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*33*	*5*
Proportion of LT volume in LT lane group, P_{LT}			*0.868*	*0.000*
Proportion of LT volume in opposing flow, P_{LTO}			*0.000*	*0.868*
Adjusted flow rate for opposing approach, v_O (veh/h)			*85*	*38*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*1.100*	*0.167*
Opposing flow per lane, per cycle, $v_{olc} = v_O C/3600$ (veh/C/ln)			*2.833*	*1.267*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*9.044*	*21.488*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_u/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*2.581*	*-0.895*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*25.956*	*13.512*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*0*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.132*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.4*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.107*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*0*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \le f_m \le 1.00)$			*0.774*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. near-term + JIOCAM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	60.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	40	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.020*	*0.019*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.188*	*0.127*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.018*	*0.018*	*0.028*	*0.030*
Opposing flow rate,[3] v_o (veh/h)	1279	368	85	38
$OCC_r = OCC_{pedu}[e^{(15/3600)v_o}]$	*0.003*	*0.011*	*0.025*	*0.029*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.989*	*0.985*	*0.983*
Proportion of left turns,[5] P_{LT}	*0.383*	*0.091*	*0.868*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*0.999*	*0.999*	*0.987*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	60.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	40	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.020*	*0.019*	*0.034*	*0.034*
Effective green,[1] g (s)	60.0	63.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	40	38	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.035*	*0.034*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.054*	*0.053*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.946*	*0.968*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.481*	*0.531*	*0.000*	*0.141*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. near-term + JIOCAM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	141	368		117	1279			38	1	5	85	
Saturation flow rate, s (veh/h)	1659	3217		1659	4088			2676	1268	1660	1810	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	12.0	60.0		15.0	63.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.100	0.500		0.125	0.525			0.292	0.292	0.292	0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	166	1,609		207	2,146			781	370	484	528	
v/c ratio, X	0.850	0.229		0.564	0.596			0.049	0.003	0.010	0.161	
Flow ratio, v/s	0.085	0.114		0.071	0.313			0.014	0.001	0.003	0.047	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c; $Yc = \Sigma$ (critical lane groups, v/s)	0.445											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.51**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*141*	*368*		*117*	*1279*			*38*	*1*	*5*	*85*	
Lane Group Capacity,[2] c (veh/h)	*166*	*1609*		*207*	*2146*			*781*	*370*	*484*	*528*	
v/c ratio[2], X = v/c	***0.85***	***0.23***		***0.56***	***0.60***			***0.05***	***0.00***	***0.01***	***0.16***	
Total green ratio,[2] g/C	*0.100*	*0.500*		*0.125*	*0.525*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*53.11*	*16.94*		*49.42*	*19.70*			*30.54*	*60.00*	*60.00*	*31.59*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], d_2; $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*38.96*	*0.33*		*10.67*	*1.23*			*0.12*	*0.01*	*0.04*	*0.65*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***92.1***	***17.3***		***60.1***	***20.9***			***30.7***	***60.0***	***60.0***	***32.2***	
LOS by lane group (Exhibit 16-2)	***F***	***C***		***E***	***C***			***C***	***E***	***E***	***C***	
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***28.2***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*near-term + JIOC*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	8	1128	7	16	576	4	606	0	12	87	1	62
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. near-term + JIOCPM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*8*	*1128*	*7*	*16*	*576*	*4*	*606*	*0*	*12*	*87*	*1*	*62*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*9*	*1200*	*7*	*17*	*613*	*4*	*645*	*0*	*13*	*93*	*1*	*66*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*9*	*1207*		*17*	*617*			*645*	*13*	*93*	*1*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.007*	-	*0.006*	*0.028*	-	*0.006*	*1.000*	-				*66.000*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.689*	*0.689*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.999*		*1.000*	*0.999*			*1.000*	*1.000*	*1.000*	*0.050*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.983*	*0.983*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*3467*		*1660*	*4442*			*2375*	*1125*	*1660*	*92*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. near-term + JIOCPM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*645*	*93*
Proportion of LT volume in LT lane group, P_{LT}			*1.000*	*0.000*
Proportion of LT volume in opposing flow, P_{LTo}			*0.000*	*1.000*
Adjusted flow rate for opposing approach, v_o (veh/h)			*1*	*645*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*21.500*	*3.100*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*0.033*	*21.500*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*-4.906*	*1.069*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*-4.743*	*30.515*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*39.743*	*4.485*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*29*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.000*
E_{L1} (refer to Exhibit C16-3)			*1.4*	*2.7*
$E_{L2} = \max[(1 - P_{THo}^n)/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.114*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*29*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.689*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. near-term + JIOCPM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.016*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_0 (veh/h)	617	1207	1	645
$OCC_r = OCC_{pedu}[e^{(5/3600)v_0}]$	*0.007*	*0.003*	*0.028*	*0.012*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.996*	*0.997*	*0.983*	*0.993*
Proportion of left turns,[5] P_{LT}	*0.007*	*0.028*	*1.000*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.983*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Effective green,[2] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.049*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.951*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.006*	*0.006*	*0.000*	*0.000*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. near-term + JIOCPM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	9	1207		17	617			645	13	93	1	
Saturation flow rate, s (veh/h)	1660	3467		1660	4442			2375	1125	1660	92	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	5.0	70.0		5.0	70.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.042	0.583		0.042	0.583			0.292	0.292	0.292	0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	69	2,022		69	2,591			693	328	484	27	
v/c ratio, X	0.1301	0.5969		0.2458	0.2381			0.931	0.0396	0.1921	0.0372	
Flow ratio, v/s	0.005	0.348		0.010	0.139			0.272	0.012	0.056	0.011	
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c; $Y_c = \Sigma$ (critical lane groups, v/s)	0.630											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.72**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB		
Lane Group													
Adjusted flow rate,[2] v (veh/h)	*9*	*1207*		*17*	*617*			*645*	*13*		*93*	*1*	
Lane Group Capacity,[2] c (veh/h)	*69*	*2022*		*69*	*2591*			*693*	*328*		*484*	*27*	
v/c ratio[2], X = v/c	***0.13***	***0.60***		***0.25***	***0.24***			***0.93***	***0.04***		***0.19***	***0.04***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*	*0.000*		*0.000*	*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.40*	*15.98*		*55.67*	*12.10*			*41.33*	*60.00*		*60.00*	*30.43*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*		*0.5*	*0.5*	
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*3.85*	*1.31*		*8.28*	*0.22*			*20.94*	*0.23*		*0.88*	*2.57*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*		*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)													
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*		*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***59.3***	***17.3***		***64.0***	***12.3***			***62.3***	***60.2***		***60.9***	***33.0***	
LOS by lane group (Exhibit 16-2)	***E***	***C***		***E***	***B***			***E***	***E***		***E***	***C***	
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***29.5***												
Intersection Level of Service (Exhibit 16-2)	***C***												

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	Julian Ng	Intersection	Salt Lake Blvd. & Luapele Dr.
Agency or Company	JNI	Area Type	☐ CBD ☒ Other
Date Performed	February 2, 2018	Jurisdiction	CCH DTS
Analysis Time Period	AM Peak Hour	Analysis Year	near-term + JIOC

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	110	863	14	23	902	299	60	0	56	70	5	18
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*10.0*	*75.0*		*5.0*	*70.0*			*30.0*			*30.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: Salt Lake Blvd. & Luapele Dr. near-term + JIOCAM Peak Hour

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*110*	*863*	*14*	*23*	*902*	*299*	*60*	*0*	*56*	*70*	*5*	*18*
Peak-hour factor, PHF	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*
Adjusted flow rate, v_p = V/PHF (veh/h)	*124*	*970*	*15*	*26*	*1013*	*336*	*67*	*0*	*63*	*79*	*6*	*20*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*124*	*985*		*26*	*1349*			*130*			*105*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.126*	-	*0.015*	*0.019*	-	*0.249*	*0.515*	-	*0.485*	*0.752*	-	*0.190*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*			*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.806*			*0.692*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.963*			*0.927*			*0.974*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.991*			*0.987*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.974*			*0.990*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5118*		*1660*	*4939*			*2531*			*1297*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description: Salt Lake Blvd. & Luapele Dr. near-term + JIOCAM Peak Hour

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*30.0*	*30.0*
Effective permitted green time for LT lane group,[1] g (s)			*30.0*	*30.0*
Opposing effective green time, g_o (s)			*30.0*	*30.0*
Number of lanes in LT lane group,[4] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*67*	*79*
Proportion of LT volume in LT lane group, P_{LT}			*0.515*	*0.752*
Proportion of LT volume in opposing flow, P_{LTo}			*0.752*	*0.515*
Adjusted flow rate for opposing approach, v_o (veh/h)			*105*	*130*
Lost time for LT lane group, t_L			*5*	*5*

Computation

	NB	SB	EB	WB
LT volume per cycle, LTC = v_{LT}C/3600			*2.233*	*2.633*
Opposing flow per lane, per cycle, $v_{olc} = v_o$C/3600 (veh/C/ln)			*3.500*	*4.333*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC^{*}0.629)}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*2.211*	*1.172*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.750*	*0.750*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*4.463*	*6.135*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*25.537*	*23.865*
$n = \max[(g_q - g_f)/2, 0]$			*2*	*5*
$P_{THo} = 1 - P_{LTo}$			*0.248*	*0.485*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.6*
$E_{L2} = \max[(1 - P_{THo}^{o})/P_{LTo}, 1.0]$			*1.3*	*1.9*
$f_{min} = 2(1 + P_{LT})/g$			*0.101*	*0.117*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*2*	*5*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ ($f_{min} \le f_m \le 1.00$)			*0.806*	*0.692*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term + JIOCAM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{pb} = 1.0$	*0.151*	*0.115*	*0.407*	*0.278*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.015*	*0.016*	*0.032*	*0.034*
Opposing flow rate,[3] v_o (veh/h)	1349	985	105	130
$OCC_r = OCC_{pedu}[e^{-(v_o/3600)n_o}]$	*0.002*	*0.004*	*0.028*	*0.029*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.999*	*0.996*	*0.983*	*0.983*
Proportion of left turns,[5] P_{LT}	*0.126*	*0.019*	*0.515*	*0.752*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.991*	*0.987*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Effective green,[1] g (s)	75.0	70.0	30.0	30.0
$v_{bicg} = v_{bic}(C/g)$	32	34	80	80
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.032*	*0.033*	*0.050*	*0.050*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.047*	*0.049*	*0.088*	*0.088*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.953*	*0.970*	*0.947*	*0.947*
Proportion of right turns,[5] P_{RT}	*0.015*	*0.249*	*0.485*	*0.190*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.974*	*0.990*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term + JIOCAM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2	
Phase type	P	P		P	P			P			P	
Lane Group												
Adjusted flow rate, v (veh/h)	124	985		26	1349			130			105	
Saturation flow rate, s (veh/h)	1660	5118		1660	4939			2531			1297	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	
Effective green time, g (s), $g = G + Y - t_L$	10.0	75.0		5.0	70.0			30.0			30.0	
Green ratio, g/C	0.083	0.625		0.042	0.583			0.250			0.250	
Lane group capacity,[1] c = s(g/C), (veh/h)	138	3,199		69	2,881			633			324	
v/c ratio, X	0.896	0.308		0.376	0.468			0.205			0.324	
Flow ratio, v/s	0.075	0.192		0.016	0.273			0.051			0.081	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c; $Yc = \Sigma$ (critical lane groups, v/s)	0.429											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.49**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB	
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*124*	*985*		*26*	*1349*			*130*			*105*	
Lane Group Capacity,[2] c (veh/h)	*138*	*3199*		*69*	*2881*			*633*			*324*	
v/c ratio[2], X = v/c	***0.90***	***0.31***		***0.38***	***0.47***			***0.21***			***0.32***	
Total green ratio,[2] g/C	*0.083*	*0.625*		*0.042*	*0.583*			*0.250*			*0.250*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*54.49*	*10.45*		*55.98*	*14.33*			*35.58*			*36.72*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	
Incremental delay[3], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*52.80*	*0.25*		*14.88*	*0.55*			*0.73*			*2.63*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***107.3***	***10.7***		***70.9***	***14.9***			***36.3***			***39.4***	
LOS by lane group (Exhibit 16-2)	***F***	***B***		***E***	***B***			***D***			***D***	
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***20.1***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*near-term + JIOC*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	42	1540	25	40	779	18	308	0	59	81	0	3
% heavy vehicles, %HV	1	1	1	1	1	1	1	1	1	1	1	1
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			10		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.3		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term + JIOCPM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*42*	*1540*	*25*	*40*	*779*	*18*	*308*	*0*	*59*	*81*	*0*	*3*
Peak-hour factor, PHF	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*
Adjusted flow rate, v_p = V/PHF (veh/h)	*44*	*1605*	*26*	*42*	*812*	*19*	*321*	*0*	*62*	*84*	*0*	*3*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*44*	*1631*		*42*	*831*			*383*			*87*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.027*	-	*0.016*	*0.051*	-	*0.023*	*0.838*	-	*0.162*	*0.966*	-	*0.034*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.990*	*0.990*		*0.990*	*0.990*			*0.990*			*0.990*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a (***0.90*** *CBD,* ***1.00*** *other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.719*			*0.691*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.997*			*0.976*			*0.995*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.987*			*0.990*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.992*			*0.998*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1693*	*5219*		*1693*	*5214*			*2455*			*1365*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term + JIOCPM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*321*	*84*
Proportion of LT volume in LT lane group, P_{LT}			*0.838*	*0.966*
Proportion of LT volume in opposing flow, P_{LTo}			*0.966*	*0.838*
Adjusted flow rate for opposing approach, v_o (veh/h)			*87*	*383*
Lost time for LT lane group, t_L			*5*	*5*

Computation

LT volume per cycle, LTC = $v_{LT}C/3600$			*10.700*	*2.800*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*2.900*	*12.767*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC^{-0.629})}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*-4.232*	*1.766*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*2.717*	*18.874*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*32.283*	*16.126*
$n = \max[(g_q - g_f)/2, 0]$			*7*	*17*
$P_{THo} = 1 - P_{LTo}$			*0.034*	*0.162*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*2.0*
$E_{L2} = \max[(1 - P_{THo}^n)/P_{LTo}, 1.0]$			*1.0*	*1.2*
$f_{min} = 2(1 + P_{LT})/g$			*0.105*	*0.112*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*7*	*17*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \le f_m \le 1.00)$			*0.719*	*0.691*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term + JIOCPM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	10	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}$ [1 - 0.5(g_q/g_p)]	*0.008*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_o (veh/h)	831	1631	87	383
$OCC_r = OCC_{pedu}$ [$e^{-(5/3600)v_o}$]	*0.002*	*0.002*	*0.025*	*0.018*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.999*	*0.998*	*0.985*	*0.989*
Proportion of left turns,[5] P_{LT}	*0.027*	*0.051*	*0.838*	*0.966*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.987*	*0.990*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	10
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Effective green,[1] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}$(C/g)	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.041*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.959*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.016*	*0.023*	*0.162*	*0.034*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.992*	*0.998*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. near-term + JIOCPM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2	
Phase type	P	P		P	P			P			P	
Lane Group												
Adjusted flow rate, v (veh/h)	44	1631		42	831			383			87	
Saturation flow rate, s (veh/h)	1693	5219		1693	5214			2455			1365	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	
Effective green time, g (s), g = G + Y - t_L	5.0	70.0		5.0	70.0			35.0			35.0	
Green ratio, g/C	0.042	0.583		0.042	0.583			0.292			0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	71	3,045		71	3,041			716			398	
v/c ratio, X	0.624	0.536		0.595	0.273			0.535			0.219	
Flow ratio, v/s	0.026	0.312		0.025	0.159			0.156			0.064	
Critical lane group/phase (v)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.493											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.56**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB	
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*44*	*1631*		*42*	*831*			*383*			*87*	
Lane Group Capacity,[2] c (veh/h)	*71*	*3045*		*71*	*3041*			*716*			*398*	
v/c ratio[2], X = v/c	***0.62***	***0.54***		***0.60***	***0.27***			***0.53***			***0.22***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*			*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*56.57*	*15.15*		*56.51*	*12.39*			*35.67*			*32.15*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*35.05*	*0.68*		*31.95*	*0.22*			*2.85*			*1.26*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***91.6***	***15.8***		***88.5***	***12.6***			***38.5***			***33.4***	
LOS by lane group (Exhibit 16-2)	***F***	***C***		***F***	***B***			***D***			***C***	
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***20.4***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*near-term + JIOC*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	177	481	21	48	350	488	51	68	36	803	54	365
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*30.0*		*10.0*	*20.0*	*60.0*	*30.0*	*30.0*	*30.0*		*60.0*	*60.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term + JIOC AM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*177*	*481*	*21*	*48*	*350*	*488*	*51*	*68*	*36*	*803*	*54*	*365*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*189*	*511*	*22*	*51*	*373*	*519*	*55*	*73*	*38*	*854*	*57*	*389*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*189*	*533*		*51*	*373*	*519*	*55*	*73*	*38*		*911*	*389*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.041*							*0.937*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.994*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.985*	*0.985*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5099*		*1660*	*3470*	*1660*	*1660*	*1845*	*1660*		*5089*	*1636*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term + JIOC AM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	189	533		51	373	519	55	73	38		911	389
Saturation flow rate, s (veh/h)	1660	5099		1660	3470	1660	1660	1845	1660		5089	1636
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	20.0	30.0		10.0	20.0	60.0	30.0	30.0	30.0		60.0	80.0
Green ratio, g/C	0.13	0.20		0.07	0.13	0.40	0.20	0.20	0.20		0.40	0.40
Lane group capacity,[1] c = s(g/C), (veh/h)	221	1,020		111	463	664	332	369	332		2,035	654
v/c ratio, X	0.854	0.523		0.461	0.806	0.782	0.166	0.198	0.114		0.447	0.594
Flow ratio, v/s	0.114	0.105		0.031	0.107	0.313	0.033	0.040	0.023		0.179	0.238
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.704											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.75**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*189*	*533*		*51*	*373*	*519*	*55*	*73*	*38*		*911*	*389*
Lane Group Capacity,[2] c (veh/h)	*221*	*1020*		*111*	*463*	*664*	*332*	*369*	*332*		*2035*	*654*
v/c ratio[2], X = v/c	***0.85***	***0.52***		***0.46***	***0.81***	***0.78***	***0.17***	***0.20***	***0.11***		***0.45***	***0.59***
Total green ratio,[2] g/C	*0.13*	*0.20*		*0.07*	*0.13*	*0.40*	*0.20*	*0.20*	*0.20*		*0.40*	*0.53*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*63.57*	*53.60*		*67.40*	*63.12*	*39.28*	*49.64*	*49.98*	*49.12*		*32.89*	*23.91*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*31.96*	*1.92*		*13.18*	*13.96*	*8.89*	*1.07*	*1.20*	*0.70*		*0.71*	*3.94*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***95.5***	***55.5***		***80.6***	***77.1***	***48.2***	***50.7***	***51.2***	***49.8***		***33.6***	***27.9***
LOS by lane group (Exhibit 16-2)	***F***	***E***		***F***	***E***	***D***	***D***	***D***	***D***		***C***	***C***
Intersection delay, $d_1 = \frac{\Sigma(d_n)(v_n)}{\Sigma v_A}$ (s/veh)	***49.6***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☑ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*near-term + JIOC*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	203	318	46	88	707	1,024	68	111	27	473	56	249
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*19.0*	*61.0*		*10.0*	*52.0*	*87.0*	*24.0*	*24.0*	*24.0*		*35.0*	*35.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term + JIOC PM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*203*	*318*	*46*	*88*	*707*	*1,024*	*68*	*111*	*27*	*473*	*56*	*249*
Peak-hour factor, PHF	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*
Adjusted flow rate, v_p = V/PHF (veh/h)	*209*	*328*	*47*	*91*	*729*	*1056*	*70*	*115*	*28*	*488*	*58*	*257*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*209*	*375*		*91*	*729*	*1056*	*70*	*115*	*28*		*545*	*257*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.125*							*0.894*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.980*	*0.980*		*0.980*	*0.980*	*0.980*	*0.980*	*0.980*	*0.980*		*0.980*	*0.980*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.981*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.978*	*0.978*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1676*	*5084*		*1676*	*3504*	*1676*	*1676*	*1863*	*1676*		*5103*	*1640*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term + JIOC PM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	209	375		91	729	1056	70	115	28		545	257
Saturation flow rate, s (veh/h)	1676	5084		1676	3504	1676	1676	1863	1676		5103	1640
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	19.0	61.0		10.0	52.0	87.0	24.0	24.0	24.0		35.0	54.0
Green ratio, g/C	0.13	0.41		0.07	0.35	0.58	0.16	0.16	0.16		0.23	0.23
Lane group capacity,[1] c = s(g/C), (veh/h)	212	2,067		112	1,215	972	268	298	268		1,191	383
v/c ratio, X	0.984	0.181		0.814	0.600	1.09	0.261	0.386	0.104		0.458	0.671
Flow ratio, v/s	0.125	0.074		0.054	0.208	0.630	0.042	0.062	0.017		0.107	0.156
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.973											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**1.04**											

Lane Group Capacity, Control Delay, and LOS Determination

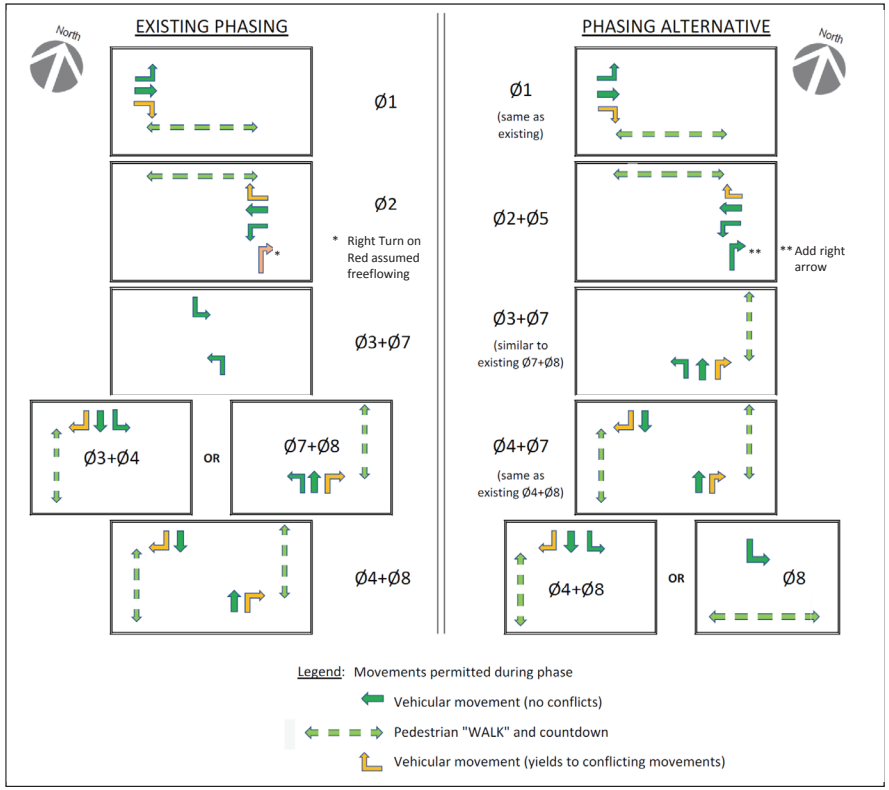
	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*209*	*375*		*91*	*729*	*1056*	*70*	*115*	*28*		*545*	*257*
Lane Group Capacity,[2] c (veh/h)	*212*	*2067*		*112*	*1215*	*972*	*268*	*298*	*268*		*1191*	*383*
v/c ratio[2], X = v/c	***0.98***	***0.18***		***0.81***	***0.60***	***1.09***	***0.26***	***0.39***	***0.10***		***0.46***	***0.67***
Total green ratio,[2] g/C	*0.13*	*0.41*		*0.07*	*0.35*	*0.58*	*0.16*	*0.16*	*0.16*		*0.23*	*0.36*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*65.35*	*28.51*		*69.08*	*40.42*	*31.50*	*55.23*	*56.40*	*53.82*		*49.36*	*40.50*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*57.82*	*0.19*		*45.65*	*2.20*	*55.12*	*2.35*	*3.74*	*0.78*		*1.27*	*9.03*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***123.2***	***28.7***		***114.7***	***42.6***	***86.6***	***57.6***	***60.1***	***54.6***		***50.6***	***49.5***
LOS by lane group (Exhibit 16-2)	***F***	***C***		***F***	***D***	***F***	***E***	***E***	***D***		***D***	***D***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***64.0***											
Intersection Level of Service (Exhibit 16-2)	***E***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

Mitigation Alternative: Signal Phasing Modification

Figure D-1 illustrates the signal phasing at the intersection of Kahuapaani Street (east leg) and Salt Lake Boulevard (north and south legs). The left side shows the existing signal phasing, which includes split phasing for the approaches crossing Salt Lake Boulevard and leading left turns for the Salt Lake Boulevard approaches. The right side of Figure D-1 shows a modified phasing that changes the existing southbound left turn from leading (occurring before the opposing through movement) to lagging (after the opposing through movement). When the south pedestrian crossing of Salt Lake Boulevard is actuated, the southbound through movement (Ø4) is terminated and to allow that crossing to begin concurrent with the beginning of the southbound left turn phase (Ø8).



The existing phasing splits the movements of the eastbound (Ø1 – shopping center exit) and westbound (Ø2 – Kahuapaani Street) approaches; the only conflicts during these phases are between the vehicular right turns and pedestrians crossing Salt Lake Boulevard allowed in the same signal phase. The westbound phase is followed by actuated phases that serve the southbound (Ø3) and northbound (Ø7) left turns from Salt Lake Boulevard; after the left turn movements are served or when the maximum phase interval is reached, the appropriate left turn phase terminates and the opposing through movement is given the green (Ø3 often has a longer duration that Ø7 due to higher volume). Pedestrian crossing in front of the shopping center is concurrent with the southbound through movement (Ø4), while the pedestrian crossing of Kahuapaani Street is concurrent with the northbound through movement (Ø8).

With the existing phasing, the left turns from Salt Lake Boulevard are "protected" movements – i. e., no conflicting vehicular or pedestrian movements. Right turn movements, however, conflict with pedestrian crossings, which occur at the same time as the adjacent through movements. Right turns on red are not prohibited, which introduces the additional potential conflict that would occur when pedestrians are crossing in front of the vehicle wishing to make a right turn.

The right side of Figure D-1 shows a modified signal phasing. Conflicts between right turns and pedestrian crossings during the same signal phase are similar to those in the existing phasing. For the purpose of analyzing future capacities and levels of service, right turns on red have been assumed to be prohibited.

The eastbound (shopping center exit) and westbound (Kahuapaani Street) approaches are split, each having their own phase, similar to existing; a green right turn arrow for the northbound right turn movement would be added (since this movement would have no conflicts during this phase, the provision of a green arrow will maximize flow during this phase), and this addition would also allow for prohibition of right turns on red.

Southbound left turns from Salt Lake Boulevard to Kahuapaani Street are moved from leading (before the opposing through movement) to lagging (after the opposing through movement). This change will allow for the termination of the green for the southbound through movement concurrent with the termination of the green for the northbound through movement when pedestrian crossing of the south leg is actuated. The pedestrian clearance interval for the south leg crossing would overlap into the green serving the shopping center exit (Ø1), thereby allowing for a shorter green in Ø1; the time saved would be distributed to the other phases to increase the capacity for the other movements.

The alternative phasing described above was found to mitigate the over-capacity situation that would result from the existing phasing. The alternative phasing (and addition of the northbound right turn arrow) would allow for prohibition of right turns on red, if such a measure were to be instituted. Since the alternative phasing also reduces overall utilization, from 1.04 to 0.90 (Table 11), use of Leading Pedestrian Interval (LPI) phasing could also be possible (LPI is a technique that allows pedestrians use of a crosswalk before turning traffic, improving safety by making pedestrians more visible).

INPUT WORKSHEET

General Information		Site Information	
Analyst	Julian Ng	Intersection	Salt Lake Blvd. & Kahuapaani St.
Agency or Company	JNI	Area Type	☐ CBD ☒ Other
Date Performed	February 12, 2019	Jurisdiction	CCH DTS
Analysis Time Period	AM Peak Hour	Analysis Year	near-term + JIOC

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	177	481	21	48	350	488	51	68	36	803	54	365
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	20.0	30.0		10.0	20.0	60.0	30.0	30.0	30.0		60.0	60.0
Y + R (s) Cycle length, C = 150.0 s	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: Salt Lake Blvd. & Kahuapaani St. near-term + JIOC AM Peak Hour

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	177	481	21	48	350	488	51	68	36	803	54	365
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adjusted flow rate, v_p = V/PHF (veh/h)	189	511	22	51	373	519	55	73	38	854	57	389
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	189	533		51	373	519	55	73	38		911	389
Proportion[1] of LT or RT (P_{LT} or P_{RT})			0.041							0.937		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	1900	1900		1900	1900	1900	1900	1900	1900		1900	1900
Number of lanes, N	1	3		1	2	1	1	1	1		3	1
Approach width	12	36		12	24	12	12	12	12		36	12
Lane width, W	12	12		12	12	12	12	12	12		12	12
Lane width adjustment factor, f_w	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Heavy-vehicle adjustment factor, f_{HV}	0.971	0.971		0.971	0.971	0.971	0.971	0.971	0.971		0.971	0.971
Grade adjustment factor, f_g	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Parking adjustment factor, f_p	0.900	1.000		0.900	1.000	0.900	0.900	1.000	0.900		1.000	0.900
Bus blockage adjustment factor, f_{bb}	1.000	0.993		1.000	0.990	1.000	1.000	1.000	1.000		1.000	1.000
Area type adj. factor, f_a (***0.90*** *CBD,* ***1.00*** *other)*	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Lane utilization adjustment factor, f_{LU}	1.000	0.933		1.000	0.950	1.000	1.000	1.000	1.000		0.933	1.000
Left-turn adjustment factor, f_{LT}	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Right-turn adjustment factor, f_{RT}	1.000	0.994		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Left-turn ped/bike adjustment factor, f_{Lpb}	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		0.985	0.985
Right-turn ped/bike adjustment factor, f_{Rpb}	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	1660	5099		1660	3470	1660	1660	1845	1660		5089	1636

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: Salt Lake Blvd. & Kahuapaani St. near-term + JIOC AM Peak Hour

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	189	533		51	373	519	55	73	38		911	389
Saturation flow rate, s (veh/h)	1660	5099		1660	3470	1660	1660	1845	1660		5089	1636
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	20.0	30.0		10.0	20.0	60.0	30.0	30.0	30.0		60.0	80.0
Green ratio, g/C	0.13	0.20		0.07	0.13	0.40	0.20	0.20	0.20		0.40	0.40
Lane group capacity,[1] c = s(g/C), (veh/h)	221	1,020		111	463	664	332	369	332		2,035	654
v/c ratio, X	0.854	0.523		0.461	0.806	0.782	0.166	0.198	0.114		0.447	0.594
Flow ratio, v/s	0.114	0.105		0.031	0.107	0.313	0.033	0.040	0.023		0.179	0.238
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.704											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.75**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	189	533		51	373	519	55	73	38		911	389
Lane Group Capacity,[2] c (veh/h)	221	1020		111	463	664	332	369	332		2035	654
v/c ratio[2], X = v/c	**0.85**	**0.52**		**0.46**	**0.81**	**0.78**	**0.17**	**0.20**	**0.11**		**0.45**	**0.59**
Total green ratio,[2] g/C	0.13	0.20		0.07	0.13	0.40	0.20	0.20	0.20		0.40	0.53
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	63.57	53.60		67.40	63.12	39.28	49.64	49.98	49.12		32.89	23.91
Incremental delay calibration,[3] k	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	31.96	1.92		13.18	13.96	8.89	1.07	1.20	0.70		0.71	3.94
Initial queue delay, d_3 (s/veh) (Appendix F)	0	0		0	0	0	0	0	0		0	0
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	1.000	1.000		1.000	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	**95.5**	**55.5**		**80.6**	**77.1**	**48.2**	**50.7**	**51.2**	**49.8**		**33.6**	**27.9**
LOS by lane group (Exhibit 16-2)	**F**	**E**		**F**	**E**	**D**	**D**	**D**	**D**		**C**	**C**
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***49.6***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☑ Other
Date Performed	*February 12, 2019*	Jurisdiction	*HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*near-term + JIOC*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	203	318	46	88	707	1,024	68	111	27	473	56	249
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*45.0*		*15.0*	*65.0*	*100.0*	*10.0*	*10.0*	*10.0*		*35.0*	*35.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term + JIOC PM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*203*	*318*	*46*	*88*	*707*	*1,024*	*68*	*111*	*27*	*473*	*56*	*249*
Peak-hour factor, PHF	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*
Adjusted flow rate, v_p = V/PHF (veh/h)	*209*	*328*	*47*	*91*	*729*	*1056*	*70*	*115*	*28*	*488*	*58*	*257*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*209*	*375*		*91*	*729*	*1056*	*70*	*115*	*28*		*545*	*257*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.125*							*0.894*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.980*	*0.980*		*0.980*	*0.980*	*0.980*	*0.980*	*0.980*	*0.980*		*0.980*	*0.980*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.981*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.978*	*0.978*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1676*	*5084*		*1676*	*3504*	*1676*	*1676*	*1863*	*1676*		*5103*	*1640*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. near-term + JIOC PM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	209	375		91	729	1056	70	115	28		545	257
Saturation flow rate, s (veh/h)	1676	5084		1676	3504	1676	1676	1863	1676		5103	1640
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	20.0	45.0		15.0	65.0	100.0	10.0	10.0	10.0		35.0	55.0
Green ratio, g/C	0.13	0.30		0.10	0.43	0.67	0.07	0.07	0.07		0.23	0.23
Lane group capacity,[1] c = s(g/C), (veh/h)	224	1,525		168	1,518	1,118	112	124	112		1,191	383
v/c ratio, X	0.935	0.246		0.543	0.480	0.94	0.626	0.926	0.251		0.458	0.671
Flow ratio, v/s	0.125	0.074		0.054	0.208	0.630	0.042	0.062	0.017		0.107	0.156
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	Note: Innovative phasing does not lend itself to normal computation of 'X'					0.973		Revised computation of Y_c will be weighted 'X' of critical lane groups				
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$						1.04		**0.90**		**X_c for modified phasing**		

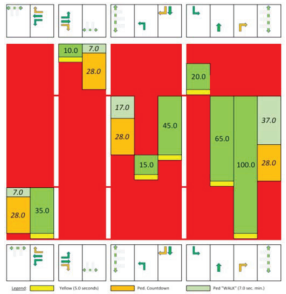
Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*209*	*375*		*91*	*729*	*1056*	*70*	*115*	*28*		*545*	*257*
Lane Group Capacity,[2] c (veh/h)	*224*	*1525*		*168*	*1518*	*1118*	*112*	*124*	*112*		*1191*	*383*
v/c ratio[2], X = v/c	***0.94***	***0.25***		***0.54***	***0.48***	***0.94***	***0.63***	***0.93***	***0.25***		***0.46***	***0.67***
Total green ratio,[2] g/C	*0.13*	*0.30*		*0.10*	*0.43*	*0.67*	*0.07*	*0.07*	*0.07*		*0.23*	*0.37*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*64.36*	*39.68*		*64.24*	*30.41*	*22.52*	*68.18*	*69.63*	*66.44*		*49.36*	*39.89*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*45.39*	*0.38*		*12.04*	*1.09*	*16.55*	*23.66*	*62.84*	*5.30*		*1.27*	*9.03*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***109.7***	***40.1***		***76.3***	***31.5***	***39.1***	***91.8***	***132.5***	***71.7***		***50.6***	***48.9***
LOS by lane group (Exhibit 16-2)	***F***	***D***		***E***	***C***	***D***	***F***	***F***	***E***		***D***	***D***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***49.8***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

Phase Diagrams:



Modified Phasing

Appendix E
Intersection Analyses Worksheets
Long-Term Future Conditions

20 sheets follow:

Arizona Street/Halawa Drive and Kamehameha Highway – no P-079 (4)
Luapele Drive and Salt Lake Boulevard – no P-079 (4)
Kahuapaani Street at Salt Lake Boulevard – no P-079 (2)

Arizona Street/Halawa Drive and Kamehameha Highway (4)
Luapele Drive and Salt Lake Boulevard (4)
Kahuapaani Street at Salt Lake Boulevard – mitigated (2)

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*2037 baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	133	180	233	159	565	617	29	7	1	5	103	14
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*12.0*	*58.0*		*17.0*	*63.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2037 baseline AM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*133*	*180*	*233*	*159*	*565*	*617*	*29*	*7*	*1*	*5*	*103*	*14*
Peak-hour factor, PHF	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*
Adjusted flow rate, v_p = V/PHF (veh/h)	*148*	*200*	*259*	*176*	*628*	*686*	*32*	*7*	*1*	*6*	*115*	*16*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*148*	*459*		*176*	*1314*			*39*	*1*	*6*	*115*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.322*	-	*0.564*	*0.134*	-	*0.522*	*0.821*	-				*0.139*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.770*	*0.770*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.915*		*1.000*	*0.922*			*1.000*	*1.000*	*1.000*	*0.981*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*0.999*	*0.999*		*0.999*	*0.999*			*0.988*	*0.988*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1659*	*3174*		*1658*	*4093*			*2668*	*1264*	*1660*	*1810*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2037 baseline AM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_0 (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*32*	*6*
Proportion of LT volume in LT lane group, P_{LT}			*0.821*	*0.000*
Proportion of LT volume in opposing flow, P_{LTO}			*0.000*	*0.821*
Adjusted flow rate for opposing approach, v_0 (veh/h)			*115*	*39*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*1.067*	*0.200*
Opposing flow per lane, per cycle, $v_{olc} = v_0C/3600$ (veh/C/ln)			*3.833*	*1.300*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*9.292*	*20.607*
Opposing queue ratio, $qr_0 = \max[1 - R_{po}(g_u/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_0^{1.061} - t_L$			*4.545*	*-0.813*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*25.708*	*14.393*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*0*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.179*
E_{L1} (refer to Exhibit C16-3)			*1.6*	*1.4*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.104*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*0*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.770*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2037 baseline AM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	58.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	41	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \le 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \le 5000$)	*0.021*	*0.019*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \ge g_p$ then $f_{Lpb} = 1.0$	*0.195*	*0.127*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.019*	*0.018*	*0.028*	*0.030*
Opposing flow rate,[3] v_0 (veh/h)	1314	459	115	39
$OCC_r = OCC_{pedu}[e^{(15/3600)v_0}]$	*0.003*	*0.009*	*0.024*	*0.029*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.991*	*0.986*	*0.983*
Proportion of left turns,[5] P_{LT}	*0.322*	*0.134*	*0.821*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*0.999*	*0.999*	*0.988*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	58.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	41	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \le 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \le 5000$)	*0.021*	*0.019*	*0.034*	*0.034*
Effective green,[1] g (s)	58.0	63.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	41	38	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.035*	*0.034*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.055*	*0.053*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.945*	*0.968*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.564*	*0.522*	*0.000*	*0.139*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2037 baseline AM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	148	459		176	1314			39	1	6	115	
Saturation flow rate, s (veh/h)	1659	3174		1658	4093			2668	1264	1660	1810	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	12.0	58.0		17.0	63.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.100	0.483		0.142	0.525			0.292	0.292	0.292	0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	166	1,534		235	2,149			778	369	484	528	
v/c ratio, X	0.892	0.299		0.749	0.611			0.050	0.003	0.012	0.218	
Flow ratio, v/s	0.089	0.145		0.106	0.321			0.015	0.001	0.004	0.064	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c; $Yc = \Sigma$ (critical lane groups, v/s)	0.474											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.54**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*148*	*459*		*176*	*1314*			*39*	*1*	*6*	*115*	
Lane Group Capacity,[2] c (veh/h)	*166*	*1534*		*235*	*2149*			*778*	*369*	*484*	*528*	
v/c ratio[2], X = v/c	***0.89***	***0.30***		***0.75***	***0.61***			***0.05***	***0.00***	***0.01***	***0.22***	
Total green ratio,[2] g/C	*0.100*	*0.483*		*0.142*	*0.525*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*53.36*	*18.72*		*49.45*	*19.94*			*30.55*	*60.00*	*60.00*	*32.15*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*46.02*	*0.50*		*19.52*	*1.31*			*0.12*	*0.01*	*0.05*	*0.95*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***99.4***	***19.2***		***69.0***	***21.2***			***30.7***	***60.0***	***60.0***	***33.1***	
LOS by lane group (Exhibit 16-2)	***F***	***C***		***E***	***C***			***C***	***E***	***E***	***C***	
Intersection delay, $d_1 = \frac{\Sigma(d_n)(v_n)}{\Sigma v_A}$ (s/veh)	***30.6***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*2037 baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	9	1181	13	34	604	4	635	1	12	164	1	115
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2037 baseline PM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*9*	*1181*	*13*	*34*	*604*	*4*	*635*	*1*	*12*	*164*	*1*	*115*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*9*	*1257*	*14*	*36*	*642*	*5*	*675*	*1*	*13*	*174*	*1*	*123*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*9*	*1271*		*36*	*647*			*676*	*13*	*174*	*1*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.007*	-	*0.011*	*0.056*	-	*0.008*	*0.999*	-				*#####*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.690*	*0.690*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.999*			*1.000*	*1.000*	*1.000*	*0.050*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.983*	*0.983*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*3464*		*1660*	*4441*			*2376*	*1126*	*1660*	*92*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2037 baseline PM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*675*	*174*
Proportion of LT volume in LT lane group, P_{LT}			*0.999*	*0.000*
Proportion of LT volume in opposing flow, P_{LTO}			*0.000*	*0.999*
Adjusted flow rate for opposing approach, v_o (veh/h)			*1*	*676*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*22.500*	*5.800*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*0.033*	*22.533*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*-4.921*	*-2.396*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*-4.743*	*31.808*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*39.743*	*3.192*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*34*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.001*
E_{L1} (refer to Exhibit C16-3)			*1.4*	*2.7*
$E_{L2} = \max[(1 - P_{THo}^n)/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.114*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*34*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.690*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2037 baseline PM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.016*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_0 (veh/h)	647	1271	1	676
$OCC_r = OCC_{pedu}[e^{(5/3600)v_0}]$	*0.006*	*0.003*	*0.028*	*0.012*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.996*	*0.997*	*0.983*	*0.993*
Proportion of left turns,[5] P_{LT}	*0.007*	*0.056*	*0.999*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.983*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Effective green,[2] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.049*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.951*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.011*	*0.008*	*0.000*	*0.000*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2037 baseline PM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	9	1271		36	647			676	13	174	1	
Saturation flow rate, s (veh/h)	1660	3464		1660	4441			2376	1126	1660	92	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	5.0	70.0		5.0	70.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.042	0.583		0.042	0.583			0.292	0.292	0.292	0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	69	2,021		69	2,590			693	328	484	27	
v/c ratio, X	0.1301	0.629		0.5205	0.2498			0.9754	0.0396	0.3593	0.0372	
Flow ratio, v/s	0.005	0.367		0.022	0.146			0.284	0.012	0.105	0.011	
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.673											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.77**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*9*	*1271*		*36*	*647*			*676*	*13*	*174*	*1*	
Lane Group Capacity,[2] c (veh/h)	*69*	*2021*		*69*	*2590*			*693*	*328*	*484*	*27*	
v/c ratio[2], X = v/c	***0.13***	***0.63***		***0.52***	***0.25***			***0.98***	***0.04***	***0.36***	***0.04***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.40*	*16.45*		*56.33*	*12.19*			*42.07*	*60.00*	*60.00*	*30.43*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*3.85*	*1.50*		*25.29*	*0.23*			*28.68*	*0.23*	*2.07*	*2.57*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***59.3***	***18.0***		***81.6***	***12.4***			***70.8***	***60.2***	***62.1***	***33.0***	
LOS by lane group (Exhibit 16-2)	***E***	***C***		***F***	***B***			***E***	***E***	***E***	***C***	
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***33.2***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*2037 baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	67	904	14	24	945	183	41	0	38	74	3	19
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*10.0*	*75.0*		*5.0*	*70.0*			*30.0*			*30.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2037 baseline AM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*67*	*904*	*14*	*24*	*945*	*183*	*41*	*0*	*38*	*74*	*3*	*19*
Peak-hour factor, PHF	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*
Adjusted flow rate, v_p = V/PHF (veh/h)	*75*	*1016*	*16*	*27*	*1062*	*205*	*46*	*0*	*43*	*83*	*4*	*21*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*75*	*1032*		*27*	*1267*			*89*			*108*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.073*	*-*	*0.016*	*0.021*	*-*	*0.162*	*0.517*	*-*	*0.483*	*0.769*	*-*	*0.194*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*			*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.815*			*0.723*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.976*			*0.928*			*0.974*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.991*			*0.986*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.975*			*0.990*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5118*		*1660*	*5006*			*2562*			*1351*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2037 baseline AM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*30.0*	*30.0*
Effective permitted green time for LT lane group,[1] g (s)			*30.0*	*30.0*
Opposing effective green time, g_o (s)			*30.0*	*30.0*
Number of lanes in LT lane group,[4] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*46*	*83*
Proportion of LT volume in LT lane group, P_{LT}			*0.517*	*0.769*
Proportion of LT volume in opposing flow, P_{LTo}			*0.769*	*0.517*
Adjusted flow rate for opposing approach, v_o (veh/h)			*108*	*89*
Lost time for LT lane group, t_L			*5*	*5*

Computation

	NB	SB	EB	WB
LT volume per cycle, LTC = $v_{LT}C/3600$			*1.533*	*2.767*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*3.600*	*2.967*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC^{*}0.629)}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*4.737*	*0.871*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.750*	*0.750*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*4.668*	*3.343*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*25.263*	*26.657*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*2*
$P_{THo} = 1 - P_{LTo}$			*0.231*	*0.483*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.5*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.6*
$f_{min} = 2(1 + P_{LT})/g$			*0.101*	*0.118*
$g_{diff} = \max[g_q - g_o, 0]$ (except when left-turn volume is 0)[4]			*0*	*2*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \le f_m \le 1.00)$			*0.815*	*0.723*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 baseline AM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{pb} = 1.0$	*0.151*	*0.115*	*0.407*	*0.278*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.015*	*0.016*	*0.032*	*0.034*
Opposing flow rate,[3] v_o (veh/h)	1267	1032	108	89
$OCC_r = OCC_{pedu}[e^{(5/3600)v_o}]$	*0.003*	*0.004*	*0.027*	*0.030*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.996*	*0.984*	*0.982*
Proportion of left turns,[5] P_{LT}	*0.073*	*0.021*	*0.517*	*0.769*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.991*	*0.986*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Effective green,[1] g (s)	75.0	70.0	30.0	30.0
$v_{bicg} = v_{bic}(C/g)$	32	34	80	80
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.032*	*0.033*	*0.050*	*0.050*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.047*	*0.049*	*0.088*	*0.088*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.953*	*0.970*	*0.947*	*0.947*
Proportion of right turns,[5] P_{RT}	*0.016*	*0.162*	*0.483*	*0.194*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.975*	*0.990*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 baseline AM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2	
Phase type	P	P		P	P			P			P	
Lane Group												
Adjusted flow rate, v (veh/h)	75	1032		27	1267			89			108	
Saturation flow rate, s (veh/h)	1660	5118		1660	5006			2562			1351	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	
Effective green time, g (s), g = G + Y - t_L	10.0	75.0		5.0	70.0			30.0			30.0	
Green ratio, g/C	0.083	0.625		0.042	0.583			0.250			0.250	
Lane group capacity,[1] c = s(g/C), (veh/h)	138	3,199		69	2,920			640			338	
v/c ratio, X	0.542	0.323		0.390	0.434			0.139			0.320	
Flow ratio, v/s	0.045	0.202		0.016	0.253			0.035			0.080	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.378											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.43**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB	
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*75*	*1032*		*27*	*1267*			*89*			*108*	
Lane Group Capacity,[2] c (veh/h)	*138*	*3199*		*69*	*2920*			*640*			*338*	
v/c ratio[2], X = v/c	***0.54***	***0.32***		***0.39***	***0.43***			***0.14***			***0.32***	
Total green ratio,[2] g/C	*0.083*	*0.625*		*0.042*	*0.583*			*0.250*			*0.250*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*52.80*	*10.57*		*56.02*	*13.95*			*34.96*			*36.68*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	
Incremental delay[3], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*14.40*	*0.27*		*15.76*	*0.47*			*0.45*			*2.48*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***67.2***	***10.8***		***71.8***	***14.4***			***35.4***			***39.2***	
LOS by lane group (Exhibit 16-2)	***E***	***B***		***E***	***B***			***D***			***D***	
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***16.9***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*2037 baseline*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	18	1614	26	42	816	8	158	0	31	85	0	3
% heavy vehicles, %HV	1	1	1	1	1	1	1	1	1	1	1	1
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			10		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.3		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2037 baseline PM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*18*	*1614*	*26*	*42*	*816*	*8*	*158*	*0*	*31*	*85*	*0*	*3*
Peak-hour factor, PHF	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*
Adjusted flow rate, v_p = V/PHF (veh/h)	*18*	*1681*	*27*	*44*	*850*	*8*	*165*	*0*	*32*	*88*	*0*	*3*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*18*	*1708*		*44*	*858*			*197*			*91*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.011*	-	*0.016*	*0.051*	-	*0.009*	*0.838*	-	*0.162*	*0.967*	-	*0.033*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.990*	*0.990*		*0.990*	*0.990*			*0.990*			*0.990*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.720*			*0.671*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.999*			*0.976*			*0.996*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.987*			*0.987*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.992*			*0.998*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1693*	*5220*		*1693*	*5225*			*2461*			*1320*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2037 baseline PM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*165*	*88*
Proportion of LT volume in LT lane group, P_{LT}			*0.838*	*0.967*
Proportion of LT volume in opposing flow, P_{LTo}			*0.967*	*0.838*
Adjusted flow rate for opposing approach, v_o (veh/h)			*91*	*197*
Lost time for LT lane group, t_L			*5*	*5*

Computation

LT volume per cycle, LTC = $v_{LT}C/3600$			*5.500*	*2.933*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*3.033*	*6.567*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC^{-0.629})}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*-2.164*	*1.444*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*2.986*	*9.385*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*32.014*	*25.615*
$n = \max[(g_q - g_f)/2, 0]$			*5*	*8*
$P_{THo} = 1 - P_{LTo}$			*0.033*	*0.162*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.7*
$E_{L2} = \max[(1 - P_{THo}^n)/P_{LTo}, 1.0]$			*1.0*	*1.2*
$f_{min} = 2(1 + P_{LT})/g$			*0.105*	*0.112*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*5*	*8*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ ($f_{min} \le f_m \le 1.00$)			*0.720*	*0.671*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 baseline PM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	10	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_e/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_e/g_p)]$	*0.008*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_o (veh/h)	858	1708	91	197
$OCC_r = OCC_{pedu}[e^{-(5/3600)v_o}]$	*0.002*	*0.002*	*0.025*	*0.023*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.999*	*0.998*	*0.985*	*0.986*
Proportion of left turns,[5] P_{LT}	*0.011*	*0.051*	*0.838*	*0.967*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.987*	*0.987*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	10
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Effective green,[1] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.041*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.959*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.016*	*0.009*	*0.162*	*0.033*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.992*	*0.998*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 baseline PM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2	
Phase type	P	P		P	P			P			P	
Lane Group												
Adjusted flow rate, v (veh/h)	18	1708		44	858			197			91	
Saturation flow rate, s (veh/h)	1693	5220		1693	5225			2461			1320	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	
Effective green time, g (s), $g = G + Y - t_L$	5.0	70.0		5.0	70.0			35.0			35.0	
Green ratio, g/C	0.042	0.583		0.042	0.583			0.292			0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	71	3,045		71	3,048			718			385	
v/c ratio, X	0.255	0.561		0.624	0.282			0.274			0.236	
Flow ratio, v/s	0.011	0.327		0.026	0.164			0.080			0.069	
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c; $Y_c = \Sigma$ (critical lane groups, v/s)	0.433											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.50**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB	
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*18*	*1708*		*44*	*858*			*197*			*91*	
Lane Group Capacity,[2] c (veh/h)	*71*	*3045*		*71*	*3048*			*718*			*385*	
v/c ratio[2], X = v/c	***0.26***	***0.56***		***0.62***	***0.28***			***0.27***			***0.24***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*			*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.70*	*15.48*		*56.57*	*12.46*			*32.72*			*32.33*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	
Incremental delay[4], d_2; $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*8.52*	*0.75*		*35.05*	*0.23*			*0.95*			*1.44*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***64.2***	***16.2***		***91.6***	***12.7***			***33.7***			***33.8***	
LOS by lane group (Exhibit 16-2)	***E***	***C***		***F***	***B***			***C***			***C***	
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***18.4***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	Julian Ng	Intersection	Salt Lake Blvd. & Kahuapaani St.
Agency or Company	JNI	Area Type	☐ CBD ☒ Other
Date Performed	February 12, 2019	Jurisdiction	CCH DTS
Analysis Time Period	AM Peak Hour	Analysis Year	2037 baseline

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	186	455	22	49	357	499	54	71	34	761	56	383
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*30.0*		*10.0*	*20.0*	*60.0*	*30.0*	*30.0*	*30.0*		*60.0*	*60.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Kahuapaani St. 2037 baseline AM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*186*	*455*	*22*	*49*	*357*	*499*	*54*	*71*	*34*	*761*	*56*	*383*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*198*	*484*	*23*	*53*	*380*	*531*	*57*	*76*	*36*	*810*	*60*	*407*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*198*	*507*		*53*	*380*	*531*	*57*	*76*	*36*		*869*	*407*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.045*							*0.931*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.993*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.985*	*0.985*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5096*		*1660*	*3470*	*1660*	*1660*	*1845*	*1660*		*5090*	*1636*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Kahuapaani St. 2037 baseline AM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	198	507		53	380	531	57	76	36		869	407
Saturation flow rate, s (veh/h)	1660	5096		1660	3470	1660	1660	1845	1660		5090	1636
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	20.0	30.0		10.0	20.0	60.0	30.0	30.0	30.0		60.0	80.0
Green ratio, g/C	0.13	0.20		0.07	0.13	0.40	0.20	0.20	0.20		0.40	0.40
Lane group capacity,[1] c = s(g/C), (veh/h)	221	1,019		111	463	664	332	369	332		2,036	654
v/c ratio, X	0.894	0.497		0.479	0.821	0.800	0.172	0.206	0.108		0.427	0.622
Flow ratio, v/s	0.119	0.099		0.032	0.110	0.320	0.034	0.041	0.022		0.171	0.249
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.729											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.78**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*198*	*507*		*53*	*380*	*531*	*57*	*76*	*36*		*869*	*407*
Lane Group Capacity,[2] c (veh/h)	*221*	*1019*		*111*	*463*	*664*	*332*	*369*	*332*		*2036*	*654*
v/c ratio[2], X = v/c	***0.89***	***0.50***		***0.48***	***0.82***	***0.80***	***0.17***	***0.21***	***0.11***		***0.43***	***0.62***
Total green ratio,[2] g/C	*0.13*	*0.20*		*0.07*	*0.13*	*0.40*	*0.20*	*0.20*	*0.20*		*0.40*	*0.53*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*63.96*	*53.30*		*67.49*	*63.26*	*39.70*	*49.71*	*50.06*	*49.06*		*32.56*	*24.45*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*38.20*	*1.73*		*14.10*	*15.07*	*9.76*	*1.12*	*1.26*	*0.66*		*0.66*	*4.42*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***102.2***	***55.0***		***81.6***	***78.3***	***49.5***	***50.8***	***51.3***	***49.7***		***33.2***	***28.9***
LOS by lane group (Exhibit 16-2)	***F***	***E***		***F***	***E***	***D***	***D***	***D***	***D***		***C***	***C***
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***50.6***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☑ Other
Date Performed	*February 12, 2019*	Jurisdiction	*HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*2037 baseline*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	212	328	51	84	676	980	71	117	29	489	58	261
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*45.0*		*15.0*	*65.0*	*100.0*	*10.0*	*10.0*	*10.0*		*35.0*	*35.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. 2037 baseline PM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*212*	*328*	*51*	*84*	*676*	*980*	*71*	*117*	*29*	*489*	*58*	*261*
Peak-hour factor, PHF	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*
Adjusted flow rate, v_p = V/PHF (veh/h)	*219*	*338*	*53*	*87*	*697*	*1010*	*74*	*120*	*29*	*504*	*60*	*269*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*219*	*391*		*87*	*697*	*1010*	*74*	*120*	*29*		*564*	*269*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.136*							*0.894*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.980*	*0.980*		*0.980*	*0.980*	*0.980*	*0.980*	*0.980*	*0.980*		*0.980*	*0.980*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.980*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.979*	*0.979*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1676*	*5075*		*1676*	*3504*	*1676*	*1676*	*1863*	*1676*		*5104*	*1641*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. 2037 baseline PM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	219	391		87	697	1010	74	120	29		564	269
Saturation flow rate, s (veh/h)	1676	5075		1676	3504	1676	1676	1863	1676		5104	1641
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), $g = G + Y - t_L$	20.0	45.0		15.0	65.0	100.0	10.0	10.0	10.0		35.0	55.0
Green ratio, g/C	0.13	0.30		0.10	0.43	0.67	0.07	0.07	0.07		0.23	0.23
Lane group capacity,[1] c = s(g/C), (veh/h)	224	1,523		168	1,518	1,118	112	124	112		1,191	383
v/c ratio, X	0.980	0.257		0.519	0.459	0.90	0.662	0.966	0.259		0.474	0.703
Flow ratio, v/s	0.131	0.077		0.052	0.199	0.602	0.044	0.064	0.017		0.110	0.164
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	Note: Innovative phasing does not lend itself to normal computation of 'X'					0.962		Revised computation of Y_c will be weighted 'X' of critical lane groups				
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$						1.03		**0.89**		**X_c for modified phasing**		

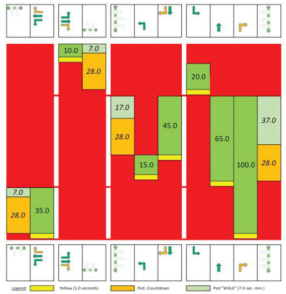
Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*219*	*391*		*87*	*697*	*1010*	*74*	*120*	*29*		*564*	*269*
Lane Group Capacity,[2] c (veh/h)	*224*	*1523*		*168*	*1518*	*1118*	*112*	*124*	*112*		*1191*	*383*
v/c ratio[2], X = v/c	***0.98***	***0.26***		***0.52***	***0.46***	***0.90***	***0.66***	***0.97***	***0.26***		***0.47***	***0.70***
Total green ratio,[2] g/C	*0.13*	*0.30*		*0.10*	*0.43*	*0.67*	*0.07*	*0.07*	*0.07*		*0.23*	*0.37*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*64.80*	*39.82*		*64.08*	*30.06*	*20.96*	*68.35*	*69.83*	*66.48*		*49.56*	*40.53*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*55.20*	*0.41*		*11.02*	*1.00*	*11.86*	*26.83*	*72.17*	*5.55*		*1.35*	*10.33*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***120.0***	***40.2***		***75.1***	***31.1***	***32.8***	***95.2***	***142.0***	***72.0***		***50.9***	***50.9***
LOS by lane group (Exhibit 16-2)	***F***	***D***		***E***	***C***	***C***	***F***	***F***	***E***		***D***	***D***
Intersection delay, $d_1 = \frac{\Sigma(d_a)(v_a)}{\Sigma v_A}$ (s/veh)	***49.7***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

Phase Diagrams:



Modified Phasing

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*2037 JIOC + infill existing JIOC Makalapa*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	133	180	279	188	565	639	31	8	1	6	111	15
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*12.0*	*58.0*		*17.0*	*63.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*133*	*180*	*279*	*188*	*565*	*639*	*31*	*8*	*1*	*6*	*111*	*15*
Peak-hour factor, PHF	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*	*0.90*
Adjusted flow rate, v_p = V/PHF (veh/h)	*148*	*200*	*310*	*208*	*628*	*710*	*34*	*8*	*1*	*7*	*124*	*17*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*148*	*510*		*208*	*1338*			*42*	*1*	*7*	*124*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.290*	-	*0.608*	*0.155*	-	*0.531*	*0.810*	-				*0.137*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.764*	*0.764*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.909*		*1.000*	*0.920*			*1.000*	*1.000*	*1.000*	*0.982*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*0.999*	*0.999*		*0.999*	*0.999*			*0.988*	*0.988*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1659*	*3152*		*1658*	*4087*			*2646*	*1254*	*1660*	*1811*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*34*	*7*
Proportion of LT volume in LT lane group, P_{LT}			*0.810*	*0.000*
Proportion of LT volume in opposing flow, P_{LTo}			*0.000*	*0.810*
Adjusted flow rate for opposing approach, v_o (veh/h)			*124*	*42*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*1.133*	*0.233*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*4.133*	*1.400*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*8.803*	*19.805*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_u/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*5.109*	*-0.570*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*26.197*	*15.195*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*0*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.190*
E_{L1} (refer to Exhibit C16-3)			*1.6*	*1.4*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.103*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*0*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.764*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	58.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	41	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.021*	*0.019*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.195*	*0.127*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.019*	*0.018*	*0.028*	*0.030*
Opposing flow rate,[3] v_0 (veh/h)	1338	510	124	42
$OCC_r = OCC_{pedu}[e^{(15/3600)v_0}]$	*0.003*	*0.009*	*0.024*	*0.028*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.998*	*0.991*	*0.986*	*0.983*
Proportion of left turns,[5] P_{LT}	*0.290*	*0.155*	*0.810*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*0.999*	*0.999*	*0.988*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	58.0	63.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p))	41	38	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.021*	*0.019*	*0.034*	*0.034*
Effective green,[1] g (s)	58.0	63.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	41	38	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.035*	*0.034*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.055*	*0.053*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.945*	*0.968*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.608*	*0.531*	*0.000*	*0.137*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	148	510		208	1338			42	1	7	124	
Saturation flow rate, s (veh/h)	1659	3152		1658	4087			2646	1254	1660	1811	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	12.0	58.0		17.0	63.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.100	0.483		0.142	0.525			0.292	0.292	0.292	0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	166	1,523		235	2,146			772	366	484	528	
v/c ratio, X	0.892	0.335		0.886	0.624			0.054	0.003	0.014	0.235	
Flow ratio, v/s	0.089	0.162		0.125	0.327			0.016	0.001	0.004	0.068	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c; $Yc = \Sigma$ (critical lane groups, v/s)	0.485											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.55**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*148*	*510*		*208*	*1338*			*42*	*1*	*7*	*124*	
Lane Group Capacity,[2] c (veh/h)	*166*	*1523*		*235*	*2146*			*772*	*366*	*484*	*528*	
v/c ratio[2], X = v/c	***0.89***	***0.33***		***0.89***	***0.62***			***0.05***	***0.00***	***0.01***	***0.23***	
Total green ratio,[2] g/C	*0.100*	*0.483*		*0.142*	*0.525*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*53.36*	*19.11*		*50.55*	*20.13*			*30.59*	*60.00*	*60.00*	*32.32*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*46.00*	*0.59*		*35.22*	*1.38*			*0.13*	*0.01*	*0.05*	*1.04*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***99.4***	***19.7***		***85.8***	***21.5***			***30.7***	***60.0***	***60.1***	***33.4***	
LOS by lane group (Exhibit 16-2)	***F***	***C***		***F***	***C***			***C***	***E***	***E***	***C***	
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***32.5***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Kamehameha Hwy. & Halawa Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*HDOT-HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*2037 JIOC + infill existing JIOC Makalapa*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	9	1181	16	40	604	4	635	1	12	202	2	143
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		
Signal Phasing Information												
Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*9*	*1181*	*16*	*40*	*604*	*4*	*635*	*1*	*12*	*202*	*2*	*143*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*9*	*1257*	*17*	*43*	*642*	*5*	*675*	*1*	*13*	*215*	*2*	*153*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*9*	*1274*		*43*	*647*			*676*	*13*	*215*	*2*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.007*	-	*0.013*	*0.066*	-	*0.008*	*0.999*	-				*76.500*
Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)												
Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*	*1900*	*1900*	*1900*	
Number of lanes, N	*1*	*2*		*1*	*3*			*2*	*1*	*1*	*1*	
Approach width	*12*	*24*		*12*	*24*			*24*	*12*	*12*	*12*	
Lane width, W	*12*	*12*		*12*	*8*			*12*	*12*	*12*	*12*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*0.867*			*1.000*	*1.000*	*1.000*	*1.000*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*	*0.971*	*0.971*	*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*	*0.900*	*0.900*	*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.990*		*1.000*	*0.993*			*1.000*	*1.000*	*1.000*	*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.950*		*1.000*	*0.933*			*0.950*	*1.000*	*1.000*	*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.690*	*0.690*	*1.000*	*1.000*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.999*			*1.000*	*1.000*	*1.000*	*0.050*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.983*	*0.983*	*1.000*	*1.000*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*3463*		*1660*	*4440*			*2378*	*1126*	*1660*	*92*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Kamehameha Hwy. & Halawa Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_0 (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*675*	*215*
Proportion of LT volume in LT lane group, P_{LT}			*0.999*	*0.000*
Proportion of LT volume in opposing flow, P_{LTO}			*0.000*	*0.999*
Adjusted flow rate for opposing approach, v_0 (veh/h)			*2*	*676*
Lost time for LT lane group, t_L			*5*	*5*
Computation				
LT volume per cycle, LTC = $v_{LT}C/3600$			*22.500*	*7.167*
Opposing flow per lane, per cycle, $v_{olc} = v_0C/3600$ (veh/C/ln)			*0.067*	*22.533*
Arrival type (1-6, very poor to exceptional, 3=random)			*3*	*3*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC*0.629)}] - t_L$ $g_f \leq g$ (except exclusive left-turn lanes)[3]			*-4.921*	*-3.201*
Opposing queue ratio, $qr_0 = \max[1 - R_{po}(g_u/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_0^{1.061} - t_L$			*-4.565*	*31.808*
$g_u = g - g_q$ if $g_q \geq g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*39.565*	*3.192*
$n = \max[(g_q - g_f)/2, 0]$			*0*	*35*
$P_{THo} = 1 - P_{LTo}$			*1.000*	*0.001*
E_{L1} (refer to Exhibit C16-3)			*1.4*	*2.7*
$E_{L2} = \max[(1 - P_{THo}^{n})/P_{LTo}, 1.0]$			*1.0*	*1.0*
$f_{min} = 2(1 + P_{LT})/g$			*0.114*	*0.057*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*0*	*35*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ $(f_{min} \leq f_m \leq 1.00)$			*0.690*	*1.000*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.016*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_0 (veh/h)	647	1274	2	676
$OCC_r = OCC_{pedu}[e^{(5/3600)v_0}]$	*0.006*	*0.003*	*0.028*	*0.012*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	2
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.996*	*0.997*	*0.983*	*0.993*
Proportion of left turns,[5] P_{LT}	*0.007*	*0.066*	*0.999*	*0.000*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.983*	*1.000*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	34	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.017*	*0.017*	*0.034*	*0.034*
Effective green,[2] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.049*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	2	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.951*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.013*	*0.008*	*0.000*	*0.000*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	1
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*1.000*	*1.000*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_0 = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Kamehameha Hwy. & Halawa Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Capacity Analysis

Phase number	1	2		5	6			3	3	3	3	
Phase type	P	P		P	P			P	P	P	P	
Lane Group												
Adjusted flow rate, v (veh/h)	9	1274		43	647			676	13	215	2	
Saturation flow rate, s (veh/h)	1660	3463		1660	4440			2378	1126	1660	92	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0	0.0	5.0	5.0	
Effective green time, g (s), g = G + Y - t_L	5.0	70.0		5.0	70.0			35.0	0.0	0.0	35.0	
Green ratio, g/C	0.042	0.583		0.042	0.583			0.292	0.292	0.292	0.292	
Lane group capacity,[1] c = s(g/C), (veh/h)	69	2,020		69	2,590			694	329	484	27	
v/c ratio, X	0.1301	0.6307		0.6217	0.2498			0.9747	0.0396	0.444	0.0743	
Flow ratio, v/s	0.005	0.368		0.026	0.146			0.284	0.012	0.130	0.022	
Critical lane group/phase (√)		√		√				√				
Sum of flow ratios for critical lane groups, Y_c; $Yc = \Sigma$ (critical lane groups, v/s)	0.678											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.77**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB		WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*9*	*1274*		*43*	*647*			*676*	*13*	*215*	*2*	
Lane Group Capacity,[2] c (veh/h)	*69*	*2020*		*69*	*2590*			*694*	*329*	*484*	*27*	
v/c ratio[2], X = v/c	***0.13***	***0.63***		***0.62***	***0.25***			***0.97***	***0.04***	***0.44***	***0.07***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*	*0.000*	*0.000*	*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*55.40*	*16.48*		*56.57*	*12.19*			*42.06*	*60.00*	*60.00*	*30.77*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*	*0.5*	*0.5*	*0.5*	
Incremental delay[4], d_2; $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*3.85*	*1.51*		*35.41*	*0.23*			*28.52*	*0.23*	*2.93*	*5.31*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*	*0*	*0*	*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*	*1.000*	*1.000*	*1.000*	
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***59.3***	***18.0***		***92.0***	***12.4***			***70.6***	***60.2***	***62.9***	***36.1***	
LOS by lane group (Exhibit 16-2)	***E***	***C***		***F***	***B***			***E***	***E***	***E***	***D***	
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***33.9***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*2037 JIOC + infill existing JIOC Makalapa*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	113	904	14	24	945	308	62	0	57	74	5	19
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			20		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.4		
Green time (s)	*10.0*	*75.0*		*5.0*	*70.0*			*30.0*			*30.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*113*	*904*	*14*	*24*	*945*	*308*	*62*	*0*	*57*	*74*	*5*	*19*
Peak-hour factor, PHF	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*	*0.89*
Adjusted flow rate, v_p = V/PHF (veh/h)	*127*	*1016*	*16*	*27*	*1062*	*346*	*69*	*0*	*65*	*83*	*6*	*21*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*127*	*1032*		*27*	*1408*			*134*			*110*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.123*	-	*0.016*	*0.019*	-	*0.246*	*0.515*	-	*0.485*	*0.755*	-	*0.191*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*			*0.971*			*0.971*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.803*			*0.684*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.963*			*0.927*			*0.974*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.992*			*0.987*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.974*			*0.990*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5118*		*1660*	*4941*			*2523*			*1281*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description *Salt Lake Blvd. & Luapele Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*30.0*	*30.0*
Effective permitted green time for LT lane group,[1] g (s)			*30.0*	*30.0*
Opposing effective green time, g_o (s)			*30.0*	*30.0*
Number of lanes in LT lane group,[4] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*69*	*83*
Proportion of LT volume in LT lane group, P_{LT}			*0.515*	*0.755*
Proportion of LT volume in opposing flow, P_{LTo}			*0.755*	*0.515*
Adjusted flow rate for opposing approach, v_o (veh/h)			*110*	*134*
Lost time for LT lane group, t_L			*5*	*5*

Computation

LT volume per cycle, LTC = $v_{LT}C/3600$			*2.300*	*2.767*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*3.667*	*4.467*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC^{*}0.629)}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*2.022*	*0.871*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.750*	*0.750*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*4.804*	*6.395*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*25.196*	*23.605*
$n = \max[(g_q - g_f)/2, 0]$			*3*	*6*
$P_{THo} = 1 - P_{LTo}$			*0.245*	*0.485*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*1.6*
$E_{L2} = \max[(1 - P_{THo}^{o})/P_{LTo}, 1.0]$			*1.3*	*1.9*
$f_{min} = 2(1 + P_{LT})/g$			*0.101*	*0.117*
$g_{diff} = \max[g_q - g_o, 0]$ (except when left-turn volume is 0)[4]			*3*	*6*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ ($f_{min} \le f_m \le 1.00$)			*0.803*	*0.684*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_q/g_p if $g_q \geq g_p$ then $f_{pb} = 1.0$	*0.151*	*0.115*	*0.407*	*0.278*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.015*	*0.016*	*0.032*	*0.034*
Opposing flow rate,[3] v_o (veh/h)	1408	1032	110	134
$OCC_r = OCC_{pedu}[e^{(5/3600)v_o}]$	*0.002*	*0.004*	*0.027*	*0.029*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.999*	*0.996*	*0.984*	*0.983*
Proportion of left turns,[5] P_{LT}	*0.123*	*0.019*	*0.515*	*0.755*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.992*	*0.987*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	75.0	70.0	30.0	30.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	20
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	32	34	80	80
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.016*	*0.017*	*0.040*	*0.040*
Effective green,[1] g (s)	75.0	70.0	30.0	30.0
$v_{bicg} = v_{bic}(C/g)$	32	34	80	80
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.032*	*0.033*	*0.050*	*0.050*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.047*	*0.049*	*0.088*	*0.088*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$ $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.953*	*0.970*	*0.947*	*0.947*
Proportion of right turns,[5] P_{RT}	*0.016*	*0.246*	*0.485*	*0.191*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.974*	*0.990*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2	
Phase type	P	P		P	P			P			P	
Lane Group												
Adjusted flow rate, v (veh/h)	127	1032		27	1408			134			110	
Saturation flow rate, s (veh/h)	1660	5118		1660	4941			2523			1281	
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0	
Effective green time, g (s), $g = G + Y - t_L$	10.0	75.0		5.0	70.0			30.0			30.0	
Green ratio, g/C	0.083	0.625		0.042	0.583			0.250			0.250	
Lane group capacity,[1] c = s(g/C), (veh/h)	138	3,198		69	2,882			631			320	
v/c ratio, X	0.918	0.323		0.390	0.489			0.212			0.343	
Flow ratio, v/s	0.077	0.202		0.016	0.285			0.053			0.086	
Critical lane group/phase (√)	√				√						√	
Sum of flow ratios for critical lane groups, Y_c $Yc = \Sigma$ (critical lane groups, v/s)	0.447											
Total lost time per cycle, L (s)	15											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.51**											

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB	
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*127*	*1032*		*27*	*1408*			*134*			*110*	
Lane Group Capacity,[2] c (veh/h)	*138*	*3198*		*69*	*2882*			*631*			*320*	
v/c ratio[2], X = v/c	***0.92***	***0.32***		***0.39***	***0.49***			***0.21***			***0.34***	
Total green ratio,[2] g/C	*0.083*	*0.625*		*0.042*	*0.583*			*0.250*			*0.250*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*54.59*	*10.57*		*56.02*	*14.57*			*35.64*			*36.92*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	
Incremental delay[3], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*57.18*	*0.27*		*15.76*	*0.59*			*0.77*			*2.91*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Delay = $d = d_1(PF) + d_2 + d_3$ (s/veh)	***111.8***	***10.8***		***71.8***	***15.2***			***36.4***			***39.8***	
LOS by lane group (Exhibit 16-2)	***F***	***B***		***E***	***C***			***D***			***D***	
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***20.4***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is $(1 + P_L)(3600/C)$
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Luapele Dr.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 2, 2018*	Jurisdiction	*CCH DTS*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*2037 JIOC + infill existing JIOC Makalapa*

Volume and Timing Input

	NB			SB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	43	1614	26	42	816	19	315	0	61	85	0	3
% heavy vehicles, %HV	1	1	1	1	1	1	1	1	1	1	1	1
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Pretimed (P) or actuated (A)	P	P	P	P	P	P	P	P	P	P	P	P
Arrival type, AT	3	3	3	3	3	3	3	3	3	3	3	3
Approach pedestrian volume,[2] v_{ped} (p/h)	20			20			20			10		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	100			100			100			100		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	28.4			28.4			28.4			28.3		
Green time (s)	*5.0*	*70.0*		*5.0*	*70.0*			*35.0*			*35.0*	
Y + R (s) Cycle length, C = 120.0 s		*5.0*			*5.0*			*5.0*			*5.0*	

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Volume Adjustment

	NB			SB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*43*	*1614*	*26*	*42*	*816*	*19*	*315*	*0*	*61*	*85*	*0*	*3*
Peak-hour factor, PHF	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*	*0.96*
Adjusted flow rate, v_p = V/PHF (veh/h)	*44*	*1681*	*27*	*44*	*850*	*19*	*329*	*0*	*63*	*88*	*0*	*3*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*44*	*1708*		*44*	*869*			*392*			*91*	
Proportion[1] of LT or RT (P_{LT} or P_{RT})	*0.026*	-	*0.016*	*0.051*	-	*0.022*	*0.839*	-	*0.161*	*0.967*	-	*0.033*

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*			*1900*			*1900*	
Number of lanes, N	*1*	*3*		*1*	*3*			*2*			*1*	
Approach width	*12*	*36*		*12*	*36*			*24*			*14*	
Lane width, W	*12*	*12*		*12*	*12*			*12*			*14*	
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.067*	
Heavy-vehicle adjustment factor, f_{HV}	*0.990*	*0.990*		*0.990*	*0.990*			*0.990*			*0.990*	
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*			*1.000*			*1.000*	
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.993*			*1.000*			*1.000*	
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.933*			*0.950*			*1.000*	
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*			*0.718*			*0.693*	
Right-turn adjustment factor, f_{RT}	*1.000*	*0.998*		*1.000*	*0.997*			*0.976*			*0.996*	
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.987*			*0.990*	
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*			*0.992*			*0.998*	
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1693*	*5219*		*1693*	*5215*			*2455*			*1367*	

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

SUPPLEMENTAL WORKSHEET FOR PERMITTED LEFT TURNS OPPOSED BY SINGLE-LANE APPROACH

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Input

	NB	SB	EB	WB
Cycle length, C (s)	*120.0*			
Total actual green time for LT lane group,[1] G (s)			*35.0*	*35.0*
Effective permitted green time for LT lane group,[1] g (s)			*35.0*	*35.0*
Opposing effective green time, g_o (s)			*35.0*	*35.0*
Number of lanes in LT lane group,[2] N			*2*	*1*
Adjusted LT flow rate, v_{LT} (veh/h)			*329*	*88*
Proportion of LT volume in LT lane group, P_{LT}			*0.839*	*0.967*
Proportion of LT volume in opposing flow, P_{LTo}			*0.967*	*0.839*
Adjusted flow rate for opposing approach, v_o (veh/h)			*91*	*392*
Lost time for LT lane group, t_L			*5*	*5*

Computation

LT volume per cycle, LTC = $v_{LT}C/3600$			*10.967*	*2.933*
Opposing flow per lane, per cycle, $v_{olc} = v_oC/3600$ (veh/C/ln)			*3.033*	*13.067*
Opposing platoon ratio, R_{po}			*1.00*	*1.00*
$g_f = G[e^{-0.860(LTC^{-0.629})}] - t_L$ $g_f \le g$ (except exclusive left-turn lanes)[3]			*-4.276*	*1.444*
Opposing queue ratio, $qr_o = \max[1 - R_{po}(g_o/C), 0]$			*0.708*	*0.708*
$g_q = 4.943 v_{olc}^{0.762} qr_o^{1.061} - t_L$			*2.986*	*19.300*
$g_u = g - g_q$ if $g_q \ge g_f$, or $g_u = g - g_f$ if $g_q < g_f$			*32.014*	*15.700*
$n = \max[(g_q - g_f)/2, 0]$			*7*	*18*
$P_{THo} = 1 - P_{LTo}$			*0.033*	*0.161*
E_{L1} (refer to Exhibit C16-3)			*1.5*	*2.1*
$E_{L2} = \max[(1 - P_{THo}^n)/P_{LTo}, 1.0]$			*1.0*	*1.2*
$f_{min} = 2(1 + P_{LT})/g$			*0.105*	*0.112*
$g_{diff} = \max[g_q - g_f, 0]$ (except when left-turn volume is 0)[4]			*7*	*18*
$f_{LT} = f_m = [g_f/g] + \left[\frac{g_u/g}{1 + P_{LT}(E_{L1} - 1)}\right] + \left[\frac{g_{diff}/g}{1 + P_{LT}(E_{L2} - 1)}\right]$ ($f_{min} \le f_m \le 1.00$)			*0.718*	*0.693*

Notes

1. Refer to Exhibits C16-4, C16-5, C16-6, C16-7, and C16-8 for case-specific parameters and adjustment factors
2. For exclusive left-turn lanes, N is equal to the number of exclusive left-turn lanes. For shared left-turn lanes, N is equal to the sum of the shared left-turn, through, and shared right-turn (ifone exists) lanes in that approach.
3. For exclusive left-turn lanes, g_f = 0, and skip the next step. Lost time, t_L, may not be applicable for protected-permitted case.
4. If opposing left-turn volume is 0, then g_{diff} = 0.

SUPPLEMENTAL WORKSHEET FOR PEDESTRIAN-BICYCLE EFFECTS ON PERMITTED LEFT TURNS AND RIGHT TURNS

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Permitted Left Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	10	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Opposing queue clearing green,[3,4] g_q (s)	*11.303*	*8.027*	*12.201*	*8.328*
Effective pedestrian green consumed by opposing vehicle queue, g_e/g_p if $g_q \geq g_p$ then $f_{Lpb} = 1.0$	*0.161*	*0.115*	*0.349*	*0.238*
$OCC_{pedu} = OCC_{pedg}[1 - 0.5(g_q/g_p)]$	*0.008*	*0.016*	*0.028*	*0.030*
Opposing flow rate,[3] v_o (veh/h)	869	1708	91	392
$OCC_r = OCC_{pedu}[e^{-(5/3600)v_o}]$	*0.002*	*0.002*	*0.025*	*0.018*
Number of cross-street receiving lanes,[1] N_{rec}	2	1	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.999*	*0.998*	*0.985*	*0.989*
Proportion of left turns,[5] P_{LT}	*0.026*	*0.051*	*0.839*	*0.967*
Proportion of left turns using protected phase,[6] P_{LTA}	0	0	0	0
$F_{Lpb} = 1.0 - P_{LT}(1 - A_{pbT})(1 - P_{LTA})$	*1.000*	*1.000*	*0.987*	*0.990*

Permitted Right Turns

	NB	SB	EB	WB
Effective pedestrian green time[1,2] g_p (s)	70.0	70.0	35.0	35.0
Conflicting pedestrian volume,[1] v_{ped} (p/h)	20	20	20	10
Conflicting bicycle volume,[1,7] v_{bic} (bicycles/h)	20	20	20	20
v_{pedg} (= v_{ped} (C/g_p)	17	34	69	69
$OCC_{pedg} = v_{pedg}/2000$ if ($v_{pedg} \leq 1000$) or $OCC_{pedg} = 0.4 + v_{pedg}/10{,}000$ if ($1000 < v_{pedg} \leq 5000$)	*0.009*	*0.017*	*0.034*	*0.034*
Effective green,[1] g (s)	70.0	70.0	35.0	35.0
$v_{bicg} = v_{bic}(C/g)$	34	34	69	69
$OCC_{bicg} = 0.02 + v_{bicg}/2700$	*0.033*	*0.033*	*0.045*	*0.045*
$OCC_r = OCC_{pedg} + OCC_{bicg} - (OCC_{pedg})(OCC_{bicg})$	*0.041*	*0.049*	*0.078*	*0.078*
Number of cross-street receiving lanes,[1] N_{rec}	1	2	3	3
Number of turning lanes,[1] N_{turn}	1	1	1	1
$A_{pbT} = 1 - OCC_r$ if $N_{rec} = N_{turn}$; $A_{pbT} = 1 - 0.6(OCC_r)$ if $N_{rec} > N_{turn}$	*0.959*	*0.970*	*0.953*	*0.953*
Proportion of right turns,[5] P_{RT}	*0.016*	*0.022*	*0.161*	*0.033*
Proportion of right turns using protected phase,[8] P_{RTA}	1	1	0	0
$FR_{pb} = 1.0 - P_{RT}(1 - A_{pbT})(1 - P_{RTA})$	*1.000*	*1.000*	*0.992*	*0.998*

Notes

1. Refer to Input Worksheet
2. If intersection signal timing is given, use Walk + flashing Don't Walk (use G + Y if no pedestrian signals). If signal timing must be estimated, use (Green Time - Lost Time per Phase) from Quick Estimation Control Delay and LOS Worksheet.
3. Refer to supplemental worksheets for left turns.
4. If unopposed left turn, then $g_q = 0$, $v_o = 0$, and $OCC_r = OCC_{pedu} = OCC_{pedg}$
5. Refer to Volume Adjustment and Saturation Flow Rate Worksheet.
6. Ideally determined from field data; alternatively, assume it equal to (1 - permitted phase f_{LT})/0.95.
7. If $v_{bic} = 0$ then $v_{bicg} = 0$, $OCC_{bicg} = 0$, and $OCC_r = OCC_{pedg}$.
8. P_{RTA} is the proportion of protected green over the total green, $g_{prot}/(g_{prot} + g_{perm})$. If only permitted right-turn phase existis, then $P_{RTA} = 0$.

CAPACITY AND LOS WORKSHEET

General Information

Project Description: *Salt Lake Blvd. & Luapele Dr. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Capacity Analysis

Phase number	1	1		1	1			2			2
Phase type	P	P		P	P			P			P
Lane Group											
Adjusted flow rate, v (veh/h)	44	1708		44	869			392			91
Saturation flow rate, s (veh/h)	1693	5219		1693	5215			2455			1367
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0			5.0			5.0
Effective green time, g (s), $g = G + Y - t_L$	5.0	70.0		5.0	70.0			35.0			35.0
Green ratio, g/C	0.042	0.583		0.042	0.583			0.292			0.292
Lane group capacity,[1] c = s(g/C), (veh/h)	71	3,045		71	3,042			716			399
v/c ratio, X	0.624	0.561		0.624	0.286			0.548			0.228
Flow ratio, v/s	0.026	0.327		0.026	0.167			0.160			0.067
Critical lane group/phase (√)		√		√				√			
Sum of flow ratios for critical lane groups, Y_c; $Y_c = \Sigma$ (critical lane groups, v/s)	0.513										
Total lost time per cycle, L (s)	15										
Critical flow rate to capacity ratio, X_c; $X_c = (Y_c)(C)/(C - L)$	**0.59**										

Lane Group Capacity, Control Delay, and LOS Determination

	NB			SB				EB			WB	
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*44*	*1708*		*44*	*869*			*392*			*91*	
Lane Group Capacity,[2] c (veh/h)	*71*	*3045*		*71*	*3042*			*716*			*399*	
v/c ratio[2], X = v/c	***0.62***	***0.56***		***0.62***	***0.29***			***0.55***			***0.23***	
Total green ratio,[2] g/C	*0.042*	*0.583*		*0.042*	*0.583*			*0.292*			*0.292*	
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*56.57*	*15.48*		*56.57*	*12.50*			*35.83*			*32.25*	
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*			*0.5*			*0.5*	
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*35.05*	*0.75*		*35.05*	*0.24*			*3.00*			*1.33*	
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*			*0*			*0*	
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*			*1.000*			*1.000*	
Delay = d = $d_1(PF) + d_2 + d_3$ (s/veh)	***91.6***	***16.2***		***91.6***	***12.7***			***38.8***			***33.6***	
LOS by lane group (Exhibit 16-2)	***F***	***C***		***F***	***B***			***D***			***C***	
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***20.7***											
Intersection Level of Service (Exhibit 16-2)	***C***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☒ Other
Date Performed	*February 12, 2019*	Jurisdiction	*CCH DTS*
Analysis Time Period	*AM Peak Hour*	Analysis Year	*2037 JIOC + infill existing JIOC Makalapa*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	186	501	22	50	366	510	54	71	37	837	56	383
% heavy vehicles, %HV	3	3	3	3	3	3	3	3	3	3	3	3
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*30.0*		*10.0*	*20.0*	*60.0*	*30.0*	*30.0*	*30.0*		*60.0*	*60.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. 2037 JIOC + infill existing JIOC Makalapa bldgsAM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*186*	*501*	*22*	*50*	*366*	*510*	*54*	*71*	*37*	*837*	*56*	*383*
Peak-hour factor, PHF	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*	*0.94*
Adjusted flow rate, v_p = V/PHF (veh/h)	*198*	*533*	*23*	*54*	*390*	*543*	*57*	*76*	*39*	*891*	*60*	*407*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*198*	*556*		*54*	*390*	*543*	*57*	*76*	*39*		*950*	*407*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.041*							*0.937*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.971*	*0.971*		*0.971*	*0.971*	*0.971*	*0.971*	*0.971*	*0.971*		*0.971*	*0.971*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.994*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.985*	*0.985*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1660*	*5099*		*1660*	*3470*	*1660*	*1660*	*1845*	*1660*		*5089*	*1636*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. 2037 JIOC + infill existing JIOC Makalapa bldgs AM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	198	556		54	390	543	57	76	39		950	407
Saturation flow rate, s (veh/h)	1660	5099		1660	3470	1660	1660	1845	1660		5089	1636
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	20.0	30.0		10.0	20.0	60.0	30.0	30.0	30.0		60.0	80.0
Green ratio, g/C	0.13	0.20		0.07	0.13	0.40	0.20	0.20	0.20		0.40	0.40
Lane group capacity,[1] c = s(g/C), (veh/h)	221	1,020		111	463	664	332	369	332		2,036	654
v/c ratio, X	0.894	0.545		0.488	0.843	0.818	0.172	0.206	0.117		0.467	0.622
Flow ratio, v/s	0.119	0.109		0.033	0.112	0.327	0.034	0.041	0.023		0.187	0.249
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c $Y_c = \Sigma$ (critical lane groups, v/s)	0.736											
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$	**0.79**											

Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group												
Adjusted flow rate,[2] v (veh/h)	*198*	*556*		*54*	*390*	*543*	*57*	*76*	*39*		*950*	*407*
Lane Group Capacity,[2] c (veh/h)	*221*	*1020*		*111*	*463*	*664*	*332*	*369*	*332*		*2036*	*654*
v/c ratio[2], X = v/c	***0.89***	***0.55***		***0.49***	***0.84***	***0.82***	***0.17***	***0.21***	***0.12***		***0.47***	***0.62***
Total green ratio,[2] g/C	*0.13*	*0.20*		*0.07*	*0.13*	*0.40*	*0.20*	*0.20*	*0.20*		*0.40*	*0.53*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*63.96*	*53.87*		*67.53*	*63.47*	*40.12*	*49.71*	*50.06*	*49.15*		*33.20*	*24.45*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*38.20*	*2.09*		*14.57*	*16.86*	*10.75*	*1.12*	*1.26*	*0.72*		*0.77*	*4.42*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***102.2***	***56.0***		***82.1***	***80.3***	***50.9***	***50.8***	***51.3***	***49.9***		***34.0***	***28.9***
LOS by lane group (Exhibit 16-2)	***F***	***E***		***F***	***F***	***D***	***D***	***D***	***D***		***C***	***C***
Intersection delay, $d_I = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***51.2***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

INPUT WORKSHEET

General Information		Site Information	
Analyst	*Julian Ng*	Intersection	*Salt Lake Blvd. & Kahuapaani St.*
Agency or Company	*JNI*	Area Type	☐ CBD ☑ Other
Date Performed	*February 12, 2019*	Jurisdiction	*HWY*
Analysis Time Period	*PM Peak Hour*	Analysis Year	*2037 JIOC + infill existing JIOC Makalapa*

Volume and Timing Input

	SB			NB			EB			WB		
	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]	LT	TH	RT[1]
Volume, V (veh/h)	212	333	51	92	737	1,068	71	117	29	495	58	261
% heavy vehicles, %HV	2	2	2	2	2	2	2	2	2	2	2	2
% Grade	0	0	0	0	0	0	0	0	0	0	0	0
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Approach pedestrian volume,[2] v_{ped} (p/h)	25			25			25			25		
Approach bicycle volume,[2] v_{bic} (bicycles/h)	20			20			20			20		
Parking (Y or N)	N			N			N			N		
Parking maneuvers, N_m (maneuvers/h)	0			0			0			0		
Bus stopping N_B (buses/h)	5			5			0			0		
Crosswalk length (ft)	80			80			80			80		

Signal Phasing Information

Min. timing for pedestrians,[3] G_p (s)	23.5			23.5			23.5			23.5		
Green time (s)	*20.0*	*45.0*		*15.0*	*65.0*	*100.0*	*10.0*	*10.0*	*10.0*		*35.0*	*35.0*
Y + R (s) Cycle length, C = 150.0 s	*5.0*	*5.0*		*5.0*	*5.0*	*5.0*	*5.0*	*5.0*	*5.0*		*5.0*	*5.0*

Notes

1. RT volumes, as shown, exclude RTOR
2. Approach pedestrian and bicycle volumes are those that conflict with right turns from the subject approach.
3. Refer to Equation 16-2

VOLUME ADJUSTMENT AND SATURATION FLOW RATE WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Volume Adjustment

	SB			NB			EB			WB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Volume, V (veh/h)	*212*	*333*	*51*	*92*	*737*	*1,068*	*71*	*117*	*29*	*495*	*58*	*261*
Peak-hour factor, PHF	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*	*0.97*
Adjusted flow rate, v_p = V/PHF (veh/h)	*219*	*343*	*53*	*95*	*760*	*1101*	*74*	*120*	*29*	*510*	*60*	*269*
Lane Group												
Adjusted flow rate in lane group, v (veh/h)	*219*	*396*		*95*	*760*	*1101*	*74*	*120*	*29*		*570*	*269*
Proportion[1] of LT or RT (P_{LT} or P_{RT})			*0.134*							*0.895*		

Saturation Flow Rate (see Exhibit 16-7 to determine adjustment factors)

Base saturation flow, s_0 (pc/h/ln)	*1900*	*1900*		*1900*	*1900*	*1900*	*1900*	*1900*	*1900*		*1900*	*1900*
Number of lanes, N	*1*	*3*		*1*	*2*	*1*	*1*	*1*	*1*		*3*	*1*
Approach width	*12*	*36*		*12*	*24*	*12*	*12*	*12*	*12*		*36*	*12*
Lane width, W	*12*	*12*		*12*	*12*	*12*	*12*	*12*	*12*		*12*	*12*
Lane width adjustment factor, f_w	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Heavy-vehicle adjustment factor, f_{HV}	*0.980*	*0.980*		*0.980*	*0.980*	*0.980*	*0.980*	*0.980*	*0.980*		*0.980*	*0.980*
Grade adjustment factor, f_g	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Parking adjustment factor, f_p	*0.900*	*1.000*		*0.900*	*1.000*	*0.900*	*0.900*	*1.000*	*0.900*		*1.000*	*0.900*
Bus blockage adjustment factor, f_{bb}	*1.000*	*0.993*		*1.000*	*0.990*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Area type adj. factor, f_a *(**0.90** CBD, **1.00** other)*	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Lane utilization adjustment factor, f_{LU}	*1.000*	*0.933*		*1.000*	*0.950*	*1.000*	*1.000*	*1.000*	*1.000*		*0.933*	*1.000*
Left-turn adjustment factor, f_{LT}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Right-turn adjustment factor, f_{RT}	*1.000*	*0.980*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Left-turn ped/bike adjustment factor, f_{Lpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*0.979*	*0.979*
Right-turn ped/bike adjustment factor, f_{Rpb}	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Adjusted saturation flow, s (veh/h) $s = s_0 N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb}$	*1676*	*5077*		*1676*	*3504*	*1676*	*1676*	*1863*	*1676*		*5104*	*1641*

Notes

1. P_{LT} = 1.000 for exclusive left turn lanes, and P_{RT} = 1.000 for exclusive right turn lanes. Otherwise, they are equal to the proportions of turning volumes in the lane group.

CAPACITY AND LOS WORKSHEET

General Information

Project Description *Salt Lake Blvd. & Kahuapaani St. 2037 JIOC + infill existing JIOC Makalapa bldgs PM Peak Hour*

Capacity Analysis

Phase number	1	6		5	2	2	4	4	4		3	3
Phase type	P	P		P	P	P	P	P	P		P	P
Lane Group												
Adjusted flow rate, v (veh/h)	219	396		95	760	1101	74	120	29		570	269
Saturation flow rate, s (veh/h)	1676	5077		1676	3504	1676	1676	1863	1676		5104	1641
Lost time, t_L (s), $t_L = l_1 + Y + e$	5.0	5.0		5.0	5.0	5.0	5.0	5.0	5.0		5.0	5.0
Effective green time, g (s), g = G + Y - t_L	20.0	45.0		15.0	65.0	100.0	10.0	10.0	10.0		35.0	55.0
Green ratio, g/C	0.13	0.30		0.10	0.43	0.67	0.07	0.07	0.07		0.23	0.23
Lane group capacity,[1] c = s(g/C), (veh/h)	224	1,523		168	1,518	1,118	112	124	112		1,191	383
v/c ratio, X	0.980	0.260		0.567	0.501	0.99	0.662	0.966	0.259		0.479	0.703
Flow ratio, v/s	0.131	0.078		0.057	0.217	0.657	0.044	0.064	0.017		0.112	0.164
Critical lane group/phase (√)	√					√		√				√
Sum of flow ratios for critical lane groups, Y_c Yc = Σ (critical lane groups, v/s)	Note: Innovative phasing does not lend itself to normal computation of 'X'					1.016		Revised computation of Y_c will be weighted 'X' of critical lane groups				
Total lost time per cycle, L (s)	10											
Critical flow rate to capacity ratio, X_c $X_c = (Y_c)(C)/(C - L)$						1.09		**0.94**		**X_c for modified phasing**		

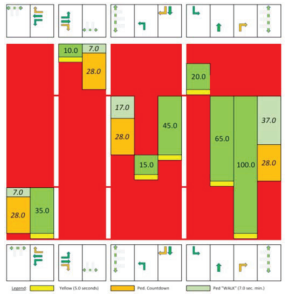
Lane Group Capacity, Control Delay, and LOS Determination

	SB			NB			EB			WB		
Lane Group	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Adjusted flow rate,[2] v (veh/h)	*219*	*396*		*95*	*760*	*1101*	*74*	*120*	*29*		*570*	*269*
Lane Group Capacity,[2] c (veh/h)	*224*	*1523*		*168*	*1518*	*1118*	*112*	*124*	*112*		*1191*	*383*
v/c ratio[2], X = v/c	***0.98***	***0.26***		***0.57***	***0.50***	***0.99***	***0.66***	***0.97***	***0.26***		***0.48***	***0.70***
Total green ratio,[2] g/C	*0.13*	*0.30*		*0.10*	*0.43*	*0.67*	*0.07*	*0.07*	*0.07*		*0.23*	*0.37*
Uniform delay, $d_1 = \frac{0.50\,C\,[1 - (g/C)]^2}{1 - [\min(1,X)g/C]}$ (s/veh)	*64.80*	*39.86*		*64.40*	*30.75*	*24.28*	*68.35*	*69.83*	*66.48*		*49.63*	*40.53*
Incremental delay calibration,[3] k	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*
Incremental delay[4], d_2 $d_2 = 900T[(X - 1) + \sqrt{(X-1)^2 + 8kIX/cT}]$ (s/veh)	*55.20*	*0.41*		*13.15*	*1.18*	*23.58*	*26.83*	*72.17*	*5.55*		*1.38*	*10.33*
Initial queue delay, d_3 (s/veh) (Appendix F)	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*		*0*	*0*
Uniform delay, d_1 (s/veh) (Appendix F)												
Progression adjustment factor, PF	*1.000*	*1.000*		*1.000*	*1.000*	*1.000*	*1.000*	*1.000*	*1.000*		*1.000*	*1.000*
Delay = d = d_1(PF) + d_2 + d_3 (s/veh)	***120.0***	***40.3***		***77.6***	***31.9***	***47.9***	***95.2***	***142.0***	***72.0***		***51.0***	***50.9***
LOS by lane group (Exhibit 16-2)	***F***	***D***		***E***	***C***	***D***	***F***	***F***	***E***		***D***	***D***
Intersection delay, $d_1 = \frac{\Sigma(d_A)(v_A)}{\Sigma v_A}$ (s/veh)	***53.8***											
Intersection Level of Service (Exhibit 16-2)	***D***											

Notes

1. For permitted left turns, the minimum capacity is (1 + P_L)(3600/C)
2. Primary and secondary phase parameters are summed to obtain lane group parameters.
3. For pretimed or nonactuated signals, k = 0.5. Otherwise, refer to Exhibit 16-13.
4. T = analysis duration (h); typically, T = 0.25, which is for the analysis duration of 15 min.
   I = upstream filtering metering adjustment factor; I = 1 for isolated intersections.

Phase Diagrams:



Modified Phasing

Appendix B-1
Air Quality Study

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AIR QUALITY STUDY

FOR THE PROPOSED

P-079 JOINT INTELLIGENCE OPERATIONS CENTER

PEARL HARBOR, OAHU, HAWAII

Prepared for:

Helber Hastert & Fee, Planners

January 2019

B.D. NEAL & ASSOCIATES

Applied Meteorology • Air Quality • Computer Science

P.O. BOX 1808 • KAILUA-KONA, HAWAII 96745 • TELPHONE (808) 329-1627 • FAX (808) 325-6739
EMAIL: bdneal@bdneal.com

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1.0 SUMMARY

The U.S. Navy is proposing the P-079 Joint Intelligence Operations Center (JIOC) at Joint Base Pearl Harbor-Hickam, Makalapa Compound on the island of Oahu. The proposed project would construct a new building on the Makalapa Compound for the JIOC, which is currently housed in two buildings near Kamehameha Highway. This study examines the potential short- and long-term air quality impacts that could occur as a result of construction and use of the proposed facilities and suggests mitigative measures to reduce any potential air quality impacts where possible and appropriate.

Both federal and state standards have been established to maintain ambient air quality. At the present time, six parameters are regulated by the U.S. Environmental Protection Agency including: particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. The Hawaii Department of Health regulates these same six parameters in addition to hydrogen sulfide. Hawaii air quality standards are comparable to the national standards except those for nitrogen dioxide and carbon monoxide which are more stringent than the national standards.

Regional and local climate together with the amount and type of human activity generally dictate the air quality of a given location. The climate of the Pearl Harbor area is very much affected by its leeward and coastal situation. Winds are predominantly trade winds from the east northeast except for occasional periods when kona storms may generate strong winds from the south or when the trade winds are weak and landbreeze-seabreeze circulations may develop. Wind speeds typically vary

between about 5 and 15 miles per hour providing relatively good ventilation much of the time. Temperatures in leeward areas of Oahu are generally very moderate with average daily temperatures ranging from about 70°F to 84°F. The extreme minimum temperature recorded at nearby Daniel K. Inouye International Airport is 54°F, while the extreme maximum temperature is 95°F. This area of Oahu is one of the drier locations in the state with rainfall often highly variable from one year to the next. Monthly rainfall has been measured to vary from as little as a trace to as much as 10 inches or more. Average annual rainfall amounts to about 18 inches with summer months being the driest.

Except for periodic impacts from volcanic emissions (vog) and possibly occasional localized impacts from traffic congestion, the present air quality of the project area appears to be reasonably good based on nearby air quality monitoring data. Air quality data from the nearest monitoring stations operated by the Hawaii Department of Health suggest that all national air quality standards are currently being met.

If the proposed project is implemented, there may be some short- and/or long-term impacts on air quality that may occur either directly or indirectly as a consequence of project construction and use. Short-term impacts from fugitive dust could occur during the project construction phases. To a lesser extent, exhaust emissions from construction equipment, from the minor disruption of traffic, and from workers' vehicles may also affect air quality during the period of construction. State air pollution control regulations require that there be no visible fugitive dust emissions at the property line. Hence, an effective dust control plan must be implemented to ensure compliance with state

regulations. Fugitive dust emissions can be controlled to a large extent by watering of active work areas, using wind screens, keeping adjacent paved roads clean, and by covering of open-bodied trucks. Other dust control measures to consider include limiting the area that is disturbed at any given time and/or mulching or chemically stabilizing inactive areas that have been worked. Paving and landscaping of project areas early in the construction schedule will also reduce dust emissions. Exhaust emissions can be mitigated by moving construction equipment and workers to and from the project site during off-peak traffic hours.

To assess the potential long-term impact of emissions from project-related motor vehicle traffic operating on roadways in the project area after construction is completed, a computerized air quality modeling study was undertaken using the U.S. EPA's MOVES2014a and CAL3QHC emissions and dispersion models. The air quality modeling study estimated current highest concentrations of carbon monoxide at intersections in the project vicinity and predicted future levels both with and without the proposed project based on the project traffic study. Carbon monoxide is selected for modeling because it is both the most stable and the most abundant of the pollutants generated by motor vehicles. Furthermore, carbon monoxide air pollution is generally considered to be a microscale problem that can be addressed locally to some extent, whereas other air pollutants from motor vehicles most often are regional issues that cannot be addressed by a single project. Model results indicated that present 1-hour and 8-hour highest estimated carbon monoxide concentrations are well within both the state and the national ambient air quality standards. In the year 2027 without the project, maximum modeled carbon monoxide concentrations were predicted to decrease (improve) slightly despite an increase in traffic, and concentrations would

remain well within standards. This is because emissions from the increase in traffic will be more than offset by the retirement of older, more-polluting vehicles over time. New vehicles emit only a small fraction of the carbon monoxide emitted from vehicles manufactured 20 years ago. With the project in the year 2027, the highest estimated carbon monoxide concentrations indicated no measurable impact compared to the without project case. Concentrations would remain well within standards. The recommended traffic mitigation measures were also found to have no impact on air quality. For the longer-term horizon (year 2037) without the project, maximum-modeled carbon monoxide concentrations were predicted to continue to decrease (improve) slightly or remain unchanged, and concentrations would remain well within standards. With the project in the year 2037, the highest estimated carbon monoxide concentrations indicated no measurable impact compared to the without project case. Concentrations would remain well within standards. Due to the negligible impact the project is expected to have, implementing mitigation measures for long-term traffic-related air quality impacts would be unnecessary.

Periodic operation of emergency backup diesel generators associated with the proposed facility would result in only minor emissions of air pollutants.

2.0 INTRODUCTION

The U.S. Navy is proposing the P-079 Facility Project at Pearl Harbor on the island of Oahu (see Figure 1 for project location). The proposed project would construct a new building on the Makalapa Compound within the Joint Base Pearl Harbor Hickam (JBPHH). The project would involve the relocation of existing functions of the Joint Intelligence Operations Center (JIOC) from two buildings located near Kamehameha Highway, along with JIOC personnel from other facilities at JBPHH, to a new facility located near Luapele Gate and the relocation of personnel from Camp Smith. The project would also include the construction of a parking lot for approximately 700 cars and an access road connected to existing internal roadways. The long-term analysis for this project assumes the reuse of the two vacated Makalapa Compound buildings. The Makalapa Compound is bounded by Kamehameha Highway on the west, Radford Drive on the south, the H-1 Freeway on the east, and a shopping center and Halawa Stream on the north. Three roadway intersections have been identified where significant peak-hour traffic volume increases could occur (Ng, 2018). These include Halawa Drive at Kamehameha Highway, Luapele Road at Salt Lake Boulevard and Kahuapaani Street at Salt Lake Boulevard.

The purpose of this study is to describe existing air quality in the project area and to assess the potential short- and long-term direct and indirect air quality impacts that could result from construction and use of the proposed facilities as planned. Measures to mitigate project impacts are suggested where possible and appropriate.

3.0 AMBIENT AIR QUALITY STANDARDS

Ambient concentrations of air pollution are regulated by both national and state ambient air quality standards (AAQS). National AAQS are specified in Section 40, Part 50 of the Code of Federal Regulations (CFR), while State of Hawaii AAQS are defined in Chapter 11-59 of the Hawaii Administrative Rules. Table 1 summarizes both the national and the state AAQS that are specified in the cited documents. As indicated in the table, national and state AAQS have been established for particulate matter, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone and lead. The state has also set a standard for hydrogen sulfide. National AAQS are stated in terms of both primary and secondary standards for most of the regulated air pollutants. National primary standards are designed to protect the public health with an "adequate margin of safety". National secondary standards, on the other hand, define levels of air quality necessary to protect the public welfare from "any known or anticipated adverse effects of a pollutant". Secondary public welfare impacts may include such effects as decreased visibility, diminished comfort levels, or other potential injury to the natural or man-made environment, e.g., soiling of materials, damage to vegetation or other economic damage. In contrast to the national AAQS, Hawaii State AAQS are given in terms of a single standard that is designed "to protect public health and welfare and to prevent the significant deterioration of air quality".

Each of the regulated air pollutants has the potential to create or exacerbate some form of adverse health effect or to produce environmental degradation when present in sufficiently high concentration for prolonged periods of time. The AAQS specify a maximum allowable concentration for a given air pollutant for one

or more averaging times to prevent harmful effects. Averaging times vary from one hour to one year depending on the pollutant and type of exposure necessary to cause adverse effects. In the case of the short-term (i.e., 1- to 24-hour) AAQS, both national and state standards allow a specified number of exceedances each year.

The Hawaii AAQS are in some cases considerably more stringent than the comparable national AAQS. In particular, the Hawaii 1-hour AAQS for carbon monoxide is four times more stringent than the comparable national limit.

The national AAQS are reviewed periodically, and multiple revisions have occurred over the past 30 years. The latest revisions include the nitrogen dioxide and sulfur dioxide standards in 2010, the particulate matter standards in 2012 and the ozone standard in 2015. In general, the national AAQS have become more stringent with the passage of time and as more information and evidence become available concerning the detrimental effects of air pollution. Changes to the Hawaii AAQS over the past several years have tended to follow revisions to the national AAQS, making several of the Hawaii AAQS the same as the national AAQS.

4.0 REGIONAL AND LOCAL CLIMATOLOGY

Regional and local climatology significantly affects the air quality of a given location. Wind, temperature, atmospheric turbulence, mixing height and rainfall all influence air quality. Although the climate of Hawaii is relatively moderate throughout

most of the state, significant differences in these parameters may occur from one location to another. Most differences in regional and local climates within the state are caused by the mountainous topography.

Hawaii lies well within the belt of northeasterly trade winds generated by the semi-permanent Pacific high-pressure cell to the north and east. On the island of Oahu, the Koolau and Waianae Mountain Ranges are oriented almost perpendicular to the trade winds, which accounts for much of the variation in the local climatology of the island. The site of the proposed project is located in the leeward area of the Koolau Mountains.

Wind frequency data for the Daniel K. Inouye International Airport (HNL) (formerly known as Honolulu International Airport), which is located about 3 miles to the south of the project site, are given in Table 2-A. These data, which were collected several years ago, can be expected to be reasonably representative of the project area, although there is some evidence that northeast trade winds have diminished slightly and east trade winds have increased (Garza et al., 2012). Wind frequency for HNL show that the annual prevailing wind direction for this area of Oahu is east northeast. On an annual basis, 34.7 percent of the time the wind was from this direction, and more than 62 percent of the time the wind was in the northeast quadrant. Winds from the south were infrequent occurring only a few days during the year and mostly in winter in association with kona storms. Wind speeds averaged about 10 knots (12 mph) and mostly vary between about 5 and 15 knots (6 and 17 mph).

More recent trade wind direction trend data for the period of 1984-2009 (see Table 2-B) indicate a downward trend in northeast trade wind frequency, although it remained the most common annual wind direction (59% of the time) (Garza et al., 2012). The second most common wind was from the east, occurring 17% of the time; and, as in the earlier data set, winds from the south were much less frequent (4%).

Air pollution emissions from motor vehicles, the formation of photochemical smog and smoke plume rise all depend in part on air temperature. Within the temperature range in Hawaii, cooler temperatures tend to result in lower emissions of carbon monoxide from automobiles, lower concentrations of photochemical smog and lower ground-level concentrations of air pollution from elevated plumes. In Hawaii, the annual and daily variations of temperature depend to a large degree on elevation above sea level, distance inland and exposure to the trade winds. Average temperatures at locations near sea level generally are warmer than those at higher elevations. Areas exposed to the trade winds tend to have the least temperature variation, while inland and leeward areas often have the most. Based on more than 25 years of data collected at the Daniel K. Inouye International Airport, average annual daily minimum and maximum temperatures in the project area are about 70°F and 84°F, respectively [1]. The extreme minimum temperature on record at the airport is 54°F, and the extreme maximum is 95°F.

Small scale, random motions in the atmosphere (turbulence) cause air pollutants to be dispersed as a function of distance or time from the point of emission. Turbulence is caused by both mechanical and thermal forces in the atmosphere. It is oftentimes measured and described in terms of Pasquill-Gifford stability

class. Stability class 1 is the most turbulent and class 6 the least. Thus, air pollution dissipates the best during stability class 1 conditions and the worst when stability class 6 prevails. Stability class 6 typically occurs in rural areas during the night when there is a lot of cooling of the surface due radiative processes. Urban and suburban areas with a lot of paved surfaces tend to inhibit stability class 6. In the project area, which is largely urban, stability class 5 is probably the highest stability class that occurs, developing during clear, calm nighttime or early morning hours when temperature inversions form due to radiational cooling. Stability classes 1 through 4 occur during the daytime, depending mainly on the amount of cloud cover and incoming solar radiation and the onset and extent of the sea breeze.

Mixing height is defined as the height above the surface through which relatively vigorous vertical mixing occurs. Low mixing heights can result in high ground-level air pollution concentrations because contaminants emitted from or near the surface can become trapped within the mixing layer. In Hawaii, minimum mixing heights tend to be high because of mechanical mixing caused by the trade winds and because of the temperature moderating effect of the surrounding ocean. Low mixing heights may sometimes occur, however, at inland locations and even at times along coastal areas early in the morning following a clear, cool, windless night. Coastal areas also may experience low mixing levels during sea breeze conditions when cooler ocean air rushes in over warmer land.

Rainfall can have a beneficial effect on the air quality of an area in that it helps to suppress fugitive dust emissions, and it

also may "washout" gaseous contaminants that are water-soluble. Rainfall in Hawaii is highly variable depending on elevation and on location with respect to the trade wind. The project area is one of the drier areas on Oahu due to its leeward and near sea level location. Average annual rainfall measured at nearby Daniel K. Inouye International Airport amounts to about 18 inches [1]. Most of the rainfall usually occurs during the winter months. Monthly rainfall may vary from as little as a trace to more than 10 inches. Recent studies have shown that over the past 30 to 40 years, northeast trade wind days have tended to decrease (Garza et al., 2012). In contrast, east trade winds were found to increase in frequency, though this increase did not fully offset the decrease in northeast trade winds. This has resulted in a trend of decreasing northeast trade wind speeds and decreasing trade wind rainfall.

5.0 PRESENT AIR QUALITY

Present air quality in the project area is mostly affected by air pollutants from motor vehicles due to the urban situation. Table 3 presents an air pollutant emission summary for the island of Oahu for calendar year 2014. The emission rates shown in the table pertain to manmade emissions only, i.e., emissions from natural sources are not included. Much of the particulate emissions on Oahu originate from area sources, such as the mineral products industry and agriculture. Sulfur oxides are emitted almost exclusively by point sources, such as power plants, refineries and other industrial sources. Nitrogen oxides emissions emanate predominantly from industrial point sources, although area sources (mostly motor vehicle traffic) also contribute a significant share. The majority of carbon monoxide emissions occur from area sources (motor vehicle traffic), while

hydrocarbons are emitted mainly from point sources. In the specific project area, there are currently manmade emissions from ongoing mass transit construction, ships and aircraft. Pollutant emissions from these types of activities are generally accounted for in Table 3. Due to the distances of these activities from the study areas and (in the case of the mass transit construction) temporary nature of the activity, they are not expected to measurably affect pollutant emissions levels relevant to this study and are not quantitatively assessed.

Natural sources of air pollution emissions that could affect the project area at times but cannot be quantified very accurately include the ocean (sea spray), plants (aero-allergens), wind-blown dust, and perhaps distant volcanoes on the island of Hawaii.

The State Department of Health operates a network of air quality monitoring stations at various locations on Oahu. Each station, however, typically does not monitor the full complement of air quality parameters. Table 4 shows annual summaries of air quality measurements that were made nearest to the project area for several of the regulated air pollutants for the period 2011 through 2015. These are the most recent data that are currently available.

As indicated in Table 4, during the 2011-2015 period, sulfur dioxide, particulate and carbon monoxide were monitored by the State Department of Health at an air quality station located at downtown Honolulu. Nitrogen dioxide was measured at Kapolei and ozone was monitored at Sand Island. The concentrations reported

were consistently low compared to the standards for all parameters except for ozone. Maximum 8-hour ozone concentrations reached up to about 75% of the standard. Ozone concentrations tend to be high in Hawaii due to the abundant sunshine and the island setting.

6.0 SHORT-TERM IMPACTS OF PROJECT

Short-term direct and indirect impacts on air quality could potentially occur due to project construction. For a project of this nature, there are two potential types of air pollution emissions that could directly result in short-term air quality impacts during project construction: (1) fugitive dust from vehicle movement, soil excavation and demolition activities; and (2) exhaust emissions from on-site construction equipment. Indirectly, there also could be short-term impacts from slow-moving construction equipment traveling to and from the project site, from a temporary increase in local traffic caused by commuting construction workers, and from the disruption of normal traffic flow caused by roadway lane closures.

Fugitive dust emissions may arise from the grading and dirt-moving activities associated with demolition, site clearing and preparation work. The emission rate for fugitive dust emissions from construction activities is difficult to estimate accurately. This is because of its elusive nature of emission and because the potential for its generation varies greatly depending upon the type of soil at the construction site, the amount and type of dirt-disturbing activity taking place, the moisture content of exposed soil in work areas, and the wind speed. State of Hawaii Air Pollution Control Regulations [2] prohibit visible emissions

of fugitive dust from construction activities at the property line. Thus, an effective dust control plan for the project construction phase is essential.

Adequate fugitive dust control can usually be accomplished by the establishment of a frequent watering program to keep bare-dirt surfaces in construction areas from becoming significant sources of dust. In dust-prone or dust-sensitive areas, other control measures such as limiting the area that can be disturbed at any given time, applying chemical soil stabilizers, mulching and/or using wind screens may be necessary. Control regulations further stipulate that open-bodied trucks be covered at all times when in motion if they are transporting materials that could be blown away. Haul trucks tracking dirt onto paved streets from unpaved areas is often a significant source of dust in construction areas. Some means to alleviate this problem, such as road cleaning or tire washing, may be appropriate. Paving of parking areas and/or establishment of landscaping as early in the construction schedule as possible can also lower the potential for fugitive dust emissions.

On-site mobile and stationary construction equipment also will emit air pollutants from engine exhausts. The largest of this equipment is usually diesel-powered. Nitrogen oxides emissions from diesel engines can be relatively high compared to gasoline-powered equipment, but the annual standard for nitrogen dioxide is not likely to be violated by short-term construction equipment emissions. Also, the new short-term (1-hour) standard for nitrogen dioxide is based on a three-year average; thus, for construction projects that typically do not extend beyond a year or two, it is unlikely that relatively short-term construction

emissions would exceed the standard. Carbon monoxide emissions from diesel engines are low and should be relatively insignificant compared to vehicular emissions on nearby roadways. Motor vehicle traffic on roadways is mostly powered by gasoline engines, which inherently emit more carbon monoxide than diesel engines.

Project construction activities, if unmitigated, can obstruct the normal flow of traffic for short periods of time such that overall vehicular emissions in the project area could temporarily increase. This potential problem should be avoided by keeping roadways open during peak traffic hours and by moving heavy construction equipment and workers to and from construction areas during periods of low traffic volume.

7.0 LONG-TERM IMPACTS OF PROJECT

7.1 Roadway Traffic

After construction is completed, use of the proposed facilities may result in increased motor vehicle traffic in the project area, potentially causing long-term impacts on ambient air quality. Motor vehicles with gasoline-powered engines are significant sources of carbon monoxide. They also emit nitrogen oxides and other contaminates.

Federal air pollution control regulations require that new motor vehicles be equipped with emission control devices that reduce emissions significantly compared to a few years ago. In 1990, the President signed into law the Clean Air Act Amendments of 1990, which revised and expanded the Act and provided the U.S.

Environmental Protection Agency broader authority to implement and enforce regulations reducing air pollutant emissions. This legislation required further emission reductions from stationary and mobile sources, which have been phased in since 1994 (e.g., Title IV of the 1990 Amendments to the Clean Air Act Acid Rain Deposition Control, which began in 1995). Additional restrictions were signed into law during the Clinton administration (e.g., 40 CFR Part 50 National Ambient Air Quality Standards for Particulate Matter in 1997), and these began to take effect during the following decade. The added restrictions on emissions from new motor vehicles will lower average emissions each year as more and more older vehicles leave the state's roadways. For example, under the Obama Administration, fuel economy standards for new cars and light trucks were issued for model years 2017-2025 (known as corporate average fuel economy [CAFE] standards) were issued, which would nearly double the fuel efficiency of new cars and light trucks over that of similar vehicles that were currently on the road. These restrictions are factored into the emissions estimates for the project discussed later. In August 2018, the Trump Administration proposed a pause in the rate of emissions reductions established by the CAFE program. The Trump Administration’s proposal would freeze the fuel economy standards at 2020 levels. Even if the Trump Administration proposal were implemented, the reductions in pollutant emissions required under prior provisions would result in substantial improvements (i.e., declines in pollutant emissions).

To evaluate the potential long-term ambient air quality impact of motor vehicle traffic using the proposed new roadway facilities, computerized emission and atmospheric dispersion models can be used to estimate ambient carbon monoxide concentrations along roadways within the project area. Carbon monoxide is selected for

modeling because it is both the most stable and the most abundant of the pollutants generated by motor vehicles. Furthermore, carbon monoxide air pollution is generally considered to be a microscale problem that can be addressed locally to some extent, whereas nitrogen oxides air pollution most often is a regional issue that cannot be addressed by a single project.

For this project, five scenarios were selected for the carbon monoxide modeling study: (1) year 2017 with present conditions, (2) year 2027 without the project, (3) year 2027 with the project, (4) year 2037 without the project, and (5) year 2037 with the project. To begin the modeling study of the five scenarios, critical receptor areas in the vicinity of the project were identified for analysis. Generally speaking, roadway intersections are the primary concern because of traffic congestion and because of the increase in vehicular emissions associated with traffic queuing. For this study, the three key intersections identified in the traffic study [3] were selected for air quality analysis. These included the following intersections:

- Halawa Drive at Kamehameha Highway
- Luapele Road at Salt Lake Boulevard
- Kahuapaani Street at Salt Lake Boulevard.

The traffic study describes the existing and projected future traffic conditions and laneage configurations of the study intersections in detail. In performing the air quality impact analysis, situations without and with recommended traffic mitigation measures were evaluated for the year 2027.

The main objective of the modeling study was to estimate maximum 1-hour average carbon monoxide concentrations for each of the three scenarios studied. To evaluate the significance of the estimated concentrations, a comparison of the predicted values for each scenario was made. Comparison of the estimated values to the national and state AAQS was also used to provide another measure of significance.

Maximum carbon monoxide concentrations typically coincide with peak traffic periods. The traffic impact assessment report evaluated both morning and afternoon peak-traffic periods. Typically, afternoon peak-hour traffic volumes are higher, but atmospheric dispersion conditions are generally worse during the morning. Thus, the air quality study evaluated both morning and afternoon peak-traffic periods.

Vehicular carbon monoxide emissions for each year studied were calculated using EPA’s Motor Vehicle Emission Simulator (MOVES) computer model [4]. Federal Corporate Fuel Economy (CAFE) standards as well as other federal emission regulations are factored into MOVES. The Trump Administration recently proposed changes to the CAFE standards, but it is not expected that this will have a significant affect on the conclusions reached in this study.

MOVES was configured for a project-level analysis specifically for Hawaii. Assumptions included an urban, unrestricted road type, default fuel supply and fuel formulation, default vehicle age distribution and morning and afternoon ambient temperatures of 70°F

and 90°F, respectively. MOVES emission factors were generated both for idling and for moving traffic.

After computing vehicular carbon monoxide emissions through the use of MOVES, these data were then input to an atmospheric dispersion model. EPA air quality modeling guidelines [5] currently recommend that the computer model CAL3QHC [6] be used to assess carbon monoxide concentrations at roadway intersections, or in areas where its use has previously been established, CALINE4 [7] may be used. Until a few years ago, CALINE4 was used extensively in Hawaii to assess air quality impacts at roadway intersections. In December 1997, the California Department of Transportation recommended that the intersection mode of CALINE4 no longer be used because it was thought the model had become outdated. Studies have shown that CALINE4 may tend to over-predict maximum concentrations in some situations. Therefore, CAL3QHC was used for the subject analysis.

CAL3QHC was developed for the U.S. EPA to simulate vehicular movement, vehicle queuing and atmospheric dispersion of vehicular emissions near roadway intersections. It is designed to predict 1-hour average pollutant concentrations near roadway intersections based on input traffic and emission data, roadway/receptor geometry and meteorological conditions.

Input peak-hour traffic data were obtained from the traffic study cited previously. This included vehicle approach volumes, saturation capacity estimates, intersection laneage and signal timings. All emission factors that were input to CAL3QHC for

free-flow traffic on roadways were obtained from MOVES based on assumed free-flow vehicle speeds corresponding to the posted or design speed limits.

Model roadways were set up to reflect roadway geometry, physical dimensions and operating characteristics. Concentrations predicted by air quality models generally are not considered valid within the roadway-mixing zone. The roadway-mixing zone is usually taken to include 3 meters on either side of the traveled portion of the roadway and the turbulent area within 10 meters of a cross street. Model receptor sites were thus located at the edges of the mixing zones near all intersections that were studied for all three scenarios. This acknowledges that pedestrian sidewalks already exist or may exist in the future in these locations. All receptor heights were placed at 1.8 meters above ground to simulate levels within the normal human breathing zone.

Input meteorological conditions for this study were defined to provide "worst-case" or highest estimated results. One of the key meteorological inputs is atmospheric stability category. For these analyses, atmospheric stability category 5 was assumed for the morning cases, while atmospheric stability category 4 was assumed for the afternoon cases. These are the most conservative stability categories that are generally used for estimating worst-case pollutant dispersion within urban areas for these periods. A surface roughness length of 100 cm and a mixing height of 1000 meters were used in all cases. Worst-case wind conditions were defined as a wind speed of 1 meter per second with a wind direction resulting in the highest predicted concentration. Concentration estimates were calculated at wind directions of every 5 degrees.

Existing background concentrations of carbon monoxide in the project vicinity are believed to be at reasonably low levels. Department of Health monitoring stations for locations on Oahu report average carbon monoxide concentrations of less than 1 ppm. Background contributions of carbon monoxide from sources or roadways not directly considered in the analysis were conservatively accounted for by adding a background concentration of 1 ppm to all predicted concentrations for 2017. Although increased traffic is expected to occur within the project area within the next few years with or without the project, background carbon monoxide concentrations may not change significantly since individual emissions from motor vehicles are forecast to decrease with time due to the probable retirement of older vehicles that emit more air pollution. Hence, a background value of 1 ppm was assumed to persist for the future scenarios studied.

Predicted Highest 1-Hour Concentrations

Table 5 summarizes the final results of the modeling study in the form of the estimated highest 1-hour morning and afternoon ambient carbon monoxide concentrations. These results can be compared directly to the state and the national AAQS. Estimated highest carbon monoxide concentrations are presented in the table for five scenarios: year 2017 with existing traffic, year 2027 without the project, year 2027 with the project (both without and with traffic mitigation), year 2037 without the project and year 2037 with the project. The locations of these estimated highest 1-hour concentrations all occurred at or very near the indicated intersections.

As indicated in the table, the highest estimated 1-hour concentration within the project vicinity for the present (2017) case was 2.1 ppm. This was projected to occur during the afternoon peak traffic hour at the intersection of Kahuapaani Street and Salt Lake Boulevard. Predicted highest 1-hour concentrations at other locations studied for the 2017 scenario ranged between 1.4 and 1.8 ppm. All predicted maximum-modeled 1-hour concentrations were well within both the national AAQS of 35 ppm and the state standard of 9 ppm.

In the year 2027 without the proposed project, the highest 1-hour carbon monoxide concentration in the project area was predicted to reach 1.5 ppm. This was predicted to occur during the afternoon peak traffic hour at the intersection of Kahuapaani Street and Salt Lake Boulevard. Peak-hour concentrations would be slightly lower at other locations and times studied. Compared to the existing case, predicted concentrations for the year 2027 without the project decreased (improved) at all locations, and maximum-modeled concentrations remained well within the state and national standards. This suggests that emissions from higher traffic volumes and increased traffic congestion in the next several years will likely be more than offset by the retirement of older, more-polluting vehicles over time.

Predicted 1-hour maximum-modeled concentrations for the 2027 with project scenario (without the recommended traffic mitigation at the Salt Lake Boulevard-Kahuapaani Street intersection) remained unchanged at the study intersections compared to the without project case, suggesting the air quality impacts of implementing the project will be indistinguishable from future air quality

conditions without the project. Forecast highest concentrations at all locations studied remained well within the state and federal standards. The analysis also shows that the traffic mitigation recommended in the project traffic report would have no effect on maximum-modeled carbon monoxide concentrations at the intersection of Kahuapaani Street and Salt Lake Boulevard.

In the year 2037 without the proposed project, the highest 1-hour carbon monoxide concentration in the project area was predicted to reach 1.2 ppm. (Traffic mitigation measures were assumed to be implemented.) This was predicted to occur during the afternoon peak traffic hour at all three of the intersections that were studied. Peak-hour morning concentrations would be slightly lower. Compared to the existing case, predicted concentrations for the year 2037 without the project decreased (improved) at all locations, and maximum-modeled concentrations remained well within the state and national standards.

Predicted 1-hour maximum concentrations for the 2037 with project scenario remained unchanged at the study intersections compared to the 2037 without project case, suggesting the project will have no measurable impact on air quality. Forecast worst-case concentrations at all locations studied remained well within the state and federal standards.

Predicted Maximum 8-Hour Concentrations

Maximum 8-hour carbon monoxide concentrations were estimated by multiplying the maximum-modeled 1-hour values by a persistence factor of 0.5. This accounts for two factors: (1) traffic volumes

averaged over eight hours are lower than peak 1-hour values, and (2) meteorological conditions are more variable (and hence more favorable for dispersion) over an 8-hour period than they are for a single hour. Based on monitoring data, 1-hour to 8-hour persistence factors for most locations generally vary from 0.4 to 0.8 with 0.6 being the most typical. One study based on modeling [8] concluded that 1-hour to 8-hour persistence factors could typically be expected to range from 0.4 to 0.5. EPA guidelines [9] recommend using a value of 0.7 unless a locally derived persistence factor is available. Recent monitoring data for locations on Oahu reported by the Department of Health [10] suggest that this factor may range between about 0.2 and 0.6 depending on location and traffic variability. Considering the location of the project and the traffic pattern for the area, a 1-hour to 8-hour persistence factor of 0.5 will likely yield reasonable estimates of worst-case 8-hour concentrations.

The resulting estimated highest 8-hour concentrations are indicated in Table 6. For the 2017 scenario, the estimated highest 8-hour carbon monoxide concentrations for the three locations studied ranged from 0.8 to 1.0 ppm. The estimated highest concentrations for the existing case were well within both the state standard of 4.4 ppm and the national limit of 9 ppm.

For the year 2027 without project scenario, predicted maximum concentrations at the three intersections studied ranged from 0.6 to 0.8 ppm, decreasing (improving) compared to the existing scenario. All predicted concentrations were within the standards.

For the 2027 with project scenario, maximum-modeled concentrations remained unchanged compared to the without project case, indicating no measurable project impact. The analysis also indicates that the recommended traffic mitigation at the intersection of Kahuapaani Street and Salt Lake Boulevard would have no impact on maximum carbon monoxide concentrations. All predicted 8-hour concentrations for this scenario were well within both the national and the state AAQS.

For the year 2037 without project scenario, predicted maximum concentrations at all three intersections studied were 0.6 ppm, decreasing (improving) compared to the existing scenario. All predicted concentrations were within the standards.

For the 2037 with project scenario, maximum-modeled concentrations remained unchanged compared to the without project case, indicating no measurable project impact. All predicted 8-hour concentrations for this scenario were well within both the national and the state AAQS.

Conservativeness of Estimates

The results of this study reflect several assumptions that were made concerning both traffic movement and worst-case meteorological conditions. One such assumption concerning worst-case meteorological conditions is that a wind speed of 1 meter per second (2 miles per hour or 1.9 knots) with a steady direction for 1 hour will occur. A steady wind of 1 meter per second blowing from a single direction for an hour is extremely unlikely and may occur only once a year or less. With wind speeds of 2 meters per

second (4.5 miles per hour or 3.5 knots), for example, computed carbon monoxide concentrations would be only about half the values given above. As generally indicated in Table 2-A, wind speeds of at least 2 meters per second (4 knots) occur over 90 percent of the time on an annual basis. Wind speeds of 7 to 16 knots (3 to 8 meters per second) occur with the greatest frequency (65 percent), and would be typical near the areas studied.

7.2 Emergency Diesel Generators

The proposed new facility will include three 1-MW diesel generators and two 1.5-MW diesel generators. These will only be used to provide emergency power. Operation is expected to occur only a few hours per year during power outages and during scheduled generator testing. The primary air pollutants in the exhaust will include nitrogen oxides (NOx), sulfur oxides (SOx), total organic compounds (TOC), carbon monoxide (CO), and particulates. There may also be some evaporative losses of TOC but these should be insignificant due to the low volatility of diesel fuel.

Table 7 shows an estimate of the annual emissions that would occur from the emergency diesel generators assuming 100 hours per year of operation (with two of the 1-MW generators and one of the 1.5-MW generators in use at any given time). As indicated in the table, the annual emissions will be minimal compared to the area-wide emissions shown in Table 3. Any impacts on air quality from emergency generator operation should be negligible.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Based on ambient air quality data that are available from the Department of Health, it is likely that all state and federal ambient air quality standards are currently being met in the project area.

Project-related short-term impacts on air quality may occur from the emission of fugitive dust during construction phases. To

control dust, the project construction contractor should prepare a dust control plan that will ensure that state regulations related to fugitive dust will be met. Typical dust control measures include:

- Watering of active work areas and any temporary unpaved work roads at least twice daily on days without rainfall
- Use of wind screens around the project perimeter and/or limiting the area that is disturbed at any given time
- Mulching or use of chemical soil stabilizers to control wind erosion of inactive areas of the site that have been disturbed
- Covering of dirt-hauling trucks when traveling on roadways to prevent windage
- Implementing a routine road cleaning and/or tire washing program to reduce fugitive dust emissions that may occur as a result of trucks tracking dirt onto paved roadways in the project area
- Establishment of landscaping early in the construction schedule.

The specific dust control measures used will depend, in part, on the amount and nature of earthwork that is needed, soil type, wind and precipitation conditions, and the nearness of neighbors.

During construction phases, emissions from engine exhausts (primarily consisting of carbon monoxide and nitrogen oxides) will also occur both from on-site construction equipment and from vehicles used by construction workers and from trucks traveling to and from the project. Increased vehicular emissions due to disruption of traffic by construction equipment and/or commuting

construction workers can be alleviated by moving equipment and personnel to the site during off-peak traffic hours.

After the proposed project is completed, any long-term impacts on air quality in the project area due to emissions from project-related motor vehicle traffic should be negligible. Maximum concentrations of carbon monoxide should remain within both the state and the national ambient air quality standards. Implementing any air quality mitigation measures for long-term traffic-related impacts is unnecessary.

Periodic operation of the emergency diesel generators associated with the proposed facility will result in emissions of air pollutants, but the quantities will be minor in comparison to area-wide emissions.

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DeLorme Street Atlas USA® 2011

Figure 1 - Project Location

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MN (9.5° E)

0 2 4 6 8 10 mi

Data Zoom 9-0

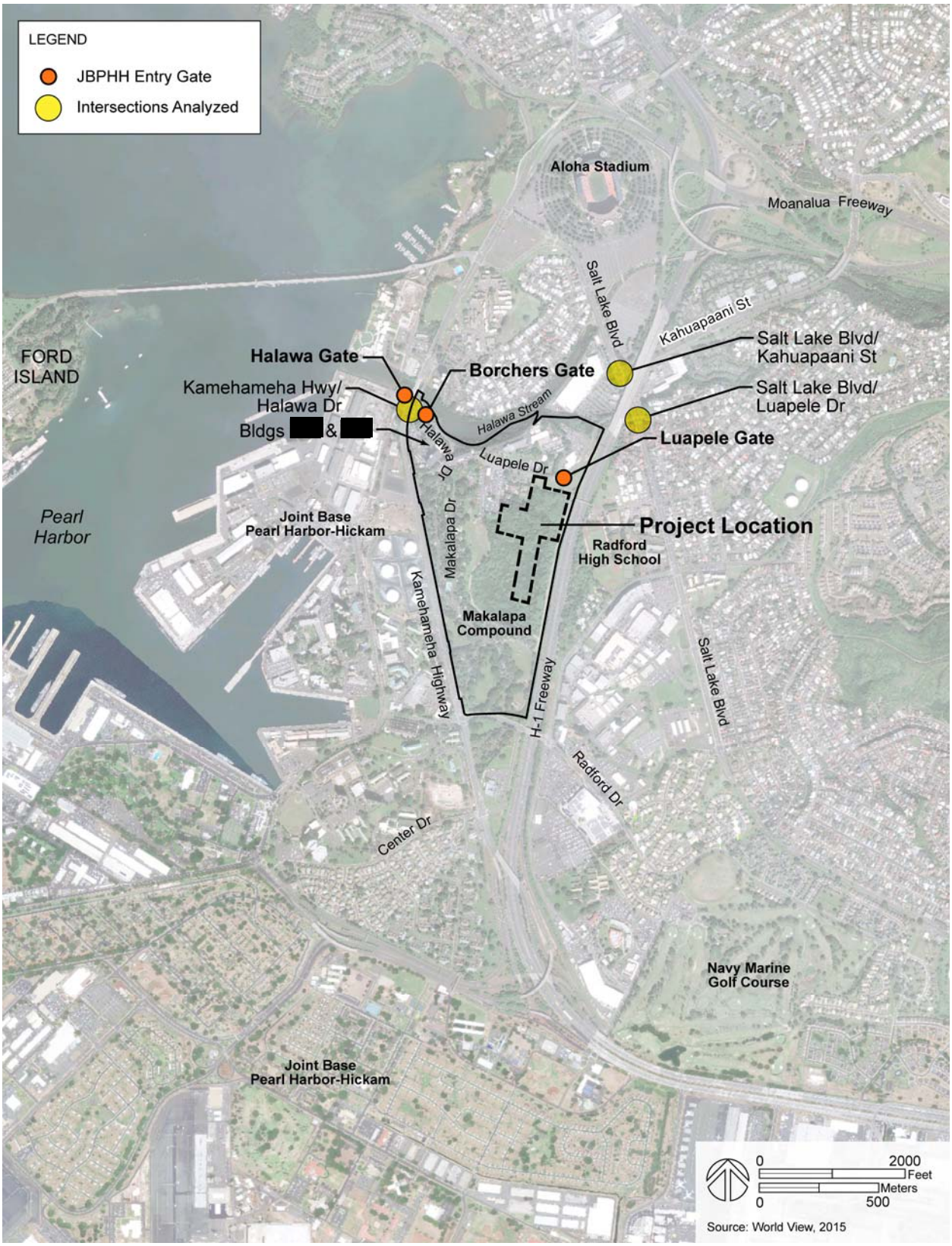

Figure 2: Intersections Analyzed

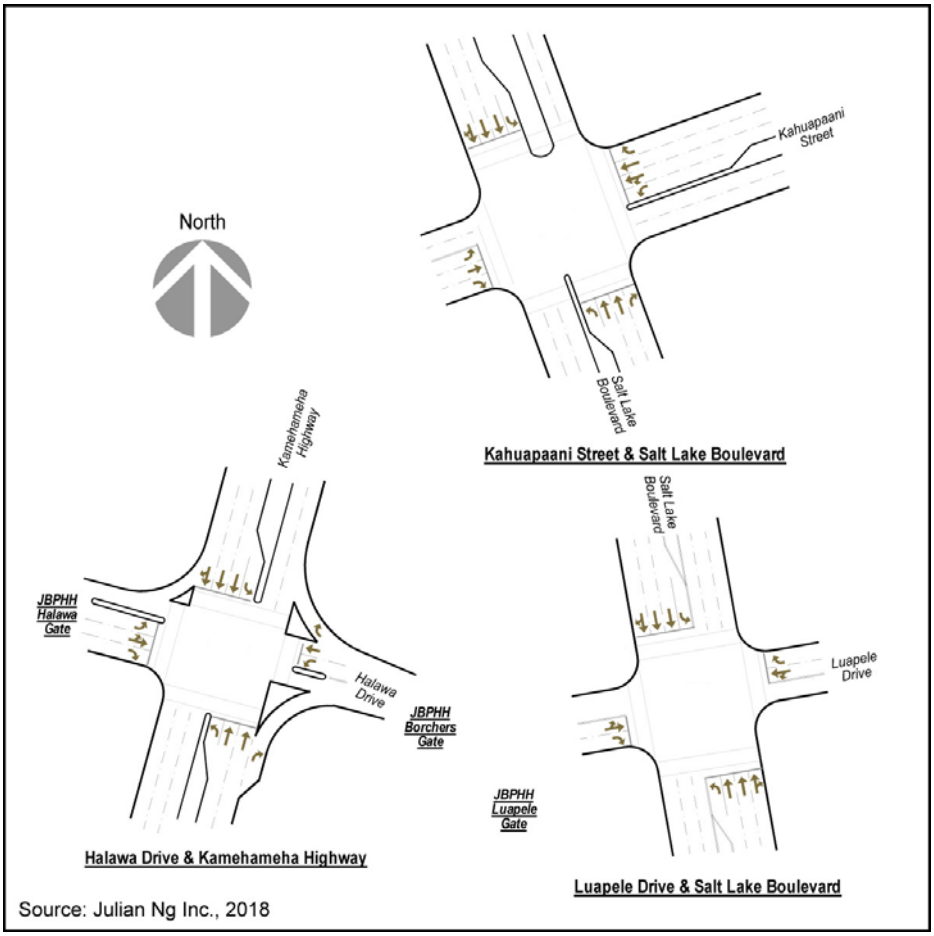

Figure 3: Configuration of Intersections Analyzed

Table 1

SUMMARY OF STATE OF HAWAII AND NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	Maximum Allowable Concentration		
		National Primary	National Secondary	State of Hawaii
Particulate Matter (<10 microns)	Annual 24 Hours	- 150 $\mu g/m^3$ (a)	- 150 $\mu g/m^3$ (a)	50 $\mu g/m^3$ 150 $\mu g/m^3$ (b)
Particulate Matter (<2.5 microns)	Annual 24 Hours	12 $\mu g/m^3$ (c) 35 $\mu g/m^3$ (d)	15 $\mu g/m^3$ (c) 35 $\mu g/m^3$ (d)	- -
Sulfur Dioxide	Annual 24 Hours 3 Hours 1 Hour	- - - 0.075 ppm (e)	- - 0.5 ppm (b) -	80 $\mu g/m^3$ 365 $\mu g/m^3$ (b) 1300 $\mu g/m^3$ (b) -
Nitrogen Dioxide	Annual 1 Hour	0.053 ppm 0.100 ppm (f)	0.053 ppm -	70 $\mu g/m^3$ -
Carbon Monoxide	8 Hours 1 Hour	9 ppm (b) 35 ppm (b)	- -	5 mg/m^3 (b) 10 mg/m^3 (b)
Ozone	8 Hours	0.070 ppm (g)	0.070 ppm (g)	157 $\mu g/m^3$ (b)
Lead	3 Months Quarter	0.15 $\mu g/m^3$(h) -	0.15 $\mu g/m^3$(h) -	- 1.5 $\mu g/m^3$
Hydrogen Sulfide	1 Hour	-	-	35 $\mu g/m^3$ (b)

[a] Not to be exceeded more than once per year on average over a 3-year period.
[b] Not to be exceeded more than once per year.
[c] Three-year average of the weighted annual arithmetic mean.
[d] 98th percentile value of the 24-hour concentrations averaged over three years.
[e] Three-year average of annual 99th percentile daily 1-hour maximum.
[f] 98th percentile value of the daily 1-hour maximum averaged over three years.
[g] Three-year average of annual fourth-highest daily 8-hour maximum.
[h] Maximum arithmetic 3-month mean concentration for a 3-year period.

Table 2-A

ANNUAL WIND FREQUENCY FOR HONOLULU INTERNATIONAL AIRPORT 1965-1974 (%)

Wind Direction	Wind Speed (knots)									Total
	0-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	>40	
N	0.5	2.5	1.3	0.5	0.0	0.0	0.0	0.0	0.0	4.8
NNE	0.3	1.2	1.6	1.5	0.2	0.0	0.0	0.0	0.0	4.7
NE	0.3	2.1	6.1	11.0	3.2	0.3	0.0	0.0	0.0	23.0
ENE	0.2	2.5	10.9	16.6	4.1	0.3	0.0	0.0	0.0	34.7
E	0.1	1.0	2.5	2.8	0.5	0.0	0.0	0.0	0.0	7.0
ESE	0.0	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0	1.1
SE	0.0	0.3	0.8	1.0	0.1	0.0	0.0	0.0	0.0	2.2
SSE	0.1	0.4	1.2	0.7	0.1	0.0	0.0	0.0	0.0	2.4
S	0.1	0.5	1.4	0.6	0.1	0.0	0.0	0.0	0.0	2.7
SSW	0.0	0.3	0.8	0.3	0.0	0.0	0.0	0.0	0.0	1.5
SW	0.0	0.2	0.8	0.4	0.0	0.0	0.0	0.0	0.0	1.5
WSW	0.0	0.3	0.5	0.4	0.0	0.0	0.0	0.0	0.0	1.2
W	0.1	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1
WNW	0.2	1.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	2.0
NW	0.4	2.3	0.8	0.1	0.0	0.0	0.0	0.0	0.0	3.8
NNW	0.5	2.3	0.8	0.2	0.0	0.0	0.0	0.0	0.0	3.8
Calm	2.5									2.5
Total	5.4	18.3	30.6	36.5	8.5	0.7	0.0	0.0	0.0	100.0

Source: Climatography of the United States No. 90 (1965-1974), Airport Climatological Summary, Honolulu International Airport, Honolulu, Hawaii, U.S. Department of Commerce, National Climatic Center, Asheville, NC, August 1978.

Table 2-B

ANNUAL WIND DIRECTION FREQUENCY FOR HONOLULU INTERNATIONAL AIRPORT 1984-2009(%)

Wind Direction	Wind Frequency
N	5%
NE	59%
E	17%
SE	5%
S	4%
SW	5%
W	4%
NW	2%

Source: Garza, J.A., P.-S. Chu, C.W. Norton, and T.A. Schroeder (2012), Changes of the prevailing trade winds over the islands of Hawaii and the North Pacific, *J. Geophys. Res., 117,* D11109, doi: 10.1029/2011JD016888.

Table 3

AIR POLLUTION EMISSIONS INVENTORY FOR ISLAND OF OAHU, 2014

Air Pollutant	Total (tons/year)
Particulate (PM10)	16,685
Particulate (PM2.5)	4,649
Sulfur Oxides	14,778
Nitrogen Oxides	29,337
Carbon Monoxide	108,267
Hydrocarbons	23,289

Source: U.S. EPA, National Emissions Inventory, 2014

Table 4

ANNUAL SUMMARIES OF AIR QUALITY MEASUREMENTS FOR MONITORING STATIONS NEAREST P-079 JIOC FACILITY PROJECT

Parameter / Location	2011	2012	2013	2014	2015
Sulfur Dioxide / Downtown Honolulu					
1-Hour Averaging Period:					
Highest Concentration (ppm)	0.024	0.031	0.022	0.018	0.013
99th Percentile Concentration (ppm)	-	-	-	0.006	0.010
No. of Averages Greater than 0.075 ppm	0	0	0	0	0
3-Hour Averaging Period:					
Highest Concentration (ppm)	0.012	0.026	0.017	0.015	0.007
2nd Highest Concentration (ppm)	0.008	0.021	0.011	0.014	0.007
No. of State AAQS Exceedances	0	0	0	0	0
24-Hour Averaging Period:					
Highest Concentration (ppm)	0.005	0.009	0.005	0.008	0.003
2nd Highest Concentration (ppm)	0.002	0.005	0.003	0.006	0.002
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration (ppm)	0.001	0.001	0.001	0.001	0.000
Particulate (PM-10) / Downtown Honolulu					
24-Hour Averaging Period:					
Highest Concentration ($\mu g/m^3$)	50	32	35	30	36
2nd Highest Concentration ($\mu g/m^3$)	35	28	28	29	29
No. of State AAQS Exceedances	0	0	0	0	0
Annual Average Concentration ($\mu g/m^3$)	12	12	11	13	12
Particulate (PM-2.5) / Downtown Honolulu					
24-Hour Averaging Period:					
Highest Concentration ($\mu g/m^3$)	25	17	18	12	17
98th Percentile Concentration ($\mu g/m^3$)	9	13	16	10	10
No. of Averages Greater than 35 $\mu g/m^3$	0	0	0	0	0
Annual Average Concentration ($\mu g/m^3$)	5	5	5	4	4
Carbon Monoxide / Downtown Honolulu					
1-Hour Averaging Period:					
Highest Concentration (ppm)	1.4	1.0	1.6	2.0	1.4
2nd Highest Concentration (ppm)	1.1	1.0	1.5	1.8	1.3
No. of State AAQS Exceedances	0	0	0	0	0
8-Hour Averaging Period:					
Highest Concentration (ppm)	0.8	0.7	1.2	1.0	1.0
2nd Highest Concentration (ppm)	0.8	0.7	1.2	1.0	1.0
No. of State AAQS Exceedances	0	0	0	0	0

Table 4 (cont.)

ANNUAL SUMMARIES OF AIR QUALITY MEASUREMENTS FOR MONITORING STATIONS NEAREST P-079 JIOC FACILITY PROJECT

Parameter / Location	2011	2012	2013	2014	2015
Nitrogen Dioxide / Kapolei					
1-Hour Averaging Period:					
Highest Concentration (ppm)	0.025	0.027	0.031	0.043	0.031
98th Percentile Concentration (ppm)	0.025	0.023	0.030	0.025	0.022
No. of Averages Greater than 0.100 ppm	0	0	0	0	0
Annual Average Concentration (ppm)	0.003	0.003	0.003	0.004	0.004
Ozone / Sand Island					
8-Hour Averaging Period:					
Highest Concentration (ppm)	0.047	0.045	0.051	0.062	0.052
2nd Highest Concentration (ppm)	0.047	0.044	0.050	0.061	0.050
4th Highest Concentration (ppm)	0.046	0.044	0.047	0.057	0.049
No. of Daily Max 8-hr Ave > 0.075 ppm	0	0	0	0	0

Source: State of Hawaii Department of Health, “Annual Summaries, Hawaii Air Quality Data, 2011 - 2015”

Table 5

ESTIMATED HIGHEST 1-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR P-079 JIOC FACILITY PROJECT (parts per million)

Roadway Intersection	Year/Scenario									
	2017 Present		2027 Without Project		2027 With Project		2037 Without Project		2037 With Project	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Halawa Drive at Kamehameha Highway	1.4	1.7	1.1	1.3	1.1	1.3	1.1	1.2	1.1	1.2
Luapele Road at Salt Lake Boulevard	1.5	1.8	1.3	1.4	1.3	1.4	1.1	1.2	1.1	1.2
Kahuapaani Street at Salt Lake Boulevard	1.7	2.1	1.3	1.5	1.3 (1.3)	1.5 (1.5)	(1.1)	(1.2)	(1.1)	(1.2)

Hawaii State AAQS: 9 National AAQS: 35

Note: Values in table enclosed within parentheses pertain to situation that includes mitigation recommended in project traffic report.

Table 6

ESTIMATED HIGHEST 8-HOUR CARBON MONOXIDE CONCENTRATIONS ALONG ROADWAYS NEAR P-079 JIOC FACILITY PROJECT (parts per million)

Roadway Intersection	Year/Scenario				
	2017 Present	2027 Without Project	2027 With Project	2037 Without Project	2037 With Project
Halawa Drive at Kamehameha Highway	0.8	0.6	0.6	0.6	0.6
Luapele Road at Salt Lake Boulevard	0.9	0.7	0.7	0.6	0.6
Kahuapaani Street at Salt Lake Boulevard	1.0	0.8	0.8 (0.8)	(0.6)	(0.6)

Hawaii State AAQS: 4.4 National AAQS: 9

Note: Values in table enclosed within parentheses pertain to situation that includes mitigation recommended in project traffic report.

Table 7

ESTIMATED AIR POLLUTION EMISSIONS FROM EMERGENCY DIESEL GENERATORS AT P-079 JIOC FACILITY[a]

Air Pollutant	Emission Rate (tons/year)
Particulate	0.6
Sulfur Oxides	0.6
Carbon Monoxide	1.8
Total Organic Compounds	0.7
Nitrogen Oxides	8.2

[a]Based on U.S. EPA emission factors for uncontrolled gasoline and diesel industrial engines [11]. Assumes two 1-MW diesel generators and one 1.5-MW diesel generators each operating 100 hours per year. Because the generators would only be operated on an emergency basis during temporary power outages, 100 hours per year was deemed a reasonable proxy to account for routine testing as well as irregular emergency use.

Appendix B-2
Greenhouse Gas Calculations

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GREEN FOOTSTEP

YOUR BUILDING. YOUR CARBON. AND WHAT YOU CAN DO ABOUT IT

Rocky Mountain Institute

REPORT

Project Name:	**P-079** JIOC New Construction, Makalapa Crater
Location:	HICC Miscellaneous, United States, NORTH AMERICA
Created by:	Gail Renard
Date:	Jun 18, 2018

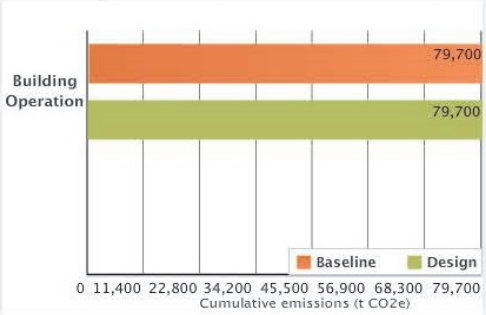
Your building will consume 93 kBtu per sq. ft. of energy each year in order to operate. Based on the mix of fuels used at the building and those used to create electricity in HICC Miscellaneous, United States, NORTH AMERICA, this amount of energy translates to 3187 t CO2e of emissions each year (including non-building operational emissions, if applicable). Your total annual offset emissions, based on your amount of on-site renewable energy and off-site carbon investments, is equal to 0 t CO2e each year, which yields a net annual operational emissions of 3187 t CO2e.

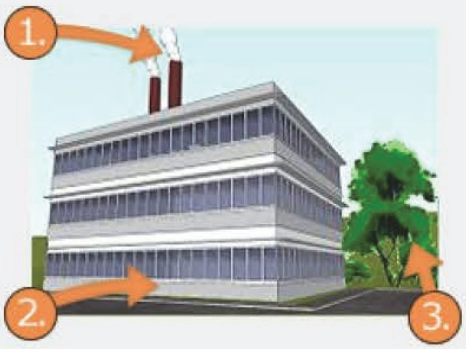
How do the emissions from this project translate to climate change? The total cumulative emissions of your building over its estimated lifetime is 180,000, which is a 0 percent reduction from the baseline you defined for your project. These emissions will result in a net increase in the atmospheric concentration of greenhouse gas. In order to avoid sea level rise above one meter and other effects of climate change, we need to stop increasing and stabilize this concentration of greenhouse gas at 450 ppm. (This information is based on the IPCC AR4 Synthesis Report, found at www.ipcc.ch.)

DATA SUMMARY

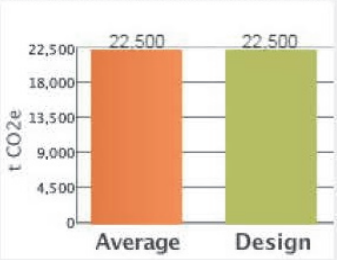
Cumulative Emissions Over 25 Years

1. Operational Emissions - 25 Years

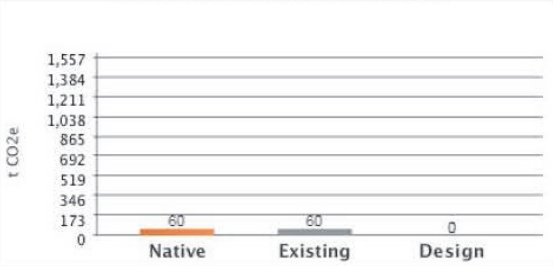




2. Embodied Emissions from Construction



3. Average Site Carbon Storage



Does your building meet the Architecture 2030 Challenge? **NO**

© 2009 Rocky Mountain Institute. All rights reserved. Site by: FIREANT STUDIO

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Appendix C
Endangered Species Act Section 7 Consultation Correspondence

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawai‘i 96850

In Reply Refer To:
01EPIF00-2021-I-0429

September 22, 2021

Sherri R. Eng
Director, Regional Environmental Department
Navy Region Hawai‘i
850 Ticonderoga St. STE 110
JBPHH, Hawai‘i 96860-5101

Subject: Request for Informal Consultation on Proposed Joint Intelligence Operations Center at Joint Base Pearl Harbor-Hickam, Makalapa, O‘ahu .

Dear Director Eng:

The U.S. Fish and Wildlife Service (Service) received your letter dated August 02, 2021, requesting our concurrence with your determination that construction of the proposed Joint Intelligence Operations Center (JIOC) at the Joint Base Pearl Harbor-Hickam (JBPHH) Makalapa Compound, may affect, but is not likely to adversely affect the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), Hawaiian stilt (*Himantopus mexicanus knudseni*), Hawaiian petrel (*Pterodroma sandwichensis*), Hawaiian distinct population segment (DPS) band-rumped storm petrel (*Oceanodroma castro*), and threatened Newell's Townsend's shearwater (*Puffinus auricularis*). This response is in accordance with section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 *et seq*.).

Project Description

Joint Base Pearl Harbor-Hickam proposes to construct a Command, Control, Communications, and Intelligence facility to consolidate the Indo-Pacific Command. The proposed action would include a new operations building along with supporting infrastructure and facilities. Project implementation is anticipated to begin in 2022 with construction completed in 2025.

The proposed action is located within the Makalapa Compound that is used for base housing, command buildings and recreation facilities. The installation is part of JBPHH and is bordered by Halawa stream to the north, H-1 freeway to the east, Radford Drive to the south, and Kamehameha highway to the west of the action area. The project site is currently in an undeveloped non-native forest consisting of kiawe (*Prosopis pallida*) and ‘Opiuma (*Pithecellobium dulce*), which reach heights of 40 feet. The understory consists of koa haole

(*Leucaena leucocephala*) and grasses. Historically, the project site is located within the former Makalapa crater that has been developed since the 1940s. Wetlands do not currently exist within the area and the surrounding environment has been altered to inhibit wetland conditions.

The proposed action consists of constructing a 3-story building for the JIOC east of Makalapa Drive. The facility would be constructed on an approximately 16-acre site that includes a 174,000 square foot structure. Supporting facilities on the project footprint include an electrical substation/switching station, sanitary lift station, storm water detention facility and a 700 vehicle parking lot. The facility would also include three single-story attached wings for a central utility plant, warehouse, and food court. To support the new building, relief sewer lines would be upgraded at the Makalapa compound, along Center Drive and South Avenue.

In accordance with anti-terrorism force protection requirements, the JIOC would be enclosed by chain-link fence 800 feet long by 6 feet tall, topped with three strands of barbed wire (total of 0.45 miles). The new fence would be a secondary security barrier for the new building as required by military standards.

The parking lot would use low-impact development strategies including vegetated bio swales and an infiltration basin allowing storm water to percolate. A six-foot high perimeter safety fence with a vehicle access gate would surround the basin. No barbed wire would be used on the basin fence.

The proposed action also includes site preparation, which would consist of vegetation clearing and grubbing, removal of any buried construction debris encountered during excavation, and grading.

<u>Avoidance and Minimization Measures</u>

To reduce likelihood of negatively impacting listed species during the proposed project the Navy will:

- Not remove or trim any trees 15 feet or taller during the Hawaiian hoary bat pupping season (June 1-September 15).
- If any pups are discovered in the construction zone, outside of this season, vegetation clearing would immediately stop and operations would be moved to a minimum of 300 feet away. Construction would not resume until the bat pups have departed the area on their own accord.
- Barbed wire fencing will only be used on fencing when required by anti-terrorism force protection standards and would not reach a length likely of impacting bat(s) over the 20 year lifespan of the fence.
- Outdoor lighting will be designed in accordance with Unified Facilities Criteria Interior and Exterior Lighting Systems and Control, UF 3-530-01 as of 1 April 2015, and outdoor lighting would be fully shielded so the bulbs can only be seen from below, as allowable by safety, security, and antiterrorism force protection requirements.
- Every effort will be made to avoid nighttime construction during the seabird fledging period (September 15-December 15).

- No temporary or permanent areas of standing water would be created by the action and the storm water detection facility would be designed such that there is no exposed standing water or standing water that is accessible to water birds (e.g. bioswale).

Analysis of Effects

Threats to Hawaiian hoary bats include barbed wire fence and removal of woody vegetation containing non-volant pups. Hawaiian hoary bats have been documented near the Makalapa Compound, but the proposed project will not remove woody vegetation greater than 15 feet tall during the hoary bat pupping season, and the use of barbed wire will be minimized to only that required by the anti-terrorism force protection standards, so adverse effects to hoary bats are highly unlikely. Therefore the effect to the Hawaiian hoary bat is considered discountable.

Hawaiian seabirds may traverse the project area at night during the breeding, nesting and fledging seasons (March 1 to December 15). Outdoor lighting could result in seabird disorientation, fallout, and injury or mortality. The proposed project will shield all lights, so the bulb may only be seen from below, as allowable by safety, security, and anti-terrorism force protection requirements and nighttime construction will be avoided between March 1 and December 15, so seabird fallout and other negative impacts to seabirds is unlikely. Therefore, the effect to Hawaiian seabirds is discountable.

Hawaiian stilts may be found in a variety of wetland habitats including wherever ephemeral or persistent standing water may occur. Although the JIOC is bound at its north side by the Halawa stream, this water body does not provide valuable habitat to Hawaiian stilts. Further, construction plans for the proposed project will utilize bioswales and other methods to limit or fully remove standing water present at the facility, so standing water acting as an attractant to Hawaiian stilts is unlikely. Therefore the threat to Hawaiian stilts is considered discountable.

Summary

Based upon the analysis above, we concur with the determination of the U.S. Navy that the proposed project may affect, but is not likely to adversely affect the endangered Hawaiian hoary bat, Hawaiian stilt, Hawaiian petrel, Hawaiian DPS of the band-rumped storm petrel, or the threatened Newell's Townsend's shearwater. Reinitiation of consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and: (1) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (2) if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the written concurrence; or, (3) if a new species is listed or critical habitat designated that may be affected by the identified action.

We appreciate your efforts to conserve protected species. If you have questions regarding this letter, please contact Kevin Donmoyer, Fish and Wildlife Biologist at kevin_donmoyer@fws.gov

or (808) 792-9445. When referring to this project, please include this reference number: 01EPIF00-2021-I-0429.

Sincerely,

DARREN LEBLANC Digitally signed by DARREN LEBLANC Date: 2021.09.22 08:52:28 -10'00'

Darren LeBlanc
Planning and Consultation Team Manager

cc: Nicole Olmsted, Noel Dunn, Patricia Kataoka, Cory Campora, John Bigay, Gail Renard, Lorraine Shaughnessy

DEPARTMENT OF THE NAVY
COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
JBPHH, HAWAII 96860-5101

5000-45C
N45
August 2, 2021

Earl Campbell, PH.D.
Acting Field Supervisor
U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard
Room 3-122, Box 50088
Honolulu, Hi 96850

Dear Dr. Campbell:

SUBJECT: BIOLOGICAL EVALUATION FOR THE JOINT INTELLIGENCE OPERATIONS CENTER AT JOINT BASE PEARL HARBOR-HICKAM, MAKALAPA

Pursuant to Section 7(a)(2) of the Endangered Species Act (ESA), Joint Base Pearl Harbor-Hickam (JBPHH) requests informal consultation related to construction of the Joint Intelligence Operations Center (JIOC) at the Makalapa Compound, JBPHH. Construction is anticipated to begin in 2022 on 16 acres of non-native kiawe forest.

JBPHH has developed this Biological Evaluation to assess the potential impacts to threatened and endangered species from the proposed JIOC and species list 01EPIF00-2021-SL-0313 provided by the Service. Based on the impacts analyzed, JBPHH has made a determination the action may affect, but not likely adversely affect the Hawaiian hoary bat, Newell's shearwater, Hawaiian petrel, band-rumped storm-petrel, and Hawaiian stilt. Our determination is based on construction schedule and other avoidance and minimization measures. JBPHH requests your concurrence with our finding based on the provided Biological Evaluation.

Please direct correspondence regarding this matter to Mr. Justin Fujimoto, Natural Resource Manager, NAVFAC Pacific at justin.fujimoto@navy.mil or 472-1407.

Sincerely,

SHERRI R. ENG
Director
Regional Environmental Department
By direction of the
Commander

Enclosure: 1. Biological Evaluation for the Joint Intelligence Operations Center

Biological Evaluation for the Joint Intelligence Operations Center, Makalapa Compound, Joint Base Pearl Harbor-Hickam

Prepared by:
Naval Facilities Engineering Systems Command Pacific,
Terrestrial Natural Resources

July 2021

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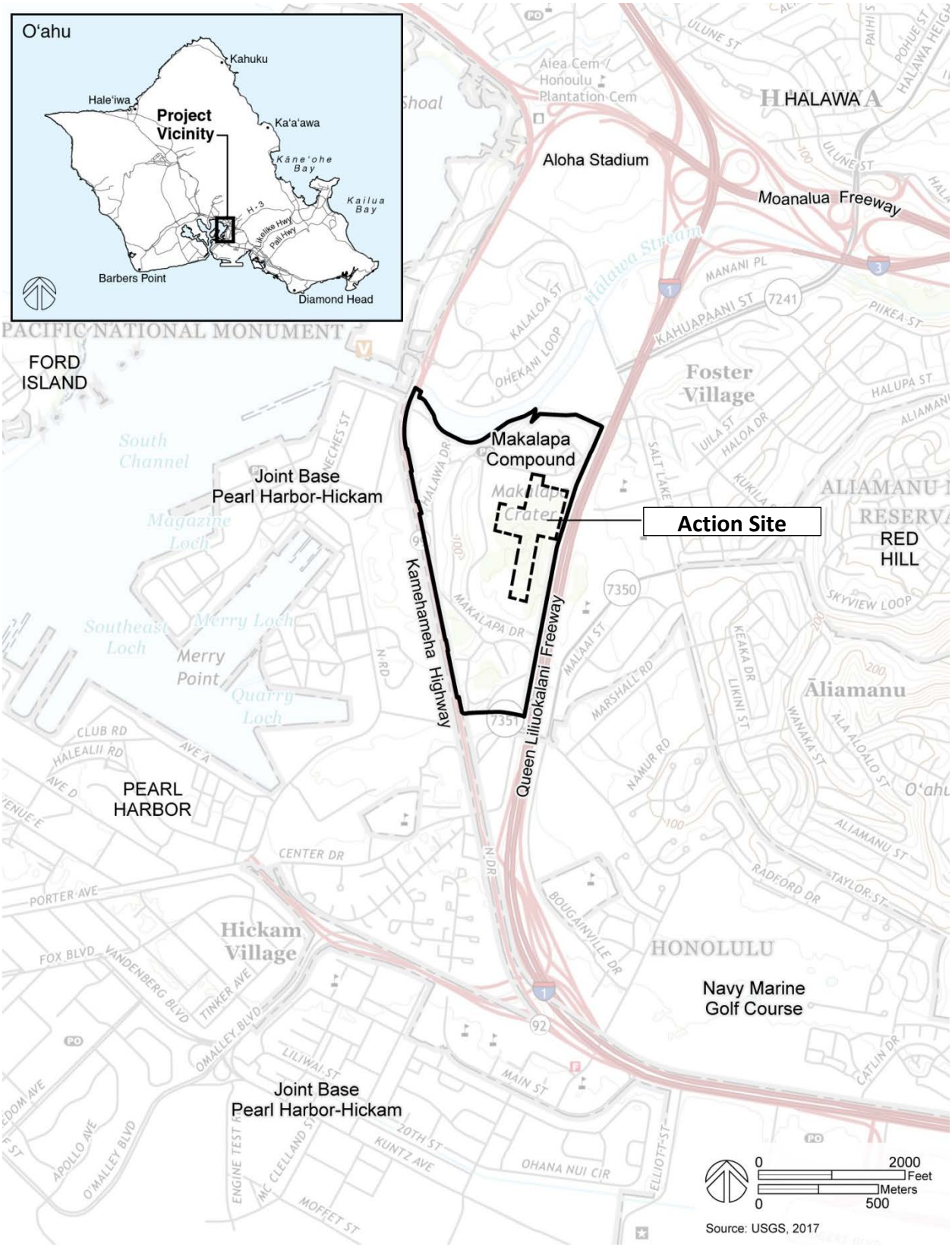
1.0 Introduction

Joint Base Pearl Harbor-Hickam (JBPHH) proposes to construct a Command, Control, Communications, and Intelligence facility to consolidate the Indo-Pacific Command Joint Intelligence Operations Center (JIOC) at JBPHH Makalapa Compound. The proposed action would include a new operations building along with supporting infrastructure and facilities. Project implementation is anticipated to begin in 2022 with construction completed in 2025.

1.1 Action Location

The proposed action is located within the Makalapa Compound that is used for base housing, command buildings and recreation facilities. The installation is part of Joint Base Pearl Harbor-Hickam and is bordered by Halawa stream to the north, H-1 freeway to the east, Radford drive to the south, and Kamehameha highway to the west of the action area. The action site is shown in Figure 1, and is currently in an undeveloped, non-native forest between recreational facilities and base housing.

Figure 1. Action Site Map (UTM coordinates 21.360648, -157.932603)



1.2 Purpose and Need

Currently operating in five buildings within JBPHH and Marine Corps Base Hawaii's Camp H.M. Smith, JIOC is faced with space, utility, and infrastructure constraints at the locations of existing facilities. In 2010, a Basic Facilities Requirements assessment documented a substantial unmet space requirement for JIOC. A 2012 Department of the Navy (DON) study investigated alternatives for maximizing efficiencies of internal operations and joint operations with US Indo-Pacific Command staff, component commands, and forward deployed forces.

The proposed action is needed because JIOC's existing facilities do not allow the flexibility to accommodate evolving technologies that support intelligence analysis and collaboration. The proposed action would improve JIOC's ability to expand, adapt and integrate new technologies in support of mission requirements. Many of JIOC's current work spaces were initially constructed in the 1940's and are not functionally-suited or readily adaptable to a modern, technology-driven work environment. Furthermore, the facilities and personnel are spread over several mile distance. The proposed action is needed to improve the integration and close collaboration required to support the intelligence community's operational processes. Accommodating new surveillance technologies and collocating personnel are needed to more capably support national, strategic, and operational theater intelligence.

1.3 Species Addressed in this Biological Evaluation

The Navy submitted a species list to the Service for concurrence on May 27, 2021, and received a reply on June 16, 2021 with reference number 01PEIF00-2021-SL-0313. The ESA-listed species potentially occurring within the action area and their associated critical habitat are listed in Table 1.

Table 1. Species and Critical Habitat covered under this consultation.

Common Name	Scientific Name	ESA Status	Critical Habitat
Hawaiian Hoary Bat	*Lasiurus cinereus semotus*	Endangered	N/A
Hawaiian petrel	*Pterodroma sandwichensis*	Endangered	N/A
Band-rumped storm-petrel	*Oceanodroma castro*	Endangered	N/A
Newell's shearwater	*Puffinus auricularis newelli*	Threatened	N/A
Hawaiian stilt	*Himantopus mexicanus knudseni*	Endangered	N/A

2.0 Details of the Proposed Action and Action Area

2.1 Proposed Action

The proposed action consists of constructing a 3-story building for the JIOC east of Makalapa drive. The facility would be constructed on an approximately 16-acre site that includes a 174,000 sq ft structure. Supporting facilities on the project footprint include an electrical substation/switching station, sanitary lift station, storm water detention facility and an at-grade

700 vehicle parking lot (Figure 3). The facility would also include three single-story attached wings for a central utility plant, warehouse, and food court (Figure 3). To support the new building, relief sewer lines would be upgraded at the Makalapa compound, along Center Drive and South Avenue at JBPHH (Figure 4). Construction is expected to begin in the second quarter of calendar year (CY) 2022, with completion in the first quarter of CY 2025.

Figure 2. Structure of the JIOC building.

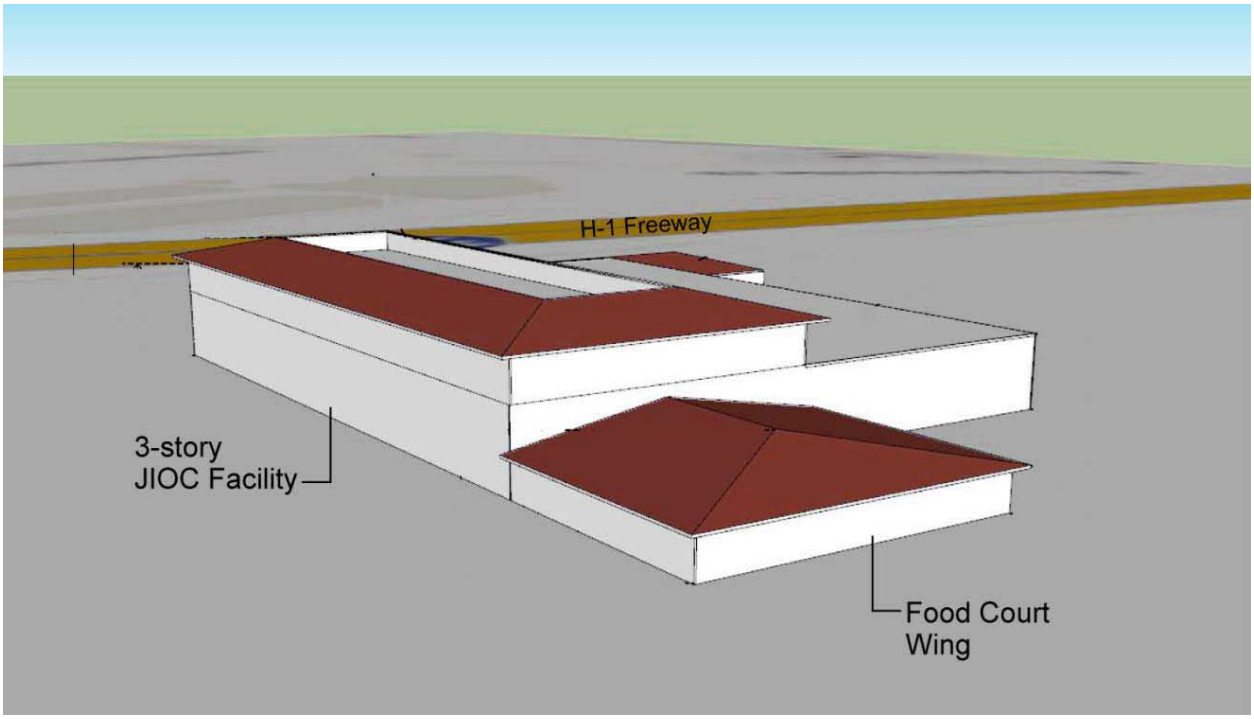


Figure 3. Project footprint on Makalapa compound.

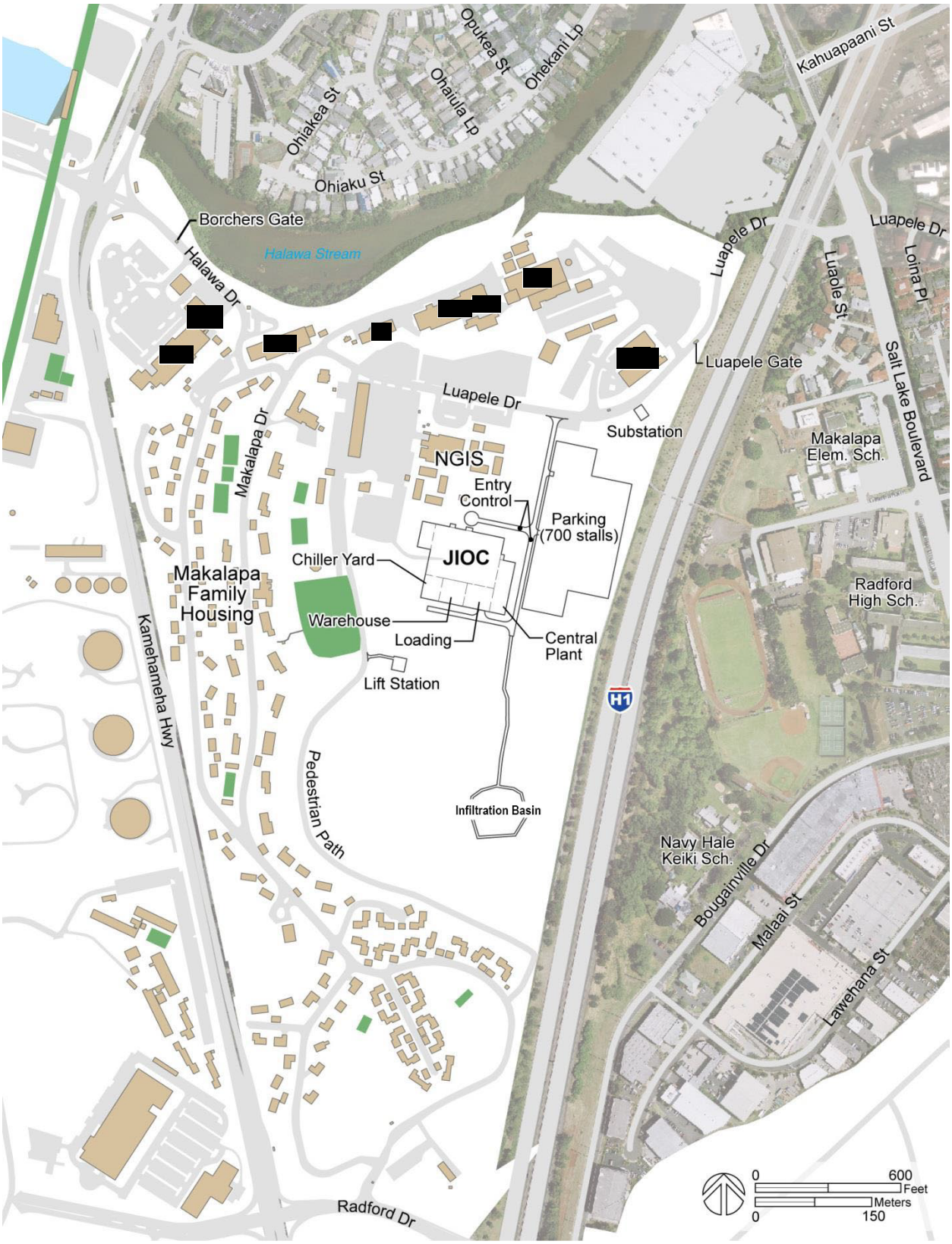
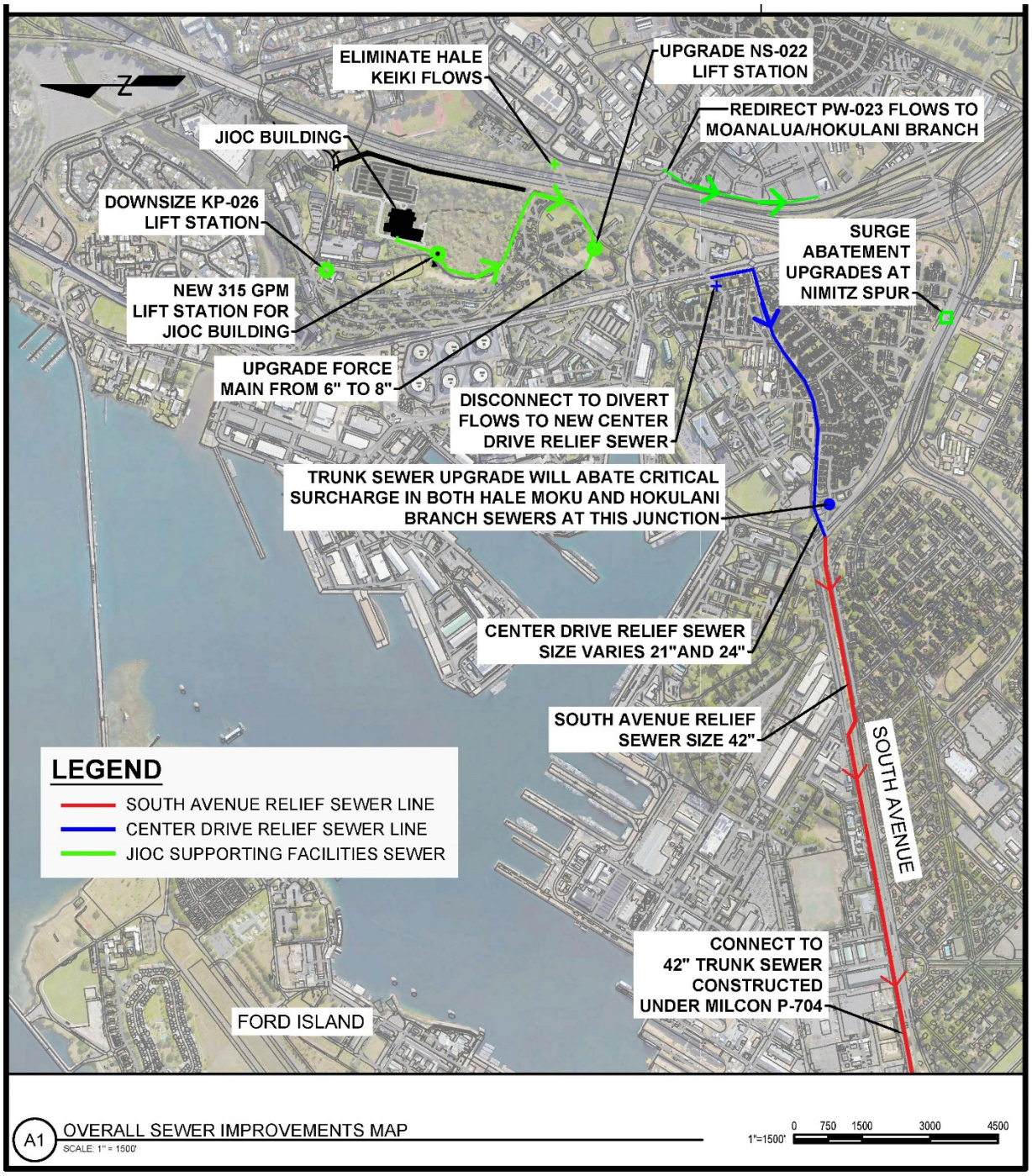


Figure 4. Overall sewer improvements map for JIOC.



In accordance with anti-terrorism force protection requirements, the JIOC would be enclosed by chain-link fence 800 feet long by 6 feet tall, topped with three strands of barbed wire (total of 0.45 miles). The new fence would be a secondary security barrier for the new building as required by military standards.

The parking lot would use low-impact development strategies including vegetated bio swales and an infiltration basin allowing storm water to percolate. A six-foot high perimeter safety fence with a vehicle access gate would surround the basin. No barbed wire would be used on the basin fence.

The proposed action also includes site preparation, which would consist of vegetation clearing and grubbing, removal of any buried construction debris encountered during excavation, and grading.

2.1 Baseline Conditions of the Action Area

The project site is vegetated with nonnative trees consisting of kiawe (*Prosopis pallida*) and Opiuma (*Pithecellobium dulce*) reaching heights of 40 ft. The understory consists of koa haole (*Leucaena leucocephala*) and grasses (Figure 5 and 6). Historically, the project site is located within the former Makalapa crater that has been developed since the 1940s. Wetlands do not currently exists within the area and the surrounding environment has been altered to inhibit wetland conditions.

Figure 5. Current vegetation of the proposed parking lot site looking south.

Figure 6. Views of Makalapa looking north and rendering of the JIOC building within the vegetation.

A: Existing view from top of [redacted]

B: Potential view from top of [redacted]

The following best management practices (BMPs) and Standard Operating Procedures (SOPs) in Table 2 would be incorporated into the proposed action to avoid impacts to minimize potential effects on federally listed threatened and endangered species:

Table 2. BMPs and SOPs

BMP/SOP	Target Species/Critical Habitat
Trees 15 feet or taller would not be removed or trimmed during the bat pupping season from June 1 through September 15. If any bat pups were to be discovered in the construction zone, outside of this season, vegetation clearing would immediately stop and operations would be moved to a minimum of 300 feet away. Construction would not resume until the bat pups have departed the area on their own accord.	Hawaiian hoary bat
Barbed wire would be used on fencing only when required by anti-terrorism/force protection standards.	Hawaiian hoary bat
Taking into consideration safety, security, anti-terrorism/force protection requirements, outdoor lighting would be designed in accordance with Unified Facilities Criteria Interior and Exterior Lighting Systems and Control, UFC 3-530-01 as of 1 April 2015, and outdoor lighting would be fully shielded so the bulbs can only be seen from below.	Newell's shearwater, Hawaiian petrel, band-rumped storm-petrel

Every effort would be made to avoid nighttime construction during the seabird fledging period, September 15 through December 15.	Newell's shearwater, Hawaiian petrel, band-rumped storm-petrel
No temporary or permanent areas of standing water would be created by the action and the storm water detention facility would be designed such that there is no exposed standing water or standing water that is accessible to water birds.	Hawaiian stilt

3.0 Description of Species and Critical Habitat

3.1 Hawaiian Hoary Bat

The Hawaiian hoary bat (*Lasiurus cinereus semotus*) may be present within the action area. The Hawaiian hoary bat was listed as federally endangered on October 13, 1970 and a recovery plan for the species was completed in 1998 (USFWS 1998). Critical habitat for this species has not been designated. The Hawaiian hoary bat is a solitary species that has been recorded on all of the main Hawaiian Islands, with the largest populations thought to be on Kauai and Hawaii Island (Amlin and Siddiqi 2015). Accurate estimates of the population are not available, but estimates for all islands have ranged from hundreds to a few thousand (USFWS 1998). Most observations of bats have been made between sea level and 7,500 feet in elevation, but their presence has been documented up to 13,198 feet in elevation (Gon et al. 1993).

3.1.1 Habitat use and Ecology

The Hawaiian hoary bat uses a wide variety of habitats including native, non-native, and agricultural areas. Vegetation cover and structure appear to be more important than a particular vegetation species. As an example, Hawaiian hoary bats have been known to use eucalyptus (*Eucalyptus globulus*), albizia (*Albizia falcataria*), ironwood (*Casuarina equisetifolia*), ohia (*Metrosieros polymorpha*), koa (*Acacia koa*), and mamane-naio forest (*Sophorachrysophylla – Myoporum sandwicense*) for foraging and roosting (Koob 2012). Rangelands near forest edges, rural yards, agriculture windbreaks, and croplands may also be used for foraging. Transition areas or forest breaks are generally considered good hoary bat habitats (Koob 2012). Hoary bats forage at night, on native and non-native insects such as moths, beetles, termites, leafhoppers, and flies (USFWS 1998).

Breeding has been documented on all islands except for Niihau and Kahoolawe (Pacific Rim Conservation 2013). Breeding occurs in the autumn when adults congregate in the lowlands and prepare for mating in what is termed "fall swarming" (Bonaccorso et al. 2012). In mid-June, females give birth to two pups or occasionally one, and the pups are typically dependent on their mother and are unable to fly until late August/early September (USFWS 1998). Roosting primarily occurs in woody vegetation exceeding 15 feet in height (Amlin and Siddiqi 2015).

3.1.2 Detection within Joint Base Pearl Harbor-Hickam

JBPHH has not conducted bat surveys at the Makalapa compound, but samples have been taken near the action area. Studies by West Inc. placed two detectors at Hospital Point (2.3 miles away) and Hickam Airfield (1.7 miles away) during the first year of the island-wide survey. No bat detections were made from June 2017 to 2018 (Thompson et al 2019). Additionally, JBPHH contracted USGS-Pacific Island Ecosystem Research Center (PIERC) to conduct acoustic sampling for bats at Ford Island (1.2 miles away), Red Hill Storage Facility (2.6 miles away), and Ahua Reef (3.4 miles away). The Ford island location was sampled from November 2012 to March 2013 with a bat detection. The Red Hill Storage Facility was sampled from January to December 2014 for a total of 190 recording nights. Bat detections were recorded on two nights August 10th at 21:39 and August 26th at 21:48 for a detection rate of 0.011 (Bonaccorso et al. 2014). The Ahua Reef site was sampled from November 2012 to March 2013 with a bat detection (Bonaccorso et al. 2012).

3.1.3 Threats to the Species

Because accurate population estimates of Hawaiian hoary bats are limited and historical distribution information is lacking, the decline of the species has largely been inferred (USFWS 1998). Observations and species records suggest that bats are absent from historically occupied ranges (USFWS 1998). Because little research has been conducted on this species, factors threatening this species are assumed to be similar to those threatening bat species found in North America (USFWS 1998). The primary factors associated with Hawaiian hoary bat declines are thought to be habitat loss, collision with structures, and possibly pesticide use (USFWS 2010). Effects of pesticides have not been fully investigated as to whether they effect bats directly, or indirectly through limiting prey (USFWS 1998).

Roost disturbance is a common threat for all bats worldwide (Koob 2012). For the Hawaiian hoary bat, this could be clearing or pruning trees where bats roost. The availability of roosting sites and suitable roosting habitat are important to pregnant lactating females and fledging bats (USFWS 2010). Disturbing roosting sites when juvenile bats are fledging (July to September) has the highest potential for mortality because young bats are not able to evade disturbance. Bat numbers on Oahu are thought to have decreased significantly, perhaps due to deforestation that occurred in the early nineteenth century (USFWS 1998). Mortality of breeding adults and females may also limit the recovery of the species. Current loss of forests and land conversions from agriculture contribute to habitat loss (USFWS 2010).

3.2 Newell's shearwater, Hawaiian petrel, band-rumped storm petrel

Habitat modeling and acoustic verification detected Newell's shearwater on Mt. Kaala and Poamoho (Young et al. 2019). Newell's shearwater may fly over the action area to reach nesting habitats, but birds have not been documented at JBPHH installations and the potential to occur in the action area is very low to unlikely. Populations of the Band–rumped storm petrel are known to occur on Kauai, Maui, and Hawaii island (DNLR 2015). The Band–rumped storm petrel has not been documented at JBPHH installations and the potential to occur in the action area is very low to unlikely. The Hawaiian petrel is known to nest on Kauai, Maui, Lanai, Hawaiian island and possibly on Molokai (DNLR 2015). Grounded birds have been recovered on Oahu and recently detected via acoustic monitoring in the lower Kaala region, likely attracted by low frequency sound of a satellite communication facility (Young et al. 2019). The Hawaiian petrel has not been documented at JBPHH installations and the potential to occur in the action area is very low to unlikely.

3.3 Hawaiian stilt

The Hawaiian stilt is present on JBPHH installations within wetland habitats such as ditches, tidal flats and waterways (NAVFAC PAC 2011). The Makalapa compound does not support wetland habitats for Hawaiian stilt, but grassy areas exist that could attract stilts after heavy rain events. Hawaiian stilts do not typically frequent the action area or adjacent grassy sites, but their presence within the proposed site is possible after the vegetation is cleared.

4.0 Effects Analysis

This section presents an analysis of direct and indirect effects on federally listed species due to implementation of the action. Direct effects are the immediate effects of the project on the species or its habitat. Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur.

4.1 Hawaiian Hoary Bat: Vegetation Clearing

Vegetation clearing would have a direct effect on bats by the loss of roosting habitat and possibly harming pups in trees that are unable to fly. The action area has non-native trees with canopy cover greater than 15 feet tall, potentially providing suitable habitat for bats to roost; therefore, direct impacts could occur if flightless bats (pups and/or fledglings) are in trees during removal and are unable to escape. Direct harm is unlikely, however, because the clearing or trimming of vegetation taller than 15 feet would only occur outside of the bat pupping season (June 1 through September 15). Once vegetation clearing is finished, bats would be able to occupy surrounding vegetation on the installation that is similar to the project site. Considering the action, biology of the bats, and this avoidance measure to be implemented, the Navy has determined that vegetation clearing associated with this action

may affect the Hawaiian hoary bat, but is not likely to adversely affect (NLAA) individuals or populations of this species.

4.2 Hawaiian Hoary Bat: Collision with Barbed Wire

Hawaiian hoary bats forage for insects from as low as 3 feet to higher than 500 feet above the ground. At these lower levels, foraging bats are not able to detect barbed wire fences which can cause injury or mortality to Hawaiian hoary bats. The USGS has estimated a mortality rate of bats colliding with barbed wire fencing. They estimate 0.013 bats killed per mile of barbed wire per year (USFWS 2014). In the case of this project, the use of barbed wire would be reduced as much as possible, but cannot be completely avoided. Treating each of the 3 barbed wire strands independently results in the following analysis: 0.013 (mortality rate) x 0.15 miles (total length of fence with barbed wire) x 3 separate strands x 20 years (estimated lifetime of the fence) = 0.117 bat mortalities per 20 years. Additionally, bat occupancy is estimated to be low or infrequent in the project area based on nearby surveys. For these reasons the Navy has determined that barbed wire associated with the project may affect, but is not likely to adversely affect (NLAA) the Hawaiian hoary bat, or jeopardize the continued existence of the species.

4.3 Seabirds: Fallout Due to Outdoor Night Lighting

Under the proposed action, the greatest potential impact to Newell's shearwater, Hawaiian petrel, and band-rumped storm-petrel would be from fallout/disorientation from associated night-lighting during construction and operations. However, the likelihood of the species occurring in the action area is low, and with the implementation of avoidance and minimization measures listed in Table 2, including fully shielded lighting and avoidance of nighttime construction during the seabird fledging period (September 15 through December 15), the likelihood of potential impacts would be so low as to be negligible. Furthermore, under the proposed action, no seabird breeding or foraging habitat would be impacted. Due to the species' unlikely occurrence in the action area, construction and operations activities are not likely to disturb individuals. Therefore, the proposed action may affect but is not likely to adversely affect the Newell's shearwater, Hawaiian petrel, and band-rumped storm-petrel.

4.4 Hawaiian Stilt: Fallout Due to Outdoor Night Lighting

Under the proposed action, the greatest potential impact to the Hawaiian stilt would be from any standing water at the site which could potentially lead to nesting in sub-optimal habitat and put the species at risk from predation or direct physical harm from operations at the site. However, the likelihood of ephemeral or persistent standing water at the site is low, and the storm water detention facility would be designed such that there is no exposed open water that would attract water birds. Additionally there are no wetlands or water habitat in the immediate vicinity of the proposed action. Taking these factors into account, the likelihood of potential

impacts to the Hawaiian stilt would be so low as to be negligible. Therefore, the proposed action may affect, but is not likely to adversely affect, the Hawaiian stilt.

5.0 Determination and Conclusion

For this biological evaluation, the Navy examined the potential impacts of constructing the JIOC on the Hawaiian hoary bat, Newell's shearwater, Hawaiian petrel, band-rumped storm petrel, and the Hawaiian stilt. Based on avoidance and minimization measures that would be implemented and an analysis of potential impacts, the Navy's determinations of effects on these species from the proposed action are provided in Table 3. The Navy requests the Service's concurrence with these determinations.

Table 3. Effects Determination

Common Name	Scientific Name	ESA Status	Effects Determination
Hawaiian Hoary Bat	*Lasiurus cinereus semotus*	Endangered	NLAA
Hawaiian petrel	*Pterodroma sandwichensis*	Endangered	NLAA
Band-rumped storm-petrel	*Oceanodroma castro*	Endangered	NLAA
Newell's shearwater	*Puffinus auricularis newelli*	Threatened	NLAA
Hawaiian stilt	*Himantopus mexicanus knudseni*	Endangered	NLAA

6.0 Works Cited

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Young, L.C., VanderWerf, E.A., McKown, M., Roberts, P., Schlueter, J., Vorsino, A., & Sischo, D. (2019). Evidence of Newell's Shearwaters and Hawaiian Petrels on Oahu, Hawaii. The Condor: *Ornithological Applications, 121*(1).

Appendix D
CZMA Correspondence

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From: Mendes, Debra L
To: Bigay, John CIV USN (USA)
Subject: [Non-DoD Source] RE: NAVY CZMA DE MINIMIS NOTICE
Date: Tuesday, February 8, 2022 11:30:17 AM

Hello John,

Notification received.

Debra Mendes

Hawaii Coastal Zone Management Program

From: Bigay, John CIV USN (USA) <john.bigay@navy.mil>
Sent: Tuesday, February 8, 2022 10:51 AM
To: Mendes, Debra L <debra.l.mendes@hawaii.gov>
Subject: [EXTERNAL] NAVY CZMA DE MINIMIS NOTICE

Aloha, Ms. Mendes,

The Navy is preparing an Environmental Assessment for a Joint Intelligence Operations Center facility at Joint Base Pearl Harbor-Hickam (JBPHH), O'ahu, Hawai'i. The Proposed Action would construct an administrative facility to consolidate the U.S. Indo-Pacific Command (USINDOPACOM) Joint Intelligence Operations Center (JIOC) at JBPHH Makalapa Compound (a.k.a. Makalapa Crater). The JIOC facility would be a multi-story, approximately 172,000-square-foot building. The Proposed Action would also construct supporting infrastructure and facilities (e.g., parking, stormwater detention facility, and sanitary sewer lift station). Several offsite sewer system improvements are required to support operations at the proposed new JIOC facility). The proposed improvements would be made to existing Department of Defense (DoD)-owned infrastructure or within DoD-controlled land in and around JBPHH. All work would be confined to Navy-controlled property and/or utility easements within Makalapa Crater and along utility routes crossing Kamehameha Highway, along Center Drive, and into JBPHH property along South Avenue (see location map included).

The proposed action falls within Items 1 and 2 on the Navy/Marine Corps De Minimis Activities Under CZMA (see attached pdf):

Item 1. New Construction: Construction of new facilities and structures wholly within Navy/Marine Corps controlled areas (including land and water) that is similar to present use and, when completed, the use or operation of which complies with existing regulatory requirements.

The Navy would observe all mitigation/conditions for de minimis Item 1 (i.e., 1, 3, 6, 8, 9, 10, 11, 13, 14, 16).

Item 2. Utility Line Activities: Acquisition, installation, operation, construction, maintenance, or repair of utility or communication systems that use rights of way, easements, distribution

systems, or facilities on Navy/Marine Corps controlled property. This also includes the associated excavation, backfill, or bedding for the utility lines, provided there is no change in pre-construction contours.

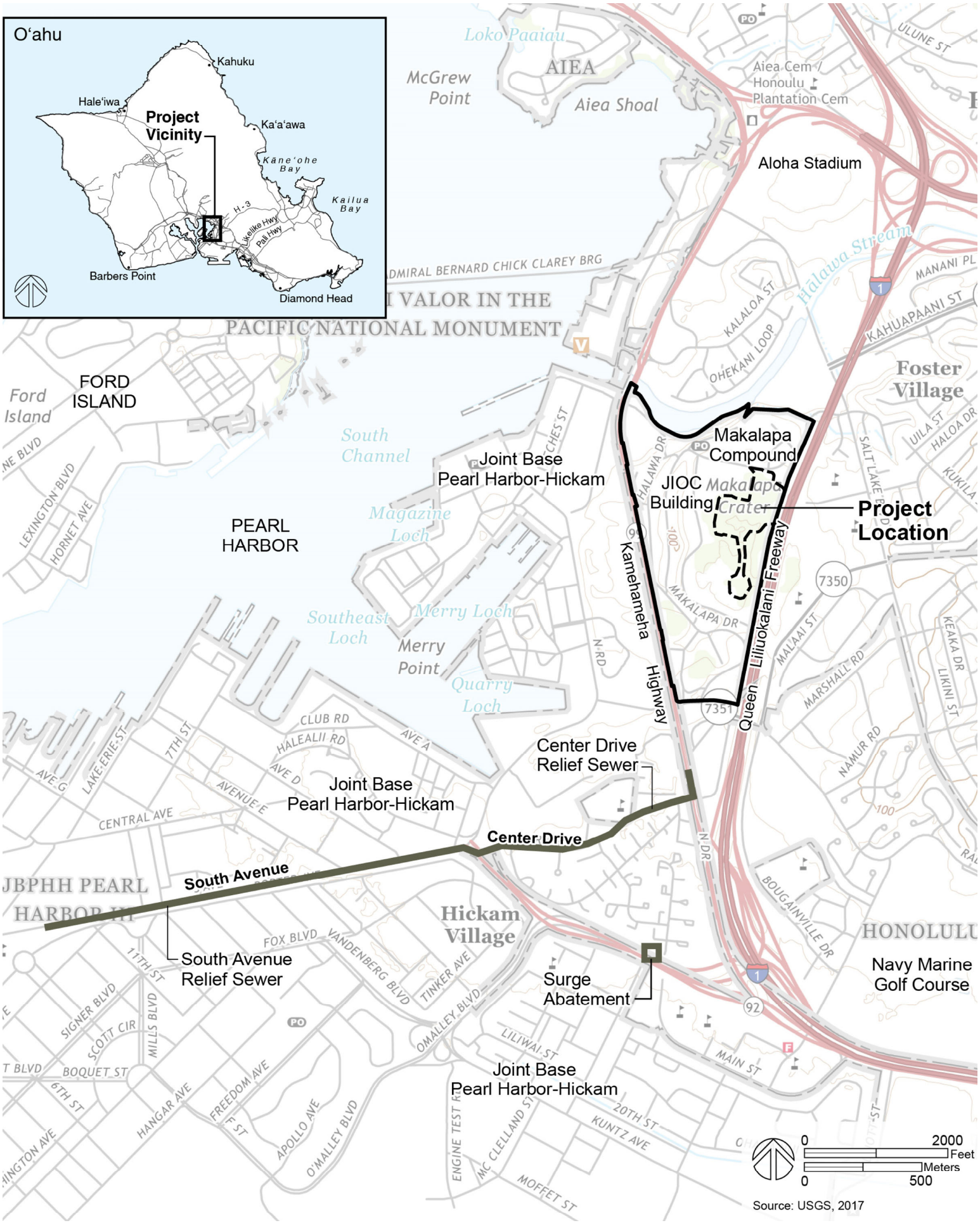
The Navy would observe all mitigation/conditions for de minimis Item 2 (i.e., 1, 10, 11, 12, 14, 16).

Per General Condition 16 of the De Minimis Activities Under CZMA, we are notifying you of the de minimis list use.

Please let me know if you have any questions.

Very Respectfully,

John Bigay
NEPA Planner
NAVFAC Pacific


O'ahu
Kahuku
Hale'iwa
Project Vicinity
Ka'a'awa
Kāne'ohe Bay
Kailua Bay
H-3
Kalanianaole Hwy
Pali Hwy
Barbers Point
Diamond Head
Loko Paaiau
McGrew Point
AIEA
Aiea Shoal
Aiea Cem / Honoulu Plantation Cem
Aloha Stadium
ULUNE ST
Halawa Stream
MANANI PL
KAHUAPAANI ST
KALALOA ST
OHEKANI LOOP
ADMIRAL BERNARD CHICK CLAREY BRG
I VALOR IN THE PACIFIC NATIONAL MONUMENT
Foster Village
FORD ISLAND
Ford Island
South Channel
Joint Base Pearl Harbor-Hickam
Makalapa Compound
JIOC Building
Makalapa Crater
Project Location
HALAWA DR
Kamehameha Highway
Queen Liliuokalani Freeway
MAKALAPA DR
PEARL HARBOR
Magazine Loch
Southeast Loch
Merry Loch
Merry Point
Quarry Loch
LEXINGTON BLVD
HORNET AVE
SALT LAKE BLVD
UILA ST
HALOA DR
KUKILA
KEAKA DR
LIKINI ST
MALAAI ST
MARSHALL RD
NAMUR RD
CLUB RD
HALEALII RD
AVE A
AVE D
AVE G
LAKE ERIE ST
7TH ST
AVENUE E
CENTRAL AVE
Center Drive Relief Sewer
Center Drive
South Avenue
JBPHH PEARL HARBOR
Hickam Village
FOX BLVD
VANDENBERG BLVD
TINKER AVE
OMALLEY BLVD
11TH ST
South Avenue Relief Sewer
Surge Abatement
BOUGAINVILLE DR
HONOLULU
Navy Marine Golf Course
SIGNER BLVD
SCOTT CIR
MILLS BLVD
BOQUET ST
6TH ST
HANGAR AVE
FREEDOM AVE
APOLLO AVE
LILIWAI ST
MAIN ST
20TH ST
KUNTZ AVE
ENGINE TEST RD
MC CLELLAND ST
MOFFET ST
0
2000
Feet
Meters
0
500
Source: USGS, 2017

LINDA LINGLE
GOVERNOR
THEODORE E. LIU
DIRECTOR
MARK K. ANDERSON
DEPUTY DIRECTOR
ABBEY SETH MAYER
DIRECTOR
OFFICE OF PLANNING

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM

OFFICE OF PLANNING
235 South Beretania Street, 6th Floor, Honolulu, Hawaii 96813
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

Telephone: (808) 587-2846
Fax: (808) 587-2824

Ref. No. P-12644

July 9, 2009

Lieutenant Commander E. J. D'Andrea
Assistant Regional Engineer
Department of the Navy
Commander
Navy Region Hawaii
850 Ticonderoga Street, Suite 110
Pearl Harbor, Hawaii 96860-5101

Attention: Mr. Brian Yamada

Dear Lt. Commander D'Andrea:

Subject: Hawaii Coastal Zone Management (CZM) Program Federal Consistency Concurrence with Modifications to the Department of the Navy De Minimis Activities in Hawaii under the Coastal Zone Management Act (CZMA)

The Hawaii CZM Program has completed the federal consistency review of the proposed modifications to the list of Department of the Navy de minimis activities under the CZMA, including changes to various activity categories, adding new activity categories, and expanding the coverage to Marine Corps Base Hawaii Kaneohe Bay and Camp Smith. The CZM Program conducted a thorough review of the request and a public notice of the CZM review was published in the State of Hawaii Office of Environmental Quality Control's publication, *The Environmental Notice*, on June 23, 2009. The public was provided an opportunity to participate in the review through July 7, 2009. There were no public comments received.

We concur that the activities identified on the modified list entitled, "Navy/Marine Corps De Minimis Activities Under CZMA" are expected to have insignificant direct or indirect (cumulative and secondary) coastal effects, and should not be subject to further review by the Hawaii CZM Program on the basis and condition that the listed activities are subject to and bound by full compliance with the corresponding "Project Mitigation / General Conditions."

The Hawaii CZM Program reserves the right to review, amend, suspend, and/or revoke the "Navy/Marine Corps De Minimis Activities Under CZMA" list whenever it finds that a listed activity or activities will have reasonably foreseeable coastal effects. CZM consistency

concurrence does not convey approval with any other regulations administered by any State or County agency.

Modifying and expanding the list of Navy de minimis activities under the CZMA was a cooperative effort between our Office and Mr. Brian Yamada from the Department of the Navy, who interned with the Hawaii CZM Program in September 2008. We appreciate the efforts of Mr. Yamada in working with our CZM staff. The de minimis activities list will result in more efficient compliance with CZMA federal consistency requirements for both the Navy and the Hawaii CZM Program.

If you have any questions, please call John Nakagawa of our CZM Program at 587-2878.

Sincerely,

Abbey Seth Mayer
Director

c: U.S. Army Corps of Engineers, Regulatory Branch (w/ copy of de minimis list)
Ms. Rebecca Hommon, Region Counsel, Navy Region Hawaii

DEPARTMENT OF THE NAVY
COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
PEARL HARBOR, HAWAII 96860-5101

5090
Ser N4/ 04163
01 JUN 2009

CERTIFIED MAIL NO. 7007 2560 0002 0326 9580

Mr. Abbey Mayer
Office of Planning
Department of Business, Economic
Development and Tourism
P. O. Box 2359
Honolulu HI 96804

Dear Mr. Mayer:

SUBJECT: REQUEST FOR CONCURRENCE WITH MODIFICATIONS TO THE DEPARTMENT OF THE NAVY DE MINIMIS ACTIVITIES UNDER THE COASTAL ZONE MANAGEMENT ACT (CZMA)

This letter is to request your concurrence with the attached list of Navy/Marine Corps de minimis activities under the CZMA. The attached de minimis list will amend the current de minimis list which was established on April 2, 2007. The new de minimis list will include the Marine Corps, and will cover areas in the Pearl Harbor Naval complex, Naval Magazine Lualualei, Naval Communications and Telecommunications Area Master Station Pacific, Pacific Missile Range Facility on Kauai, Kaneohe Marine Corps Base Hawaii, Camp Smith and all associated installations/facilities/equipment located outside of those Navy/Marine Corps properties.

The Navy and Marine Corps have determined that the listed Proposed Actions have insignificant direct or indirect (cumulative and secondary) coastal effects and should therefore be categorized as de minimis in accordance with the Department of Commerce, National Oceanic and Atmospheric Administration, CZMA Federal Consistency Regulations 15 CFR part 930.33 (3). With the corresponding mitigation and conditions applied, these actions would be exempt from a negative determination or a consistency determination from the State of Hawaii.

Should you have any questions, please contact Mr. Brian Yamada at 472-1449, by facsimile transmission at 474-5419, or by email at brian.yamada@navy.mil.

Sincerely,

E. J. D'ANDREA
Lieutenant Commander, CEC, U. S. Navy
Assistant Regional Engineer
By direction of the
Commander

Enclosure: 1.Navy De minimis Activities Under CZMA

Navy/Marine Corps De Minimis Activities Under CZMA

***covering areas in Pearl Harbor Naval Complex, Naval Magazine Lualualei, Naval Communications and Telecommunications Area Master Station (NCTAMS) Pacific, Pacific Missile Range Facility (PMRF), Kaneohe Marine Corps Base Hawaii, Camp Smith, and all associated installations/facilities/equipment located outside of these Navy/Marine Corps properties**

No.	Proposed Action	Description	Mitigation / Conditions
1	New Construction	Construction of new facilities and structures wholly within Navy/Marine Corps controlled areas (including land and water) that is similar to present use and, when completed, the use or operation of which complies with existing regulatory requirements.	1, 3, 6, 8, 9, 10, 11, 13, 14, 16
2	Utility Line Activities	Acquisition, installation, operation, construction, maintenance, or repair of utility or communication systems that use rights of way, easements, distribution systems, or facilities on Navy/Marine Corps controlled property. This also includes the associated excavation, backfill, or bedding for the utility lines, provided there is no change in preconstruction contours.	1, 10, 11, 12, 14, 16
3	Repair and Maintenance	Routine repair and maintenance of buildings, ancillary facilities, piers, wharves, dry docks, vessels, or equipment associated with existing operations and activities.	12, 14, 16
4	Aids to Navigation	Includes buoys, beacons, signs, etc. placed within Navy/Marine Corps controlled coasts and navigable waters as guides to mark safe water.	2, 5, 14, 16
5	Structures in Fleeting and Anchorage Areas	The installation of structures, buoys, floats and other devices placed within anchorage or fleeting areas to facilitate moorage of vessels within Navy/Marine Corps controlled property.	2, 5, 14, 16
6	Oil Spill and Hazardous Waste Cleanup	Activities required for the containment, stabilization, removal and cleanup of oil and hazardous or toxic waste materials on Navy/Marine Corps controlled property.	1, 8, 14, 16
7	Maintenance Dredging	Excavation and removal of accumulated sediment for maintenance to previously authorized depths.	2, 3, 4, 5, 7, 8, 9, 13, 14, 16
8	New Dredging	Excavation and removal of material from the ocean floor not to exceed 100 cubic yards below the plane of the ordinary high water mark or the mean high water mark from navigable waters of the US and; excavation and removal of material from the ocean floor within Navy/Marine Corps controlled property. This does not include dredging or degradation through coral reefs.	2, 3, 4, 5, 7, 8, 9, 13, 14, 16
9	Scientific Measuring Devices	The installation of devices which record scientific data (staff gages, tide gages, water recording devices, water quality testing and improvement devices and similar structures) on Navy/Marine Corps controlled property. Devices must not transmit acoustics (certain frequencies) that will adversely affect marine life.	1, 2, 14, 16
10	Studies and Data Collection and Survey Activities	Studies, data and information-gathering, and surveys that involve no permanent physical change to the environment. Includes topographic surveys, wetlands mapping, surveys for evaluating environmental damage, engineering efforts to support environmental analyses, core sampling, soil survey sampling, and historic resources surveys.	2, 3, 6, 8, 9, 11, 12, 13, 14, 16
11	Demolition	Demolition and disposal involving buildings or structures when done in accordance with applicable regulations and within Navy/Marine Corps controlled properties.	1, 11, 12, 14, 16
12	Military Testing and Training	Routine testing and evaluation of military equipment on or over military, or an established range, restricted area or operating area or training conducted on or over military land or water areas in which the impact is not significant.	9, 13, 14, 15, 16
13	Real Estate/Property Transfer	Real estate acquisitions or outleases of land involving new ingrants/outgrants and/or 50 acres or more where existing land use will change.	14, 16

ENCLOSURE(1)

14	Mission Changes	Mission changes, base closures/relocations/consolidations, and deployments that would cause long term population increases or decreases in affected areas.	14, 16
15	Limitation of Access to Property	Permanent closure or limitation of access to any areas that were open previously to public use, such as roads or recreational purposes (provided the access is not required by established agreements with State of Hawaii, private industry, etc.)	14, 16
16	Environmental Management Activities	Environmental management activities within Navy/Marine Corps controlled areas including, but not limited to, activities such as vegetation and mangrove removal, ditch clearing, sediment removal, invasive species removal, construction related to protecting endangered species and wildlife, and actions prescribed by the Integrated Natural Resources Management Plan (INRMP)	2, 13, 14, 16
17	Towers	Installation, operation, and maintenance of towers (such as communication towers, cellular phone antennas, wind-energy towers) within Navy/Marine Corps controlled areas.	1, 2, 6, 8,9 , 12, 13, 14, 16
18	Alternative Energy Research	Installation, operation, replacement, and removal of alternative energy research structures/equipment taking place within Navy/Marine Corps controlled areas.	1, 2, 3, 5, 6, 12, 13, 14, 16
19	Army Corps Nation Wide Permits	Work subject to an Army Corps of Engineers Nationwide permit (which are applicable to Hawaii)	16

Project Mitigation / General Conditions

1) Navy/Marine Corps controlled property refers to land areas, rights of way, easements, roads, safety zones, danger zones, ocean and naval defensive sea areas under active Navy/Marine Corps control.
2) If any listed species enters the area during conduct of construction activities, all activities should cease until the animal(s) voluntarily depart the area.
3) Turbidity and siltation from project related work shall be minimized and contained to within the vicinity of the site through appropriate use of effective silt containment devices and the curtailment of work during adverse tidal and weather conditions.
4) Dredging/filling in the marine/aquatic environment shall be scheduled to avoid coral spawning and recruitment periods.
5) All project-related materials and equipment (dredges, barges, backhoes, etc.) to be placed in the water shall be cleaned of pollutants prior to use.
6) No project-related materials (fill, revetment rock, pipe, etc.) should be stockpiled in the water (intertidal zones, reef flats, stream channels, wetlands, etc.).
7) All debris removed from the marine/aquatic environment shall be disposed of at an upland site or EPA approved ocean disposal site, and Best Management Practices shall be followed.
8) No contamination (trash or debris disposal, alien species introductions, etc.) of adjacent marine/aquatic environments (reef flats, channels, open ocean, stream channels, wetlands, etc.) shall result from project-related activities.
9) Fueling of project-related vehicles and equipment should take place away from the water and a contingency plan to control petroleum products accidentally spilled during the project shall be developed. Absorbent pads and containment booms shall be stored on-site, if appropriate, to facilitate clean-up of accidental petroleum releases.
10) Any under-layer fills used in the project shall be protected from erosion with stones (or core-loc units) as soon after placement as practicable.
11) Any soil exposed near water as part of the project shall be protected from erosion (with plastic sheeting, filter fabric, etc.) after exposure and stabilized as soon as practicable (with vegetation matting, hyrdroseeding, etc.).
12) Section 106, of the National Historic Preservation Act (NHPA), consultation requirements must be met. Also, follow guidelines in the area-specific Integrated Cultural Resources Management Plan (ICRMP) if applicable.
13) Navy/Marine Corps shall evaluate the possible impact of the action on species and habitats protected under the Endangered Species Act (ESA). If the Navy/Marine Corps determines that no such species or habitats will be affected by the action, neither U.S. Fish and Wildlife (FWS) Service nor National Oceanic and Atmospheric Administration (NOAA) concurrence is required. Should it be determined by the Navy/Marine Corps, FWS, or NOAA that the action may affect any such species or habitat, informal or formal consultation will be initiated by the Navy/Marine Corps as required by section 7 (Interagency Cooperation) of the ESA.
14) The National Environmental Policy Act (NEPA) review process will be completed.
15) The training, testing and evaluation will be conducted in accordance with applicable standard operating procedures protective of the environment.
16) Navy or Marine Corps staff shall notify State CZM of de minimis list usage for projects which require an Environmental Assessment (EA). Notification can be sent via email: to JNakagaw@dbedt.hawaii.gov

Appendix E
Noise Methodology and Calculations

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Appendix E - Noise Methodology and Calculations (Preferred Alternative)

Construction Period

Estimated impacts of the Proposed Action used Federal Transit Administration's guidance for Transit Noise and Vibration Impact Assessment guidance (U.S. Department of Transportation, 2006; available online (https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA_Noise_and_Vibration_Manual.pdf) to estimate noise levels from construction equipment to nearest noise sensitive receptor.

Formula: Leq (equip) = E.L. + 10log(U.F.) - 20log(D/50) - 10G log(D/50)

USEPA's typical sound level reduction of buildings in warm climates with closed windows (i.e., 24 dB), was used to estimate attenuation of building structures in calculating interior noise levels of nearest noise sensitive receptors.

16-in Octagonal Pile Driver	**To NGIS**				**Notes**
Leq (equip)	Leq at a receiver resulting from the				
=	operation of a single piece of equipment over a specified period of time				
E.L.	is the noise emission level of the particular piece of equipment at the reference distance of 50 feet, taken from Table 12-1				
G	is a constant that accounts for topography and ground effects, taken from Fig. 6-5				
D	is the distance from the receiver to the piece of equipment		265	feet	
U.F.	is a usage factor that accounts for the fraction of time that the equipment is in use over the specified time period		1		
		=			
	Impact Pile Driver E.L.		101	dB	16-in octagonal pile (from Table 12-1 in source doc)
		=			
	10log(U.F.)	=	0		
	D	=	265	feet	to NGIS
	G	=	0		
	D/50	=	5.3		
	log(D/50)	=	0.724276		
	20log(D/50)	=	14.48552		
	10G log(D/50)	=	0		
	Leq (equip)	=	86.5145	dB	
			-24.0000	dB	attenuation of building structure
			62.5145		

16-in Octagonal Pile Driver	**To Makalapa Family Housing (west rim)**				**Notes**
Leq (equip)	Leq at a receiver resulting from the				
=	operation of a single piece of equipment over a specified period of time				
E.L.	is the noise emission level of the particular piece of equipment at the reference distance of 50 feet, taken from Table 12-1				
G	is a constant that accounts for topography and ground effects, taken from Fig. 6-5				
D	is the distance from the receiver to the piece of equipment		780	feet	
U.F.	is a usage factor that accounts for the fraction of time that the equipment is in use over the specified time period		1		
		=			
	Impact Pile Driver E.L.		101	dB	16-in octagonal pile (from Table 12-1 in source doc)
		=			
	10log(U.F.)	=	0		
	D		780	feet	to nearest residential use
		=			
	G	=	0		
	D/50	=	15.6		
	log(D/50)	=	1.193125		
	20log(D/50)	=	23.86249		
	10G log(D/50)	=	0		
	Leq (equip)	=	77.1375	dB	
			-24.0000	dB	attenuation of building structure
			53.1375		

16-in Octagonal Pile Driver	**To Makalapa Elementary School**				**Notes**
Leq (equip) =	Leq at a receiver resulting from the operation of a single piece of equipment over a specified period of time				
E.L.	is the noise emission level of the particular piece of equipment at the reference distance of 50 feet, taken from Table 12-1				
G	is a constant that accounts for topography and ground effects, taken from Fig. 6-5				
D	is the distance from the receiver to the piece of equipment		1400	feet	
U.F.	is a usage factor that accounts for the fraction of time that the equipment is in use over the specified time period		1		
		=			
	Impact Pile Driver E.L.		101	dB	16-in octagonal pile (from Table 12-1 in source doc)
		=			
	10log(U.F.)	=	0		
	D	=	1400	feet	to nearest off-base noise sensitive receptor
	G	=	0		
	D/50	=	28		
	log(D/50)	=	1.447158		
	20log(D/50)	=	28.94316		
	10G log(D/50)	=	0		
	Leq (equip)	=	72.0568	dB	
			-24.0000	dB	attenuation of building structure
			48.0568		

Operational Period:

Existing noise profiles and estimated impacts of the Proposed Action used HDOT Highway Performance Monitoring System average annual daily traffic (AADT) data reported in 2016 (HPMS, 2016) in calculations made using HUD's Day/Night Noise Level (DNL) Calculator to estimate noise levels from roadway traffic. Outputs from the calculator are provided on the following pages.

DNL Calculations: Luaole Street – Existing Condition

Home (/) > **Programs (/programs/)** > **Environmental Review (/programs/environmental-review/)** > DNL Calculator

DNL Calculator

WARNING: HUD recommends the use of Microsoft Internet Explorer for performing noise calculations. The HUD Noise Calculator has an error when using Google Chrome unless the cache is cleared before each use of the calculator. HUD is aware of the problem and working to fix it in the programming of the calculator.

The Day/Night Noise Level Calculator is an electronic assessment tool that calculates the Day/Night Noise Level (DNL) from roadway and railway traffic. For more information on using the DNL calculator, view the **Day/Night Noise Level Calculator Electronic Assessment Tool Overview (/programs/environmental-review/daynight-noise-level-electronic-assessment-tool/)**.

Guidelines

- To display the Road and/or Rail DNL calculator(s), click on the "Add Road Source" and/or "Add Rail Source" button(s) below.
- All Road and Rail input values must be positive non-decimal numbers.
- All Road and/or Rail DNL value(s) must be calculated separately before calculating the Site DNL.
- All checkboxes that apply must be checked for vehicles and trains in the tables' headers.
- **Note #1:** Tooltips, containing field specific information, have been added in this tool and may be accessed by hovering over all the respective data fields (site identification, roadway and railway assessment, DNL calculation results, roadway and railway input variables) with the mouse.
- **Note #2:** DNL Calculator assumes roadway data is always entered.

DNL Calculator

DNL Calculator - HUD Exchange 7/13/2018

Site ID	Makalapa Crater (Existing)
Record Date	7/13/18
User's Name	GR

Road # 1 Name:	**Salt Lake Blvd: Luapele to Ala Oli (Existing)**

Road #1

Vehicle Type	**Cars** ☑	**Medium Trucks** ☑	**Heavy Trucks** ☑
Effective Distance	50	50	50
Distance to Stop Sign			
Average Speed	25	25	25
Average Daily Trips (ADT)	22397	5574	380
Night Fraction of ADT	13	13	13
Road Gradient (%)			7
Vehicle DNL	64.5407	68.5005	71.4236
Calculate Road #1 DNL	73.7592	Reset	

Road # 2 Name:	**H-1 Freeway (Off-ramp to Red Hill to Off-ramp to JBPHH) (Existing)**

Road #2

Vehicle Type	**Cars** ☑	**Medium Trucks** ☑	**Heavy Trucks** ☑
Effective Distance	90	90	90
Distance to Stop Sign			

https://www.hudexchange.info/environmental-review/dnl-calculator/ 2

Average Speed	55	55	55
Average Daily Trips (ADT)	88882	2746	3373
Night Fraction of ADT	13	13	13
Road Gradient (%)			0
Vehicle DNL	73.5464	68.4452	75.2384
Calculate Road #2 DNL	77.9823	Reset	

Add Road Source | Add Rail Source

Airport Noise Level	
Loud Impulse Sounds?	○Yes ◉No
Combined DNL for all Road and Rail sources	**79.4154**
Combined DNL including Airport	**N/A**
Site DNL with Loud Impulse Sound	

Calculate

Mitigation Options

If your site DNL is in Excess of 65 decibels, your options are:

- **No Action Alternative**: Cancel the project at this location
- **Other Reasonable Alternatives**: Choose an alternate site
- **Mitigation**
  - **Contact your Field or Regional Environmental Officer (/programs/environmental-review/hud-environmental-staff-contacts/)**

- Reconfigure the site plan to increase the distance between the noise source and noise-sensitive uses
- Incorporate natural or man-made barriers. See *The Noise Guidebook (/resource/313/hud-noise-guidebook/)*
- Construct noise barrier. See the **Barrier Performance Module (/programs/environmental-review/bpm-calculator/)**

Tools and Guidance

Day/Night Noise Level Assessment Tool User Guide (/resource/3822/day-night-noise-level-assessment-tool-user-guide/)

Day/Night Noise Level Assessment Tool Flowcharts (/resource/3823/day-night-noise-level-assessment-tool-flowcharts/)

DNL Calculations: Luaole Street – Future Without Project

Home (/) > **Programs (/programs/)** > **Environmental Review (/programs/environmental-review/)** > DNL Calculator

DNL Calculator

WARNING: HUD recommends the use of Microsoft Internet Explorer for performing noise calculations. The HUD Noise Calculator has an error when using Google Chrome unless the cache is cleared before each use of the calculator. HUD is aware of the problem and working to fix it in the programming of the calculator.

The Day/Night Noise Level Calculator is an electronic assessment tool that calculates the Day/Night Noise Level (DNL) from roadway and railway traffic. For more information on using the DNL calculator, view the **Day/Night Noise Level Calculator Electronic Assessment Tool Overview (/programs/environmental-review/daynight-noise-level-electronic-assessment-tool/)**.

Guidelines

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- All checkboxes that apply must be checked for vehicles and trains in the tables' headers.
- **Note #1:** Tooltips, containing field specific information, have been added in this tool and may be accessed by hovering over all the respective data fields (site identification, roadway and railway assessment, DNL calculation results, roadway and railway input variables) with the mouse.
- **Note #2:** DNL Calculator assumes roadway data is always entered.

DNL Calculator

DNL Calculator - HUD Exchange 7/13/2018

Site ID	Makalapa Crater (Future Without Project)
Record Date	7/13/18
User's Name	GR

Road # 1 Name:	**Salt Lake Blvd: Luapele to Ala Oli (Future Without Project)**

Road #1

Vehicle Type	**Cars** ☑	**Medium Trucks** ☑	**Heavy Trucks** ☑
Effective Distance	50	50	50
Distance to Stop Sign			
Average Speed	25	25	25
Average Daily Trips (ADT)	23519	5853	399
Night Fraction of ADT	13	13	13
Road Gradient (%)			7
Vehicle DNL	64.753	68.7126	71.6355
Calculate Road #1 DNL	73.9712	Reset	

Road # 2 Name:	**H-1 Freeway (Off-ramp to Red Hill to Off-ramp to JBPHH) (Future w/o Pı**

Road #2

Vehicle Type	**Cars** ☑	**Medium Trucks** ☑	**Heavy Trucks** ☑
Effective Distance	90	90	90
Distance to Stop Sign			

https://www.hudexchange.info/environmental-review/dnl-calculator/ 2

Average Speed	55	55	55
Average Daily Trips (ADT)	88882	2746	3373
Night Fraction of ADT	13	13	13
Road Gradient (%)			0
Vehicle DNL	73.5464	68.4452	75.2384
Calculate Road #2 DNL	77.9823	Reset	

Add Road Source | Add Rail Source

Airport Noise Level	This is the DNL (in dB) of all Road and Rail noise sources. (this does not include Airport Noise)
Loud Impulse Sounds?	○Yes ◉No
Combined DNL for all Road and Rail sources	**79.479**
Combined DNL including Airport	**N/A**
Site DNL with Loud Impulse Sound	

Calculate

Mitigation Options

If your site DNL is in Excess of 65 decibels, your options are:

- **No Action Alternative**: Cancel the project at this location
- **Other Reasonable Alternatives**: Choose an alternate site
- **Mitigation**
  - **Contact your Field or Regional Environmental Officer (/programs/environmental-review/hud-environmental-staff-contacts/)**

- Reconfigure the site plan to increase the distance between the noise source and noise-sensitive uses
- Incorporate natural or man-made barriers. See *The Noise Guidebook (/resource/313/hud-noise-guidebook/)*
- Construct noise barrier. See the **Barrier Performance Module (/programs/environmental-review/bpm-calculator/)**

Tools and Guidance

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Day/Night Noise Level Assessment Tool Flowcharts (/resource/3823/day-night-noise-level-assessment-tool-flowcharts/)

DNL Calculations: Luaole Street – Future With Project

Home (/) > Programs (/programs/) > Environmental Review (/programs/environmental-review/) > DNL Calculator

DNL Calculator

WARNING: HUD recommends the use of Microsoft Internet Explorer for performing noise calculations. The HUD Noise Calculator has an error when using Google Chrome unless the cache is cleared before each use of the calculator. HUD is aware of the problem and working to fix it in the programming of the calculator.

The Day/Night Noise Level Calculator is an electronic assessment tool that calculates the Day/Night Noise Level (DNL) from roadway and railway traffic. For more information on using the DNL calculator, view the **Day/Night Noise Level Calculator Electronic Assessment Tool Overview (/programs/environmental-review/daynight-noise-level-electronic-assessment-tool/)**.

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- **Note #2:** DNL Calculator assumes roadway data is always entered.

DNL Calculator

DNL Calculator - HUD Exchange 7/13/2018

Site ID	Makalapa Crater (Future With Project)
Record Date	7/13/18
User's Name	GR

Road # 1 Name:	**Salt Lake Blvd: Luapele to Ala Oli (Future With Project)**

Road #1

Vehicle Type	**Cars** ☑	**Medium Trucks** ☑	**Heavy Trucks** ☑
Effective Distance	50	50	50
Distance to Stop Sign			
Average Speed	25	25	25
Average Daily Trips (ADT)	24303	6048	412
Night Fraction of ADT	13	13	13
Road Gradient (%)			7
Vehicle DNL	64.8954	68.855	71.7748
Calculate Road #1 DNL	74.1117	Reset	

Road # 2 Name:	**H-1 Fwy: Off-ramp to Red Hill to Off-ramp to JBPHH (Future With Projec**

Road #2

Vehicle Type	**Cars** ☑	**Medium Trucks** ☑	**Heavy Trucks** ☑
Effective Distance	90	90	90
Distance to Stop Sign			

https://www.hudexchange.info/environmental-review/dnl-calculator/ 2

Average Speed	55	55	55
Average Daily Trips (ADT)	88882	2746	3373
Night Fraction of ADT	13	13	13
Road Gradient (%)			0
Vehicle DNL	73.5464	68.4452	75.2384
Calculate Road #2 DNL	77.9823	Reset	

Add Road Source | Add Rail Source

Airport Noise Level	
Loud Impulse Sounds?	○Yes ◉No
Combined DNL for all Road and Rail sources	**79.5211**
Combined DNL including Airport	**N/A**
Site DNL with Loud Impulse Sound	

Calculate

Mitigation Options

If your site DNL is in Excess of 65 decibels, your options are:

- **No Action Alternative**: Cancel the project at this location
- **Other Reasonable Alternatives**: Choose an alternate site
- **Mitigation**
  - **Contact your Field or Regional Environmental Officer (/programs/environmental-review/hud-environmental-staff-contacts/)**

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